Application of Emerging Digital Technologies in self-monitoring of health and water usage.

A Thesis submitted by

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ABSTRACT

Cloud computing is becoming a utility, and an increasing number of industries and users are using cloud computing. The Internet of Things (IoT), fifth generation network (5G), and mobile data that supports the self-management of private information are becoming standard. This study examines the role of cloud computing and 5G in transforming smartphones into a digital assistant for the monitoring and self-management of IoT data. To do so, this study used qualitative methods to focus on the verticals of water utilities and Coronavirus Disease 2019 (COVID-19). The study aimed to investigate the use of an integrated centralized cloud platform with narrowband-IoT (NB-IoT) and 5G that offers low power consumption connectivity for IoT devices, such as smart water meters and wearables, for COVID-19 self-management. The results of this research will assist decision makers when developing future strategies and policies for moving, planning, and implementing cloud computing, 5G, and IoT devices with the help of smart phones for self-managing COVID-19 and monitoring water usage through AMI solutions.

This research is focused on the impact of cloud computing, IoT, and 5G on water utilities and COVID-19-type pandemics for the self-management and monitoring of data using smartphones. This study further emphasis on the importance of centralized platform with 5G and NB-IOT connectivity for smart water metering(SWM), water quality monitoring and self-management of Covid-19 using a novel based approach of mobile data and IOT devices.

The data collection and analysis for self-diagnostic of Covid-19 will further elaborate on the importance and significance of cloud computing for future technologies and innovations, such as IoT, 5G, and the use of smartphones as intelligent assistants. Given the increasing adoption of cloud computing, this study investigates the disruptive impact of cloud

computing, 5G, and IoT on the smart metering and health sectors. Technological, organizational, and user behavioral factors are critical to the decision making regarding the use of cloud computing and IoT. Technology disruption occurs when a new technology exceeds the dominant technology’s primary dimension of performance, and the user’s behavior changes to use the innovation. The use of NB-IoT instead of other old, lower-power wide area networks is becoming an industry standard. NB-IoT is declared a 5G protocol and can offer 20% more coverage than 3G; its power consumption is low, resulting in 15+ years of battery life for smart meters and low device cost.

Advanced metering infrastructure (AMI) technology enables a water meter to communicate with the service provider in an automated, two-way manner **(Chapter 5-Paper 2).** AMI uses a fixed transmission network to remotely transmit and receive signals from meters, providing real-time, regular, or on-demand feedback on water use. This study surveys IoT-oriented platforms that can improve SWM applications. We present IoT-enabled platform management from the application, billing, connectivity, device, and end-user (ABCDE) perspectives that can address the real-world challenges of SWM. This paper introduces the relevant IoT platforms, cloud computing, and AMI solutions and their roles in the delivery of water utility services. End-user mobile applications play a significant role in the monitoring and control of water usage from mobile devices and set up goals for water usage. Utilities can enforce demand management through mobile applications. This paper assesses network connectivity options in terms of their effectiveness to determine the best network connectivity for water utilities. From this assessment, NB-IoT is determined to be the best network connectivity for water utilities. This paper concludes by offering practical implications from this survey for smart metering applications for water utilities.

Chapter 5 addresses the role of the cloud computing platform, and **Chapters 6 and 7** discuss the role of emerging technology for the use case of smart water . The discussion is about smart water products and the role of real-time water quality monitoring using an AMI solution. Smart meters are used only to monitor water usage and not to monitor water quality. Three methods were proposed for water quality monitoring. By using NB-IoT network connectivity to a cloud platform, data from the platform can be pushed to a mobile app for real-time notifications to avoid health-related issues from drinking contaminated water.

The last research question is about the health sector. Given the recent COVID-19 pandemic that affected the community and businesses, the importance of 5G, IoT, and cloud computing is obvious.

Recently, IoT has received significant interest in the latest research genre comprised of an array of smart cities, utilities, and—notably—healthcare. IoT innovation is altering today's healthcare and pandemic frameworks by combining social, financial, and technological ramifications. IoT innovation is converting conventional health services into more personalized systems, making the identification, management, and coordination from mobile devices easier and reducing the risks related to security and privacy as end users manage their data on the cloud through fast 5G networks **(Papers about health use case: Chapter 4 and Chapter 8, Paper 1 and Paper 5)**.

This research will enhance policy makers' knowledge when making decisions, such as selecting a network with 15+ years of longevity and road maps, because NB-IoT is a 5G protocol, and the average life span of a cellular network is 10 to 15 years. The research contribution is three-dimensional, and the key stakeholders with major benefits are water utility providers and the health sector for pandemic control. End users will have an ultimate advantage by using the novel approach discussed in Chapter 5 of this thesis. Residential users can take advantage of water quality and water usage monitoring from their mobile devices. Policy makers and government authorities can make informed decisions when selecting a cloud computing platform, IoT devices, and network and mobile applications. Governments can implement policies using the research recommendations resulting from the facts and findings of research papers. This research outcome will assist decision makers when developing future strategies and policies for moving, planning, and implementing cloud computing, 5G, and IoT devices with the help of smart phones for self-managing COVID-19 and monitoring water usage through AMI solutions.

CERTIFICATION OF THESIS

I SAJJAD AHMED declare that the PhD Thesis entitled "Application of emerging digital technologies in self-monitoring of health and water usage ."Data is not more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references, and footnotes.

This thesis is the work of Sajjad Ahmed except where otherwise acknowledged, with most of the authorship of the papers presented as a thesis by publication undertaken by the student. The work is original and has not been previously submitted for any other award, except where acknowledged.

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STATEMENT OF CONTRIBUTION

Paper 1:

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Sajjad Ahmed contributed an overall 75% to concept development, analysis, drafting, and revisions of the final submission. Professor Jianming Yong and Dr. Anup Shrestha contributed the other 25% through concept development, analysis, editing, and providing important technical inputs.

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Sajjad Ahmed contributed an overall 75% to concept development, analysis, drafting, and revisions of the final submission. Professor Jianming Yong and Dr. Anup Shrestha contributed the other 25% through concept development, analysis, editing, and providing important technical inputs.

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The manuscript has been published. Throughout the entire publication process, the manuscript has undergone a rigorous and comprehensive revision, involving extensive research efforts to ensure its high scientific quality and integrity.

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CHAPTER 1: INTRODUCTION

1.1 Background

In February 2021, the World Health Organization (WHO) officially defined COVID-19 as the Coronavirus Disease 2019. Treating COVID-19 began in more than 30 regions or countries globally immediately after the first confirmed case. Researchers throughout the world actively worked to introduce an effective cure for COVID-19. In the 21st century, popular and updated technology is introduced as IoT systems. Data and information can be realized from IoT systems, along with intelligent management and remote control. Such systems also include various monitoring functions through real-time data networking. However, applying artificial intelligence technology systems to medical work is referred to as extremely significant. In particular, in the context of the COVID-19 pandemic, the work of control and prevention is also included (Radanliev et al., 2020).

The Artificial Intelligence of Things (AIoT) system is used to control COVID-19. This system is very beneficial for the general public and patients and elevates the wearable devices that could be utilized to prevent COVID-19. Individuals have utilized such wearable devices to independently record, observe, and monitor their heart rates, body temperatures, physiological values, and respiration rates, providing quite good and adequate information to develop their own judgments. In particular, isolated individuals can easily and quickly obtain information about changes in their significant signs. Most importantly, AIoT applications for front-line clinical practices can be utilized to improve established, modern, and intelligent medical care. AIoT also includes remote intensive care, remote screening, and intelligent diagnosis, enabling it to be perceived as one of the most important and broad breakthroughs for conventional pandemic control and prevention (Wu and Luo, 2019).

Screening people becomes unnecessary if remote screening in emergency rooms is broadly used; therefore, remote screening can be utilized to reduce the probability of being exposed to viruses. Screening is also used in intelligent diagnosis, which can assist with solving the particular problems of low accuracy and slow speed that are associated with manually reading images on scanned reports. Considered an auxiliary method, intelligent diagnosis can be utilized to assist front-line doctors in quickly examining patients when they are infected. Intelligent diagnosis is also primarily used with isolated patients and those being considered for receiving treatment. The technology of remote intensive care is specifically utilized for patients who have been infected with COVID-19 and can be applied to cured patients after leaving the hospital. Doctors utilize 5G technologies, including Wi-Fi devices and various other third-party mobile devices, to obtain information related to patients' vital signs and to offer them suggestions. 5G technologies can also be observed as a development of telemedicine (Niakan Kalhori et al., 2021).

During the COVID-19 pandemic, many students and faculty have been forced to stay home because of travel restrictions imposed in various countries that aimed to avoid the transmission of the virus. Institutions, clinics, and companies were forced to shift their activities to digital platforms. In addition, the stay-at-home policy resulted in a considerable change in the transportation network away from city districts and toward residential regions. Interconnections have significant challenges because they were not built to handle such a volume of data, not to mention the current rapid changes in consumer demands.

In addition, when traffic demand shifts to residential regions, city center base stations (BSs) receive little or no traffic, leading to energy losses. Furthermore, given mobility constraints, the number of maintenance personnel who visit BS cell sites to restore proper functioning in the event of a cellular or service failure has decreased. Consequently, telecom companies have had to come to terms with additional capacity demands on both the radio interface and the backhaul connections in residential neighborhoods. They have had to quickly restore everyday functioning to malfunctioning sites to minimize long-term service outages resulting in cell blackouts and have had to reduce energy losses from the underutilization of BSs in metropolitan areas, among many other issues. More advanced communication networks, such as 5G mobile communications, would be more effective in addressing the pandemic's major ramifications, given that established mobile wireless technology has significantly reduced the pandemic's impact.

Smart water management systems are not easy to introduce and implement and require the integration of various systems, given their use of complex measures for monitoring, controlling, and regulating water usage and the quality of available water resources. These systems also benefit by managing existing water-related equipment, such as pipes, pumps, and others. The industry currently uses a range of software and hardware instruments, such as meters, sensors, visualization and data processing tools, mobile devices, web controls, and actuators. Web and mobile control systems allow remote control of water resources and help measure the characteristics of water and water systems. Water technology using IoT is beneficial and using imaging can identify corrosion in water pipes to avoid serious damage to users and the utility. Technology provides access to different leakage points on pipes to reduce water waste and the corresponding impact on the environment. Poor management of wastewater can result in driving water contamination, which has significant health implications for the community. Utility industries have used IoT to determine the flow of water and the water pressure inside pipes to make replacement and rehabilitation decisions.

This new era of technology offers several tools that can handle or manage disaster situations, such as COVID-19. According to most experts, IoT is expected to generate tens of billions of connected devices in the coming years. The path to getting there is unclear; however, businesses are already seeking to streamline IoT growth and promptly provide robust solutions (Wiggins, 2020). Using an IoT application enablement framework (AEP) is one of the easiest ways to do so.

The term AEP is a relatively recent term that is often used to describe a software platform category aimed at the IoT market. The theory is that AEPs enable the efficient development of a final solution. The debate is over whether this is done simply because AEPs essentially rely on the availability of professional software developers and operations personnel who are motivated to make it work.

AEPs provide a comprehensive monitoring solution that predicts and reacts to water flow, water pressure, and consumer intake data. AEP is a Digital Utility Platform that uses the NB-IoT network to provide analytics from fully integrated digital meters (Ratasuk et al., 2015). The platform can display data from automated ultrasonic meters that quantify usage and temperature and detect consumer leakage by measuring the overnight minimum flow.

Moreover, the different circumstances related to shortages of medical facilities or staff can be considered. The telemedicine aspect can be utilized to solve particular problems that are required to a certain degree. Doing so is impossible without considering the possibility of cross-infection and human contact. IoT plays a significant role in treatments used by medical facilities and in facilitating the management of society. To say that AIoT can be used to help all of society in resisting the novel coronavirus without considering its characteristics would be wrong. Various aspects of the pandemic are gradually being brought under control by an increasing number of enterprises without considering the small and large consequences. These enterprises also implement AIoT technology to maintain their production and work. AIoT is also used to eliminate dilemmas brought about by the pandemic. In another case, the pneumonia related to COVID-19 has been treated by robots and 5G in various regions. Moreover, the use of 5G information technologies and networks to manage and control COVID-19 has been discussed (Chen et al., 2021).

Since the COVID-19 epidemic became a pandemic, our everyday lives and how we operate our businesses have changed dramatically. The pandemic has affected nearly every aspect of society. Many companies have shuttered as workers were urged to work remotely, schools were shuttered and switched to online educational platforms, and events were rescheduled or moved. To decrease patient contact and prevent the transfer of illness, physician visits were postponed, delayed, or accessed remotely. All these enterprises now rely heavily on both fixed and mobile networks to continue operating.

Consequently, online learning technologies such as Zoom, Microsoft 365, Canvas, and others are increasing in popularity, as is using social networking sites such as Facebook, Instagram, and Snapchat for social interactions. Furthermore, in many nations, the use of multiple channels, such as online games, Netflix, YouTube, and others, increased as people attempted to stay entertained during the lockdowns.

The research scope and the inherent connection between Covid-19 and smart water are unequivocally established, as evidenced by the increasing need for smart phones, mobile applications, and data analysis for self-diagnosis and monitoring, as reflected in current industry trends. In the past, smart metering has been utilized with Low Power Wide Area Networks (LPWANs) that were specifically designed and configured for metering data transmission exclusively. However, recent advancements and technological changes have necessitated a shift towards a centralized platform, where data from multiple sensors is collected through NB-IOT (Narrowband Internet of Things) mobile networks and transmitted to a device management platform prior to being made available for end users' monitoring and self-management.

1.2 This novel approach is akin to the concept of self-diagnosis for Covid-19, where end users are empowered to manage their own data and engage in self-diagnostic activities. Notably, the overall framework for this approach is similar, with the pivotal role of cloud computing, artificial intelligence (AI), 5G, and the Internet of Things (IoT) being instrumental in leveraging data from mobile handsets for effective Covid-19 management.Role of Emerging technologies (5G, IoT and Cloud) for self-monitoring in different industries with example of two use cases

This section is an additional component of the thesis document that elucidates the rationale behind selecting two specific verticals as use cases for the research. The primary focus was on smart utilities, and within the utilities sector, water was chosen as a compelling use case to underscore the significance of emerging technologies for enabling self-service. To illustrate the applicability of this approach across various industries and segments, the timely and topical issue of COVID-19 in the years 2020 and 2021 was also included as a use case.

Although the two use cases, namely water and COVID-19, may not seem directly related, they share similarities in terms of the utilization of technology for self-service through mobile applications. This exemplifies how this approach can be replicated in multiple industries and sectors, as a single industry or vertical would not suffice to adequately demonstrate the proposed research work's concept and framework.

Irrespective of the industry, the overall architecture and framework remain consistent. Data is collected from IoT sensors, cameras, or other connected devices and transmitted through various networks such as cellular, low-power wide area networks (LPWANs), Lorawan, Sigfox, or satellite, to a connectivity management platform, and then to a device management platform. Visualization and reporting are facilitated through an application enablement platform before the data is sent to the end users, who can then self-manage it from their mobile handsets.

Figures 7, 8, and 9 serve as noteworthy examples of how IoT, 5G, cloud computing, and AI are employed for self-service in the context of COVID-19 and smart water. Figure 8 provides additional details on the integration of smart cities, smart transport, smart energy, smart parks, and smart retail.

The selection of the use cases was based on the wide-ranging demand and relevance of the verticals. Water, being a critical utility for any society, was prioritized over smart energy or transport, as it is indispensable for human survival. The quality, distribution, management, and monitoring of water are pivotal for ensuring public health. Similarly, COVID-19 was chosen due to its criticality as a global health crisis that significantly impacted social life and public health worldwide. The research shares the same aims and goals for both verticals, emphasizing the importance of emerging technologies and self-service in their contexts.

1.3 Roll-out of 5G networks

5G technology will continue to work for the next 10 to 15 years, which is the normal life span of cellular technology. Each step along the path from the start of 1G to the full deployment of 5G—from 1G to 2G to 3G to 4G, and then to 5G—was approximately 10 years long. In Australia and other developed countries, 2G has been deactivated, and the planned 3G shutdown is expected to release spectrum capacity for 5G, given that spectrum costs and technology efficiency are forcing operators to utilize their resources more effectively. Enhanced mobile broadband will offer much higher speeds than 3G and 4G. Low latency, low device power consumption, low-cost modules, better coverage, low data needs, two-way communication, 3GPP standards, security scalability, and future-proof longevity for NB-IoT and cellular technologies are making them more preferred for delivering utility metering and health management functions, such as for COVID-19. For example, NB-IoT may be the best technology for connecting millions of smart water meters because there will be no need to deploy a private network; moreover, NB-IoT as a 5G protocol will continue to work for the life of the meters—10 to 15 years.

The life span of different technologies as per GSM is illustrated as follows (Attaran, 2021).

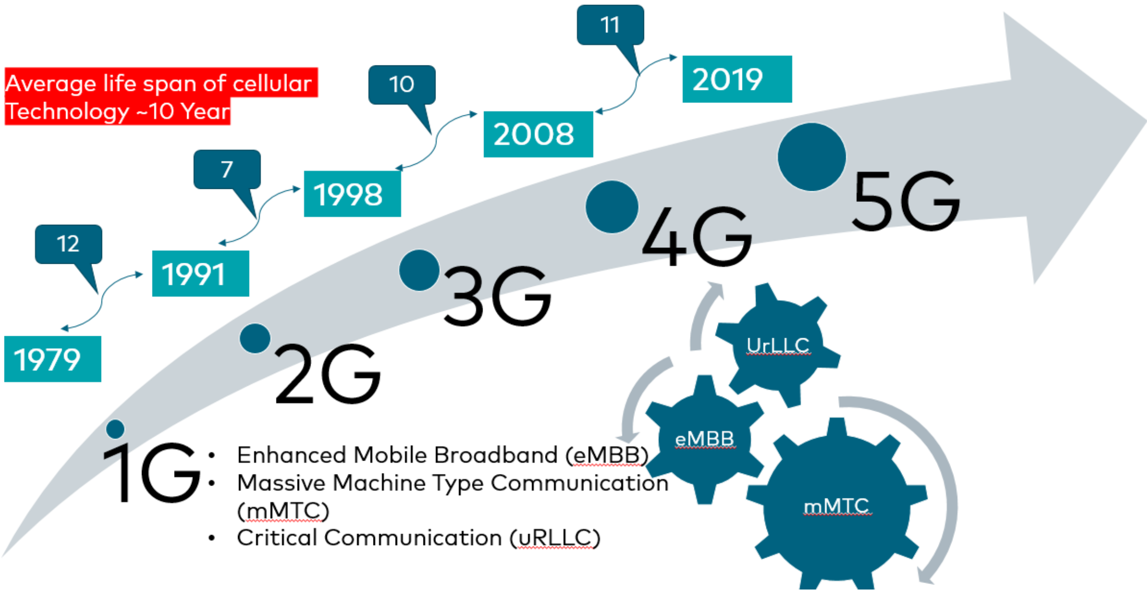


Figure 1 Life span of Cellular Technologies

The 5G mobile network is considered to be disruptive for the production models and industrial organizations because of its technical characteristics, including ultra-reliable low latency and the stronger network security that is also utilized in massive machine-type communication to enhance the efficiency of the energy of devices. Hence, the rollout of these technologies can be critical to reducing the extension of broadband services to beyond the mobile Internet for complex IoT systems. High reliability and low latency are needed to support the complex and critical applications used throughout the economic sector (Fujii et al., 2021).

5G mobile networks are utilized to support innovative uses throughout the industry. These networks are also used to enhance broadband experiences, along with the large scale of IoT and mission-critical services used to offer innovation to segmented latency levels. Although edge computing is specifically used for the 4G environment, combining it with 5G networks and AI can enable new uses in the particular vertical industries that are also required to enhance the adoption of industry models. Gains in competitiveness and productivity to enhance sustainability can also be achieved. Building smart factories and taking complete advantage of technologies, such as robotics and automation, is probable when developing 5G networks. 5G can also be used for augmented reality, artificial intelligence, and IoT at various stages in the value chain (Agarwal et al., 2021).

When compared with existing wireless networks, 5G networks will provide fast information speeds and greater capacity to process massive device connections, reduce latency, increase reliability and mobility, and improve the energy economy. All of these capabilities could be provided by 5G networks, which offer three types of support: advanced wireless broadband; ultra-reliable, low-latency telecommunications; and enormous, machine-type communication systems. Self-organizing systems and machine learning (ML) have been merged to allow 5G networks to function intelligently and autonomously. AI will be fully integrated into B5G systems, despite the fact that it is only partially deployed in 5G technology. Given the significant changes in the systems that deliver services and operating processes that resulted from governmental and other organizations' restrictions and the telecommuting initiatives utilized to prevent the spread of COVID-19, AI in 5G technologies will enhance the advanced processes that are expected to be essential in the ongoing and prospective pandemic circumstances.

Therefore, this thesis focuses on the role of AI-driven 5G technology in solving the challenges that existing networks confront as a result of the COVID-19 pandemic. This thesis focuses on the connectivity problems that AI can solve in 5G. Although only a few AI-based technologies are appropriate for 5G, some of the AI solutions addressed in this thesis will be used in B5G networks. Given the enormous number of publications on using AI and ML techniques in 5G and B5G structures and the in-depth evaluations of the use of ML algorithms in both 5G and B5G connections, this study does not replicate the work of these publications. The goal of this thesis is to uncover some of the specific networking challenges faced by existing networks as a consequence of the COVID-19 pandemic and the possible AI/ML-driven solutions that might help 5G and B5G networks manage these challenges.

The key competitive edge of 5G is the occurrence of real-time access to the information required for decision making by considering its complete role in the value chain when a more efficient utilization of resources and better meeting demand are required. This competitive edge has been made possible and probable through cloud-based solutions that enhance the ability to integrate the various stages in the chain. To design such solutions, similar software can be utilized along with the implementation and simulation of the configuration. 5G also includes the particular instructions required to operate physical production line systems and, hence, can be used to improve the flexibility and quality of operations. The traditional assembly process has been replaced by such solutions. In the specific event of changes, broader flexibility for configuring production plants can be offered, as well as processes for streamlining and reducing costs. 5G technology is also utilized to reduce delivery time and improve logistics management and specifically to capture consumer attention in positive ways. Several other specific uses include control systems, designing and planning industrial automation systems, and other field devices required to offer the information needed to complete the optimization process. Additionally, incorporating artificial intelligence into decision making enables resource management to optimize the complete view to reduce environmental footprints in different areas, such as the exploitation of natural resources, consumption, manufacturing, transport, and logistics (Karthika and Kalaiselvi, 2021).

Because of the COVID-19 outbreak, our daily lives and routines have changed in dramatic and drastic ways. The pandemic has also affected the particular ways by which we have conducted our business activities. Generally, each sector of the economy, including transportation, health, manufacturing, and education, was affected by the pandemic. That the pandemic was a global disaster can be said. Several companies shut down because of their specific advice to workers to work from home. Even schools closed their classrooms and offered online classes. Doctors canceled their appointments because they were busy with emergency treatments of patients to prevent COVID-19 deaths. They also postponed their appointments and attempted to reduce their contact with patients, which were good steps to curtailing the spread of the virus. The discussion is about the dependability of these sectors, which continued to operate because of wired and wireless communication (Pouttu et al., 2020).

The outbreak caused online learning platforms, online working platforms, and working from home to become all too common, which was the key reason for increasing the utilization of social media platforms for social connections, such as WhatsApp, Twitter, and Facebook. Moreover, the urge to use multimedia platforms also increased. YouTube, Netflix, online gaming, and other platforms kept people in many countries entertained during the lockdown (Ahmed et al., 2020).

All of these factors created increased existing network traffic because of policies implemented in various countries that restricted individuals' movements to reduce the spread of this particular infection. The global spread of the virus caused a broad range of workers and students to stay home; thus, all of the normal activities of hospitals, schools, and industries shifted to online platforms. Additionally, the traffic pattern suddenly shifted from city centers to residential areas because of the stay-at-home policies. The situation became crucial and challenging for existing networks because they were not designed to accommodate such a magnitude of traffic demand or the sudden shift in the traffic pattern.

Moreover, the particular shift in the traffic demand toward residential areas resulted in no traffic or little demand being placed on the base stations in city centers, also resulting in wasted energy. Additionally, restrictions in movements mean that fewer maintenance workers were in the Wi-Fi range who were eager to access BS cell sites to restore them to normal functionality during outages and failures (Kaur, 2020).

Yet, operators of radio access networks (RAN) and backhaul networks in residential areas had to grapple with increasing demand for capacity. These networks were also used to promptly restore normal operations to various faulty sites to prevent prolonged service failures because of cell outages and to prevent energy wastage because of the underutilized BSs in city centers, as well as from several other challenges. It is also not considered more worthy due to the technologies of existing networks and the impact of the pandemic that has been reduced greatly. Hence, the deployment and development of more innovative and advanced technologies, such as 5G mobile networks and beyond, are considered more effective in alleviating the negative effects of the pandemic in numerous sectors (Chamola et al., 2020).

5G has been completed deployed in only a few countries and is likely to continue to be deployed in the near future. Relative to existing networks, 5G offers a high data rate with high security and privacy. A high level of device connectivity is possible with 5G, which also provides connectivity with a high level of energy efficiency. 5G is capable of providing a high level of reliable communications, and its three high service levels are famously known as enhanced Mobile Broadband (eMBB). eMBB is used to enhance mobile broadband services. The second service provided by a 5G network is ultra-reliable low-latency communications (URLLC). The last service provided by 5G is massive machine-type communications (MTC). In addition to these three main services provided by 5G, the technology also provides many other services, such as self-organizing or enabling a network to self-organize and AI capability or being capable of implementing artificial intelligence. Therefore, 5G can work not only with intelligence but also at an autonomous level. AI is partially implemented in 5G—but before 5G was fully implemented in other network technologies (Sun, 2021).

COVID-19 has severely affected all aspects of human life throughout the world, including social, religious, and economic aspects. Society faces significant fears from COVID-19-related problems. Many studies found that COVID-19 started from the Chinese city of Wuhan, and that the virus spread from a zoonotic virus, which transfers to humans from an animal. The coronavirus spreads very rapidly from person to person through social interactions. To avoid contracting this pathogen, we social distance from each other, and the WHO provides different advice from time to time to help people avoid contracting COVID-19. The WHO has also attempted to mitigate different problems using already available local recourses, such as IoT, cloud computing, and handset data, and implemented a general framework to reduce the various issues created by the COVID-19 pandemic (Thomas et al., 2021).

No vaccine is 100% effective against the SARS-CoV-2 virus. However, many resources exist to help us to mitigate the impact of the COVID-19 vaccination. These resources are very effective and easy to implement because they are already working throughout society. Society has already adjusted to 5G information technology, mobile handset data, AI, and cloud computing terms. These technologies have a significant impact on self-management and allow people throughout the world to make online purchases and work online. They do not have to go to the office and face the possibility of contracting the SARS-CoV-2 virus. Instead, they work online from home through their devices. Workers share different tasks to control COVID-19.

Using their handsets, people can save their data on the cloud, making their data almost completely secure and easily shareable with other managerial and field staff. These technologies also help students continue their studies online from home, and the teacher uses different apps to deliver lectures. Students learn from the online lectures and submit their assignments using different cloud applications. People can work online, teach students online, and make online purchases—many applications exist that allow people to purchase different products globally. Therefore, 5G information technology, mobile handset data, AI, and cloud computing play significant roles in self-management and in helping people mitigate COVID-19 issues (Wu and Luo, 2019).

Advanced Metering Infrastructure (AMI) is a term that is used in IoT; AMI is two-way communication technology that helps provide user demand data to service providers through a signal received from a meter. AMI uses a fixed network for transmission, receives information from the user’s meter, and takes actions on the user’s meter signal on the basis of observations of demand and information received from the cloud. AMI also helps provide real-time feedback and on-demand information. IoT helps objects become smarter by assisting them in communicating with each other. IoT is used by individuals to obtain goals and helps with understanding relevant tools and technologies. For example, IoT helps developers organize their work. Different platforms indirectly or directly provide guidelines to address real-world issues with the help of IoT technologies. IoT also significantly assists with mitigating COVID issues and supports self-management.

Our research supports the implementation of different IoT concepts to support self-management and mitigate COVID-19-related issues. 5G, which can provide autonomous operations using intelligence, is very useful during the pandemic because it is updated and can work at greater efficiency. 5G can work on dynamic resource allocation. However, as we have previously known, 5G networks implement static resource allocation. Given this dynamic resource allocation facility, 5G can work during sudden shifts in network traffic, which can be explained with the following example. When network traffic needs to change from the center of a province to a residential area, then the traffic will be mange on an atomic basis, which is desirable during the pandemic because network traffic suddenly increased as most people moved to working from home. Moreover, AI can prove optimization and support for the medical and health care fields. During COVID-19, 5G enabled the provision of online health services and could manage serious situations.

1.4 Motivation of the study

The motivation of this research is examined by exploring its scope. The scope of this research is huge because it evaluates a list of the benefits of technologies. This research also explores the accuracy of these technologies in controlling the COVID-19 pandemic. The particular benefits of these technologies can be examined or evaluated through numerous aspects, including efficiency, security, traceability, accuracy, and cost reduction. Also considered significant and important for health care organizations is to provide adequate solutions for managing COVID-

19, which has become critical given the outbreak. Using the various innovative technologies, such as mobile handset data, cloud computing, AI, and 5G information technology, can enable the easy maintenance of subsequent records for the entire network and patients, providing a more accurate, consistent, and transparent solution. The use of these technologies enables improved management of COVID-19 and represents sources for user-level self-management of COVID-19 and water utility data.

This research is about the role of mobile technology with the assistance of cloud computing, 5G, and IoT for the health sector and smart utilities. Again, the focus is on two major areas from both key verticals. This study narrowed its focus to smart water and Covid-19 after considering the broad use cases and research work in the health sector and utilities. Connectivity is important for any technological innovation; however, 5G connectivity combined with cloud computing and IoT can empower end users to have access to all of the data from their mobile devices and this study focuses on how this mobile data can be made secured and in control of users instead of creating security risks.

An example of a COVID-19 patient’s journey from being infected to recovering is as follows. The technology impact during each stage is clear.

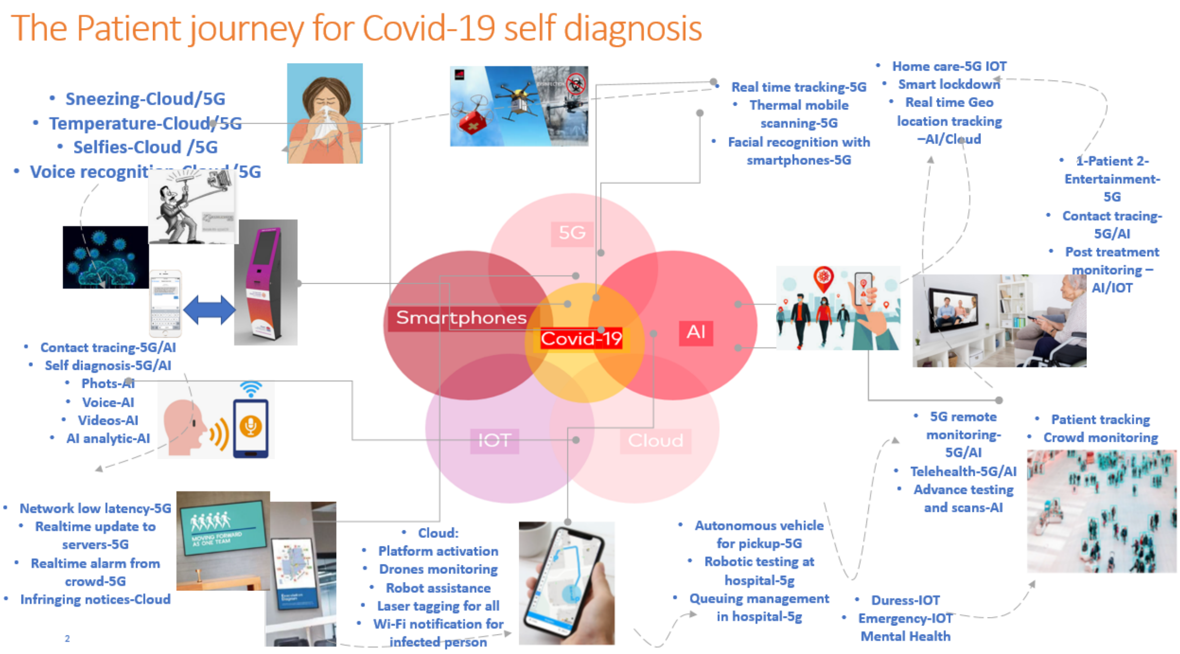


Figure 2 COVID-19 patient journey for self-diagnosis using mobile data

Internet of Intelligence (IOI) and Internet of Medical Things (IoMT) will play a key role in the future medical roadmap for self-diagnosis and remote care. All of the data will be accessible from mobile devices, with centralized medical control centers and drones, robots, IoT sensors, and video chatbots to help reduce the load on hospitals during pandemics. Aged care and home care services will be provided with centralized medical control centers, robots will behave like nurses, and low latency 5G technology will enable doctors to perform surgeries from home using augmented and virtual reality.

1.5 Research questions and objectives

The research questions were developed to highlight the most important points of the research and will be answered in the various parts of this study. All of these questions revolve around the title of the research, and the key concepts of this thesis are explored and discussed throughout the research.

The research is centered on investigating the synergistic utilization of data collected from handsets, including an array of sensors, technologies, applications, artificial intelligence, and platforms. To substantiate the research hypothesis, two distinct use cases, namely COVID-19 and smart utilities, were judiciously selected. These use cases exemplify the pervasive adoption of mobile data for self-management and monitoring, serving as compelling illustrations of the research idea.

The key research question of the thesis is:

What is the role of mobile handset data, cloud computing, artificial intelligence, and 5G information technology in the user-level self-management of COVID-19 and water utility data? \

1.6 Research aims and objectives

The aims of this research were developed to highlight the most important points to be made throughout its entirety. All of these aims, and objectives revolve around the title of the research, and this research also explores the key concepts of the thesis that have been discussed throughout. The key aim of the thesis is to explore the role of mobile handset data, cloud computing, artificial intelligence, and 5G information technology in the user-level self-management of COVID-19 and water utility data.

Role of Emerging technologies (5G, IoT and Cloud) to promote self-service with example of two use case is discussed in this thesis.

The end goal of the research is to develop a framework for the self-diagnosis of infections during pandemics such as COVID-19 using mobile data and implementing a similar approach for smart utilities and monitoring water using mobile devices. These goals can help with accessing real-time water usage, water quality, and critical notifications, such as contaminated drinking water. Exploring the role of Cloud computing, 5G and IOT with self-assessment using mobile apps and data is the key objective and goal of this research.

The following is a framework for the self-diagnosis of COVID-19 using mobile data for which the input or source data will come from different and new innovations, such as drones, robots, AR/VR, thermal cameras, and wearables devices.

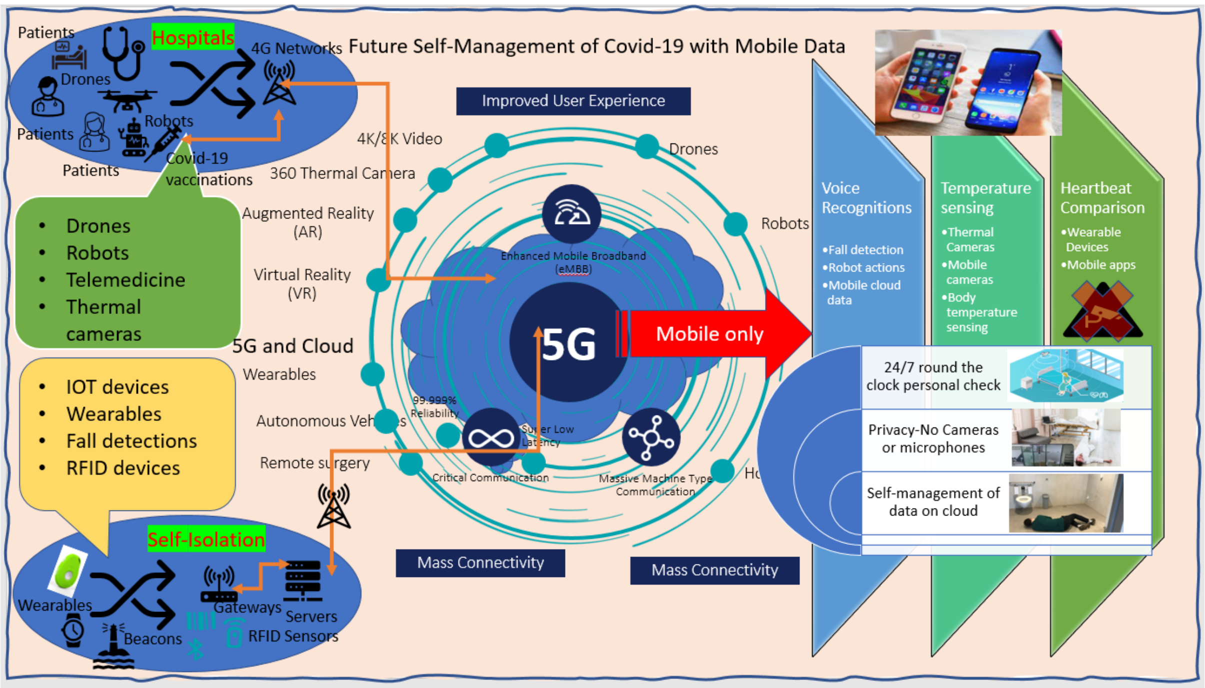


Figure 3 Future self-management of COVID-19 using mobile data

In a similar manner, water utilities and end users have no access to water-related issues from their mobile devices, and different sensors deployed in the field are connected to multiple platforms for monitoring, with no data being pushed to mobile apps. A centralized app to ingest all water-related data for dashboarding and notification to the mobile app is the key requirement for efficient water management.

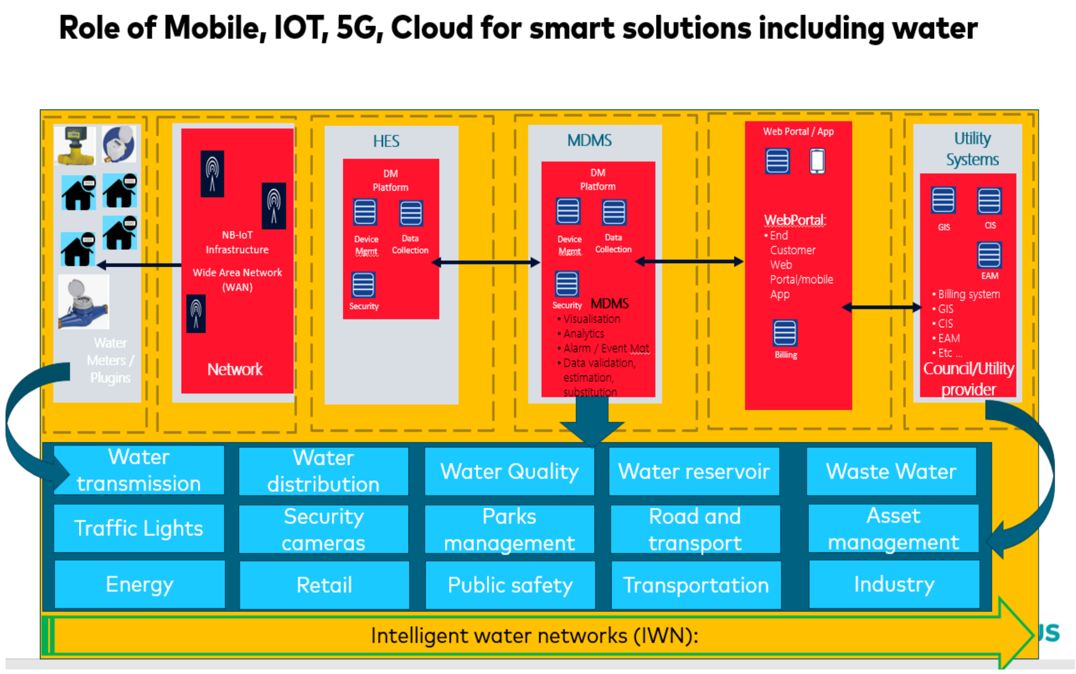


Figure 4 Advanced metering infrastructure frameworks

1.7 Contribution of Research

As is best known, three key review publications are directly connected to this study. Started by emphasizing the significance of mobile connections in supporting medical, training, and retail businesses during the pandemic, followed by a brief review of various significant 5G technologies, including URLLC, mMTC, cloud, and others, that will benefit numerous areas. The COVID-19 epidemic was summarized by Chamola et al. (2020), who included past pandemics, different phases of pandemic epidemics, diagnostic procedures, treatments, and preventative efforts. Following that, a short assessment of the pandemic's influence on several sectors of the economy, as well as the related data, was offered. IoT, drones, robotics, smartwatches, 5G, and other innovations that will be required to mitigate the consequences of the pandemic were also explored. Telecom plays a major role in fighting the pandemic, focusing on health, education, and commerce, as well as different techniques for boosting network connectivity to remote locations by employing robots, balloons, and drones (Saeed et al., 2020). These studies also investigated three concerns raised by the use of transmitters and receivers to combat the COVID-19 epidemic: confidentiality, protection, and deceit, as well as the importance of communication systems in the economy's existence. In addition, also shown were a number of wireless network-capable innovations that were useful during the pandemic and would continue to be useful thereafter. Many review articles on AI's application in 5G and B5G systems have been published.

Nevertheless, in this research, we take a rigorous approach to examining the role of AI-driven 5G technology in addressing pandemic-related issues in many sectors, as well as the challenges that current networks face as a result of increasing demand during the pandemic. This study is specifically interested in how AI deployment in 5G technology might address the networking difficulties that modern networks face as a result of the pandemic. Also examined is how AI-driven 5G might be used to enable new technologies, such as IoT, robotics, autonomous driving, robots, and other technologies, that are required to counteract the pandemic's consequences across a variety of industries. The following are the contributions of this thesis.

- Five important regions affected by the COVID-19 outbreak are reviewed, as well as the overall economic effect of the outbreak. Unlike Chamola et al. (2020), who only considered the pandemic's economic effect in these places, we also included its psychological and social consequences.
- The massive increase in traffic demand placed on existing services as users shift from conventional to distributed mobile devices through digital sites highlights existing networks' fundamental issues. Chamola et al. (2020), and Saeed et al. (2020) hardly mentioned the impact on current networks.
- This thesis concentrates on the role of AI-driven 5G networks in reducing the pandemic's adverse implications in the aforementioned key sectors, as well as how they operate as a

catalyst for other technology needed to solve pandemic-related difficulties.

- The importance of AI-driven 5G in addressing the difficulties that current networks face was also thoroughly examined. Very little consideration exists of how AI-driven 5G may overcome the difficulties that current networks face in the aforementioned previous articles.
- This study specifically focuses on the key role of AI and several other technologies in the driven networks of 5G for reducing the negative effects of the pandemic in their key identified sectors and for measuring the actions required to combat the challenges relevant to this pandemic.
-
- Finally, a quick overview is provided of how AI-driven 5G might contribute to detecting future pandemics and the development of a pandemic-resilient civilization that can withstand disruptions. Lessons learned from the pandemic are briefly discussed and, thus, should be considered when constructing new networks.

The COVID-19 pandemic's severe impacts on various sectors, including healthcare, entertainment, communication, and industry, have been mitigated by both fixed and mobile connectivity. The pandemic would have had a significantly larger effect if these communication tools had not been available, and many of these businesses would have come to a standstill. The primary sectors affected by the outbreak may be identified to get a sense of the scale of the challenges that these companies face. Because these companies are becoming more dependent on communications networks to support their global operations, existing networks are seeing extraordinary traffic loads. As a result, to keep activities running in these impacted sectors, we will go through certain issues that current networks are seeing as a result of the rapid growth in customer needs. Most importantly, relative to modern networks, 5G networks' larger capacity and sophisticated technology may be able to manage most pandemic-related concerns. We will stress the importance of 5G and the associated technologies in addressing COVID-19-related difficulties and current network limits. Finally, to avoid being caught off guard by future pandemics, we will look at how 5G connections might be used to identify future outbreaks, as well as how more technology and large-scale robots could be employed to build a pandemic-resistant civilization.

The overarching contribution of this research lies in the exploration of emerging technologies for self-monitoring of water usage and COVID-19. The concept and framework presented in this thesis are specifically tailored for two verticals, but the same model can be extrapolated to other verticals as well. Notably, an advanced implementation of a similar solution has been observed in Australia, which underscores the need for further research to establish a future-proofed solution akin to the Intelligent Water Network.

Currently, self-monitoring for a single solution is feasible through ongoing projects worldwide. However, the paradigm shift towards multiple inputs from diverse sensors in the realm of the Internet of Intelligence necessitates machine-to-machine decision-making for automated implementation of actions and next steps. The role of artificial intelligence (AI), edge computing, machine learning, 5G, and the Internet of Things (IoT) will be pivotal in empowering end users to proactively manage their environment and surroundings through mobile monitoring.

Overall, this research elucidates the potential of leveraging cutting-edge technologies to enable self-monitoring in the domains of water usage and COVID-19, with potential applications across different verticals.

CHAPTER 2: LITERATURE REVIEW

The literature covers most of cloud computing's benefits, risks, and service and delivery models. Resources are limited on how this information will benefit all actors—telecom sector operators, vendors, and end users, utility provider, regulator, and end users.

Discussion and research are provided on the fourth industrial revolution; however, it covers new technologies, such as AI, IoT, enterprise intelligence (EI), robotics, and big data (Schwab, 2016). Not much research exists on cloud computing, which is a core enabler of the fourth revolution. The cloud computing position is similar to engines, electricity, and processors during the first three revolutions. This research will explain and define the role of cloud computing in new technologies from the telecom industry perspective for smart utilities and pandemics like Covid-19.

According to Kshetri (2013), cloud computing has become a major driver of the IT world, and the research is primarily focused on the IT industry. Limited research exists that covers telecom sectors and considers the role of all of the actors. In every industry, the software service provider is considered to be a cloud service provider (Lian et al., 2014). Small and medium-sized enterprises take advantage of cloud service providers such as Amazon and Google to reduce costs, benefit from scalability, and save through low power consumption (Puthal et al., 2015). However, all of these services are considered from the IT sector, and the role of the IOT, 5G and telecom industry is overlooked.

Cloud computing is mostly covered in the literature on computer science, economics, engineering, and technology adoption related to the technology-organization-environment (TOE), diffusion of innovation framework (DOI), and business administration (Senarathna, 2016). This research will also cover industries from the telecom standpoint, such as utilities and health end users, along with its impact on vendors and operators while considering the organization's size and different service models. Cloud computing is becoming a fifth utility and will be a basic requirement of day-to-day life (Buyya et al., 2009).

2.1 AMI literature review

Australian water utilities increasingly acknowledge metering using smart technologies to effectively achieve and manage demand, the services provided to customers, operational effectiveness, and the optimization of the workforce and labor. Intelligence water network projects for New Zealand and Australian water utilities are increasingly being integrated into the present water systems to outline these networks' outputs and challenges. Accordingly, networks for smart meters and intelligent water are gaining momentum in Australia and New Zealand. In Australia, the installation and implementation of more than 250,000 smart meters have been completed, and further plans are in place (Stewart et al., 2010). Recent digital technologies have made it comparatively easy to compute and authenticate water system economics instead of customer engagement and satisfaction. Smart metering technology distribution, particularly to avoid business costs by decreasing operations, reducing the number of wholesale purchases made, and complying with infrastructure expansion, is creating business scenarios (Kabalci, 2016). Moreover, some utilities used to have well-improvised trails or operative tasks, coupled with an identical advanced comprehension of the broader benefits of smart metering or intelligent water networks (IWN). Simultaneously, other utilities are constrained by a limited approach to the overall understanding and awareness of establishing business events, technological probabilities, and applying data and the broader aids associated with smart metering (Yang et al., 2019).

In contemporary studies, freshwater requests have been universally amplified mainly because of the world's growing population, which has become attached to varying eating habits and lifestyles related to improved water intake (Brooks, 2006). Advanced water consumption is more noticeable in urban areas because of their sophisticated population concentrations and increased industrial production that consume large volumes of water (Koech et al., 2018). Nearly 90% of the people in Australia live in urban areas. Water supply in the country is mainly to utilities that are owned and controlled by national government water utility companies and resident councils. These companies possess and sustain the water supply infrastructure, including water meters. Presently, the water supply in urban areas for both commercial and domestic use is a significant challenge because of the adverse effects of climate change (Walker et al., 2015). Typical responses to freshwater scarcity are using different methods to conserve water, mainly reducing water consumption, and minimizing wastage. Water preservation in urban areas includes combined approaches extending beyond the employed measures, such as restrictions on inflowing showers and taps, optimization of urinal and toilet flushing, and applying efficiency to water-based applications and machinery, such as rainwater collection, programmed leak detection, sewage water reuse, electrical taps, and arid or no-water urinals (Peker, 2020).

The most effective approach prevalently employed for efficient urban water management is water metering. Water meters measure the volume of water (on a volumetric basis, including liters and megaliters) supplied to consumers over a specific duration. Water improvements in Australia were introduced after the Council of Australian Government (COAG) contract in 1994 announced collective water assemblies in urban zones to endorse impartiality in water usage duties and enhanced management of demand (Brooks, 2006). Conventionally, water meters are read physically at set time intervals. Meter reading among most local houses in Australia is quarterly. This approach is sufficient for billing determinations but provides inadequate data about definite water use behavior, leakages, and seasonal differences (Beal and Flynn, 2015).

Overall, efficient water resource management demands precise, timely, and consistent water consumption practices of measurement and control (Willis et al., 2010). Such practices are vital because water management and conservation remain a significant challenge in Australia.

Information and communication (ICT) and IoT offer original resolutions to managing water circulation while expanding a new group of meters and sensors (Suciu et al., 2017a). These innovations address the data overload problem. Effective urban water management is a big challenge, mainly with increased population growth coupled with high costs and energy used for water (Suciu et al., 2017a). Cyberinfrastructure growth can aid in accessing, sharing, visualizing, and analyzing data in the scientific community when dealing with water (MB, 2019). New smart water distribution systems must adhere to protocols categorized into business, functional, and non-functional (Lund et al., 2021). For example, they must adapt to diverse water distribution network typology, evaluate water distribution network performance improvements, provide data to different stakeholders, and reduce water wastage. Cyberinfrastructure growth can aid in accessing, sharing, visualizing, and analyzing data in the scientific community that deals with water (Suciu et al., 2017a). Overall, improved information flow in the supply chain and water distribution helps reinforce more accurate decisions.

2.1.1 Literature review on different service models

Water utilities have recorded a paradigm shift in viewing their client relations and interactions with their water networks following the expansion of IWN. Other technologies or demands that are simultaneously evolving include customers' expectations of their water and energy utility coupled with their time of usage and how they reflect it in their bills. As previously noted, many smart meters and announcement systems currently being fixed in Australia possess an explicit requirement to fulfill the persistence of assisting on these requirements composed of potentially operative and principal savings that have computerized the monitoring of water supply and demand. The country is following likely resolutions to manage and include meter data with the existing core utility structures (Sovacool et al., 2021). Most importantly, the government is pursuing solutions to extract value from the data for both utility and to meet customer needs. Australia still records limited partnerships and information sharing (especially between private and government organizations) (Beal and Flynn, 2015). Existing utilities are repeating previously held trails and are capitalizing on many communication systems with various network compatibilities and amenabilities that adhere to national principles.

2.1.2 Automated meter reading (AMR)

Automatic meter readings (AMR) in liters per day capita (LPDC) were reduced by 5.3% on the basis of trial by reduction. AMR collect data from water metering devices and transfer them to a central station for processing for billing purposes (Palaniappan et al., 2015). These systems are invaluable digital advancements that can promote an improved understanding of living because metering is a daily life activity. This activity addresses many challenges common in conventional meter reading systems, including human resource requirements, efficiency, accuracy, lack of customers during metering visits, and delayed work. Moreover, AMR is inexpensive and valuable (saving time and value using this approach) (Lovell, 2017). AMR is more notable or advantageous on the basis of the capability to forecast energy demands starting from households, Australia, and the world. AMR systems have become the most implemented technologies in water utility sectors, including GSM, PLC, and hybrid technologies (Yang et al., 2019).

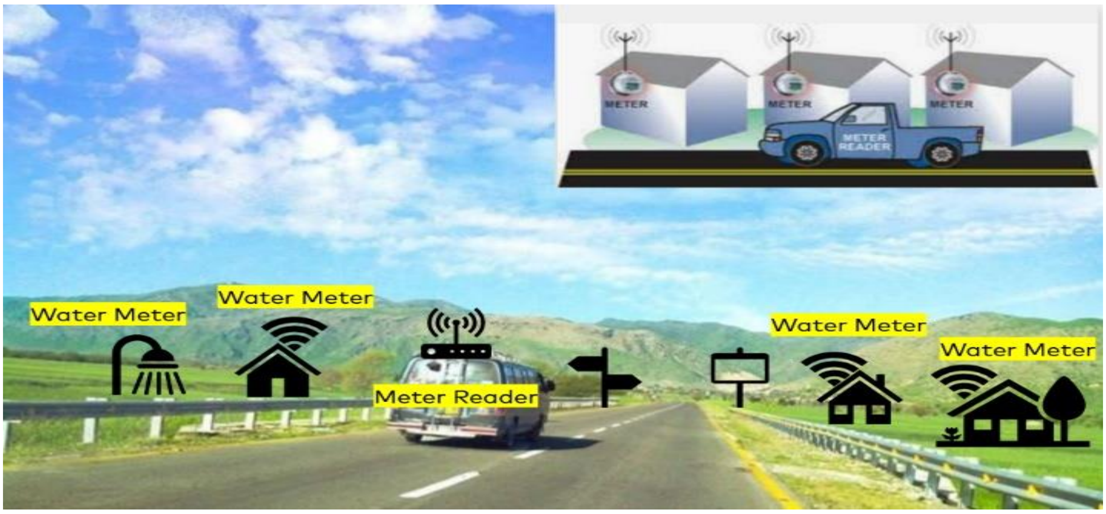


Figure 5 AMR network

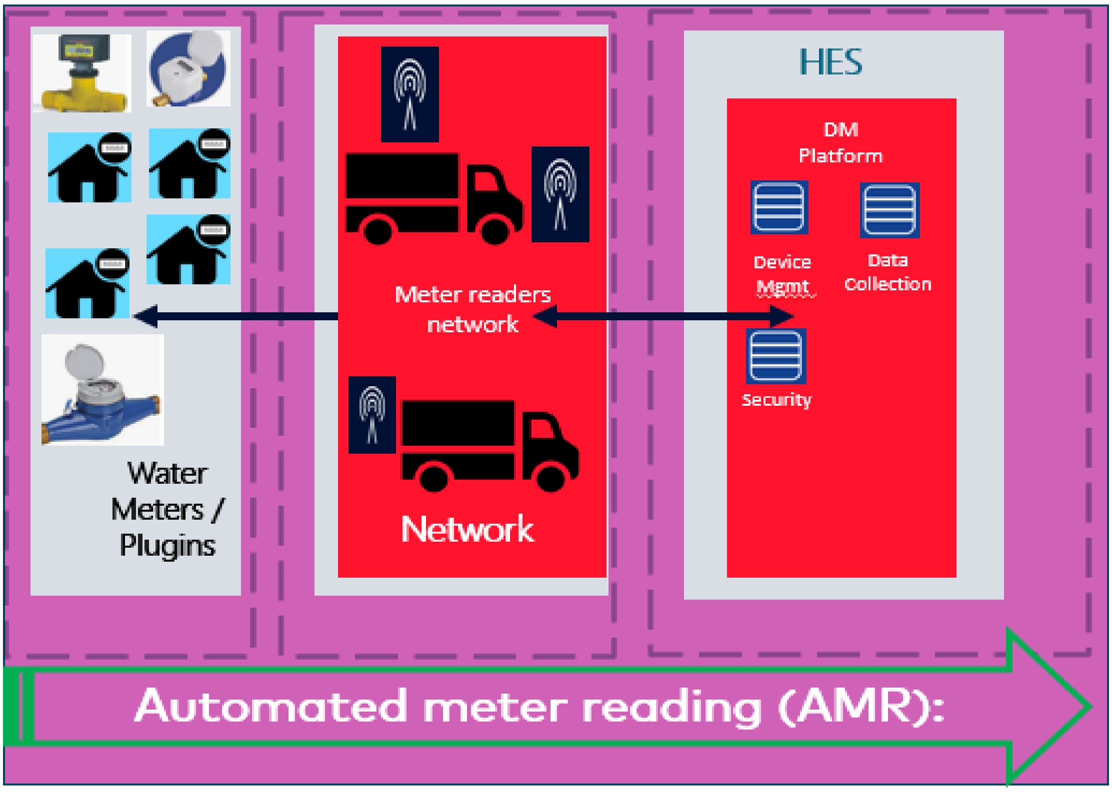


Figure 6 AMR network and telecom

2.1.3 Advanced metering infrastructure (AMI)

The average consumption saving is 5.8%, and with advanced metering infrastructure (AMI), customers receive notifications via SMS or email. A succession on subsystems should be attained to achieve an intelligent grid. Each subsystem's solid establishment and functionality are vital to overall SG performance because each layer's output feeds the next layer (Ikpehai et al., 2016). Accordingly, AMI is not a single innovation but is a configured infrastructure integrating different technologies to accomplish its objectives (Koech et al., 2018). The infrastructure encompasses smart meters, various communication network levels of an infrastructure hierarchy, meter data management systems, and approaches to incorporate data collected into software application platforms and boundaries (Cabrera and Cabrera, 2017).

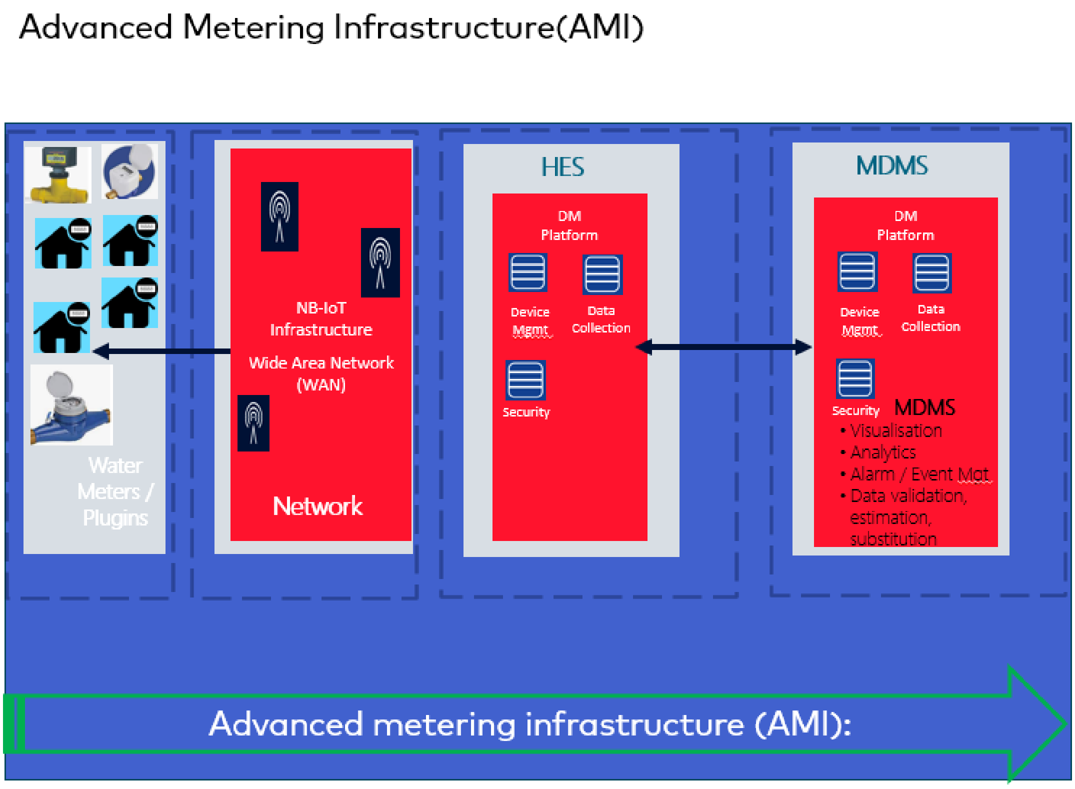


Figure 7 AMI network

2.1.4 Smart water metering (SWM)

Water meters assist with urban water administration, particularly for billing purposes (Worthington and Higgs, 2014). Recent smart water metering (SWM) innovation addresses significant resolution and recurrent water intake data that can be utilized to improvise the responses and feedback of customers, hence improving water preservation and the associated management (Randall and Koech, 2019). In Australia, water utilities are applied largely on a pilot basis. The

Wide Bay Water Corporation (WBWC) smart metering project has been regarded to be presented as the first large-scale SWM technology and related improved work (Randall and Koech, 2019). The important drivers of SWM in the country incorporate and use the water infrastructure and related planning for development, to improve the highest demand estimation and administration, and for manual meter readings and operating cost declines (Giurco et al., 2010). Added drivers comprise the stimulus for the motivation of water utilities to assume sustainable procedures while improving their reputations with consumers (Cole and Stewart, 2013).

Smart water metering (SWM):

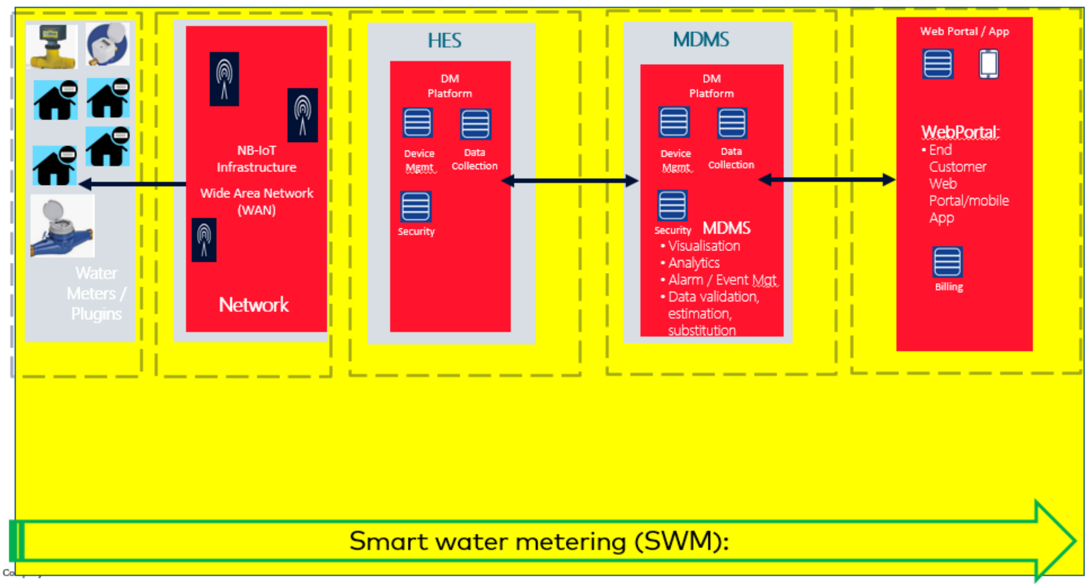


Figure 8 SWN network

2.1.5 Intelligent water networks (IWN)

IWN encompass intelligent device integration, including water meters, meter data, business processes, systems, and pressure sensors, and using this information to guide the strategy and investments (Boyle et al., 2013). Intelligent systems are essential for data collection and analysis of water management (Suciu et al., 2017b). Effective urban water management remains the main challenge in population growth conditions. Even in regions without water supply problems, effective leadership and water loss reduction are necessary (Stewart et al., 2018).

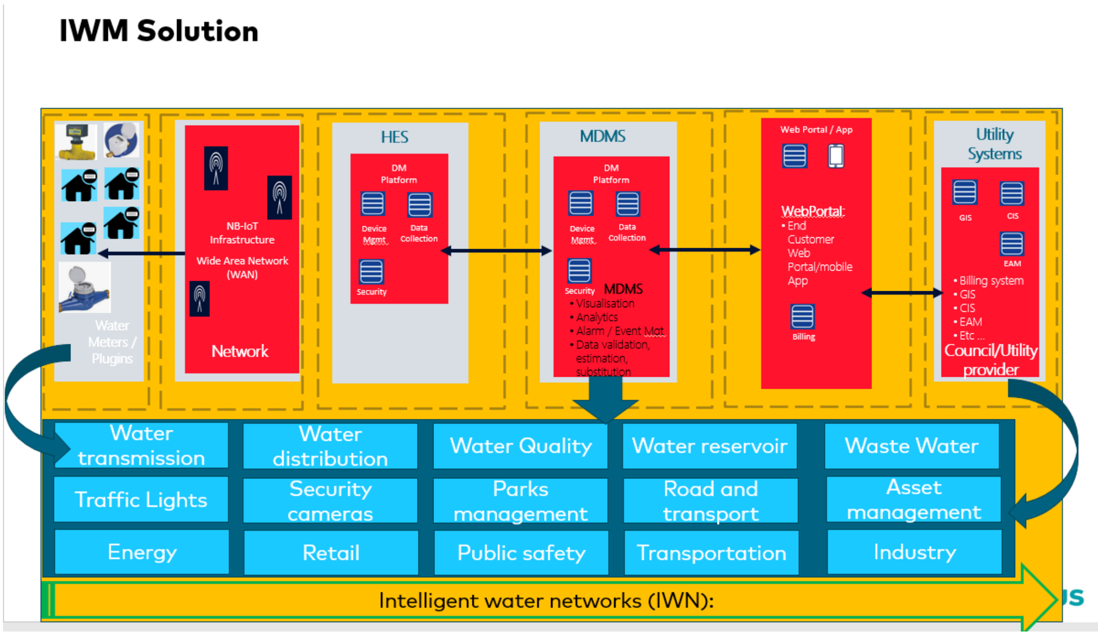


Figure 9 IWN

2.1.6 Summary of Water systems:

The paradigm shift from manual water meter readings to smart and automated meter readings can be likened to the evolution of cellular technology from 2G to 5G. Automated Meter Reading (AMR) emerged as the initial solution, eliminating the need for physical meter readings through the synchronization of transmitters and receivers. Data was transmitted from the meters to a receiver in a vehicle that would come into proximity of the devices, obviating the need for on-site meter readings.

Subsequently, Advanced Metering Infrastructure (AMI) replaced AMR by connecting the meters to wireless networks, eliminating the need for driving around to collect meter data. Wireless networks were utilized to collect meters data on a daily basis and generate monthly reports based on actual usage. AMI, along with Smart Water Networks (SWN), represents the most advanced versions of smart metering, providing customers with near real-time access to water usage data. This data is pushed down to end users' mobile apps, enabling them to monitor their water usage trends by the hour, or even down to 5-minute intervals.

The greatest advantage of AMI and SWN is the empowerment of end users to actively manage their water usage, mitigating water leakages through system-generated notifications. Utilities have the flexibility to choose from a range of available technologies for implementing smart water metering, depending on the size and geographical spread of their metering infrastructure. Prior to the availability of Narrowband Internet of Things (NB-IoT) via public telecom networks, utilities utilized dedicated water metering networks such as LORAWAN and Sigfox, or proprietary protocols like WISE, Taggle, and Modbus. However, NB-IoT has emerged as a preferred option for many utilities due to its quick access to public networks, ease of rollout, and the fact that utilities are not burdened with the operation and maintenance of the networks, as telecom providers take care of the mobile networks.

2.2 Importance of Cloud Computing in Smart Metering

2.2.1 Cloud computing benefits

A significant body of literature discusses the benefits of cloud computing, such as flexibility (Senarathna, 2016), reductions in infrastructure costs, lower integration costs, and less data center space and required hardware (Evans, 2018). Cloud computing can also improve the utilization of the frequency spectrum for telecom operators (Wu et al., 2015) and has features of elasticity and automation (Gholami, 2017). Saving time, the efficient use of computing services, on-demand services, and pay-as-you-go or per-use (Mohammed et al., 2016) are key benefits of cloud computing (Giweli, 2013). In telecom networks with a cloud RAN (Mohammed et al., 2016), energy consumption can be reduced by 9.45% and deployment costs by 12.88%, which positively affects operators' overall profits (Chen et al., 2017). According to a survey, five major reasons to adopt cloud computing are responsiveness and improved agility, accelerated product development and innovation, cost savings, modernization of data centers, and moving capital expenditures to operating expenditures (KPMG, 2016). All of the benefits from cloud computing are from the IT perspective, and a research gap exists related to the role IOT, 5G and cloud computing .Having different sensors, products, and monitoring devices connected to a single cloud will make it easy for all industries to manage their operations and production. Currently, all of these options are either manually done or have a unique platform for each service. This research will explore the role of telecom and cloud computing in delivering these services to end users.

2.2.2 Cloud computing risk

The major research gap identified that needs to be explored is regarding a discussion of the contributing factors and barriers, such as security concerns (Ali et al., 2017), use of different service models—private, public, and hybrid cloud—and the need for a telecom industry (Mohammed et al., 2016). Cloud computing security and privacy are risky because of multi-tenancy and virtualization (Giweli, 2013); however, this is related to the IT sector, and research is needed that reviews these issues from the water utilities industry viewpoint because 25 billion devices will be connected to the Internet and the cloud (GSMA, 2018). Data losses, threats to data integrity, software failures, multi-cloud environment failures, or Internet outages can create problems for firms that mainly rely on cloud computing (AlZain, 2014). Connecting all industries and devices is a major security concern and depends on the devices and services connected to the cloud. Mitigating the risks and control can be different, and this research will explore the growth of cloud computing despite its security issues and how cloud computing can impact decision makers. Blackberry had much better security than did Samsung; however, Samsung is leading the mobile market, and Blackberry, even with its great security features, is out of the competition.

2.2.3 Cloud computing deployment and service models for telecommunication

The research on the telecom industry and how cloud computing can be used for end users and generate revenue for telecom industries is not large. Water utilities users' requirements are different from those of the

IT sector, and no single solution exists for all businesses to meet the specific needs of all customers (Gholami, 2017). For some organizations, security is a high priority relative to costs, and other factors need to be considered, such as the bandwidth required, scalability, and storage capacity (Gholami, 2017). A hybrid cloud solution can reduce the risks related to security, serviceability, and integrity (AlZain, 2014); however, can it be used for water utilities end users and industries? According to a survey by Rightscale, 95% of respondents use cloud services, and 67% use hybrid solutions (Rightscale, 2017). The use of multi-clouds and hybrid clouds is growing because of the digital transformation for cost savings in IT, and software as a service (SaaS) was the largest cloud computing category in 2018 (IDC, 2018). The decision to use SaaS, platform as a service (PaaS), or infrastructure as a service (IaaS) (Yu et al., 2016) and deployment models such as public, private, hybrid, or community can be different depending on businesses' many factors and needs (Ali, 2016). Today, cloud computing is no more an IT product as it is a day-to-day utility for individuals and businesses, such as farms, logistics, smart cities, and homes. Cloud computing will be controlling or monitoring devices with backend solutions, and more research is required to cover its use in the utilities, cloud as a service (CaaS), platform as a platform service (PaapS), and connectivity and management as a service (CmaaS), how these new types of cloud usage will add value for water utilities , and what the impact will be on utilities and end users.

2.2.4 Conceptual model: Technology-organization-environment framework

TOE is a widely used model for the adoption of cloud computing in an organization (Gangwar et al., 2015). TOE demonstrates the use of cloud adoption in the utilities from the three aspects of technology, organization, and the environment (Ali, 2016).

For cloud computing adoption in the smart water industry, IT engineers and end users will consider product maturity, complexity, and integration with existing internal and external IT systems (Martins et al., 2016), migration of services, cost-benefit analyses with alternate options (Ali, 2016), and how these services will add value relative to current technologies in use. The water utility is moving toward using the cloud in infrastructure and as a source of revenue when providing services to end users. The adoption of cloud computing and its service model depends on organizational factors, such as organization size (Martins et al., 2016), IT engineers' experiences, management support, readiness for cloud technology, and revenue generation possibilities with cloud computing adoption and innovativeness (Ali, 2016).

The environmental context for the utility sector considering the role of 4G/5G operators, vendors, meter suppliers and end users was not previously researched regarding the adoption of cloud computing. External factors will affect the adoption of cloud computing, such as type of industry, its partners, and its suppliers (Borgman et al., 2013).

TOE Framework

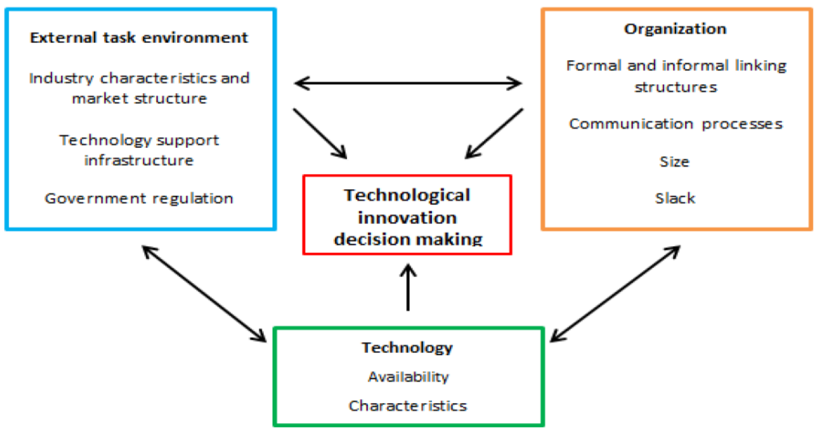


Figure 10 TOE framework

2.2.5 Network connectivity solutions

To promote smart water meters, the Internet connection has become critical. Moreover, deploying a new local area network is not needed in regions in which NB-IoT is available (Babu Loganathan, 2021). In areas with accessible NB-IoT reception, other variables, such as service delivery, repairs, and energy usage, will be nil. According to GSM's most recent protocol update, NB-IoT has been designated as a 5G technology. Utilities that do not have access to 4G or 5G can utilize another low-power, wide area network such as LORWAN or Sigfox. Ultimately, in areas with no Telco or WiFi service, LORAWAN may be used, but it requires a 3G/4G/fiber connection backup. When compared with installing a 4G site, LORAWAN is inexpensive.

LORAWAN gateways will need local power, servicing, and Internet access to backup telecom networks. Utilities will clearly not simultaneously utilize all of the connection choices. Their usage will be influenced by other factors, such as the type of service requested, the cost of the service, and the amount of electricity consumed. Utilities struggle to use several systems and logins from numerous providers. The platforms differ as well and traversing them effectively might be difficult. In contrast, utilities use various techniques to supply network access because Internet concepts differ. As a result, telecommunications experts have devised solutions for interactions and administration from a single location, eliminating the need for many providers and platforms. Single-source data administration can be used to access inaccessible regions while employing mobile applications to assist with the task. Data transmission from smart meters to a meter data management system platform is achieved using the NB-IoT network provided by public networks, such as Optus, Telstra, or Vodafone in Australia. The activation of the NB-IoT network and providing national coverage is a network provider's decision. A couple of options exist for areas with no public NB-IoT network or if utilities decide to use a private, low-power network, such as LORWAN, SIGFOX, or the Taggle and Suez networks (Koech et al., 2021).

2.3 Covid-19 literature review

IoT is a fast-evolving system that connects real-time interconnected networks to the Internet. IoT is beneficial in a range of industries because of the shift from a basic component to a new feature. IoT will have a long-term impact on medical signal surveillance, treatment, and clinical hospital services. Before being transferred to a health-monitoring gadget, patients are coupled with detectors, and information is connected to control systems. Data are often stored in a cloud, which makes it easier to handle vast volumes of data while ensuring security. Because the information transit from the sensor to the web center may lead to a loss of confidentiality and integrity, and encoding incoming information from low-resource devices is challenging, security is a critical feature of IoT. Because the Internet is a dispersed environment, it is the most effective method for storing healthcare information that allows physicians to communicate with far-flung patients and similarly. IoT and the cloud collaborate for actual analysis, which complicates data sending and receiving. A unique framework is proposed for managing IoT actual information and scientific studies' superfluous IoT information, which is then examined in a heterogeneous area that promotes Software SaaS to eliminate IoT and cloud problems (Dehury and Sahoo, 2016). This research develops a service management platform for IoT systems in the cloud that includes either a three-layer architecture or five core features: a client layer that collects information from digital homes, medical workers, social networking sites, and smart medical services; a supplier service that provides physical data exchange, professional services, cloud computing, and safety and confidentiality; and a center portion that maintains the core infrastructure.

An IoT infrastructure for the early diagnosis of cardiac problems installs a machine learning method (Wickramasinghe et al., 2017). This infrastructure uses a three-tier structure to collect sensor information from peripheral gear and save it in the cloud and a regression-based classifier to detect cardiac disease. For cloud storage of the data model's assessment, this proposed architecture employs Apache HBase and Apache Mahout. As a consequence of this research, a patient may be able to obtain an early diagnosis of heart problems.

An IoT system was developed for monitoring and diagnosing patients with arthritis in the preliminary phase (Parthasarathy and Vivekanandan, 2020). The suggested framework is divided into three tiers, the first of which collects data from sensors. The data are stored in the cloud at the second layer. The third part is utilized to optimize the information obtained, which includes edema and uric acid (UA), suggesting that a paradigm will be implemented using Apache Redshift and OpenStack.

This research does not handle real-time data, and this approach is quite expensive. The method's design may be studied, and a sensor can be utilized instead of a camera to minimize the total cost of the procedure.

Researchers created the temporal fuzzy ant miner tree (TFAMT) classification, which is a blend of ant colony optimization (ACO), logistic regression, and fuzzy rules that are used to identify medical information (Bhuvaneswari and Manikandan, 2018). This research is being utilized to assist the elderly with prevalent age-related ailments and pharmaceutical requirements. Medical concerns are detected by evaluating behavioral and physical patterns in homes using Internet of Things (IoT), which collects real-time data from digital devices.

2.3.1 Role of 5G in Internet of Medical Things

IoT is a network of connected devices, machines, humans, and technologies that share data for sophisticated applications and hardware. Cell devices, tablet computers, consumer devices, cars, wearable technology, and detectors that can connect to IoT are among such items. IoT enables items to be controlled at a distance through an existing network, allowing for the tight integration of the physical and digital worlds, performance and productivity, accuracy, and cost reductions (Chhatlani et al., 2016).

Cellular, Bluetooth, and Wi-Fi will be used to empower IoT communications, and 5G will be the technology that links this equipment. IoT systems will have a wide range of abilities and data requirements, and a 5G network must be capable of supporting them all.

The development of a 5G system that connects all of these gadgets while accounting for power, data use, and spectrum utilization is required in a fully evolved IoT ecosystem. American firms spent more than $232 billion on IoT equipment, technology, applications, and connections in 2018, and much more than $357 billion in 2019, according to industry analyst IDC.

The 5G network opens up new choices in healthcare, such as scanning, diagnostics, big data, and therapy, because of its rapid connectivity, intelligent management, and data capacity. Certain devices such as clinical wearable technology and sensor systems are included, as well as a slew of others that track and transmit medical data such as vitals and data on physical exercise, personal security, and medication compliance—known as IoMT. These technologies will deliver never-before-seen healthcare diagnostics and high-definition videoconferences, all at an affordable price.

2.3.2 Integration with the cloud

A mobile application allows for remote health monitoring. The cloud platform stores IoT data, giving it additional adaptability, adaptability, and computing power. IoT data are effectively kept on a cloud-based storage server because they are acquired from different sensors. A few scientists' clinical operations are incorporated into the cloud using cloud computing, which improves the practice of healthcare. Learners' physiologically based qualities are captured and stored in a distinct way using cloud technology. The user system collects data from IoT medical devices, which are then transported to the cloud element for analysis on the basis of emergency alarm signals from physicians and institutions. The hierarchical computer architecture (HiCH) was developed for a medical assessment framework (Azimi et al., 2017) and includes autonomous data handling and analysis at the material's edge.

2.3.3 Big data and IoT in healthcare

Recently, the big data storage technique has been highly crucial for keeping massive amounts of clinical data. The big data technique is used to govern online storage as it expands in size. As per a new study, combining big data and the cloud influences the far-flung domain of healthcare. The Amazon Elastic MapReduce (EMR) is a novel approach to dealing with massive quantities of data and collecting them into a group. The Amazon EMR employs a different procedure to import information into an Hbase ensemble. The program is used to import sensor information from Amazon S3 to Hbase as an Apace pig. Apace pig is a tool that analyzes data stored in a distributed database, enabling applications and services to scale up dramatically (Manogaran et al., 2018). In huge IoT datasets, a simple technique for the semantic interpretation of big data has been devised. This novel approach is designed to anticipate air quality in urban areas and provide city people with a better lifestyle (Ullah et al., 2017). To examine the characteristics of air quality indicators (AQIs) for urban healthcare, the recommended UHBigDataSys leverages the Spring Framework (Chen et al., 2018).

2.3.4 Key role of IoT in COVID-19

The world has been combating a pandemic caused by a new lethal respiratory illness called coronavirus since early 2020, with the goal of slowing the virus's growth and developing a vaccine. Despite the fact that most attempts to create a therapy or stop the growth of COVID-19 have failed, an urgent need exists for the worldwide surveillance of people with symptomatic and asymptomatic COVID-19 infections (Zhang et al., 2020).

IoT technology has gained significant attention in the healthcare industry in recent years because it plays a critical role in different stages of infectious diseases. Because COVID-19 is very common, patients must be connected to and followed by their physicians during all phases of the disease (Christaki, 2015a).

Early detection is critical during the initial phase of COVID-19 because the infection is so highly transmissible that even asymptomatic individuals can quickly disseminate it to others. The quicker a person is identified, the less likely the virus will propagate and the faster the person will receive proper treatment. In actuality, IoT systems help accelerate the diagnosis process by collecting information from individuals, which may be accomplished by using different tools to record core temperatures, obtaining samples from suspect situations, and so on (Phelan et al., 2020a).

After an individual has been diagnosed with COVID-19, the second phase of this disease, known as the quarantine period, starts. The patient must be segregated during treatment. In this stage, IoT devices may be used to monitor various patients' medications and officials' stay-at-home directions. They can also clean without having to engage with humans and use wearable monitoring bands, disinfecting agents, and other technologies (Christaki, 2015b).

As per the Centers for Disease Control and Prevention (CDC), most children with moderate symptoms may recuperate at home without medication; however, there is no guarantee that patients will not get sick again. COVID-19 may manifest itself in a number of ways. The chance of a return of symptoms and probable infectivity is significant in the case of potential reinfections during the post-recovery phase. To prevent reinfection, IoT devices such as wristbands and crowd monitoring equipment should be used to track people and maintain proper distance. Furthermore, IoT technology was useful in supporting individuals, healthcare professionals, and regulators during the COVID-19 epidemic. Smartwatches, drones, robots, IoT buttons, and phone applications are just a few of the IoT platforms and technologies used to tackle COVID-19 (Phelan et al., 2020b).

2.4 Research Gap

This research addresses a significant gap in the current literature by examining the role of emerging technologies, specifically cloud computing and Advanced Metering Infrastructure (AMI), in the context of self-assessment with mobile handset. The literature review conducted in this chapter comprehensively examines the existing research on cloud computing, AMI, and the impact of the Covid-19 pandemic, revealing a gap in the identification of the role of these technologies in enabling self-assessment through mobile devices.

To illustrate this gap, consider the example of water quality monitoring in a swimming pool using Internet of Things (IoT) sensors. While individual sensors for monitoring water quality, people count, weather forecast, and temperature are available, there is currently no integrated platform that consolidates these diverse data sources and makes them accessible to end users through a mobile app. Such a platform would enable residents to make informed decisions about using the pool based on real-time data, such as chlorine levels, pool occupancy, weather conditions, and temperature at different times of the day. Moreover, this data could also be valuable for maintenance teams in scheduling pool cleaning based on actual usage patterns derived from people count data.

The research presented in the ABCDE platform paper is unique as it proposes a specialized platform for utilities that provides end users with access to monitor their water usage and integrates it with other utility systems, such as billing, customer information, and customer relationship management. While traditional smart metering solutions may offer automated meter reading options, they typically lack the functionality of a mobile application that allows customers to view their water usage in real-time by hour, and compare it with that of their neighbors or similar residential users.

The research framework presented in this study employs two case examples, namely Covid-19 and smart water metering, to elucidate the role of emerging technologies in facilitating self-assessment using mobile data. By addressing this research gap, this study contributes to the existing body of literature and sheds light on the potential of integrating cloud computing, AMI, and mobile applications for self-assessment in various domains.

CHAPTER 3: METHODOLOGY

3.1 Methodology

The researcher employed a secondary qualitative research methodology to acquire the most relevant information for this survey study. To improve water management systems, a qualitative research design is used to gather in-depth and valuable information on IoT and smart water technologies. Data and information on various water technologies using IoT are required for this study. Several studies have demonstrated that a quantitative research strategy produces data in the form of numbers and statistics rather than detailed knowledge about the scenario. The use of a qualitative research strategy is justified because this type of survey article will provide exploratory knowledge on smart water technologies and IoT used for water management and control.

According to the study's requirements, data gathering methods can be classified as primary or secondary. A primary study collects information through interviews and surveys, whereas a secondary study collects information from prior studies and research articles. Because several research papers exist on IoT and water technology, obtaining a large amount of information on this topic through secondary research is simple. This study offers information on various goods connected to smart water systems and IoT, which necessitates the exploration of information pertaining to water-related technologies to complete it. For information on sensors and monitoring technology for water resources, researchers can look at publications and blogs, as well as other resources. As a result, even though the researcher is employing a primary qualitative research design, it is advantageous for the researcher to employ a secondary qualitative research design because the objectives can be easily met by studying secondary papers and studies. The researcher is using articles and blogs that were most up-to-date and contained relevant information on the study issue. The papers that have been published in reputable publications that are relevant to computers and technology have been selected as the source of information for this paper. Because the researcher does not copy and paste ideas from other studies, this paper contains less plagiarism (Silveira et al., 2020).

Data from all Australian utilities and regional councils were used for an initial analysis of the market, customer issues, billing records, complaints, water leakages, and non-revenue water. The available data were used to conduct a market assessment that explored existing issues and projects(Bureau of Meteorology, 2022). The Australian market is in an advanced water management stage and has trialed smart metering solutions in many councils. The results show a 5 to 8% saving as well, as per a research study done by Griffith University. The data available were provided by the utilities and councils to the planning department over 10 years—a major reason for using these data because collecting this level of data from 77 councils with 9.3 million connections is almost impossible. The data were provided by the councils and utilities, cleaned up by the planning department, and shared with the public to understand water industry challenges. The data are available in Excel form. Further analysis was completed to make them more useable for this research.

Table 1 Australia water meters by state

Region	# of Council/Utilities	Total Connected Properties	% Of Total
Australian Capital Territory	1	176,000	2%
New South Wales - Country	25	613,600	7%
New South Wales – Metro	2	2,167,922	23%
Northern Territory	2	61,771	1%
Queensland	21	1,818,312	20%
South Australia	1	728,000	8%
Tasmania	1	187,583	2%
Victoria	16	2,635,001	28%
Western Australia	8	926,227	10%
(blank)			0%
Grand Total	77	9,314,416	100%

The design and optimization of smart measurement and monitoring systems for water-related applications serve a variety of functions. Many diverse types of water meters are available, some of which convey information on water levels using pointers, and others have digital displays. Smart meters are being created to address the increasing demand for energy in many parts of the world. The use of advanced technology makes it feasible to determine the activities that involve the utilization of freshwater resources. To achieve energy and water savings, a smart management solution using ICT is deployed. Using this technique makes it possible to determine the effectiveness of water distribution networks. Water distribution networks that operate on an intermittent basis may experience considerable fluctuations in the water flow. Because of high water flow and increased water pressure, the distribution system could be entirely damaged, resulting in a disruption in the distribution of water resources to other areas of the world. Water resources could not be lost or damaged if IoT is used to keep an eye on and detect bursts in the distribution system.

Remote meter readings are made possible in large part by web services and computer vision, enabling employees to assess various characteristics of the resource without having to travel to its actual location. The integration of electric counters with smart grids maintained on the cloud is made possible using optical character recognition (OCR). Water metering devices enable the accurate measurement of several characteristics of this vital natural resource. In recent years, meters have been equipped with self-powered wireless sensors that can be carried around. The use of Distributed Ledger Technology (DLT), which is a blockchain-based registration system, is also included in smart metering to optimize the metering process. Employing deep learning technology in water management systems to estimate the load is also possible. This technology aids in the most cost-effective scheduling of the energy storage system. Integrating a data analytics tool into the system to analyze a significant amount of data on the resource and to make future decisions about the use, conservation, and treatment of water is beneficial (Karthika & Kalaiselvi, 2021).

Most water networks today are built on huge, centralized systems with limited management options, creating the space for speculation when a service disruption occurs. Smart water grids (SWG) are being developed in this context with an eye toward a future in which unforeseen events can be analyzed and addressed as quickly as possible to minimize their detrimental impacts on society, the environment, and the economy. SWG technologies have the potential to improve the efficiency and sustainability of the water and energy nexus on social, technological, and environmental levels; however, they currently face several obstacles. IoT devices, cloud technology, and big data analytics are used to help humanity efficiently and effectively manage water resources. Increasing the frequency at which water quality monitoring tactics are implemented and closely monitoring fewer households at a time is a method for improving water quality throughout the world. Policy changes and smart meters with environmental quality meters are needed to monitor water quality in real time.

Water supply system assets and technologies can be used to detect leaks and other problems in a water distribution system. The most common are acoustic sensors using accelerometers, which accurately pinpoint the location of a leak and the characteristics of the pipe for small-diameter water mains. Acoustic sensors based on hydrophone sensors are more sensitive and expensive than the previous ones but are still restricted to small areas. Visual district metering areas are paired with an accelerometer and have a detection range of a few hundred meters. Today, most water networks are huge, centralized, and have limited control options. This deficiency in monitoring data offers a significant window of opportunity for speculation when systems break down. Some of these limitations, such as water quality issues, significant water losses from low operating efficiency, imbalances between demand and supply, high energy requirements to ensure proper water treatment, and the risk of losses and/or contamination of the water supply and wastewater, could be addressed through real-time monitoring and management. This research is based on the type of products available and where a research gap exists for smart metering delivery. Water quality monitoring at the residential level using proposed methods with cost limitations has been proposed using the real scenario of an urban utility network and a suburb with distribution lines and clusters of residential houses. No such solution is available at this stage, and water quality issues in bad weather such as floods and cyclones can be solved. Another focused area of the research methodology was the network technologies used in the smart metering segment. Previously, technologies were all about battery life issues because meters are in the ground for 10 to 15 years—with wireless technologies, battery life was a significant issue. With NB-IoT, this problem was resolved because utilities are not required to specially deploy a network for meter connectivity and manage extra wireless network infrastructures, such as LORAWAN or Sigfox solutions. With the existing public network, connectivity and battery life issues are no longer critical because public networks offer the same battery life without additional network management costs. The future is moving toward satellite technologies in which low orbit satellites can be used for water meters. The data are normally collected using meters every 15 or 30 minutes; however, data transmission to the network occurs once a day, which is why satellite connectivity is more suitable for water utilities. After the 3GPP release, 17 NB-IoT roaming with a satellite network will be possible, and meters can switch from cellular networks to satellite connectivity when no cellular coverage is available.

The second part of the research is about COVID-19 and the use of mobile, cloud computing, 5G, and IoT to mitigate the spread of the virus. The purpose, and corresponding methodology for this part, is to find alternate solutions that will be readily available after pandemics because vaccinations always take years to develop, but technology is already available to use. The type of technologies that have been used by different countries to help the medical staff in fighting the COVID-19 pandemic are determined, and novel-based approaches for future pandemics that use mobile-only data that will be in the control of end users without creating privacy and security risks are proposed. A fall detection concept by Apple was a key motivator for this research work and in determining how to replicate these solutions for COVID-19 through the self-management and self-diagnosis of COVID-19.

3.2 Hypothesis

The integration of a user-friendly mobile application with a centralized platform utilizing emerging technologies, such as Internet of Things (IoT) sensors, cloud computing, and mobile applications, for self-monitoring of water usage and Covid-19 related information will result in improved end-user engagement, informed decision-making, and efficient resource management across different verticals. The availability of a mobile application for end users to monitor their water usage, access real-time data on water quality, and receive Covid-19 related information will enhance user accessibility, enable proactive actions, and facilitate data-driven decision-making, leading to increased operational effectiveness, sustainability, and customer satisfaction in the utilities sector and beyond.

3.3 Water system intelligence

Smart water technologies include water pipeline surveillance, quality of water in open freshwater resources, smart water measurement devices, IoT protection for smart water systems (SWS), and other water efficiency applications. To preserve the security of customer information, security technology, and data carried over the Internet, a framework and methodology were implemented. Water quality monitoring of public water sources was another usage of IoT devices. This monitoring protects the quality of water and the economy by using low-cost systems and network virtualization. Another technology that has evolved as a consequence of IoT's broad adoption is pipe leak identification. Because leaky pipes consume a lot more water, different IoT sensors, WSNs, and cloud computing were used to identify the leak and notify the user. Sewage monitoring and purification is another anticipated IoT use to treat wastewater and repurpose it for domestic properties, saving a substantial amount of water (Liu et al., 2021).

3.4 Well-planned irrigation

IoT-based smartphone applications have emerged in agriculture to manage the amount of water supplied to crops using the temperature. These applications also manage the entire watering system, constantly analyzing soil and crop growth and guaranteeing that irrigation pumps are only activated when necessary to conserve water and manpower.

3.5 Insightful gardening

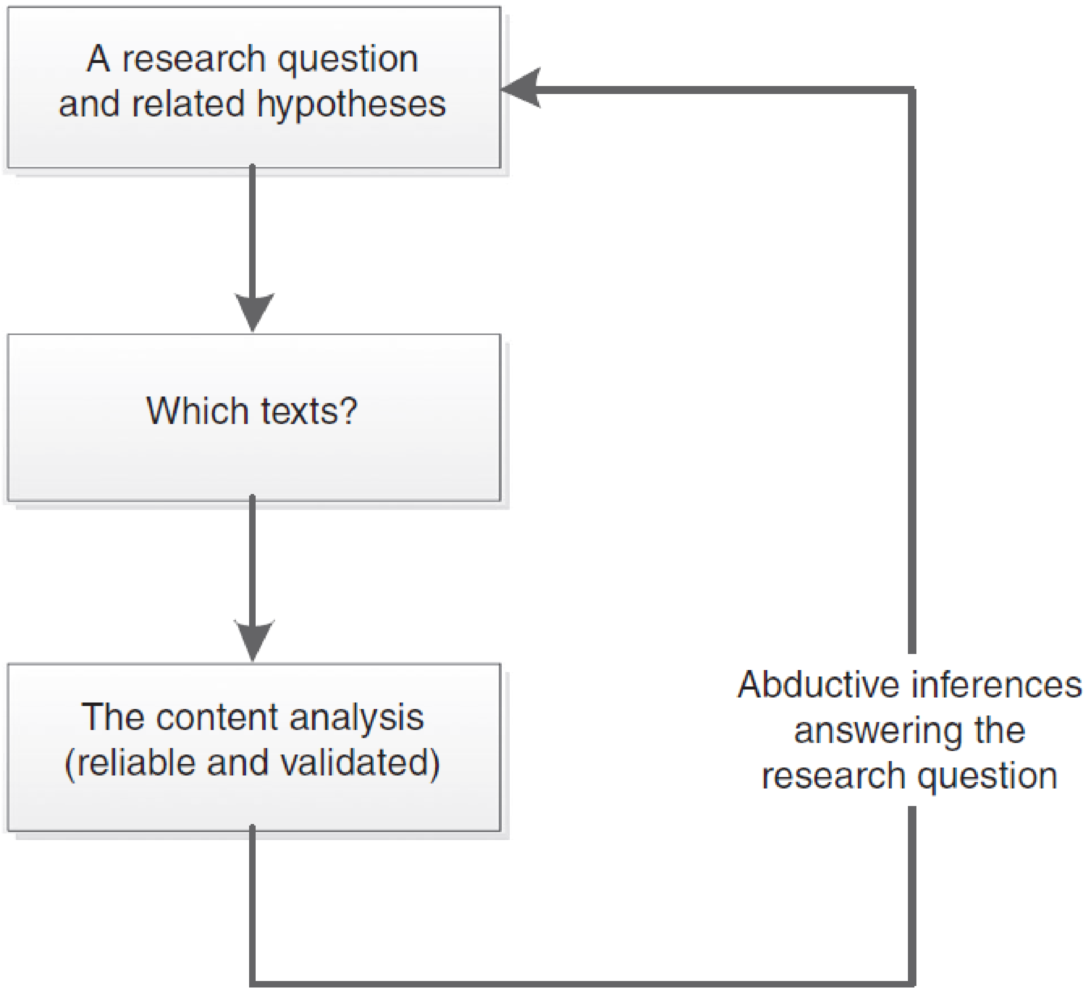
A smart horticulture application created using IoT helps elderly people who like to garden improve their mental health. This application uses a set of monitors to track temperature, illumination, moisture, and soil humidity, and a phone app reminds users of the nutritional and water requirements of their crops.

3.6 Aquaculture system

Aquaculture is a way of improving aquatic life that makes use of IoT to track and notify customers about water quality. This gadget is also used to monitor the plant’s surroundings in aquariums. Aquaculture farmers are ordered to reuse water after receiving user notifications on their smart phones, resulting in increased productivity. The vast majority of the proposed protocols were developed during the preceding year, illustrating IoT’s quick growth, especially in the water industry. More water studies are warranted when new technologies emerge, such as IoT (Yasin et al., 2021).

This study is based on qualitative data analysis. Their research papers are about two verticals only and the research question and hypothesis were selected before searching for the literature review and available literature content. The industry view was also taken in consideration to check the current availability of the proposed frameworks and solutions.

Based on the literature review and content analysis the proposed novel based approach was taken for study (Dumay and Cai, 2015). With content analysis research technique, a replicable inference to the context of their use can be made from the text as per below fig (Krippendorff, 2013). “Methods are the means whereby one collects and analyses data. Methodology refers to the philosophical issues which underlie those methods”(Dumay and Cai, 2015).



Source: Adapted from Krippendorff (2013, p. 83)

Figure 11 Content Analysis

Content analysis is used for Covid-19 and smart water metering infrastructure goals as it is flexible and can be used with qualitative and quantitative methods and frameworks, content analysis methodology was used in mass communication studies back in 1950 (White and Marsh, 2006). Content analysis can be deductive or inductive, deductive approach is mostly used for testing different theories and collating data in different time frames and situation, whereas the inductive content analysis is a discovery process for extracting finding from data analysis by the researchers (Vespestad and Clancy, 2021).The content analysis of the data from different sources is completed mainly for water utilities the data is assessed and analyzed from bureau of meteorology (BOM), the data is rigorously collected over the past 10 years from 86 utilities covering more than 90% of the residential water users(Bureau of Meteorology, 2022).The analytic construct is based on the existing practices and experts experience from the industry (White and Marsh, 2006). Abstraction of text, theme development and condensation of text is performed with qualitative content analysis (Vespestad and Clancy, 2021). Data from Australian bureau of meteorology (BoM) was analyzed based on current market trends and merged with future technological improvement from the cloud computing, 5G, IOT and mobile applications. Information collection and analysis was done by using the content analysis methodology of the BOM reports and annual water reports from different sources like Australian water association (Dumay and Cai, 2015). An intensive data collection with credible sources input is available from BOM website. One of the examples of content analysis is based on the hypothesis of leakage saving and how this can cover part of the project rollout. Based on the 10 steps highlighted by White and Marsh (2006) the data was identified from BOM website. Sampling method was used and sample unit was taken as a single water meter users. Data is available for 86 utilities and 72 of these are just providing water supply with sewerage systems as well.

Table 1.1 Utilities reporting in the 2021 Urban NPR by size group and jurisdiction

Jurisdiction	Bulk	Major	Large	Medium	Small	Total
Australian Capital Territory		1				1
New South Wales	2	3	1	13	12	31
Northern Territory			1		1	2
Queensland	2	4	4	5	7	22
South Australia		1				1
Tasmania		1				1
Victoria	1	4	6	5	1	17
Western Australia		1	1		9	11
Total	**5**	**15**	**13**	**23**	**30**	**86**

[2] National Water Initiative clauses 75–76

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Figure 12 Australian Water Utilities

Source: http://www.bom.gov.au/water/npr/docs/2020-21/National_Performance_Report_2019-20_urban_water_utilities.pdf

Location of these utilities are all around Australia.

The monthly usage of water and bills are different for each utility, water usage, leakage details, operation cost, capital cost and average bill details are given in this report.

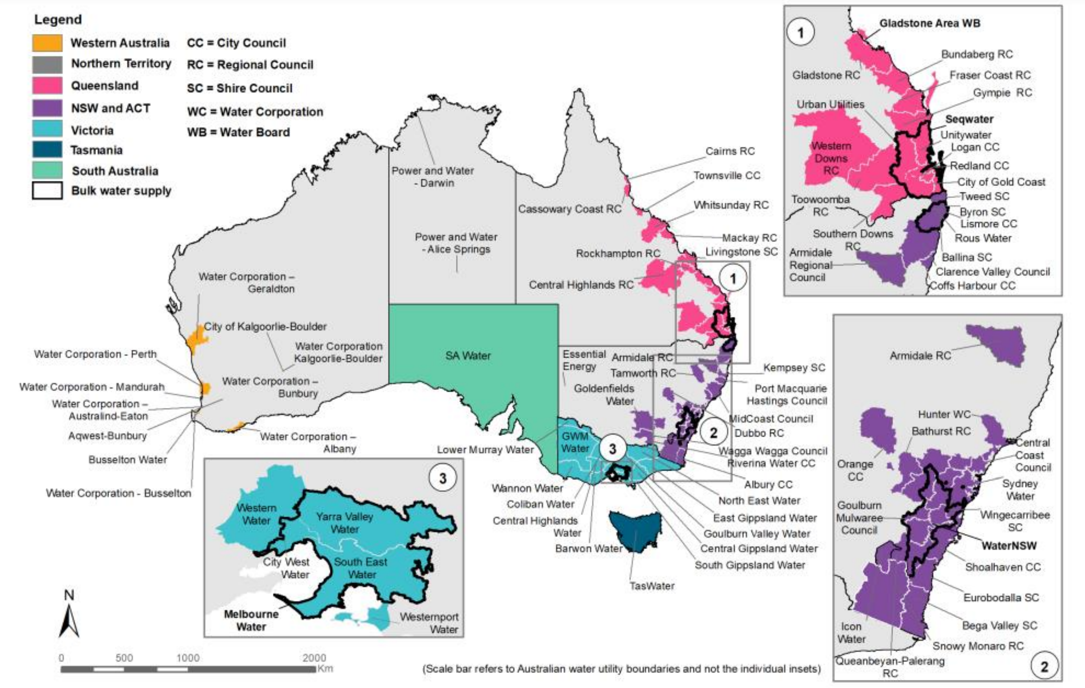

Figure 1.1 The administrative boundaries of all utilities reporting data for 2020–21

Figure 13 Australian Water Utilities locations

Source: http://www.bom.gov.au/water/npr/docs/2020-21/National_Performance_Report_2019-20_urban_water_utilities.pdf

With data analysis from the BOM report the conclusion was made that the leakage is resulting in non-revenue water and the cost of non-revenue water is almost 3% to 8% for residential users(Bureau of Meteorology, 2022).

CHAPTER 4: PAPER 1 - Towards a user-level self-management of COVID-19 using mobile devices supported by Artificial Intelligence, 5G and the Cloud

Introduction:

This scholarly paper delves into the topic of Covid-19 self-monitoring utilizing emerging technologies, which aligns with the overarching research theme that highlights the pivotal role of emerging technologies in monitoring and managing pandemics, including Covid-19. The widespread delay in Covid-19 vaccination rollout necessitated the deployment of cutting-edge technologies such as Internet of Things (IoT), Robots, 5G, and cloud computing, which played a crucial role in curbing the spread of Covid-19. Contact tracing, crowd temperature sensing, robot-assisted cleaning and medicine delivery, patrolling, and spraying were some of the innovative applications of these technologies in pandemic control. Drones were also employed for various use cases to mitigate the spread of Covid-19.

The novel approach proposed in this paper centers on the use of a mobile app for self-monitoring of Covid-19, empowering patients to proactively manage and monitor their own health status. Two specific use cases are selected, with Covid-19 serving as a prominent example, to illustrate the potential of emerging technologies in enabling self-monitoring of Covid-19. Furthermore, the findings and insights derived from this research have implications beyond the healthcare industry, as the role of emerging technologies in self-monitoring can be extrapolated to other sectors as well.

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CHAPTER 5: PAPER 2 - Role of Cloud Computing and ABCDE of platforms (Application enablement, billing management, connectivity management, device management, and end-user app) for End to End Delivery of Advance Metering Infrastructure (AMI) Solution

Introduction

This chapter presents a compelling use case that further underscores the overarching theme of this research. Specifically, it delves into the critical role of emerging technologies, such as IoT, 5G, Cloud computing, and Artificial Intelligence, in facilitating self-monitoring and empowering end users with visibility and control in the context of water utility and smart water management. The paper focuses on the pivotal role of Cloud computing in enabling five different levels of platforms that collectively manage advanced metering infrastructure for smart water metering. These specialized platforms encompass application enablement, billing management, connectivity management, device management, and end user mobile application. Leveraging NB-IoT networks and connectivity management platforms, data from IoT devices is seamlessly transferred to the central platform. Device management and billing management platforms are instrumental in performing firmware upgrades and managing billing for millions of devices deployed across residential users. Finally, the processed data is made accessible to end users through a mobile application, providing real-time insights into water usage patterns. This comprehensive approach serves to substantiate the significance of mobile apps and emerging technologies in the realm of self-monitoring for smart water metering.

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Abstract

AMI (advanced metering infrastructure) is a technology that enables a water meter to communicate with the service provider in an automatic, two-way manner. AMI uses a fixed transmission network to transmit and receive signals from meters remotely, providing real-time feedback on water use regularly or on-demand Cloud computing can help solve the problems and opportunities of emerging and future AMI.

The Internet of Things is a network that allows everyday computers to become smarter, everyday processing to become knowledgeable, and everyday communication to become more insightful. Thus, this study surveys Internet of Things-oriented platforms that are capable of improving understanding of relevant tool, technologies, and methods to meet the needs of developers. The presented IoT ABCDE platforms, either directly or indirectly, propose to address real-world challenges by developing and deploying effective Internet of Things concepts.

Therefore, this paper provides the reader with the requisite knowledge of IoT platforms, cloud computing AMI, and AMI solutions. The importance of both of these frameworks and the role of cloud computing in end-to-end distribution are also discussed in the paper. This study also looks at network connectivity in IoT platforms for water utilities to see the wireless infrastructure that offers the best connectivity, which has been crucial in the future. The paper presents various network connectivity by differentiating their effectiveness to determine the best network connectivity for water utilities. From the assessment, this paper finds NB-IoT to be the best network connectivity for water utilities. Nonetheless, the paper concludes by emphasizing the importance of securing AMI infrastructure due to its vulnerability. The report concludes by making some proposals, as it is essential to include a comprehensive summary of the paper's main topic.

Keywords: AMI, cloud computing, Internet of Things, AMI solutions, customers, end-to-end delivery, information technology, connectivity, water utilities, IoT platforms.

Introduction

The Internet of Things (IoT) concept's defines and reshapes how future services can be described. IoT integrates precise environment data with information processing to reduce costs and improve performance and precision. IoT is characterized by the International Telecommunication Union (ITU) as a network that provides access to any connected smart device, anywhere, at any time [1] .

Figure 1: Internet of Things

On the other hand, Cloud storage has been a robust, open, and cost-effective approach in this era. Cloud computing is a technological innovation that first emerged in the information technology community in 2006 [2]. Rather than using the hard disk, it involves storing data on the internet according to user orientation and accessing such data as required. Furthermore, cloud computing does not imply using a home or office's local area network, with many technological advances occurring today. Every company must become technology-empowered . Cloud computing is a global solution provider of Advanced Metering Infrastructure solutions, designing digital smart metering infrastructure solutions [3]. Thus, AMI as a service needs an ABCDE platform and cloud computing for end-to-end delivery.

Literature Review

According to Scully [4], the Internet of Things (IoT) is a set of devices that enable us to feel, gather data, control, and track the system without physically interacting with the devices. Sensors, networks, computing units, and operating systems make up these systems. [5] argue that for humanity's betterment in this computerized and automated environment, people need to introduce modern technology that offers precision, cost efficiency, and time savings while using less human resources. The twenty-first century saw significant technical advances [6]. These advances pose numerous challenges, necessitating the development of novel methods and approaches to addressing them [7]. One such method is Advanced Metering Infrastructure. This helpful tool provides operators and service utilities with real-time updates on the state of their network, which can be used for planning and output optimization [8]. At both the user and supplier ends, the collected data may be used to regulate usage. However, according to [9], Advanced Metering Infrastructure is a modern technology that requires improvement in communications, data collection, and control schemes.

Hakala [10] argued that Sensor networks, cellular networking networks, the Internet, databases, and WebGIS are all used to build an IoT-based automated water information monitoring system. However, Hakala fails to mention the best cellular network for water utilities. In his framework, [11] argued that software and hardware are used to combine water supply data collection, transmission, and remote monitoring data reception and application. On the other side, [12] suggests a smart water management paradigm that incorporates Internet of Things technology to decouple decision support and control from business process coordination and subsystem execution. The proposed smart water management model unified the interoperability and management of individual vendor appliances in a water management domain.

According to [10], he building IoT-based water meter aims to install a smart meter with high data analyzing capabilities at a low cost. Unlike other technology like ZigBee, Bluetooth, and GSM-based water meters, this meter would enable users to view real-time and historical data at any time and from any place. The proposed framework communicates with the water meter and the IoT cloud using RESTful web services.

Despite many studies providing insights on modern technology, especially cloud computing in water utilities, they fail to mention detailed information on the best ABCDE solutions and the best network connectivity. For water utility infrastructure. Many researchers have made efforts to come up with the best solutions for smart metering in fractures. However, close to none have addresses the ABCDE IoT platforms that significantly play a significant role in the water utility industry. Even though some researchers have identified various network connectivity critical in smart water meter grid infrastructure, none of them has indicated the best network connectivity solution. Thus, this paper intends to lay the groundwork for various ABCDE platforms in AMI solutions and points out the best network connectivity in smart water meter infrastructure.

AMI Solutions

Over the past few years, advanced metering infrastructure, or AMI, has been something of a buzzword in the water industry, and it's being embraced more and more by water providers under pressure to improve performance. It's easy to see the appeal, given recent advances in AMI technology. Before diving into AMI technology, it's necessary to distinguish between AMR and AMI, as the two words are often misunderstood. Automatic Meter Reading, or AMR, is a step up from a person approaching a water meter, reading the numbers, and writing them down [7]. Instead, a computer pings the meter to obtain a current reading, which is then used to produce a report. The meter communicates with the meter-reading system, but the device is unable to respond with a command.

On the other hand, AMI allows for two-way connectivity between the utility grid and the metering endpoints over a fixed network [13]. It's a much more efficient and reliable machine that's proving its worth in various settings, from remote fields to booming cities.

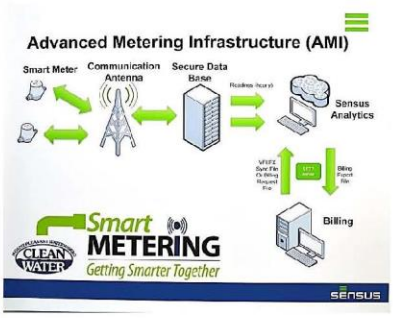


Figure 2: Advanced Metering Infrastructure

It has been more than a decade for many utilities since their advanced metering infrastructure was first established (AMI). The first wave's equipment is nearing the end of its life cycle. The underlying applications do not embrace emerging technology like artificial intelligence, cloud computing, 5G, IoT, or intelligent automation.

AMR devices have traditionally been used to read meters efficiently and correctly. These devices are indeed beneficial and are still in operation today, but many water providers discover that they face obstacles beyond just speed-reading a meter. Utilities deal with a slew of operational problems that AMI can help in specific ways [14]. According to [15], many utilities prioritize the deployment of a next-generation AMI solution that will serve as the basis for transformation. Initiatives and empower digital and business innovations. Organizations will not be able to completely understand the advanced advantages of first-wave implementations without further investment.

ABCDE of platforms for an end to end delivery of AMI solution

According to [9], an end-to-end solution (E2ES) is a concept that refers to a situation in which the manufacturer of an application program, device, or device supplies all of the customer's software and hardware specifications and no other vendor is interested in meeting those needs. Installation, integration, and setup are all included in E2ES. End-to-end strategies take care of the delivery while keeping an eye on the most cost-effective and reliable ways to start a company [16]. Data and Bonnet state that the processes are set up to ensure that prices are kept to a minimum, that the best materials are used, and that the best infrastructure is produced under market needs [17]. The hassle, risks, energy, and time associated with an end-to-end solution are considerably reduced. To keep up with ever-changing technology and customer demands, project managers often use end-to-end solution providers. A project is managed by a single provider who works on it from start to finish without the participation of any other third parties. AMI (Advanced Metering Infrastructure) is a game-changing tool with far-reaching implications for the utility industry and its customers [18] [19]. By moving facets of smart meter grid management and regulation out to the endpoints of distribution, AMI helps utilities manage supply, demand, and capacity, resulting in a better, more powerful grid. Stakeholders are currently putting in place the programs and capabilities needed to deploy AMI. AMI is a two-way communication mechanism that can enter any unit in the delivery space [20].

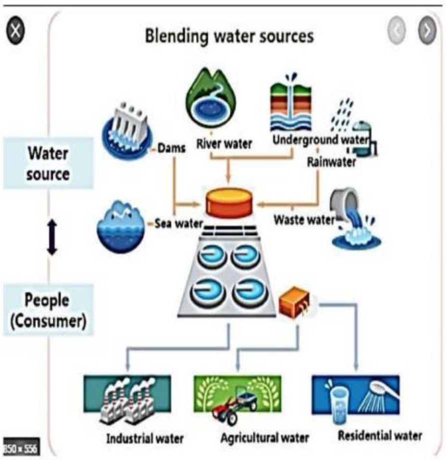


Figure 3: A Smart water grid architecture

However, to ensure end-to-end delivery of AMI solutions, cloud computing and IoT platforms must be incorporated within the system. The IoT platforms can be categorized into five parts which are termed ABCDE platforms. The ABCDE platforms required for AMI solutions include the Application enablement platform, Connectivity management platform, billing management platform, Device management platform, and End-user mobile app and web portal platform.

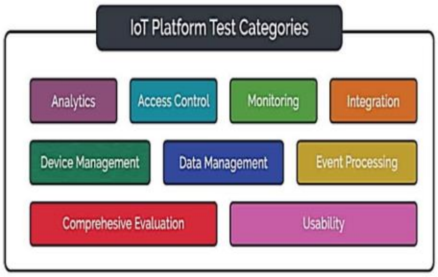


Figure 4: Categories of IoT Platforms.

Application enablement platform

The IoT opens up new revenue models and changes in how businesses interact with customers. Lasse and Kotzorek [21] argue that the ever-shifting technology environment raises a need for new worthwhile solutions to be established quickly and affordably with usability and scale in mind. An application Enablement Platform (AEP) can provide a vivid vision of a successful AMI solution. According to Lasse and Kotzorek, application enablement is a method that brings together telecommunications networks and developers to merge their network and web capabilities to build and deliver high-demand advanced services and new intelligent applications [21]. On the other hand, Guth et al. argue that it is a technology-centric offering that aims to provide consumers with a best-of-breed, industry-agnostic, extensible middleware center for developing a range of interconnected or independent IoT solutions [22].

According to most experts, the internet of things is expected to generate tens of billions of connected devices in the coming years. The path to get there is not clear, but businesses are already looking to streamline IoT growth and promptly provide robust solutions [4]. Using an IoT application enablement framework is one of the easiest ways to do so.

The term AEP is a relatively recent term that is often used to describe a category of a software platform aimed at the IoT market [23]. The theory is that AEPs find developing the final solution efficiently. It is debatable if it is simply because it essentially relies on the availability of professional software developers and operations personnel who are motivated to make it work.

AEP provides a comprehensive monitoring solution, predicting and reacting to data on water flow, pressure, and consumer intake. AEP is a Digital Utility Platform that uses the NB-IoT network to provide analytics from fully integrated digital meters [24]. The platform can display data from automated ultrasonic meters that quantify usage and temperature and detect consumer leakage by measuring the overnight flow minimum.

The next generation of AEP systems must be data-centric, allowing product developers to easily capture, store, and mine data for valuable market insights. The information gathered can be safely shared with applications. Application enablement platforms (AEPs) are intended to make IoT solutions faster and easier by delivering horizontal solution modules that can be reused across industries and market segmentation [23]. Instead of duplicating non-differentiating features, including connectivity integration, system management, data processing, data storage, and analytic insights, AEPs enable organizations to concentrate on differentiation provided by specific technologies and insights from data.

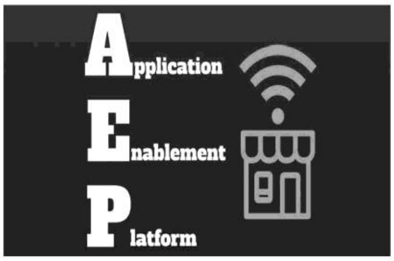


Figure 5: Application Enablement Platform.

Application enablement systems are all-in-one solutions with all of the resources used to bring an IoT framework up and running. Tools and hardware and implementation, and integration solutions are commonly included with these platforms, making it easier to get an IoT framework up and running [25]. The advantage is that enablement frameworks handle the creation, network setup, and installation tasks that are usually performed in-house, potentially saving time and money for organizations.

Billing Management Platform

The Internet of Things (IoT) is providing businesses across all industries with exciting new revenue opportunities. Data, storage, and 'smart' services can now be monetized in new ways thanks to connected hardware, networks, platforms, and solutions [26]. Companies must, however, adapt their corporate processes and invest in modern support structures that are designed for the IoT environment to take advantage of the IoT potential. Billing software is used to keep track of time and billing and invoice customers' water consumption.

Figure 6: Water bill tracking with web-based software

It assists company owners in keeping track of various invoices and accounts in a detailed manner with only a few mouse clicks. It also offers recurring services and a corporate billing solution for leasing.

Billing and payment habits are managed, tracked, and externally audited in a billing system. Bills should be reliable and transparent; transactions, processes, and programs should be accurately documented; and consumer data should be stored and secured appropriately [15]. Bribery, petty cash fraud, and money laundering are also examples of inappropriate and erroneous billing and payment procedures that can be identified and corrected with a good billing system. Accurate bills are also an effective engagement mechanism that can enable water users to save more water.

Connectivity management platform

Software platforms abound in the world, and new ones emerge regularly. Many researchers expect the IoT market to grow over 10% annually until 2026 [5]. The demand is rising due to the increasing adoption of IoT technology through manufacturing, automotive, and health care. To monitor the devices and link them, the advancement necessitates modular IoT platforms [27]. Emphasizes that in the field of networking, an IoT network usually refers to a framework that manages the communication life cycle. Activating a SIM card, changing data plans, managing billing, monitoring service, and deactivating a subscription are all needed. Connectivity management, according to Ghasempour, is a combination of connectivity resources and management tools that support IoT and M2M projects all over the world [3].

The CMP platform enables effective connectivity management over the product lifecycle, lowers the overall cost of ownership, and improves the system management. The platform also aims to reduce risk by allowing coverage and SIMs to automatically migrate to the network with the strongest signal, reducing the overall risk of the system going offline [22]. Unauthorized access to M2M and IoT networks is also eliminated with a robust security approach.

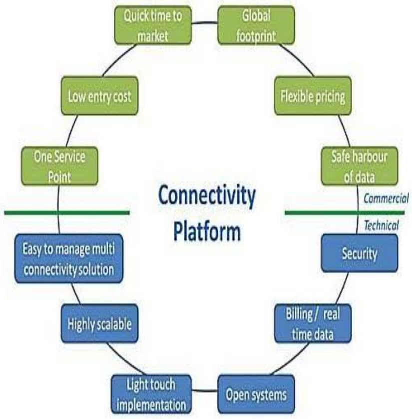


Figure 7: The critical role of connectivity platform in M2M and IoT application.

The advantages that communication management platforms (CMPs) provide to businesses are driving the global CMP industry. One of the essential features of CMP is that it allows one to bind their computer. It is a network that can accommodate various communications technologies, including cellular connectivity such as LTE, GSM, HSPA, and CDMA, and non-cellular communication such as Wi-Fi, Zigbee, Bluetooth, and low-power, wide-area (LPWA) wireless technology [28]. The platform also offers the option of bringing any networking from the preferred provider.

IoT platform typically refers to a link life-cycle management platform in the world of connectivity [29]. It is required to unlock a SIM card, adjust data plans, control billing, track operation, or deactivate a subscription. The aim of an IoT networking framework is to simplify things. However, there are many factors to remember and ways to do it. A vast number of connected devices around the world is usually the result of a good IoT rollout. Managing connectivity and keeping computers online is important. The key to IoT implementation performance at the global scale is removing all potential uncertainty [20]. The water utility industry requires a self-service framework to handle their networking in order to maintain control. The correct connectivity management software (CMP) enables effective system and cellular technology management, as well as data rate optimization for optimum IoT deployment.

A connectivity management platform can detect potential interface malfunctions either manually or automatically, depending on the rules set by the user. More specifically, since there are tens of thousands of computers, the countermeasure must be streamlined to avoid negative consequences [30]. According to many studies, a good connectivity management tool saves organizations time in terms of operations and maintenance, actionable insights from all the results, detection of problems in real time and improved ease of use and intuitive features

Various forms of network technologies have recently been used to link IoT computers. However, the optimal networking system is determined by how and when it can be built, as long as the appropriate service level is met [10]. As a result, an all-encompassing IoT network can promote collaboration and have all necessary IoT styles to demonstrate the most excellent versatility for current and future projects.

As one would expect, connectivity platforms are designed to handle the networking features of an IoT framework. These systems have the hardware, applications, and performance metrics needed to keep all of your system's devices connected [31]. These networks are mostly provided by established WiFi providers and network systems, which customize the link and make it simple to set up. High end devices such as filtration pumps, reservoirs, pumps and machineries will require remote access with security connectivity and CMP can provide the secured connectivity using mobile networks or any other connectivity modem.

Device management platform

If the adoption of the Internet of Things (IoT) continues to grow, organizations worldwide are focusing their attention on assembling moving pieces in a global environment. Given the vast scale and high sophistication of the Internet of Things, it contends that many critical elements must be appropriately considered and managed [22]. Though connectivity, smart devices, and cloud analytics are essential parts of an IoT infrastructure, IoT device management is among the most important and often forgotten facets. Smart water meters and millions of meters upgrade will be needed, firmware upgrade in bulk is only possible with DMP, smart water meters, data loggers and any other elementary devices can be upgraded managed and controlled with DMP.

A software solution that unifies and simplifies IoT application and software administration, according to Navani and Nehra, is an IoT system management tool [5]. It is similar to a connected devices platform. An IoT device management portal, in general, manages data sent by IoT users, the back-end systems that process the data, the provisioning of software upgrades to IoT devices, and general device lifecycle administration and insights on IoT devices and application use. [11] .

For the devices to matter, they must be managed following certain widely agreed principles and best practices that form the foundations of IoT device management. Learning the ropes of the process helps with decision-making throughout the IoT project. It allows for a better understanding of what happens to a linked system during its entire life cycle. The figure below indicates the cycle,

Device management systems typically oversee M2M devices deployed by a single manufacturer, ensuring that the correct drivers are used to communicate through various networks and handle those wired devices' firmware and software specifications. Complex system networking, program, and data storage processes are also part of M2M and IoT technologies [6]. New specifications and technologies are evolving in each region, enabling a diverse value chain and expanding ecosystem of service providers to help M2M and IoT develop together.

An IoT platform's device management platform guarantees that associated objects are operating correctly and that the platform's software and apps are up to date and operating. Computer provisioning, remote tuning, firmware/software upgrade control, and troubleshooting are all tasks in this module. Thousands, if not millions, of new devices, are becoming available. Bulk-actions and automation are critical components of an IoT-enabled solution for controlling costs and reducing manual labor [32].

Device management systems ensure that all devices in an IoT system are linked and stable. These platforms keep an eye on the design and take care of the day-to-day activities with the connected gadgets [33]. Consider configuration fixes, patching, logging, and notifying users of any modifications to their system. Device management platform is the centralized part in any industry, and through API, all data between different platforms is transferred via DMP, connectivity from DMO, CMP, AEP and end User platform is somehow done via device management platform.

End user mobile app and web portal

Several utilities have created mobile phone apps for consumers to view billing information, collect usage updates, make payments, and monitor outages. The outage notification feature is helpful for prompt reporting of outages without overburdening customer service representatives because cell phone networks typically remain operational during power outages [34]. The Internet of Things (IoT) market is being more crowded. Established software firms, hardware manufacturers, and a slew of new entrants enhance their products with embedded technology and extensive data services and bring to market groundbreaking IoT systems [2]. IoT architecture for end-user applications and IoT mobile apps play a significant, if not critical, role in creating a genuinely viable product in this highly competitive world.

In-home displays (IHDs), online pages, smartphone applications, and text/email allow consumers to help control their consumption and raise end-user awareness by supplying them with almost real-time details on their water consumption costs and prices. Web portals and in-home displays (IHDs) provide visually enticing facts to increase comprehension and insight into behavior that can save energy and money [14]. Water utility "dashboards" are often available on websites, giving consumers access to historical and near-real-time consumption data. IHDs and intelligent devices have water consumption warnings as well as notifications of significant peak incidents.

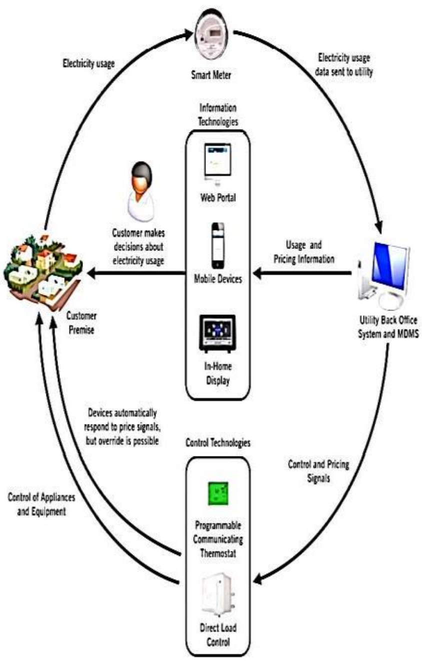


Figure 8: AMI and Customer Systems.

The In-Home-Display (IHD) is a device that is installed in the end user's home and interacts with the consumer [35]. It communicates with the consumer's smart meter primarily through Zigbee, Wireless M-Bus protocols, or PLC technology. Consumers can use IHD to track their consumption in real-time, view historical data, and receive simple utility messages.

Customer Portals (WEB and Mobile portals) are linked to Telemetering Software (AMM/MDM) to offer up-to-date information to end-users. According to Basu et al. [36], the web portal is a customized web page that allows consumers to view information about water consumption. The Mobile portal provides access to a mobile-optimized update of the customer web portal for smartphones and tablets.

Figure 9: Smart Home Water monitoring

Mobile apps can be utilized for demand management, clients can set an objective for water consumption for a week or a month. They can compare their water consumption with other residents in the suburb and optimize the water usage. With demand management, utility providers' offer some incentives and reward for water saving, an average of 5 to 8 % can be attained with the mobile apps.

Cloud computing

Every day, new technologies are being invented. Cloud computing and the Internet of Things, according to [20], have become two very closely connected future internet technologies, one supplying the other with a forum for success. IoT has progressed in combination with the increased generation of data, while cloud computing opens the way for this data to travel [37]. Cloud computing is being used as part of a new Advanced Metering Infrastructure concept. Cloud-based AMI applications have the potential to improve significantly the efficiency of the services provided by AMI. An example of an AMI system architecture using cloud computing technologies is shown in the diagram below.

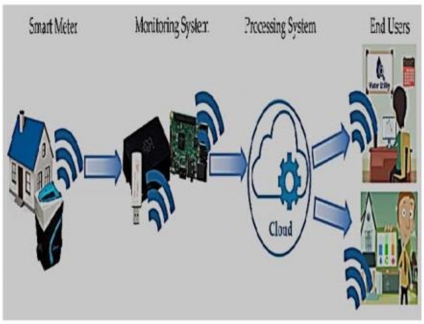


Figure 10: Smart cloud computing technology.

Distribution and retail services benefit from end-to-end intelligent meter rollout, operations, data processing, monitoring, customer experience, and more, thanks to cloud technologies. However, for many, switching processes and capacity to the cloud is not an easy task. New operating procedures, compliance threats, and additional IT tools are all part of this.

Cloud computing lowers the expense of deploying programs by allowing for on-demand, automatic, and fine-granular resource allocation. Cloud computing platforms empower agile and self-service management even in private environments, allowing physical resources to be exchanged more effectively [2] . It lowers the expense of deploying programs by allowing for on-demand, automatic, and fine-granular resource allocation. Cloud infrastructure systems empower agile and self-service management even in private environments, allowing physical resources to be exchanged more effectively [38]. Using shared infrastructures, on the other hand, increases the risk of attacks and data breaches.

Access to AMI information systems, infrastructure, and hardware platforms is now available at a low cost. It was an effective way that was unimaginable only a few years ago, thanks to web-based software providers, or cloud services, delivered in a managed solution model [39]. In this approach, utilities can take advantage of the resources and economies of scale that a broad solution vendor can deliver, rather than what usually is available within a company, without running the infrastructure internally.

Role of Cloud Computing and Platforms

IoT platforms, as previously said, are mainly used and delivered from a cloud environment. Cloud computing is a paradigm that enables users to access a configurable pool of computing power on demand [5]. loud services are used to provide organizations with the technology they need to develop IoT systems. Cloud systems, in essence, have a single repository for handling the data and backend operations. With minimum management effort, solutions can be availed and launched [38]. It provides networks, websites, and applications to consumers as pay-as-you-go subscription-based services. Cloud computing is a new computing architecture that uses the Internet to deliver on-demand services and shared infrastructure [29]. Luo et al. argue that Cloud computing functions as a utility provider since it is focused on massive servers and processing.

With smart meters, cameras, and other IoT hardware used by water providers, the volumes of data are unavoidably dealt with by utilities. For example, smart meter data is contained in meter data management (MDM) platforms that are mainly intended to handle vast data from millions of devices stored and processed on a utility basis [31]. n multiple device applications, MDM software provides a horizontal interface for integrating traditional data services (SmartMeter) such as billing, property management, and field service management. Horizontal systems for data storage are owned and used by different business divisions in the utilities and facilitate the smooth flow of business operations, thus increasing overall efficiency and reducing costs.

According to [18], AMI gives way to more sophisticated and multi-purpose intelligent metering systems in the era of IoT and IoT platforms. These technologies have a wider variety of remote control and alerting features and adequate data processing software to assist businesses and individuals in reducing their water usage. Platforms are essential for managing applications, allowing remote connections to all related objects or devices, collecting and managing data, defining business rules, and integrating analytics and visualization with IT and cloud services [37]. They play a crucial role in the growth of IoT solutions for businesses to provide value to both the company and its customers.

Based on what was discussed earlier on ABCDE platforms, An IoT platform is an IoT Application Enablement Platform, or AEP, in the strictest sense. Vendors of application enablement platforms (AEPs) provide a technology-focused portfolio intending to give an industry-agnostic and comprehensive middleware center for creating a range of interconnected or standalone IoT solutions [22]. Though platform-enabled solutions (PES) are solution-centric and strive for fast end-to-end vertical IoT solutions, companies tend to purchase cloud-based services from best-in-class rather than developing their platforms AEP vendors. Without these platforms, end-to-end delivery of AMI is not possible or at least can't meet the future water utilities requirements.

Best wireless technology Network Connectivity (LoRaWAN. LTE-M, NB-IoT, SigFox)

The overwhelming majority of the IoT we create for our clients is based on GSM, Bluetooth, and Wifi, but Polymorph's unique designs are based on LoRaWAN technology [24]. As a result, organizations make it a point to grow and find new ways to keep clients involved. The matter of which networking to use depends on the use case of the IoT product an organization is developing and what the users need.

Two promising LPWAN additions are LTE-M and Narrowband-IoT (NB-IoT). LTE-M is the contribution of the Third Generation Partnership Project (also known as "3GPP") to increase interest in low-power wide-area network (LPWAN) technologies that utilize conventional LTE networking while conserving resources [40]. NB-IoT is a 3GPP construct that questions the damage caused by Sigfox and the LoRa Alliance; however, unlike LTE-M, NB-IoT does not function within the LTE framework.

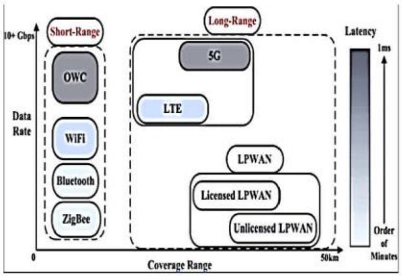


Figure 11: features of the IoT connectivity technologies in terms of data rate, coverage, and Latency

Because of its simplified waveform, NB-IoT has a significant benefit in terms of power consumption. Another important benefit is the cost. The total part cost is minimized using chipsets specially designed for NB-IoT protocols, which have a simplified construction [41].

Lastly, NB-IoT can benefit smart city implementations. According to [40], NB-IoT could have higher building penetration than LTE-M. However, because of the extensive use of LTE in the United States, implementation would be complex. Because chips that support both LTE and LTE-M are prohibitively expensive, one has to choose. But it also depends on the usage case; NB-IoT is potentially best suited to fixed assets like smart meters, while LTE-M has advantages in roaming applications like cars or drones.

SigFox is a French company based in Labège, France, founded in 2009 [42]. Because of its active marketing strategies in Europe, SigFox has gained considerable momentum in the LPWAN space. Texas Instruments, Silicon Labs, and Axom are among the many vendors that make up the ecosystem. SigFox has recently concentrated much of its attention on the increasingly growing European market, which should be considered by US-based adopters [42]. SigFox employs advanced technologies, such as slow modulation rates, to reach a more excellent range. SigFox is an ideal choice for systems where the device only has to transmit short, infrequent bursts of data due to this design choice.

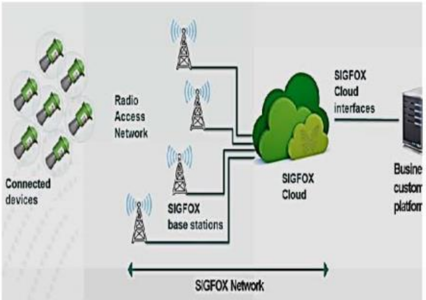


Figure 12: SIGFOX Network

Parking alarms, water meters, and intelligent garbage cans are also possible applications. It does, though, have some disadvantages. Downlink capability (sending data back to sensors/devices) is severely limited, and signal interference may become a problem.

The LoRa Alliance governs the open-standard networking layer known as LoRaWAN. It isn't entirely free, though, since the underlying chip required to implement a complete LoRaWAN stack is only available from Semtech [41]. In essence, LoRa is the chip's physical sheet. The MAC layer of LoRaWAN is the program that is installed on the chip to allow networking.

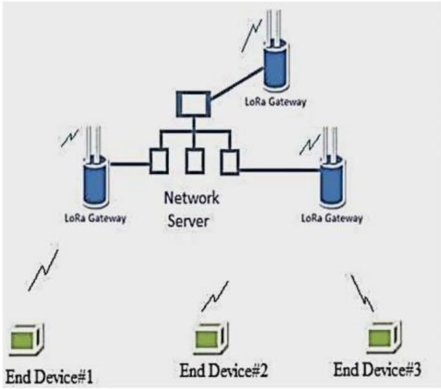


Figure 13: LoRa Network

The functionality is similar to SigFox in that it's designed for uplink-only applications with a large number of endpoints (data from sensors/devices to a gateway). Instead of using narrowband transfer, it uses encoded packets to transmit data through many frequency channels and data speeds. Since these signals are less likely to crash and clash with one another, the gateway's capability is increased.

Sigfox and LoRa dominate the unlicensed LPWAN market. Still, their main drawback is that they are closed, proprietary solutions that use their own IoT network infrastructure that is incompatible with existing cellular networks [43]. This often causes problems with connectivity between networks and inter-domain incompatibility.

Network connectivity and Telecom platforms.

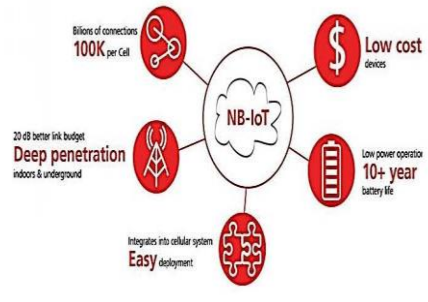
As telecoms' 5G networks evolve and the 4G to 5G transformation begins, IoT platforms' additional benefit will become more valuable [24]. Telecom companies have developed dedicated networks for their IoT platforms in some situations. LTE-M and narrowband IoT are the two protocols used by telecoms to link IoT devices to their networks (NB-IoT). As per GMSA, NB-IoT is already declared as a 5G technology which implies that it will remain available for the next 10-15 years. Besides, there is no additional cost required for the deployment of the network. For instance, site acquisition, power consumptions, installation, hardware cost of lowarn, sigfox etc as the public network provided by the telecoms will remain available for free to be utilized by the utility. The protocols are designed for connecting IoT devices to cellular networks and are low-bandwidth, low-power, and low-cost. The NB-IoT standard is most often used for low-cost and low-bandwidth data connections [44]. On the other hand, LTE-M is designed with an emphasis on higher bandwidth and smartphone connectivity.

Figure 14:NB-IoT Smart Water Metering

However, Narrowband-IoT (NB-IOT) is a Low-Power Wide Area Networking (LPWAN) platform that, like LTE-M (Long-Term Evolution for Machines), can be combined as part of 5G standards [44]. Thus, it is reasonable to conclude that this system is here to remain and can outperform other proprietary platforms that are not dependent on cellular networks due to their widespread availability.

The water industry can learn more effectively from real-time reporting, data collection, and water demand forecasting capabilities due to NB-IoT technology. A NB-IoT module is used to send a large amount of data based on metering calculations to the local water utility's management system. The real-time meter reading, accumulate weighing, reverse flow intake, water temperature, pipe pressure, and tempering warning are among the types of data transmitted over the NB-IoT network.

Cat-based chips, such as LTE-M and NB-IoT, would boost communications and open new doors for applications in industries, including utilities, as part of the low-power wide-area Mobile IoT solution for 5G networks. Multiple low-throughput devices with low delay sensitivity are supported by NB-IoT [24]. It will aid in the optimization of networks as a low-cost, low-power alternative. Besides, NB-IoT can seamlessly combine with current LTE implementations or operate independently. Thus, NB-IoT, based on LTE technology, would be the most popular solution for the utility industry, especially water delivery [44].



Besides, a theoretical model for water supply based on IoT and cloud computing presented by [1] proposed a 3G cellular network as the connectivity solution for sensors. The water business can learn more effectively from real-time reporting, data collection, and water demand forecasting capabilities with NB-IoT technology.

Conclusions

The high-level architecture using the ABCDE platform demonstrates that end-to-end solution implementation is impossible without cloud infrastructure. The mobile industry would be a disruptor because, in the past, any communication with a 10+ year battery life on a telecom 3G or 4G network was impossible. Low-power networks, such as LORAWAN and Sigfox, were needed to be deployed. There are no restrictions to deploy or maintain a network for NB-IoT.

All around the planet, smart water systems are increasing the performance of utility operations. Smart water metering, for example, provides both the customer and the service company with detailed, up-to-date, and applicable analytics on water use. At the same time, network operators are developing tailored solutions to meet the needs of the water industry. we-Bus, LoRa, Sigfox, and the 3GPP technologies NB-IoT and eMTC are the primary protocols used in smart water metering at the moment. Nonetheless. NB-IoT is best for monthly data billing because it offers reliable data analytics. Besides, NB-IoT is expected to support a wide range of computers, platforms, and systems shortly. NB-IoT is expected to support various applications, formats, and technologies soon, allowing for versatility and vendor independence. Since it is continuously being built and updated by industry professionals, it can be easily upgraded to 5G.

Overall, the safest contact solution for smart water meters is NB-IoT. NB-IoT is the most suitable for deploying smart water meters, taking into account latency, flexibility, coverage, battery life, and long-term expense. It will help in delivering utilities based on the best of what communications have to offer.

The NB-IoT water metering business model is extremely adaptable. Typically, a water meter provider can provide a complete network solution to its multinational customers, including different specialized types of meters that can be fitted with NB-IoT modules based on local wireless frequency standards, as well as server hardware or a cloud infrastructure with automated metering control and billing functions. A water meter provider may also provide solutions that enable customers to dock with their current systems by inputting and outputting data in a standard format. Normally, a mobile operator's role in a smart water metering solution is limited to providing SIM cards and charging for access. Some network operators can also offer cloud services to utilities for web server hosting, as well as IoT platform system management.

IoT cloud systems are intended for specialized business contexts such as application creation, device management, system management, heterogeneity management, data management, analytics, deployment, reporting, simulation, and research. It is clear that there are far more platforms currently available on the market; nevertheless, the most common 26 of these have been selected. Furthermore, the IoT cloud solutions have been revisited based on applicability and suitability preferences in a variety of domains. Different domains have been chosen as the foundation for the majority of IoT cloud services that are currently emerging in the IT industry. However, tests have not shown the right IoT solution. However, research has not shown the best IoT cloud network applications for water utilities industry. Nonetheless, according to this study, the ABCDE platforms play an important role in the Water utility industry.

AMI can be thought of as a connector that allows bidirectional connectivity from the user to the utility domain. This advanced technology serves as a high-speed communication channel between these entities. Bidirectional connectivity and power calculation facilities and flexible power pricing and demand-side control, self-healing capability, and interfaces for other systems are among AMI's main features. On the other hand, AMI is vulnerable to various security risks, including data breaches, financial gain, theft, and other disruptive practices. Since AMI is directly linked to revenue generation, consumer power use, and privacy, securing its infrastructure is critical.

Utilities can resist potential shocks using automated technologies to optimize and automate much of their water control activities, above and beyond intelligent meters and meter to cash applications. The utilities should create a cohesive long-term view of the Integrated Water Resource Management system (IMS) as a centralized recording system and a monitoring system for all its properties. Finally, water services can collaborate with suppliers of technical assistance and systems integrators to thoroughly assess advances in technology such as Artificial Intelligence (AI) and Machine Learning, which can process data from different sources in real-time.

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Jianming Yong received the PhD degree from the Swinburne University of Technology. He has more than 30-year experience in both IT industry and tertiary education. He is an associate professor at the Discipline of Information Systems, School of Management and Enterprise, Faculty of Business, Education, Law and Arts, University of Southern Queensland. He has been involved in many international competitive grants such as European Research grants, Australia-China grant. His research areas include e-learning, cloud computing, information security and privacy. He has been a member of the IEEE and its Computer Society over the past 20 years.

CHAPTER 6: PAPER 3 - Advanced IoT and Smart Water Technology: A Detailed Survey Analysis of Smart Water

Introduction

This chapter delves into an expansive landscape of cutting-edge smart water products, encompassing nearly fifty sophisticated solutions addressing a wide gamut of water-related challenges, such as water level monitoring, water quality assessment, flood monitoring, soil moisture measurement, sewerage monitoring, and many others. These diverse products necessitate specialized platforms and applications, demanding the establishment of a centralized platform that can seamlessly integrate and monitor these multifaceted solutions via a singular connectivity interface, readily accessible through a mobile application on end users' handheld devices. Harnessing state-of-the-art technologies, including cloud computing, 5G, IoT, and artificial intelligence, the data from these smart water products will be ingeniously integrated into a centralized platform, exemplifying the pioneering concept of self-monitoring. Mobile applications, serving as a quintessential tool, empower end users with unparalleled visibility and control, enabling them to vigilantly monitor and manage various critical water parameters with unparalleled efficacy.

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Global Ecology and Conservation

ADVANCED IOT AND SMART WATER TECHNOLOGY: A DETAILED SURVEY ANALYSIS OF DIFFERENT PRODUCTS

--Manuscript Draft--

Manuscript Number:	
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First Author:	sajjad ahmed
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	Anup Shrestha
	Jianming Yong
Abstract:	Purpose This paper aims to highlight various products related to advance IoT systems and smart water technologies to increase the learner's knowledge and increase the use of smart technologies by showing their benefits and usage. Method The researcher has used a secondary qualitative research method to gather the most relevant data. Results IoT-based smart water technologies are benefiting both utility and consumers in water monitoring, water control, water quality measurement, pressure and flow measurement, and many more. Water monitoring systems are used to monitoring chemicals and impurities in the water as well as the water level to avoid flood situations. The water quality measurement system mentioned in the study was used for determining drinking water quality and the quality of spa or pool water. Furthermore, pressure and flow measurement systems are beneficial to reduce the chances of pipe burst and protection of water transmission system. The web-based services and computer vision contributes a lot to remote meter reading and the use of a mobile application for displaying the temperature makes it easy to get the data anywhere in the world. In essence, by utilising mobile monitoring sensors and IoT technology the user can quickly detect the problem in any part of the world. Many of the applications the developer has used a mobile application that can be featured with all android mobiles. Conclusion The mentioned IoT-based smart water technologies are beneficial for both utility and consumers in terms of cost reduction, accuracy, increased system efficiency, fast transfer of data, and mobile data transfer. Based on the application they are categorised in water monitoring, water control, water quality measurement, pressure and flow measurement, and many more.
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	Faisal Nabi University of Southern Queensland Faisal.Nabi@usq.edu.au working in relevant field and research work.
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Opposed Reviewers:	

Cover letter

Sajjad Ahmed
University of Southern Queensland
Brisbane, Australia.

October 3rd, 2021

Dear Editor,

I wish to submit an original research article entitled "ADVANCED IOT AND SMART WATER TECHNOLOGY: A DETAILED SURVEY ANALYSIS OF DIFFERENT PRODUCTS" for consideration by "Global Ecology and Conservation". I confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere. In this paper, I report on smart water products and how these smart water products can help improve knowledge in said area. This is significant because by knowing more about these systems we as a society can unite and use them for noble causes, like making better choices as for water supply, quality and distribution.
We believe that this manuscript is appropriate for publication by "Global Ecology and Conservation" because it focuses on smart water and how they can contribute to optimizing smart water operations.

I have no conflicts of interest to disclose.

Please address all correspondence concerning this manuscript to me at sajjad.ahmed@usq.edu.au

Thank you for your consideration of this manuscript.

Sincerely,

Sajjad Ahmed

ADVANCED IOT AND SMART WATER TECHNOLOGY: A DETAILED SURVEY ANALYSIS OF DIFFERENT PRODUCTS

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Abstract

Purpose: This paper aims to highlight various products related to advance IoT systems and smart water technologies to increase the learner's knowledge and increase the use of smart technologies by showing their benefits and usage.

Method: The researcher has used a secondary qualitative research method to gather the most relevant data.

Results: IoT-based smart water technologies are benefiting both utility and consumers in water monitoring, water control, water quality measurement, pressure and flow measurement, and many more. Water monitoring systems are used to monitoring chemicals and impurities in the water as well as the water level to avoid flood situations. The water quality measurement system mentioned in the study was used for determining drinking water quality and the quality of spa or pool water. Furthermore, pressure and flow measurement systems are beneficial to reduce the chances of pipe burst and protection of water transmission system. The web-based services and computer vision contributes a lot to remote meter reading and the use of a mobile application for displaying the temperature makes it easy to get the data anywhere in the world. In essence, by utilising mobile monitoring sensors and IoT technology the user can quickly detect the problem in any part of the world. Many of the applications the developer has used a mobile application that can be featured with all android mobiles.

Conclusion: The mentioned IoT-based smart water technologies are beneficial for both utility and consumers in terms of cost reduction, accuracy, increased system efficiency, fast transfer of data, and mobile data transfer. Based on the application they are categorised in water monitoring, water control, water quality measurement, pressure and flow measurement, and many more.

Keywords: IoT, blockchain, water, water monitoring, secondary qualitative, smart water management.

1. Introduction

Developments in technology allow using the Internet of Things (IoT) for water management to give a safer and efficient management system for both the workers and customers. Through the use of smart technologies, the user can get accurate and real-time data on water consumption, water level, and other factors to determine the quality of water [1]. The use of smart devices is beneficial to reduce the workload of utility industry workers that are responsible to have checked and balance every inch of water-related operations. With technology, there is no need to physically check every unit of the industry and consumer touchpoints and the data can be available through digital devices and sensors. According to United Nations reports, water scarcity will be affecting approximately 20% of the population by the year 2025 [2]. This scenario will also affect the planet's inhabitants along with the world economies and ecosystems. Smart water systems are developed based on the combination of advanced technologies such as big data, the Internet of Things, and Artificial Intelligence technologies [78]. This helps to predict any damage that can be caused to water resources or on the other hand caused by the water resources. Besides this, the use of smart water technology helps to undo the damage caused by water or mishandling of water resources. In essence, the smart water system affects conservation, consumption, and water quality exist on the planet.

Smart water management systems are not easy to introduce and implement and require integration of various systems and use complex measures for monitoring, controlling, and regulating the water usage and quality of available water resources [3]. The system also benefits in managing the existing water-related equipment like pipes, pumps, etc. The industry is now using a wide range of software and hardware instruments like meters, sensors, visualisation tools, data processing tools, mobile and web controls, and actuators. Web and mobile control systems allow remote control of water resources and help to measure the characteristics of water and water system [79]. Water technology based on IoT is beneficial while using imaging which determines corrosion in water pipes to avoid any serious damage to the users and utility [4]. Technology provides access to the different leakage points on the pipes to reduce the chances of waste. Utility industries have used IoT in determining the flow of water and water pressure inside the pipes to decide on replacement or rehabilitation.

The world's population is growing day by day and there is a need to protect the water resources so that all regions can get the required water resources for their usage. According to the World Bank survey, the globe will face a 40% shortfall between available water supply and forecast demand by the year 2030 [5]. Due to the increasing world population, the globe may face a serious shortage of water supplies. According to World Bank data, 40% of the world population is affected by water shortage [5]. Misuse and mishandling of water resources may cause serious damage to the lives of the population whether humans or inhabitants. Studies have shown that almost 70% of the deaths caused by natural disasters are due to water-related disasters [6]. Looking at the figures there is a need to stabilise water usage and monitor the water quality and quantity to develop water-related policies and measures. The sustainability of water usage, climate resilience, and improvements in integrated management systems can reduce water-related challenges and issues.

This paper aims to highlight various products related to advance IoT systems and smart water technologies to increase the learner's knowledge and increase the use of smart technologies by showing their benefits and usage. The paper is structured as follows: Section 2 provides information on data collection methods. Section 3 provides theory related to the topic. Section 4 presents the results and findings of the survey. Section 5 is based on the discussion of the results and findings and finally, section 6 represents a summary of the paper along with recommendations on future research. There are many other products relkated to IoT and smart water technologies but this paper is limited to 50 items considering the length of the paper.

2. Methods

In this survey paper, the researcher has used a secondary qualitative research method to gather the most relevant data. Qualitative research design provides deep and meaningful information on the IoT and smart water technologies to improve the water management system. This study demands data and information on various water technology based on IoT and there is no need to include statistics like numbers and figures. Studies have shown that a quantitative research design provides results in terms of numbers and figures thus avoiding deep information on the scenario [7]. The use of qualitative research design is justified for this type of survey paper as it is going to represent an exploratory knowledge on the smart water technologies and IoT used for water management and control.

Data collection methods can be primary and secondary based on the study requirement [80]. Data for a primary study is collected by means of interviews and surveys while for a secondary study the data can be collected from previous studies and research papers [81]. There are many research studies on IoT and water technology thus it is easy to get a huge among of data on this topic through secondary search. This study is providing information on different products related to the smart water system and IoT which requires exploring information related to water-related technologies. The researcher can study articles and blogs to gather information on the sensors and monitoring technologies for water resources. Thus it is beneficial for the researcher to use a secondary qualitative research design despite using a primary research design as the objectives can be easily fulfilled by reviewing secondary articles and studies [8]. To gather the most relevant and recent data on the study topic, the researcher is using articles and blogs published after 2010. The articles that are published in authentic journals related to computers and technology are chosen to gather data for the paper. Besides this, the researcher has reduced plagiarism in the report by avoiding copy-pasting the ideas present in previous studies.

3. Theory

The design and optimisation of water-related smart measuring and monitoring systems serve multiple purposes. Various kinds of water meters are available that provide information on water levels through pointers while some offer digital displays. Smart meters are developed to meet the increasing need for energy in different areas of the world [82]. The determination of water usage activities is also possible through the use of advanced technology. Smart Management Solution that is based on ICT is used to realise the energy and water savings [9]. This technology helps to identify the effectiveness of the water distribution systems. Intermittent water distribution networks can face significant changes in water flow. In case of heavy water flow and increased water pressure, the distribution system can be damaged completely which disturbs the distribution of water resources to other parts of the world [83]. IoT is used for continuous monitoring and detection of bursts in the distribution system to avoid any serious damage and waste of water resources.

Web services and computer vision contributes a lot to remote meter reading [84]. This allows the staff to measure different aspects related to the resource without visiting the actual site. The use of Optical character recognition (OCR) is beneficial to integrate the electric counters in smart grids maintained on the cloud [10]. Water and gas metering systems allow measuring different aspects of this valuable resource. The meters have now come with wireless sensors that are self-powered and are portable to use [85]. Smart metering also incorporates Distributed Ledger Technology (DLT) which is a blockchain-based registration system to improve the metering process [11]. Deep learning technology can also be used in water management systems to predict loads [86]. This technology helps to schedule the energy storage system in the most economical ways. The integration of the data analytics tool is useful to analyse a large amount of data on the resource and make future decisions related to usage, saving, and treatment of water [87].

4. Results and Discussion

Smart water technologies that can be used by utility companies are as follows:

4.1. ICT Based Smart Management Solution

The use of ICT-based new technological solutions presents many opportunities to implement EU water policy. This innovative management solution promotes Water Management Programs and conservation of drinking water. This is a software solution that connects energy consumption factors and water supply factors to make the distribution system more effortless and effective [12]. The technology not only provides benefits in terms of operational cost reduction but also helps in environmental and socio-economic plans. The use of ICT also benefits in transforming the utility market and assist in making useful policies for the betterment of the water management systems. Besides this, the system reduces the cost of operation by improving the system's energy efficiency through less usage of electricity. Operation cost is reduced means the customers can now get clean water in fewer charges [88]. The system provides quick access to water resources to poor countries as the supply system can now be operated at a low cost. The system benefits in reducing the CO2 footprint that is possible by improving the measures for energy efficiency [12]. Besides this, the technology transforms the market by providing opportunities for Blockchain technology platforms to connect renewable producers and utilities [89].

4.2. Level Sensor

The use of a water level sensor allows knowing how much water is available and the frequency at which the consumers are using this resource [90]. It provides alerts on the critical levels of water and generates a signal when the water level changes quickly than expected [13].

4.3. Flood Warning Systems

Flood warning systems use cellular, radar, lightning observing systems, or satellite telemetry to link with the host network [14]. However, radio frequencies are used by the flood alert systems and can suffer from interference due to atmospheric conditions and electrical noise. These systems are used for the detection of storms and heavy rainfalls that give rise to floods.

4.4. *River Monitoring System*

The river monitoring system includes stilling well, integrated data logging system, multi-parameter sonde, submersible pressure transducer, telemetry, and live data [15]. Stilling wells installed in the riverbank or may be attached to a still structure usually used to permit inflow and outflow of water [91]. Integrated data logging is a real-time observing station and multi-parameter sondes used for arranging multiple sensors at a single site.

4.5. *Soil Moisture Monitoring (SMM)*

SMM devices give information on the water status of the soil. This information helps in planning the irrigation and the amount of water to be applied. Suction-based sensors and volumetric SMM are the two commonly available sensors [16]. Suction-based monitoring systems show the tightness of water in the soil, while volumetric type provides information on the quantity of water in the soil [92, 93].

Figure 1: Soil Moisture Monitor [16]

4.6. *Rain Gauge*

It is a meteorological instrument for the measurement of precipitating rain per unit area in a particular period. The instrument set consists of a container placed in an open space for a particular time and the precipitated water measured in millimetres [17]. The area does not count as the factor that changes the results, however, the container should be medium in size.

Figure 2: Rain Gauge [17]

4.7. Commercial Satellite Broadcasting Service for Rainfall Monitoring

This system provides real-time monitoring of accumulated rainfall over a certain time at a certain location [94]. The setting of this new system is based on a sensor network that uses IoT technology and can cover hotspots that are critical to safety [18]. The number of sensors can be reduced in this setting which has reduced cost and cannot be possible in the case of traditional measurement by using rain gauges and radars.

4.8. Weighing Type Rain Gauge

This system consists of three sensors to inform about humidity, temperature, atmospheric pressure, light intensity, and altitude [95]. The load cell is used to calculate the rain magnitude and the sensors along with this load cell are connected with a microcontroller that is an Arduino board [19]. The system has used a microcontroller to collect the sensor data while the Ethernet shield is used to send the stats to the webserver.

4.9. Pluviometry

Wireless pluviometry is a type of rain gauge used for agriculture purposes, resilient city, and smart city initiatives [96]. The system offers wireless data through a single replaceable battery. The bucket is self-managing thus can be used for a long period and provides measurement stability. This technology is available with CAT-M1and NB-IoT to improve the measurement and data transfer [20].

4.10. Smart Water Quality Monitoring System

WQM devices are now linked to IoT and other remote sensing technologies [21]. The system is effective to deliver consistent and accurate real-time data on water quality. The module can also use a GSM service so that the data can be transferred to smartphone users through SMS [97].

4.11. Sewage Water Monitoring With IoT

The use of dedicated IoT networks has made the monitoring of deep wells and long sewage systems very easy and accurate [22]. This system has reduced battery consumption for communication purposes that guarantee a long product life. The sensing probes supported by the IoT devices are relatively inexpensive thus the measurement and maintenance cost is reduced [98].

4.12. Gully Monitoring System

The system consists of sensors that are monitoring the filling level and transmissibility of a gully [99]. The results are transmitted to the operating companies so that they can make any corrections if necessary, the use of NB-IoT allows to reduce deceive cost, power consumption, maintenance effort and enables a long use of the battery [23].

4.13. Manhole Monitoring System

The use of IoT based underground manhole monitoring system allows monitoring of water pressure, atmospheric condition, and water level even when the manhole lid is not closed [24]. The technology allows controlling power lines running underground and provides the current manhole state through real-time data [100].

4.14. Web-Based Sewage Monitoring

This system uses high performance and ultra-low power microcontroller to make the energy-efficient use of sensor nodes. The signal to the base station is gathered by the microcontroller that received atmospheric signals from various connected sensors [25]. The three types of sensors used here are temperature, ultrasonic level, and light sensor.

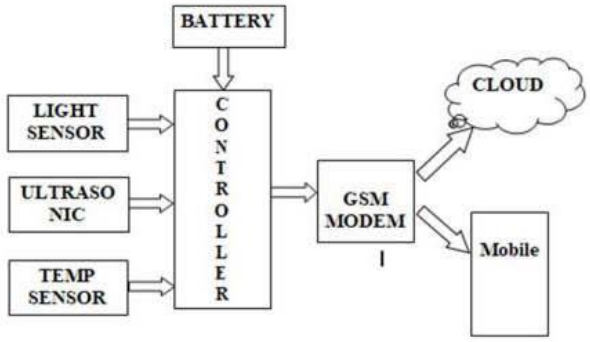

Figure 3: Web-Based Sewage Monitoring System [25]

4.15. *Combined Sewer Overflow*

IoT-based CSOs are widely used to expel water flow into the channels to reduce the overload on the sewage network and the treatment process through the storm event [26]. This system offers real-time data on the wastewater and overall sewage environment. The system connects all the sensors, displays, actuators, and other digital devices to manage the smart cities.

4.16. *Waste Water Monitoring*

IoT-based wastewater recycling and monitoring is used to make sizeable improvements in water systems and provides a safe living environment to the population. The system is equipped with several sensors and the sensor data is updated in the IoT cloud providing live monitoring [27]. A cloud web page is used to feed the sensor data. The sensor helps to switch ON the motor for recycling so that the pollution can be eliminated [28].

4.17. *Water Flow Monitoring*

This system consists of a measurement and control system along with the data-sharing system and an alerts system. The configuration consists of flow sensors and a solenoid valve. This controls the flow of water if the flow rate goes beyond the attached valve [29]. The controllers and flow sensors perform calculations and compare the flow rate.

4.18. *Theft Avoidance System*

The water management system is equipped with a data sharing and alert system to identify any theft of this valuable resource [31]. The digital system comprises IoT and GSM to share the updates of the flow rates [30]. Whenever the control centre receives a drastic change in the flow rate it sends a theft alert signal to the concerned officer.

4.19. Water Quality Monitoring (Pools And Spas)

Smart Water sensors have come with wireless data transmission capability to make the pool and spa water quality measurement easy [32]. These products are using various sensors working to monitor multiple water quality parameters to measure the water quality. The platform connects with the cloud for real-time monitoring of PH, oxygen, turbidity, salinity, and other ions that can change the quality of spa and pool water [33].

4.20. Sea Water Quality Monitoring (Beaches And Off-Shore)

This system is responsible for ocean and beach water monitoring at the beaches. Water parameters (either physical or chemical) at the oceans and beaches are monitored by considering conductivity, turbidity, dissolved oxygen, temperature, and PH [34]. The system implements IoT through five different layers so that the quality of seawater is maintained for marine animals and visitors.

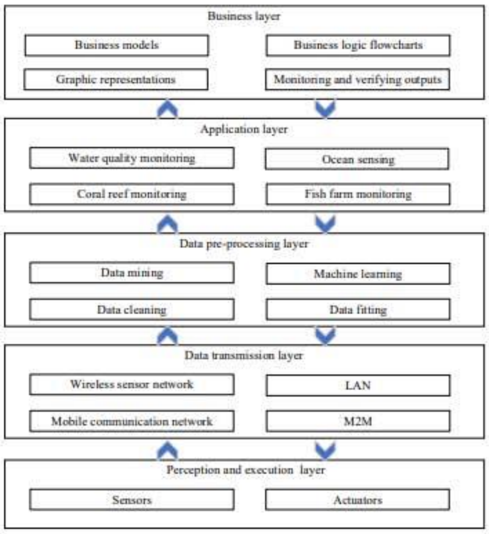

Figure 4: System Layers of Sea Water Quality Monitoring [34]

4.21. *Wave Monitoring*

This type of water monitoring system provides data on the wave magnitudes and thresholds to maintain a safe level and secure water channel navigations. The system is comprised of various wave sensors and wave threshold values are developed to monitor the safe wave level [35]. The hardware needs to be so strong so that it can handle the complex and aggressive marine environment like huge and powerful waves, tides, and typhoons [36].

4.22. *Ocean Current Monitoring*

This system helps in exploring the ocean current process by considering the temporal correlation of the velocity by which current is travelling in the sea or ocean. The current data is beneficial for rescue crews, the public, climate researchers, and fishermen. The use of IoT helps to get real-time data through telemetry transfer on current levels and patterns and can be displayed live on the data centres [37].

4.23. *Water Level Sensor for Streams and Rivers*

The use of IoT promotes automated, remote, or Bluetooth-based water level monitoring. With the use of IoT the user cannot only check the alerts but can also control or operate some equipment to maintain the water level in rivers and streams [39]. The use of GSM allows sending the alert signal to the concerned authorities. It is beneficial in the case of disaster prevention due to extreme climate changes, summer storm spring meltdowns, and various other variations across the seasons [38].

4.24. *Water Temperature Control for Solar Heaters*

Water temperature can use IoT to improve the process of temperature monitoring and controlling [40]. The sensor data can be transferred to the cloud by using web services. However, the web service capacity should be too large to handle a large increase in users [41]. The use of a mobile application for displaying the temperature makes it easy to get the data anywhere in the world.

Figure 5: Water Temperature Control for Solar Heaters [41]

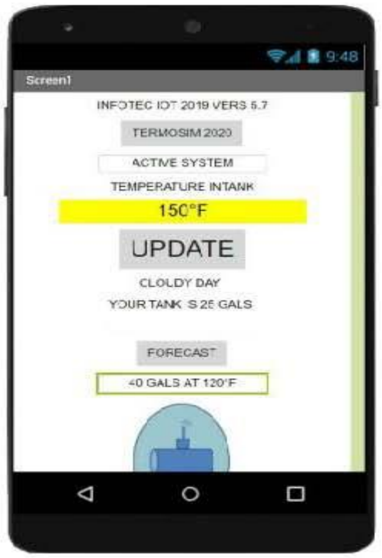

Figure 6: App MIT inventor [41]

4.25. Water Temperature Measurement for Pipelines

This service is designed to monitor the temperature of hot water inside the pipelines [42]. This meter can be fastened to the pipes through cables without even damaging the pipes and the monitor. The influence of external temperature is removed through the use of a reflector. The measurement quality and accuracy of the internal measurement are not influenced by external conditions. The technology consists of wireless sensors for temperature measurement and data is sent to the cloud through a local network [43].

4.26. Pressure Transient Sensor

This technology helps in monitoring the pressure and transient pressure of water. Data can be sent through wireless networks and the cloud-based technology helps to use 4G technology to ensure faster data transfer. Besides this, the technology provides accurate monitoring and measurement of the water pressure by gathering various samples [44]. The user can get continuous monitoring of pressure at a defined interval. Moreover, the system can provide transient recording and accurate plotting of the data [45].

4.27. Cathodic Protection

The use of IoT in cathodic protection provides a more advanced and easiest way to protect steel objects from corrosion [46]. By utilising mobile monitoring sensors and IoT technology the user can quickly detect the problem in any part of the world. This allows moving the technicians efficiently by checking the status of the CP digital dashboard which will reduce CO2 emission due to reduction in travel.

4.28. Acoustic /Vibration Sensor

The key purpose to use this technology is to reduce expenses over the water loss due to pipe leakage. The high accuracy vibration sensors are connected with the digital meter to be used for residential and commercial spaces [47]. The measurement of the leak vibration signal depends on leak size, pipe material, and distance [48].

4.29. Water Valve Technology

The water flow control valve is equipped with wifi to allow the user to remote control the flow of water. The technology offers the use of smartphones to have control over the flow of water through the water pipes [49]. This technology not only reduces the chance of water waste but also helps in protecting the pipes from overpressure and leakage.

Figure 7: Water Valve Technology [49]

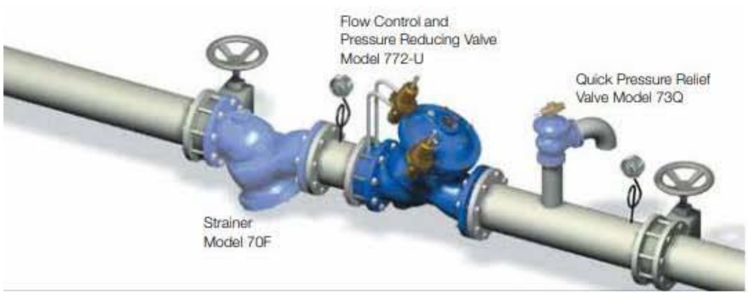

Figure 8: Water Valve Practical Representation [49]

4.30. *Humidity Sensor*

A humidity sensor is connected to Raspberry Pi devices to be used for collection, recording, and processing the temperature records [50]. The devices are connected to the internet, local network, and the actuators to control AC temperature using the Arduino microcontroller. The database stored the data of temperature records and after programming, the data is displayed on the webpage. The notification related to humidity is obtained on Android through the telegram application [50].

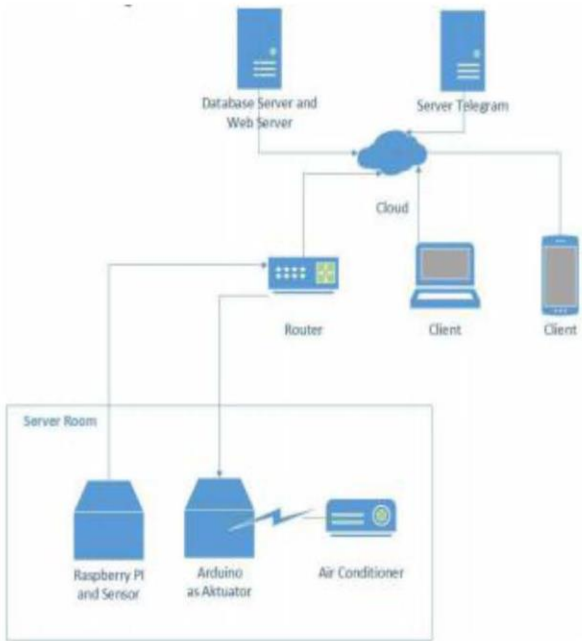

Figure 9: Humidity Sensor Setup [50]

4.31. Leaf Wetness Sensor

Each sensor for the measurement of leaf wetness is precisely maintained to detect tiny amounts of water on the surface of the leaf. The use of IoT enables real-time data on plant or leaf wetness along with the duration of wetness [51]. This is to detect the potential risk of pathogens and disease and helps in determining the accurate time for implementing preventative measures.

4.32. Arrow-Pointer Sensor for Water Measurement

The below circuit is useful to develop an automated arrow pointer system for water measurement. The figure shows that power is supplied to the circuit only if the sensor sends the signal to measure a value [53].

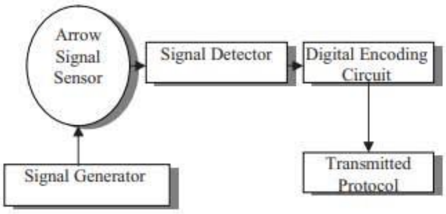

Figure 10: Arrow-Pointer Sensor Components [53]

4.33. *Smart Utility Meters*

The use of technology allows automating the process of data measurement of the utility meters. Smart water technology helps transfer meter data to both providers and consumers [52]. The use of the Convolutional Neural Networks (CNN) You Only Look Once (YOLO) model increases the accuracy of measurement [54].

4.34. *ICT Based Smart Water Management System*

The use of advanced ICT solutions like artificial intelligence and blockchain along with the integration of smart metering concepts provides benefits in terms of energy-saving and water measurement [55]. Consumers can get quality water at a low price with affordable tariff rates to fulfill socio-economic responsibility.

4.35. *Smart Load Management*

Dual-mode energy meter allows representation of two tariffs. This helps consumers to use multiple loads in the off-peak hours and fewer loads in peak hours to maintain the load on utility companies [56]. It helps in managing the use of a water pumping machine, washing machine, water heater, room heater, ironing, laundry, air conditioner, etc.

4.36. *Optical Character Recognition (OCR) for Water Utilities*

The use of OCR provides tele-measurement for the water utilities and allows a low-cost expansion of the capabilities of water meters [57]. The technology allows scanning and uploading paper utility bills or even take online PDFs. The use of OCR enables the scraping of meaningful data from the available file [58]. In essence, the OCR technology allows the user to convert documents into searchable and editable data. The convertibles documents are all scanned documents, images from digital cameras, posters, banners, and timetables [59].

4.37. Advanced Learning Methods Based Smart Water Distribution System

The water network consists of couplings, pipes, valves, sensors, and leaks. To increase system sufficiency the product consists of a pump controller, flow and pressure sensors, and servo-valves. All these elements are connected to the IoT network using microcontrollers which in this case is Arduino boards and Wi-Fi modules are used to transfer data through the cloud [60].

4.38. Remote Meter Reading

An automatic meter reader can be applied for the metering of various resources like water, gas, and electricity. The use of web services and an interface for open communication increase system efficiency and reduce the time for measurement. The hardware used for the implementation is a Raspberry Pi model as it is a very cost-effective solution [61]. The Raspberry Pi camera takes images of the meter and a lens is available to focus the image [61].

4.39. Data Aggregation and Routing Scheme

The development of smart public utility services is possible by integrating wireless sensors with the utility measurement system for routing and data aggregation schemes. This scheme improves the data sensing network and reduces the time in computing the useful data. Moreover, the system is beneficial for data transmission with improved accuracy and efficiency. The use of data analytics identifies network failures, points out faults, water theft, and leakage in the distribution network.

4.40. Graph Representation of Linear Infrastructure

Data generators and graph databases are now being used for monitoring linear infrastructures like energy distribution, roads, and water distribution networks and managing the operations of utilities [62]. The use of a data generator provides access to graph databases and helps to combine the virtual nodes with the data of the production system.

4.41. Multi-utility and Multi-service Smart Metering

This technology allows the integration of different utility meters like heating, electric, gas, and water into a distributed architecture [63]. The purpose is to access and analyze different data sets and provides a real-time overview of resource consumption and production. From the customer's point of view, his information is useful to warn them about energy usage and ensure green practices by reducing energy wastage. From a utility perspective, it allows the prediction of energy demand, improves market efficiency, and predicts peak load periods [64].

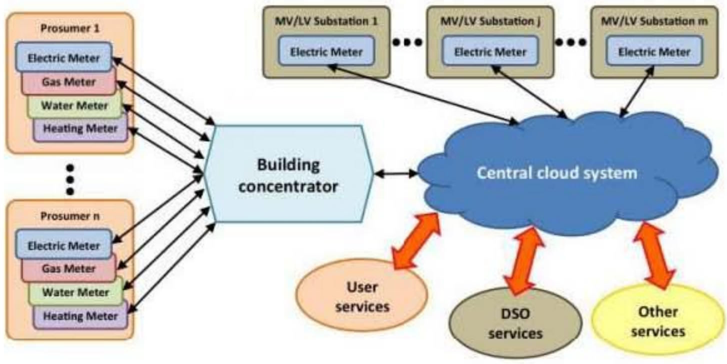

Figure 11: Multi-utility and Multi-service Smart Metering System [63]

4.42. *Self-Powered Wireless Sensor For Water/Gas Metering*

This sensor combines very low-power electronics with a micro energy harvesting generator. The harvesting module consists of an energy converter, power conditioning circuit, and energy storage platform [65]. The sensor in the module represents the element used for sensing the resources while the power conditioning circuit manages the produced electric power. The radio frequency transceiver is used to connect the data concentrator with the remote station for metering [65].

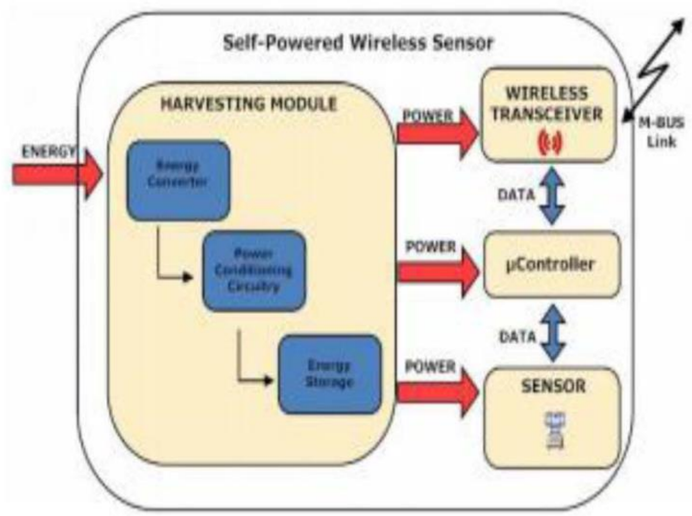

Figure 12: Self-Powered Wireless Sensor [65]

4.43. Rural Sewage Disposal

This technology uses an IoT service model to connect the internet network services with different IoT devices [66]. This model helps in accessing and manipulating the useful data from the sensors and other connected devices over the web platform through the internet. The application is useful for the deployment of a web system related to rural sewage treatment. As shown in the below figure the setup consists of disposal pools, sensors for PH, COD, flow, and A/N meter, water pumps, fans, solar panel, and battery storage [66].

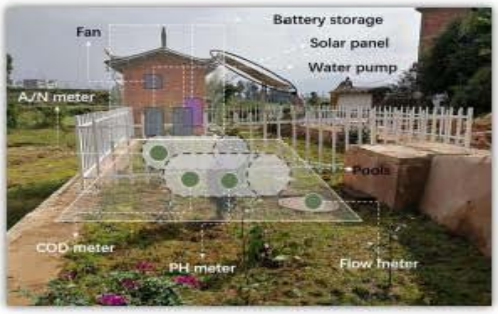

Figure 13: Rural Sewage Disposal System [66]

Figure 14: Rural Sewage Disposal System Components [66]

4.44. Load Forecasting using Deep Learning

A cost-effective energy storage system is developed by developing load forecasting modules using deep learning. The scedules of the energy storage system are based on the real-time data gathered on load forecast [67]. The use of Long-short term memory (LSTM) allows getting high accuracy results [68]. The firming constraint that is the control interval of the advanced metering infrastructure (AMI) for electricity consumption measurement allows cost control and is suitable for every tariff rate[68].

4.45. On-Line Load Monitoring Technology

The capability of identifying computational time and load in water-related home appliances like water heaters can be improved by using an artificial neural network and genetic algorithm [69]. The use of genetic algorithms allows improving the recognition accuracy of real and reactive power. Different loads may have the same reactive and real power and this can be determined by using GA [69].

4.46. Fraud Detection Technology

Technological advancements allow the detection of any fraudulent activity in using water resources and paying utility bills [71]. A huge improvement in fraud detection is due to the use of machine learning methods and techniques on the data gathered by the past monitoring. The data is extracted from the available source and a profile is created for every user during a certain period. An algorithm is run based on the feedback of previous campaigns [70]. A probability or prediction model is chosen to target the fraud excluding the customers that have check before.

4.47. Site Selection for Solid Waste Dumping

Geographic Information System (GIS) and Remote Sensing (RS) technology is used for analysing the reserve forest, water bodies, land use, transport network, and settlement to choose the suitable site to dump the solid waste [72]. It allows protection of the water resources and the living things in the surroundings. This technology allows handling foul smells, water pollution, and health issues with the residents.

4.48. Automatic Irrigation And Soil Testing System

The hardware used for soil testing and automatic irrigation includes NPK Sensor (for measuring Nitrogen, Phosphorus, and Potassium), Relay, and Soil Hygrometer sensors [73]. The data for the measurement includes fertilizer needs, soil pH, NPK rate, water pump states, and soil moisture rate [73]. For displaying the results the developer has used a mobile application that can be featured with all android mobiles.

4.49. Hybrid Localization Techniques

Low Power Wide Area Networks (LP-WAN) improves the link of IoT with the water industries for better coverage of the water resources and reduce power consumption [74]. The technology that is useful in water system monitoring and smart farming can be improved by using Long Range Wide Area Network (LoRaWAN) technology, a popular platform of LP-WANs [75]. To manage the random displacement of the sensor, LoRaWAN helps to update the network of sensors. To enhance the localisation range of an outdoor WSN, this technique uses LoRa signals and hybrid ultrasonic.

4.50. Nutrient Detection for Agricultural Purposes

The use of spectral analysis helps in determining the contents of phosphorous and nitrogen in the leaves. infrared and visible ranges are selected for the analysis and the optical sensor gives a large set of readings than the traditional techniques [76]. The technology used for the display of nutrient content in the plant leaves is a web server and monitor. The server is connected with the optical sensors to determine the colour change. The system is beneficial for improving the productivity of maize crops and reduce the cost of detection and adverse effects on the environment [77].

5. Conclusion

To summarise, IoT-based smart water technologies are benefiting both utility and consumers. Due to advancements in technology IoT is now being used for water monitoring, water control, water quality measurement, pressure and flow measurement, and many more. The major benefits provided by these technologies are cost reduction, accuracy, increased system efficiency, fast transfer of data, and mobile data transfer. Besides IoT, blockchain, AI, and data analytics can be used to further improve system accuracy and effectiveness.

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☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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I declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Sajjad Ahmed

CHAPTER 7: PAPER 4 - Self-monitoring of aquatic ecosystem for health improvement with efficient use of digitization and interpretative framework of smart metering..

Introduction

This chapter delves into the critical realm of water quality monitoring, adopting a novel and avant-garde approach. Leveraging emerging technologies, such as 5G edge computing, water quality can now be vigilantly monitored at the water distribution level or in conjunction with smart meters installed at residential properties. This groundbreaking approach mitigates the risk of contamination or water quality issues stemming from the distribution network, ensuring that end users have access to safe and reliable water supply. In contrast to the conventional practice of monitoring water quality solely at the treatment plant level, prevalent in Australia and many other regions, the concept of self-monitoring is employed to empower end users with the ability to report water quality concerns using a dedicated smart water utilities mobile application, seamlessly integrated with meter data management platforms via cutting-edge 5G or NB-IoT networks. As smart metering becomes ubiquitous in developed countries, providing end users with access to water usage reports, the need for smart water quality monitoring is equally compelling. This innovative approach enables rapid detection and reporting of water quality issues within a mere five minutes, enabling utilities and their customers in specific suburban areas to take prompt and effective remedial actions.

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A Healthcare Paradigm for Knowledge Deriving Using Online Costumers' Feedback.

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A Healthcare Paradigm for Knowledge Deriving Using Online Costumers' Feedback

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Abstract—**Today, most water networks are structured on large and centralized systems with limited management options, which leaves a gap for speculation when disruptions occur. Smart Water Grids (SWG) arise in this context towards a future where eventualities can be assessed and corrected quickly to reduce their negative impact on society, the environment, and the economy. SWG technologies have the potential to make the water and energy nexus more efficient and sustainable in social, technical, and environmental ways, but still face some challenges. Concepts such as the Internet of Things, cloud computing, and big data analytics, come into place and help humanity achieve efficient and effective water management and help the customers at their end. The implementation of water quality monitoring strategies more often, with closer monitoring of fewer households at a time, is a way to improve water quality across the world.**

Index Terms—**feedback communications, internet of things, smart grid, water resources**

I. INTRODUCTION

CURRENTLY, the global market disposes of several technological assets and tools to detect leaks and other eventualities in the water supply system. They include acoustic sensors based on accelerometers, which accurately pinpoint the location of a leak and the characteristics of the pipe for small diameter water mains; acoustic sensors based on hydrophone sensors, more sensitive and expensive than the previous ones and still restrained to small areas; high rate pressure sensors, with a wider detection range but lower resolution results in a range of a few hundred meters; visual district metering areas, combined with automated meter readings; and statistical analysis of pressure and flow, provided other datasets such as seasonal oscillations and public holidays are taken into consideration [1-4].

In the present day, most water networks are structured on large and centralized systems with limited management options. That lack of monitoring data leaves a large gap for speculation when disruptions occur within the system. Real-time monitoring and management could solve some of these limitations, such as significant water losses due to low operating efficiency and imbalances between demand and supply, high energy requirements to ensure proper water treatment, along with the risks of loss and/or contamination of the water supply and wastewater [5-8].

Figures 1 and 2 were supplied by the Urban Utilities Open Data Map (2021) [9], which shows the water and sewage infrastructure of Queensland, Australia. Urban Utilities provide drinking and recycled water as well as sewerage services for over 1.4 million people in the South East area of Queensland. The first image focuses on water supplies, showing a large grid based on a few centralized water reservoirs, distributed pumps, and treatment stations. The second image shows the sewage infrastructure (orange lines), identified according to sewer fitting (mostly wye) and control valves (mostly scour), among other characteristics. It also correlates with the water distribution systems (blue lines). These are a few examples of what sort of data can be accessed by the general population on how the water and sewerage systems of their regions are organized, bringing forth the complexity of managing such systems and the need for optimization methods, which will be discussed below.

Fig. 1. Water supply infrastructure in Queensland, Australia.

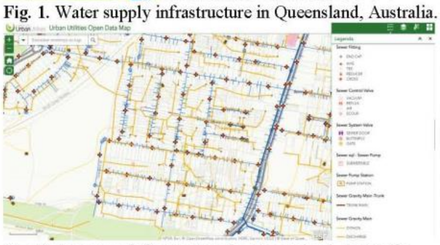

Fig. 2. Sewerage infrastructure in Queensland, Australia.

The concept of a Smart Water Grid (SWG) arises in this context and pushes society towards a future where eventualities like pipe breaks, leaks, and reservoir contamination can be assessed and corrected quickly to reduce their negative impact on society, on the environment as well as on the economy, in a sustainable and resilient manner [10]. SWG systems integrate Information and Communications Technologies (ICT), such as sensors, meters, digital controls, and analytic tools, into the management of the water distribution system, especially through the digitalization and automation of most operations regarding water quality and distribution [1, 11-13].

However, as much as it has developed to this day, there is still room for improvement in the SWG industry. To guarantee the effectiveness of these services, it is essential to consider consumers' feedback so SWG could adapt to their needs, constantly receiving complaints and suggestions [14]. Besides listening to what the users have to say about the way they are managing such an important natural resource in practical, day-to-day analysis, companies in this line of business should consider and use those comments to constantly improve themselves, as will be discussed below [15-17].

II. Smart Water and Healthcare

A. The Impact of Water Management in Public Health

Although it has been many years since authorities and the general public found out that a safe, reliable, affordable, and easily accessible, high-quality water supply is known to be essential for good health, to this day many people, especially those who live in developing countries, are unable to fully access it. These disparities end up causing diarrhea, non-diarrhoeal diseases, among other problems where water quality and distribution are not adequate [18]. As these nations become more susceptible to hunger, dehydration, and infectious diseases, their general and specific mortality rates (e.g.: child mortality) increase, joining a vicious cycle in which poverty leads to poor water management, and vice versa [19-22].

Inspired by the need to solve this problem, one of the United Nations Organization's (UNOs) Millennium Development Goals (MDG-7) was to ensure environmental stability, based on, among other factors, improving "by half the proportion of people with sustainable access to safe drinking water and basic sanitation by 2015". However, several factors act as obstacles to its process, including elevated population growth rates, insufficiency of capital investment, difficulties in developing local water resources, and ineffective instructions given by authorities to the general public [23-25].

This MDG-7 goal was partially reached, as recent reports by UNOs show: in 2012, 90% of the global population had access to an improved water source in comparison to 76% in 1990. Nevertheless, water distribution remains uneven between countries and even within nations, with a special contrast between rural and peripheral, poorer urban areas. Additionally, there is still lots of ground to cover regarding sanitation, because this part of the MDG was not reached properly by 2015 and remains an essential problem to solve [26].

As a result, investing in water management means investing in public and individual health, and becomes of interest to regional and global leadership, analyzed. All countries must make some changes to guarantee adequate water supply for their populations, as the lack of it can be related to the failure of several other goals, such as decreasing child mortality and combating waterborne diseases. Specific attitudes may differ between developing and wealthy countries. The first ones have to focus on long-term increasing water availability for domestic uses (considering many of these countries export commodities, agriculture represents a large part of water usage); improving water quality, and implementing better water-use and water-management habits by the general public and specific industries [23]. Wealthier countries, however, tend to have already more appropriate water distribution to the population but must avoid its contamination by different pollutants [27].

There are three categories of drinking water supply according to the WHO/UNICEF Joint Monitoring Program for Water-supply and Sanitation (JMP), namely [28-29]:

a) Water piped into the dwelling, plot, or yard - can be used for drinking, food preparation, personal and home hygiene;

b) Other improved sources (including public taps, protected springs, hand pumps, and rainwater harvesting) - can be used for drinking, food preparation, personal and home hygiene;

c) Unimproved sources (open water, unprotected from contamination) - should not be used for drinking, food preparation, personal and home hygiene. It should be noted that around 1 billion worldwide people still do not have access to improved sources since the late 1970s, commonly located in low-income and difficult access areas of third-world countries.

As important as this may be, economic reality cannot be overlooked - it costs both individuals and governments lots of money to ensure all the population has access to quality sources of water. These parties have to balance the costs but it is not easy, therefore the need for smart solutions that maximize access and minimize costs [30-32]. Both individual citizens and governments have financial limitations and often desire (or have the need to) direct their resources elsewhere. That is one of the reasons many initiatives function in the beginning and get abandoned over time - the initial budget dedicated to that project may not be enough to sustain it in the long term. As an alternative and a complement, the private sector (e.g.: self-supply initiatives and small enterprises) can help different countries achieve the MDG-7 goal mentioned above [33]. However, it is also dangerous depending on "private" water sources, as they can have infrastructural issues, be contaminated, or even fail in dry periods, leaving the population unattended [23, 34-35].

B. Smart Water as a Way to Improve Health Conditions

The limited nature of natural resources, including water, and the heterogeneity in its distribution and use can cause many problems when it comes to managing the water balance while trying to maintain ecological and economical balance [36-39]. That way, authorities must sort resources into Science and Technology, Healthcare, Environmental Preservation, among other sectors, bearing in mind that investing in one area, such as Smart Water development, may be beneficial and reduce costs on another one, such as Healthcare.

In that scenario, SWG brings forth some advantages, such as preventive maintenance through real-time monitoring of pipeline conditions; better planning and network operations due to real-time hydraulic and water quality monitoring, including automated valve operations and pipeline calibrations; real-time feedback on water and energy usage to customers; and the use of automated meter readings, predictive hydraulic modeling, valve operation simulation, demand precision modeling and pipeline failure analysis to better balance offer and demand [1, 40-41].

Another way SWG can help ensure adequate distribution and quality of water resources is through automating part of the tasks. Even in developing countries, population data shows a change in the characteristics of the labor force: it is getting smaller in size, but much more educated. That way, automatization could spare workers from doing menial processes, attribute those parts to machines, and dedicate the human workforce to more complex tasks, such as overseeing and coordinating tools and efforts to keep water management at its best [1, 42-43].

III. Smart Water Grid Development

A. State of the Art

Many tools available in the global market today could get us closer to the objectives mentioned in the previous section, but they are not equally distributed, nor do they prevail on the countries that need them the most. The distribution is based on incredibly complex technological, financial, and political arrangements [1]. Some examples of these technological assets are real-time water quality sensors (varying from measuring water's pH, turbidity, conductivity, optics, and even biosensors) and water quality data analytics (e.g. CANARY from Sandia National Laboratories, which contains a linear filter, a multivariate nearest-neighbor algorithm, and a set point proximity algorithm) [44-47].

Smart Metering (SM) is the "integration of meter data into business systems and the sharing of information with customers" according to the 2014 Review of Smart Metering and Intelligent Water Networks in Australia and New Zealand [48]. It is formed by the meter interface node (collects the digital meter's readings, which it is attached to), the getaway device (sends the information from the meter interface node to the back-end system), and the back-end system (processes and archives the data), so data usage and management can be analyzed by different graphs and other tools. Along with strengthening the relationship between the service provider and the consumer, SM can keep the user updated about their water consumption, for example with the attachment of LED lights to showerheads to show how many liters are used each time that person takes a shower [49-54].

Along with smart metering, water quality monitoring strategies can be used. They include chromophoric (colored) dissolved organic matter (CDOM), fluorescent dissolved organic matter (FDOM), chlorophyll fluorescence analysis, conductivity, salinity, and total dissolved solids (TDS) monitoring, water temperature recordings, dissolved oxygen levels, pH, and carbonate hardness (KH) testing, turbidity, total suspended solids (TSS), and clarity. CDOM occurs naturally in water bodies and by absorbing ultraviolet light releases an organic pollutant called tannin that turns water gloomy, acid, and lowers oxygen levels. FDOM is a part of CDOM and both can be measured with electrical optical sensors with fluorometers and sapphire lenses. Chlorophyll fluorescence, in its turn, uses algae toximeters to determine if there is algae overgrowth, which reduced oxygen levels while increasing nitrogen and phosphorus levels. The analysis of electrical conduction of electrolytes present in water bodies correlates to pollution levels. The rest of the parameters also correlate to water quality, fauna, and flora maintenance (Public Lab, 2017).

B. Future perspectives

Still, advancements are to be made in this field of work, including the replacement of short-range (e.g., DiZiC module) to medium-range (e.g., AX8052F143 RF-microcontroller) communicators; further monitoring of battery charging status, interface node operation status, and enhancements of more system elements; the implementation of intelligent leakage detection and localization algorithms; and appropriate security mechanisms [49, 55-56].

SWG technologies can help in achieving the World Health Organization's Water Safety Plans, defined as a risk-based approach to public health through "managing drinking water quality from catchment to consumer" [23]. They have the potential to make the water and energy nexus more efficient and sustainable in social, technical, environmental, and other ways [57]. However, these systems still face some challenges including [1]:

a) The absence of interoperability technical standards for sensors, wireless communications, and data analytics tools;
b) Efficient organization and powerful analytics are still needed to extract useful information from the data generated by real-time sensor and meter readings;
c) The need for job redesign (e.g., prioritizing administrative positions to the detriment of all-manual and currently automatized tasks);
d) Ways of ensuring that society accepts and understand this kind of technology - this topic will be discussed in the following sections, and;
e) The need for further research and testing to keep improving SWG systems.

Ramos et al. analyzed a real water system named RS and concluded that a higher level of efficiency was achieved through the implementation of monitoring and water loss control measures, with a reduction of associated costs. Depending on external factors (e.g.: network changes, regional legislation, type of consumption, and repair costs), time varies until economic benefits become evident, and it is essential to estimate the necessary investment to avoid project abandonment along the way, considering additional micro hydropower installations as well. [57].

IV. Consumers' Feedback As a Way of Enhancing Smart Water Grid Systems

Data can be collected directly at the site through digitization and automation, then transmitted via a wireless connection to monitoring and analysis central. In this scenario concepts, such as the Internet of Things, cloud computing, and big data analytics, come into place and help humanity achieve efficient and effective water management [58-61]. The SWG system covers the main operational aspects of water distribution through asset management, leak management, and water quality monitoring, and how automated meter readings and water conservation can help the customers at their end [1, 62].

Database interfaces can use different approaches to become more effective. The first one is to make the content of the user-database interaction more abstract, transitioning from a logical relational model to hierarchical and network models. The second option relies on enhancing the interaction process by providing feedback to the user, which was proven to enhance user performance accuracy by 12.9% [63]. Machine learning systems (MLS) bring benefits to both users and providers - users usually give feedback to MLS, which uses algorithms to incorporate findings and improve over time. Real-time keyword-based feedback can be incorporated in initial training phases while data is still limited, and although large fluctuations may initially occur in classifier behavior, accuracy was improved [64-67].

Liu et al. conducted a smart metering trial in which he described the short- and long-term impacts of online water-use feedback in 120 households in New South Wales, Australia. An online portal provided near-real-time water consumption feedback to half the sample. This group saved an average of 63.1 liters per household per day (L/hh/d) in the first 42 days and ended up saving an overall average of 24.1 L/hh/d over one year. It was proven by regression analysis that portal login activity was related to water savings, indicating an opportunity for water authorities to encourage the usage of such online portals by the general population, especially in case short-term supply constraints are needed [68].

V. Discussion

Measurements of the quality of groundwater and surface water (e.g.: light, color, temperature, sediment, chemical, and biological characteristics) help authorities see its conditions and patterns to decide how to employ resources and plan future actions, considering the influence of land use, climate change, etc. There are two ways of doing that: one is collecting samples for laboratory analysis, and the other is using probes that can record data for a specific or prolonged period in time [69]. For example, Australia is known for having high drinking water quality by worldly standards, so in this next section, we will analyze this country's guidelines.

In Australia, an average of 93% of all households were connected to mains/town water in March 2004, ranging from 85% to 98% outside and inside capital cities respectively. Still, many South Australians do not rely on this as their main source of water. In the early 2000s, however, Australians became more reliant on mains (50% in 2001 to 60% in 2004) and less dependent on rainwater tanks (from 33% in 2001 to 26% in 2004) and bottled water (from 16% in 2001 to 13% in 2004), but the consumption of water bottles increased 5% in the same period, with the level of satisfaction varying between states and territories, generally higher in the Northern (89%) and Capital (87%) territories and lower in the South (52%) mostly due to taste. The use of water filters has also increased in this period [70].

The Australian National Water Quality Management Strategy (NWQMS, 2021) sets the guidelines for water quality planning and management and is continuously updated. All is done to approach water quality management at a national level, with fewer inconsistencies between regions, to help local authorities organize water quality regionally, as well as bringing information to the general public, to preserve the environment while still stimulating economic growth. The NWQMS contemplates drinking water, effluent discharge management (also known as treated wastewater), fresh and marine water quality (natural and semi-natural water resources), groundwater, recreational water, recycled water, rural land uses, sewerage systems, and urban stormwater management [71].

Some relevant documents include the Australian Drinking Water Guidelines (2011), updated in November 2018, which are based on scientific evidence and managed by the National Health and Medical Research Council, proving once again the relation between water quality and healthcare. Another contribution to health conditions is effluent management, which follows historical guidelines. Guidelines for fresh and marine water quality are shared between Australia and New Zealand, were revised and 2018 and are available online, which facilities the diffusion of knowledge to the general population. Additionally, water usage in rural areas is essential because most of Australia's water resources are located and destined to these types of land, often deteriorated by damaging land-use practices, justifying the importance of historical guidelines to avoid even more damage and to revert what is possible. However, while NWQMS waits for contributions, it is also important to check with local authorities for more recent guidelines [72].

The water quality of South Australian inland surface, marine, and groundwaters is structured by the Environmental Protection Policy (2015), following the saying of the Environment Protection Act 1993 in its definition of environmental harm, environmental duty requirements and mandatory provisions which constitute offenses, and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000), which are currently being revised, regarding the protection of bodies of water, management of wastewater and reduction of polluting activities [73].

Such guidelines derive from quantitative measures or qualitative statements. The Commonwealth Department of Agriculture, Water and Environment publicly releases after a three-month period a list of pollutants and toxicant substances such as Alpha-cypermethrin, Bisphenol A, Dioxins, Fipronil, and Mancozeb. The Queensland Monitoring and Sampling Manual (2018) assesses water quality management framework, new or revised toxicant default guideline values and how to derive them, new physical and chemical stressors, and information for more regions, including indigenous culture and spiritual values [74].

In contrast to Australia's great statistics on water availability and quality, the worse records lie in Afghanistan. According to the World Health Organization, clean drinking water reaches an alarming percentage of 22% of Afghanis, and only 30% of them benefit from adequate sanitation facilities. In addition to country disparities, there is a significant difference between capitals and other cities in most countries, and Tasmania is a great example, with 96% of households connected to mains/town water in its capital and 67% in other regional areas [75].

Water has different environmental values (EV) such as aquatic ecosystems, primary industries, drinking water, industrial water, and recreational use. Each EV needs to have its guideline as parameters can vary between different users and uses of water across the globe. Guidelines should be based on direct impact studies and developing studies with high technical expertise in their methodologies and can use as reference sites and local data of biological or physicochemical indicators such as biodiversity and nutrients respectively. Acceptable values are calculated percentiles or other forms of comparing these values to reference conditions. Also, it is important to register that final water quality objectives consider social and economic factors besides following technical guidelines with legislative background [75].

In this scenario, SWG represents a way of improving water quality in an optimized way, without having to resort to unachievable plans, either by lack of money or lack of technology. For this to be possible it is essential to develop smart systems on top of those already available today, improving its errors and bringing in more functions. One of those, and perhaps one of the most important ones, is incorporating consumers' feedback into SWG systems. Once consumers can directly tell water companies about eventualities and what their wishes, likes and dislikes are, this branch of enterprise can keep improving itself, and perhaps one day allow all regions to have water quality and distribution systems like Australia's, reducing the disparities between different countries and regions of the planet.

VI. Conclusion

Despite the aforementioned benefits, adding water quality meters to every single housing unity is far from feasible. Regardless of its likelihood of bringing health benefits to the general population, as it would ensure every citizen with access to the water distribution system would get high-quality water, maintaining an investment like this would have an extremely high cost. That way, alternatives must be sought with the aim of expanding water quality check policies while still within a reasonable budget. Some options are installing water quality meters for every hundred or so households. It would be more efficient at filtering what may have escaped the central quality check, for example, the mixture of sewer and drinking water with the potential to carry diseases, and is still achievable.

As said before, SWG systems represent a great option of how to improve water quality and distribution without such extraordinary fees. Of course, it would be important to invest in SWG development, which is already in motion. Smart systems help optimize most of the services in today's society, like tracking packages, home security, and public transportation, and it would not be different with water systems. Thinking about expanding water distribution to different regions, not only the richer ones, one option would be to apply Smart Metering per hundred houses and improving the existing conducting lines to avoid eventualities like leaks and bursts.

Alongside smart metering, it would be important to apply water quality monitoring strategies (e.g.: CDOM, FDOM, TDS, KH testing, and TSS) more frequently. It would be safer than what happens today, with very centered smart quality checkpoints, and could possibly improve later to Smart Metering per fewer houses. Of course, if available the ideal would be to install Smart Meters for every house, and it would be in the hands of local authorities to decide how to distribute resources. Consumers' feedback can be used for, in summary, allowing water companies to make improvements continuously. That way, technology can ultimately be used in favor of healthcare and optimize the distribution of resources in countless regions.

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The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank ... ." Instead, write "F. A. Author thanks ... ." In most cases, sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page, not here.

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CHAPTER 8: PAPER 5 - The Integral Role of Mobile Handset Data, Cloud Computing, Artificial Intelligence and 5G Information Technology in The User Level Self-Management and Mitigation of COVID-19.

Introduction

The contents of this chapter build upon the groundwork laid in the first chapter, which was previously published in a conference on health and information systems. In this extended version, I delve deeper into the role of emerging technologies in addressing future challenges through novel approaches and practical use cases. Specifically, I focus on the significance of cutting-edge technologies such as 5G, IoT, artificial intelligence, and cloud computing in enabling self-monitoring and mitigation strategies for pandemics like Covid-19. By emphasizing the importance of self-monitoring and exploring novel approaches through real-world examples, I aim to contribute to the discourse on controlling and reducing the risks associated with pandemics. It's worth noting that this theme is consistent across all five papers in this thesis, albeit with different applications in the domains of health and smart water utilities.

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Health Information Science and Systems

The Integral Role of Mobile Handset Data, Cloud Computing, Artificial Intelligence, and 5G in the User-Level Self-Management and Mitigation of COVID-19

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Abstract:	This study presents technologies that are critical in reducing the harmful effects of this illness and assisting its recovery. It explores COVID-19's economic impacts before learning about new technologies and potential solutions. The research objective was to propose a solution for self-diagnosis and self-management of COVID-19 with personal mobiles and personal data using cloud solutions and mobile applications with the help of artificial intelligence, machine learning, and 5G technologies. The proposed solution based on self-diagnosis without any security risk for users' data with low cost of cloud-based data analytics by using handsets only is an innovative approach. Since the COVID-19 outbreak, the global social, economic, religious, and cultural frameworks and schedules have been affected adversely. The fear and panic associated with the new disease, which the world barely knew anything about, amplified the situation. Scientists and epidemiologists have traced the first outbreak of COVID-19 at Wuhan, China. A close examination of the genetic makeup of the virus showed that the virus is zoonotic, meaning that the virus changed hosts from animals to humans. The uncertainty associated with the above features and characteristics of the virus, as well as the high mortality rates witnessed in many parts of the globe, significantly contributed to the widespread global panic that brought the world to a standstill. Different authorities and agencies associated with securing the public have implemented different ways and methods to try and mitigate the transmission of the infection as scientists and medical practitioners work on remedies to curb the spread of COVID-19. Owing to different demographics, different parts of the globe have attempted to effectively implement locally available resources to efficiently fight and mitigate the adverse effects of the COVID-19 pandemic. The general framework given by the World Health Organization (WHO) has been implemented or enhanced in different parts of the globe by locally available resources and expertise to effectively mitigate the impact of COVID-19. There is currently no effective vaccine for COVID-19, but new technology can be available within weeks to reduce the spread of the disease, current approaches such as contact tracing and testing are not secure, and the cost of testing is high for end users. The proposed solution based on self-diagnosis without any security risk for users' data with low cost of cloud-based data analytics by using handsets only is an innovative approach.
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The Integral Role of Mobile Handset Data, Cloud Computing, Artificial Intelligence, and 5G in the User-Level Self-Management and Mitigation of COVID-19

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Abstract

This study presents technologies that are critical in reducing the harmful effects of this illness and assisting its recovery. It explores COVID-19's economic impacts before learning about new technologies and potential solutions. The research objective was to propose a solution for self-diagnosis and self-management of COVID-19 with personal mobiles and personal data using cloud solutions and mobile applications with the help of artificial intelligence, machine learning, and 5G technologies. The proposed solution based on self-diagnosis without any security risk for users' data with low cost of cloud-based data analytics by using handsets only is an innovative approach. Since the COVID-19 outbreak, the global social, economic, religious, and cultural frameworks and schedules have been affected adversely. The fear and panic associated with the new disease, which the world barely knew anything about, amplified the situation. Scientists and epidemiologists have traced the first outbreak of COVID-19 at Wuhan, China. A close examination of the genetic makeup of the virus showed that the virus is zoonotic, meaning that the virus changed hosts from animals to humans. The uncertainty associated with the above features and characteristics of the virus, as well as the high mortality rates witnessed in many parts of the globe, significantly contributed to the widespread global panic that brought the world to a standstill. Different authorities and agencies associated with securing the public have implemented different ways and methods to try and mitigate the transmission of the infection as scientists and medical practitioners work on remedies to curb the spread of COVID-19. Owing to different demographics, different parts of the globe have attempted to effectively implement locally available resources to efficiently fight and mitigate the adverse effects of the COVID-19 pandemic. The general framework given by the World Health Organization (WHO) has been implemented or enhanced in different parts of the globe by locally available resources and expertise to effectively mitigate the impact of COVID-19. There is currently no effective vaccine for COVID-19, but new technology can be available within weeks to reduce the spread of the disease, current approaches such as contact tracing and testing are not secure, and the cost of testing is high for end users. The proposed solution based on self-diagnosis without any security risk for users' data with low cost of cloud-based data analytics by using handsets only is an innovative approach.

Keywords: COVID-19, Global Economic Impact, Pandemic

1 Introduction

COVID-19 is the ancestor of all the coronaviruses. RNA viruses with only one positive DNA strand, fever, exhaustion, coughing, and difficulty in breathing are all symptoms that the host gets when exposed to this virus. Researchers have identified this virus as a member of the COVID-19 family, despite that this virus has not been linked to a known source [1]. Its DNA is mainly derived from rodents and bats. On December 19, 2019, authorities in Wuhan, Hubei province, China, announced a human infection with this virus and notified the WHO of the virus [2]. At least 213 countries and independent territories have been isolated due to COVID-19 [3]. Approximately 461 million confirmed cases of COVID-19 [4] were reported as of April 4, 2022, with 6.1 million deaths. Fig. 1 displays the number of people who died and those who were affected in the worst-affected countries. To avoid the global pandemic caused by COVID-19, immediate action is required. This study presents technologies that are critical in reducing the harmful effects of this illness and assisting its recovery. It explores COVID-19's economic impacts before learning about new technologies and potential solutions. The research objective was to propose a solution for self-diagnosis and self-management of COVID-19 with personal mobiles and personal data using cloud solutions and mobile applications with the help of artificial intelligence (AI), machine learning, and 5G technologies. The study is conducted to determine the integral role of mobile handset data, cloud computing, AI, and 5G information technology in user-level self-management and the mitigation of COVID-19.

1.1 Background

According to the WHO, public health is at risk of the spread of coronavirus [4]. According to scientists, RNA viruses with a diameter of 600–1400 nanometers are known as "Covids." Several coronavirus epidemics have occurred in recent years. A SARS-CoV epidemic occurred from 2002 to 2004, whereas a MERS-CoV outbreak was discovered in the Middle East in 2012. The SARS-CoV had spread to 37 other countries. Approximately 750 people out of 8000 cases died. More than 850 people died in the Middle East, particularly in Saudi Arabia, due to the spread of MERS-CoV [5].

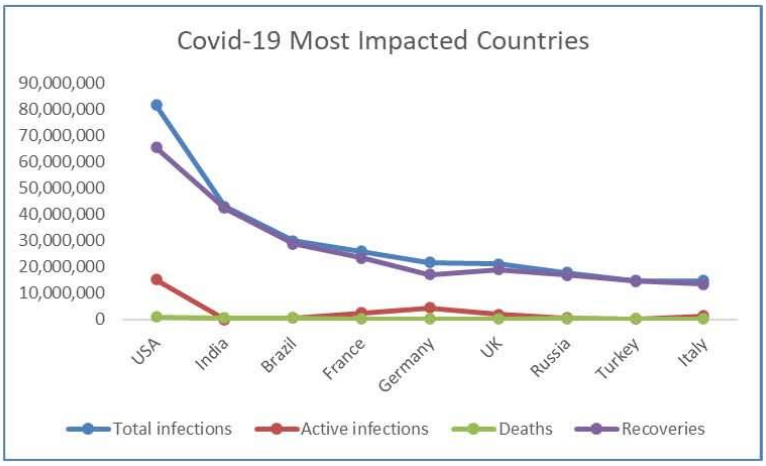

Fig. 1 Statistics of the worst-affected countries as of April 4, 2022

1.2 How are people living with the coronavirus?

There has never been such a time in human history. All people are aware of the threat posed by coronavirus. A large number of people have been vaccinated against this strain of influenza and follow the standard operating procedure. Although coronavirus has evolved to become more dangerous and potent, humans have developed resistance. Because of the worldwide decrease in coronavirus-related mortality, social fear of the disease has diminished. However, population growth rarely follows a straight line.

There are many advantages to cloud computing with 5G. The COVID-19 outbreak has had a substantial impact on health care, education, and transportation. 5G networks are critical for investigating COVID-19. The initial selection of businesses affected by pandemics was chosen to indicate the magnitude and complexity. They now require telecommunication networks to support their remote activities, which has put a strain on current networks. It was imperative that the present networks be examined quickly to guarantee that business-as-usual could continue in the impacted industries due to an increase in demand for services. Most pandemic-related issues can be addressed owing to the increased bandwidth and improved technologies of 5G networks. We emphasize the importance of 5G and comparable technologies to address the challenges associated with COVID-19 and the limitations of the current network architecture. Predicting future diseases and building a civilization that can handle pandemics by increasing digitalization and adopting large-scale automation can be achieved using 5G networks [6]. We can avoid getting caught off guard. It was also mentioned how the epidemic affected the network design.

China has been the source of several of these initial Covid-19 cases, as reported by the WHO. The rapid spread of COVID-19 has been connected to SARS. A person infected with this virus may go for 14 days without exhibiting any symptoms. This virus has a high potential for rapid spread. The ability of the virus to multiply is boosted if an infected individual becomes a silent carrier.

The signs of this disease may range from undiagnosed to life-threatening respiratory distress syndrome (MODS). Symptoms such as conjunctivitis, breathing problems, and sore throat are common in patients with COVID-19. Meanwhile, symptoms such as nasal congestion, diarrhea, and hemoptysis are only observed in a limited number of patients, including nausea and vomiting. The vast majority of infected people did not show any symptoms of sickness. Only 6% of the patients were deemed critically ill by physicians [5]. COVID-19 poses a threat to adults over 60 years of age, those with pre-existing medical disorders (e.g., hypertension or cardiovascular disease), and people with asthma. Despite multiple studies demonstrating the genesis of COVID-19, its spread remains unclear. Researchers are particularly interested on whether this virus may spread from person to person because the epidemic was linked to contact with sick animals or the consumption of their products. Coughing and sneezing are the most prevalent means of spreading infection. While still capable of spreading the virus, asymptomatic individuals do so at a lower rate than those who are ill. A droplet can fly up to 6 feet. Even if they do not show any symptoms, people who live close to someone with COVID-19 are more likely to have the disease. In addition to direct and indirect contact with infected surfaces, several transmission methods have been developed. This virus can infect steel, plastic, and copper surfaces for up to 3 days. It can last for a few hours even on cardboard. The nose is a common entry point for infectious pathogens that attach to the cell receptors in the body. By penetrating the cell membrane, spikes on the SAR-surface Cov-2 urge cells to reproduce SAR-Cov-2. Infected cells multiply more rapidly when a virus escapes from a damaged host cell and infects the uninfected cells. Subsequently, it attacks the air sacs in the lungs with viciousness and passes through the bronchial tubes.

This paper is an extended version of a paper presented at an international conference on Health Information Science and published in Springer Nature Switzerland in 2021. The title of the conference proceeding was "Toward a User-Level Self-management of COVID-19 Using Mobile Devices Supported by AI, 5G and the Cloud." The extended version covers the current technologies used in different countries to control the spread of COVID-19. The novel approach is the major extension in this paper, as the research work is required to work on a possible solution with the help of AI, 5G, and cloud computing. The initial draft of the paper was completed in the first few months from the date of the COVID-19 cases in Wuhan. The vaccination process for such pandemics always takes years, and during that period, disease control can be managed using available technologies. Similar to Apple fall detection, which was proposed in early 2000, real implementation was performed after 15 years in a similar manner; the novel approach proposed in this paper is time consuming. With self-management and without privacy risks, users can mitigate the spread of COVID-19.

The remainder of this paper is organized as follows. A few people mentioned below have looked into the current COVID-19 outbreak and updated their findings. During the last century, several epidemics have occurred. Section 2 discusses related work, Section 3 discusses past epidemics, and Section 4 presents preventive measures. Section 5 is an important part of the paper and discusses what should be done during a pandemic. Emerging technologies, such as AI and 5G networks, can aid first responders during a disaster. The most important section of the paper is Section 6, which covers the novel approach and discusses future work to mitigate and self-investigate COVID-19 with the help of handset data using 5G and cloud.

2 Related Works

COVID-19's worldwide outbreak sparked a worldwide research effort to develop vaccinations, medicines, and other therapeutic methods. There have been a lot of publications and articles published recently that examine the properties of the virus. The clinical signs of COVID-19 were examined by the authors of [7] in Wuhan, China, which included 170 patients. The authors of those deaths described the lethal impact of the virus on the body's numerous organs in laboratory investigations. They used big data and contact tracking to make sure that each victim received treatment that was customized to meet their individual requirements. According to researchers in [8], ninety-nine people died in the outbreak of COVID-19, which had a direct link to Wuhan's exotic-animal market seafood supply. The study detailed the virus's clinical, radiological, and epidemiological characteristics. Patient mortality rates were 11 percent due to ARDS and 17 percent due to multiple organ failure (ARDS). According to [7], six published research have identified COVID-19's clinical features. Short descriptions were given of COVID-19's symptoms and therapy options. COVID-19's computed tomography (CT) components are widely discussed, according to [9]. For this topic, they only scratched the surface [10]. This is a key weakness in these studies. Clinical characteristics, diagnosis, and therapy possibilities for COVID-19 are all examined in-depth in [11] and [12]. The outbreak of COVID-19 has been thoroughly researched, but no final conclusion has been reached on its likely consequences and the extent of the investigation. There is a dearth of information on the potential influence of 5G cellular networks and AI on the fight against the COVID-19 outbreak. Identifying technical techniques to decrease the effects of COVID-19's outbreak will necessitate research into its clinical, preventive, diagnostic, and therapeutic aspects. This adds to the problem. Readers will benefit from this book's thorough examination of the COVID-19 epidemic, which was triggered by the pandemic. We can get a sense of how COVID-19 has affected technology by looking back at previous outbreaks. A combination of scientific research, clinical treatment, and technological advancements can help controlling the COVID-19 spread [13].

3 Epidemics of the Past

SARS-CoV and MERS-CoV, in particular, were to blame for these outbreaks, which have been troubled by an abundance of events and pandemics this century. AH1N1, AH2N2, and AH3N2 flu strains steered each of the past four pandemics. The Spanish Flu and the Swine Flu were discovered during an H1N1 flu epidemic. There were two distinct strains of influenza that afflicted Asia and Hong Kong, both of which passed from person to person [10]. This section contains an overview of all previous pandemics. An epidemic is an outbreak that spreads quickly but is not anticipated, whereas a pandemic is an epidemic that has geographical spread of disease [14].

3.1 Flu Pandemic in Spain (1918-1919)

The Spanish flu was the worst and most destructive global pandemic in history. Around 50 million people died as a result of the 1918 Spanish flu pandemic, making it the deadliest pandemic in history. The pandemic was caused by the AH1N1 influenza virus. This sickness was spread by birds, according to popular belief. The Spanish flu had an unusually high mortality rate among the younger and healthier members of society. This resulted in the host's own cells fighting each other instead of attacking the virus, which ultimately led to the host's death [15]. Since they have higher immune systems than older people, younger people are at greater danger of contracting this deadly disease.

3.2 Flu Pandemic in Asia (1957-1958)

On February 2, 1957, Singapore became the first city to be hit by the Asian flu pandemic, which lasted for a total of six months. A total of 116,000 people in the United States died as a result of the Asian flu, while an estimated 1.1

million people died globally. This dreadful illness was caused by a genotype of influenza virus known as AH2N2 influenza virus. The A/H2N2 virus, like the A/H1N1 virus, is believed to have originated in birds. Humans can no longer be infected by an influenza virus known as A H2N2 after an eleven-year outbreak.

3.3 Flu Pandemic in Hong kong (1968-1969)

It began in Singapore in the second month of 1957, sparking the second major pandemic of the twentieth century after the Spanish flu outbreak of 1918. The Asian flu killed an estimated 1.1 million people worldwide, with 116,000 of the deaths happening in the United States. The AH2N2 influenza virus subtype was responsible for several devastating outbreaks. Believed to have been disseminated by birds like A/H1N1, the A/H2N2 virus is also thought to have been transmitted by birds. After an 11-year outbreak, the A H2N2 influenza virus changed into a type that no longer infects people. . .

3.4 Pandemic OF Swine Flu (2009-2010)

In the spring of 2009, a new strain of A/H1N1 flu developed, and the Swine Flu pandemic began. Similar to the Spanish flu, the Swine Flu was initiated by a distinct virus strain. Pigs younger than 65 years old were more susceptible to the severity of the pig flu. In the wake of the arrival of the AH1N1 flu virus, the more experienced open population has developed a higher level of resistance. It is estimated that more than 43 million people were infected, with a total of 195086 people being hospitalized and 8868 of those being killed by it, according to the US Centers for Disease Control and Prevention The Swine Flu epidemic has claimed the lives of more than 151,700 persons [16].

4 Preventive Measures

Many people from all corners of the globe have been affected since November's outbreak of COVID-19. Fig. 2 shows that prevention is always better than cure. These easy actions will help you avoid becoming a victim of identity theft or leading someone else to become one. The COVID-19 curve could be reduced if people and groups follow these recommendations. As the curve flattens, the transmission of this lethal virus will slow down to the point where existing medical institutions will be able to diagnose its effects more accurately.

1. When possible, use soap and water to thoroughly clean your hands; if that isn't possible, an alcohol-based hand sanitizer can be used instead.
2. Maintain a social distance of 3 feet (one meter) from other people. .
3. Unless absolutely required, stay in your house as much as possible. People over the age of 60, those with underlying medical concerns, and pregnant women are strongly recommended to stay away from social situations and gatherings at all costs.
4. Hands must be well cleaned before contacting anyone's eyes, nose, or mouth.

5. Wipe down and sanitize all of the regularly touched items in your workspace on a regular basis.
6. Cover your cough and sneeze with a towel, tissue paper, or handkerchief. Sneeze or cough in your own elbow pit if these are not readily available. It is important to dispose of the tissue or cloth appropriately after use.
7. The wearing of a mask when among other people has been recommended by numerous health care groups. After using the mask, be sure to properly dispose of it [17].

Regular hygiene practices including bathing, hand washing, and changing one's diet are critical in the fight against the COVID-19's rapid and widespread spread. Even after a pandemic has ended, personal hygiene and a balanced diet are still critical.

Fig. 2 Preventive measures for the COVID-19 pandemic

5 Incipient Technologies for Extenuating the Influence of the COVID-19 Pandemic

As the new COVID spreads around the globe, countries worldwide are experiencing both amazing economic growth and heartbreaking setbacks. Many people are at risk of the disease, and this is not expected to be altered soon. Despite this, a host of innovative approaches to dealing with pandemic crashes is currently under development. AI and cutting-edge media transmission systems, such as 5G, have undergone significant developments [18]. Modern technology can play a significant role in the general public health response to

COVID-19. The devastating outbreak of COVID-19 could have been prevented if previous developments had been implemented. This section describes the methods and analysis used for the current AI and 5G use in different countries for the prevention and control of the COVID-19 pandemic. After the spread of COVID-19 from Wuhan, the Chinese government implemented strict contact tracing and lockdown to avoid the spread of the virus, and technologies such as 5G and AI were used with machine learning to track the infected patients. Machine learning applications using laboratory data are used to diagnose different diseases [19]. Robots, telemedicine, and IOT are a few examples used in Wuhan. Despite the use of AI and 5G, there were a few challenges such as public privacy and security and ethical issues for data collections.

To manage these, a self-diagnostic solution with end-user mobile and consent such as Google photo management in the cloud is proposed by using a novel-based approach, as discussed in Section 6 of this paper. Further research and app development are required to achieve self-diagnostic approaches. The technology shifts from devices, sensors, robots, drones, and thermal cameras, and hospital will move to self-management of COVID-19 with the use of mobiles only. There will be no security and privacy risk as users will manage and control their data as per future framework description for COVID, as shown in Fig. 3.

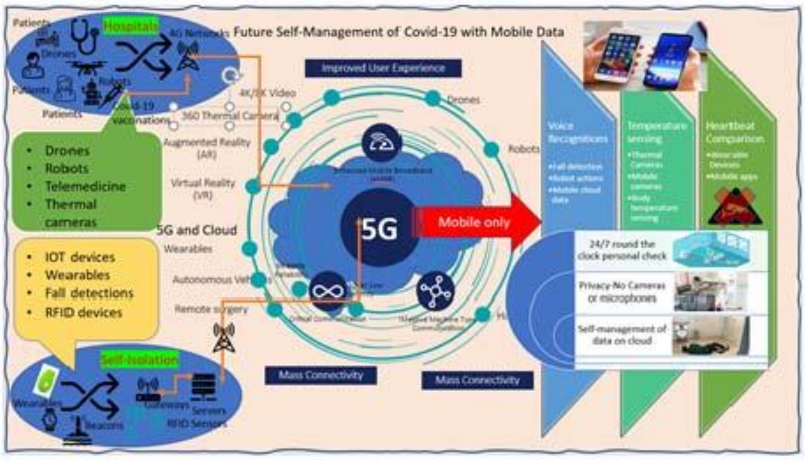

Fig. 3 COVID-19 framework from current to mobile only solution

5.1 Artificial Intelligence (AI)

AI was heralded as a watershed moment in technological advancement when it was first produced. Anti-COVID-19 efforts could benefit from AI, which can be a powerful tool [20]. If AI is applied early enough, it can minimize the spread of the corona by 40%. Anti-COVID-19 efforts could benefit from AI's ability to monitor illness progression, anticipate risk factors, make clinical diagnoses and screenings, and discover and apply lockdown procedures to protect the virus's host and prevent transmission to others. COVID-19 can only spread if AI is used. Subsequently, we will take a closer look at each of the applications that were previously mentioned.

5.1.1 Role of AI in tracing activities

All countries are working on AI applications to prevent the spread of infection.

- Several countries utilize population monitoring to track the occurrence of COVID-19 (for example, in Korea, algorithms use geolocation data, surveillance camera footage, and credit card records to trace coronavirus patients). Each person in China is assigned a color-coded risk level (red, yellow, or green) to signify their potential to spread a disease. As a complement to machine learning algorithms that analyze travel, financial, and communication data to predict future outbreaks, search engines and social media can be used to monitor disease activity in real-time and reduce the spread of COVID-19 [21].
- Many countries including Austria, China, Israel, Poland, Singapore, and Korea have implemented contact-tracing systems. When the Ebola virus spread in Israel, geolocation data were used to identify potential victims and send text messages warning them to flee.

5.1.2 Contact tracing

It would be necessary to implement an extensive contact tracking and isolation plan to contain the COVID-19 pandemic, and digital contact tracking rather than manual tracking may be more effective in managing the epidemic, according to models in published literature. Digital technologies such as contact tracing are heavily emphasized in this article because of Singapore's high population density.

Contact tracing is a critical component in reducing the number of new cases of the virus, but it is not 100% reliable [22]. In an effort to stop the spread of diseases that have no known cure, medical organizations worldwide have begun using contact tracing. Now that we have learned of this, we can stop the spread of the disease. Contact tracing is most commonly used to assist countries that have experienced a lockdown or disease outbreak in adjusting to the new normal. To avoid a second invasion, determine where the infection is spreading [23].

Contact tracing software is being developed as a part of the global effort to combat COVID-19. Similar to CovidSafe in Australia, TraceTogether in Singapore, StopCoVid in France, and the Google/Apple API (application program interface (API). Health authorities in the central government are responsible for processing all these applications. This is an example of how public health experts use contact tracing to monitor this type of activity. Google and Apple have joined forces for the first time to develop contact-tracing tools for specific locations. Users of the iOS and Android foundation apps who are COVID-19 positive will be able to utilize the app because it was developed in collaboration between Apple and Google [24].

Currently, there are 47 tools for tracking lost or stolen contacts that can be used anywhere in the world [25]. The COVI program, which aims to improve the administration of universal health systems, is being developed by Canadians using AI.

5.1.3 Monitoring of ailments

Predicting and monitoring infections, particularly those with the potential to cause confusion, is essential. Nine days before the WHO was expected to receive a report on COVID-19, Blue Dot seized it on December 19, 2019, which is 9 days earlier. AI and natural language processing (NLP) devices are used by B-Dot to identify emerging disorders. AI model B-Dot discovered COVID-19's proliferation much earlier than any human organization could. This does not mean that no human effort was required to obtain the same result. AI models are not only used by B-Dot to predict disease rates. A pandemic has been predicted by Metabiota's pandemic observation platform since its inception in 2008. These characteristics include the clinical signs of the disease, mortality rate, and therapeutic accessibility. Metabiota's epidemic tracker provides data and insights into more than 120 novel microorganisms [26]. These advances can be used to identify hazardous popular illnesses before they have a significant influence on human health, according to a group of scientists. One such example is the global virome project (GVP). The GVP combines monster families as a method of organizing a disease index that can infect people.

5.1.4 Risk prediction

It is possible to forecast the danger of COVID-19 by using AI. Risk prediction can be divided into the following categories:

- Infection risk prediction.
- Predicting the likelihood of developing severe symptoms as a result of an infection.
- How likely is it that a given treatment will harm the victim?

People's current health status, eating habits, and personal hygiene would all need to be factored into an AI model to determine how likely they are to develop a disease in the future. To describe this model, we cannot utilize the mathematical models of the above functions. An accurate and trustworthy risk assessment requires thorough examination of all AI-related tasks (AI). A list of weaknesses for those who are unable to defend themselves against COVID-19 can be compiled using ML. Infections can be treated with AI to shorten a patient's hospital stay and prevent recurrence. New AI frameworks are being developed by researchers at Stanford and the University of Chicago that can consistently identify corona infection patients who are at risk of worsening.

Therefore, doctors know in advance who needs to be admitted to the intensive care unit (ICU).

5.1.5 Diagnosis and screening of patients

To prevent the spread of illness, governments need to identify COVID-19 sufferers as soon as possible. Testing kits to conduct a thorough diagnosis are limited globally. AI has been repurposed and new tools have been developed to address this problem. Specifically, 93% of Shanghai people were scanned using AI-based rapid scanning [27]. In this section, AI will is used to study coronary artery disease screening and diagnosis.

5.1.6 Devices that scan the face

Digital infrared thermometers have grown in popularity since the outbreak of this severe disease. However, this scanning process requires the participation of frontline workers. COVID-19 patients are protected from frontline staff by using cameras with AI-based scanning technologies at hospitals, medical centers, and public places, such as malls and airports. Even in heavily crowded locations, AI-based cameras can track body temperature and facial expressions, providing authorities with important information about human movement. The temperatures of all patients were monitored using an automated system at the hospital's main entrance.

5.1.7 X-rays and MRIs

Scanners using AI and deep learning (DL) were able to reduce the radiologist workload [28]. This is especially crucial while accurately detecting patients is needed to deal with COVID-19. An Ontario-based AI start-up and the University of Waterloo teamed up to build a Convolutional Neural Network for the detection of COVID-19 in X-rays (CNN). COVID-DesignerNet created an open-source computing framework to stimulate the creation of AI instruments based on their framework. This is the design. CAD-4-COVID is an AI model developed by the Delft University of Technology. Computer-aided design 4-COVID equipment was used in the AI tuberculosis diagnostic model. When it comes to assessing whether a patient has a heart infection, there is a lack of accurate information regarding the use of AI-based equipment.

5.1.8 Therapeutic research

Without previous studies, diagnostic protocols, and treatment techniques for COVID-19, it is difficult to determine the symptoms of the disease. However, this is a significant problem. The use of AI-based methods to identify and create new COVID-19 therapies and medications has increased in laboratories and organizations. AI-based approaches and a shorter time to market for new treatments could help research current pharmaceuticals that could be utilized to treat COVID-19.

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5.1.9 Virus modeling and analysis

An in-depth understanding of the virus is necessary to develop effective diagnostic and treatment procedures. A virus needs a host cell to help it copy its own DNA in order to do so. Adhesion to the host is achieved using a lock-and-key mechanism. To prevent this, the majority of inhibitor-based mediators block the receptors of the targeted cells. A team of scientists are currently investigating this binding mechanism. ML appears to be the most powerful tool scientists have to create this type of binding mechanism model. Models trained on protein data have recently predicted interactions between P-PIs and human cells [29]. A variety of protein-folding mechanisms exploited by viruses can also be modeled using ML-based methods. Using DL methods, Centers for Disease Control Prevention (CDC) [27] can estimate a protein's structural composition using only its amino acid sequence. The three-dimensional structure of a protein is essential for understanding its function. Google's Alpha fold model predicted the sequence of proteins linked to COVID-19 at the time of the epidemic. A better understanding of the overall structure and organization of the virus can be obtained from these projections. The findings of this study could lead to the development of novel antiviral drugs.

5.1.10 Breaking fake news

An increase in myths, conspiracy theories, and misguided ideas has occurred since the COVID-19 outbreak. Using social media, there has been much effective propaganda. The goal of Google, YouTube, Twitter, WhatsApp, and Facebook is to employ AI to stop the spread of misleading information and provide accurate information. These systems found no minor flaws in the tested contents. YouTube has implemented safeguards to prevent the spread of false information on its platforms [30].

5.1.11 Enforcing lockdown measures

AI is being used by several countries, including the United States, India, China, and the United Kingdom, to enforce social segregation and lockdown processes. Computer-powered infrared cameras are used to monitor public areas by China's leading AI company. Using facial recognition software, these cameras can also identify occupants who do not follow lockdown limits in the event of an emergency. Monitors were set up in Oxford, England, to ensure that the foam adhered to open-access policies.

5.1.12 Challenges

During the COVID-19 pandemic, AI technologies are extremely beneficial. There is still a long way to go in the field of AI frameworks. Managing COVID-19 can be complicated by several AI-related issues, some of which are listed below:

1. AI algorithms require by AI data to ensure consistent and accurate outcomes. Many AI models do not work effectively because of access to historical information, despite that this is a very unusual occurrence [7].
2. Although open information regarding AI models can be a nuisance, the information itself is bold and strange, casting doubt on the practicality of such advancements.
3. A weakness of an AI algorithm is that it assumes that all possible outcomes in some random events are equal to those that exist in the prepared dataset.
4. AI is viewed as a security breach by many.
5. AI innovation is limited because of the need for human input. Controlling the use of AI in the fight against COVID-19 relies on human ingenuity [24].

The use of AI-based technologies is important in the fight against COVID-19, regardless of how challenging it is to implement them in the field. In recent years, AI has made significant progress in NLP, ML, DL, and information retrieval, all of which have greatly benefited from these advancements. Advancements in AI have made it possible for COVID-19 to wreak havoc on board structures.

It is important to keep in mind the ethical concerns that need to be addressed. Any AI policy should address these ethical issues. It appears that ethics were given high priority in this year's government AI readiness index. Ethics must be considered when establishing AI policies according to the World Economic Forum. Unless governments take ethics seriously, they are unlikely to be able to compete effectively in the global marketplace.

5.2 Fifth-Generation Cellular Technologies

The wireless cellular networks of the next generation are referred to as 5G cellular networks (or simply 5G). 5G can support international mobile phone services. All aspects of this technology's performance have increased significantly in comparison with the previous iterations of this technology. Internet of medical things (IoMT), AI, and blockchain can change the healthcare industry owing to 5G networks and new technologies. It is changing China's approach to the COVID-19 outbreak due to the country's commercialization of technologies. Because 5G makes it easier to track patient connections and viruses, medical professionals and government agencies can make better use of it. Therefore, they could conduct screenings and analyze the data more effectively. 5G technology can help countries affected by the COVID-19 outbreak by serving as a case study [30]. COVID-19 can be mitigated with the help of the IoT, big data, AI, and blockchain. Technology, including 5G, AI, and barcodes, was applied in a recently completed Wuhan hospital for COVID-19 therapy and contact tracing [25].

5.2.1 5G telemedicine

Telemedicine refers to keeping track of patients who are distant from the source of their disease. Although drones, smartphone attachments, and mobile software can be employed to provide telemedicine phase capabilities, 5G network technology can still capture this potential. Mobile technologies, such as 4G, do not have the capacity, low latency, or data transfer speeds needed to maintain a high-quality video stream that is required for a consistent debate using remote coordination. As a result of 5G's VR/AR capabilities, telemedicine encounters can be observed, and healthcare providers can get a sneak peek into prospective treatment concerns and procedures. 5G innovation was first commercially reported in China in early November of the previous year, and the telemedicine market has advanced to a new level. An emergency health center and Kunming Medical University have started an online demonstration stage and free corona therapy via 5G broadcast communications, thanks to China Telecom's cooperation [31].

Owing to this conference platform, the hospital's health team in Beijing was able to collaborate with the Beijing health care workers [32].

5.2.2 Medical imaging

Modern medical imaging processes, such as PACS, are becoming increasingly crucial in the diagnosis and treatment of medical conditions. As an alternative to RT-polymerase chain reaction (PCR), cloud computing and CT scans have been used for contract tracking. With cutting-edge portable systems that combine AI and big data analysis, PACS can provide information analysis and a board with less human work. The Wuhan Center, Leishenshan Hospital's 5G-enhanced clinical phases account for the continuous conclusion of COVID-19 patients [33]. Reverse PCR is currently used for testing; in the future, it can be performed using mobile apps and mobile data [34].

5.2.3 5G Thermal imaging

Heated envelope imaging is a beneficial tool in a wide range of industries, including healthcare. It is now possible to establish user systems with a variety of health protection and care systems because of the development of 5G networks, and thermal measurements can be performed with increased precision using the 5GC IR advanced checking framework. With 5G technologies, the data acquired by projects can be sent to the main test framework with little inactivity. COVID-19 may necessitate an open temperature check. Robots and drones equipped with 5G warm-hopeful frameworks [33] have been used in some Chinese communities to reduce the spread of COVID-19.

5.2.4 5GC robots

COVID-19 has inspired worldwide efforts to develop and distribute robots that can assist first responders in emergencies. This chapter is dominated by the 5G technology. Only 5G technology can provide robots with low latency and high bandwidth, which need to be more productive [35]. By cleaning, temperature checking, meal delivery, and prescribing medication, robots can assist medical workers to avoid direct contact with infected patients.

1. Thailand's deployed 5g robots
   COVID-19 has inspired worldwide efforts to develop and distribute robots that can assist first responders in emergencies. This chapter is dominated by 5G technology. Only 5G technology can provide robots with low latency and high bandwidth, which need to be more productive [35]. Cleaning, temperature checking, meal delivery, and medication administration can all be performed by robots, avoiding direct contact with patients [35].
2. Shanghai's China mobile's 5G robots
   To ensure that COVID-19 is widely available, China's telecom authorities have provided the Shanghai Clinic with six 5G-certified robots. These robots can perform a wide range of tasks, including cleaning and delivering medications to patients. In addition to 5G cameras and health monitors, Shanghai's communication managers have increased the complexity of COVID-19 [36].
3. WUHAN's cloudminds' 5G robots
   A slight delay occurred in the opening of Wuhan's first 5G-enabled healthcare facility. The Beijing-based business cloudminds delivers robots that can clean, disinfect, provide medication, and monitor patients' temperatures [37].
4. Patrolling robots in several cities of China

As the demand for 5G over PCs increases, robots have been built using Advantech MIC-770s in Guangzhou, China. Currently, they are being produced. Using five infrared thermometers and high-resolution cameras linked together via a distributed computing network, these robots can monitor the heat levels of up to ten people simultaneously. A person's veil can be detected by these robots that use specialized sensors.

5.3 Challenges

Because of the extensive use of COVID-19, many mechanical configurations have been developed. AI, IoT, and drone technologies are among the most cutting-edge advancements in each field. Portable systems that outperform current breakthroughs in terms of transfer speed, idleness, and adaptability are required to properly appreciate the trailblazing potential of this innovation. Portable systems will have to take off if this is to happen in the near future; it is possible that a pandemic control system such as this may be used as one component of an incredible city concept [33]. The following are just a few of the current 5G network challenges:

1. This makes it difficult to get the 5G network up and running in the early phases, as there is not much foundation.

2. In and of itself, the use of 5G technology cannot improve people's lives. This can be observed in the case of the IoMT, AI, and distributed computing [37].
3. In itself, the introduction of 5G technology will not have a positive impact on the lives of people. This can be demonstrated using IoMT, AI, and distributed computing technologies [38].

Fig. 4 5G technologies for controlling COVID-19

5.4 5G Internet of Things

The IoT will require massive deployment of connected devices and sensors, as projected by the GSM Association. Cloud solutions can access IoT sensor data over 5G networks, which are regarded as reliable. It is possible to stop the spread of COVID-19 by using IoT contact tracking and robotic interviewing, crowd temperature monitoring with cameras, surveillance drones, and the IoMT. As displayed in Fig. 4 the 5G technology will be heavily utilized in the regulation of COVID-19 [39, 40].

6 Novel-Based Approach and Discussion

A cell phone is required to detect COVID-19 in the future. End users can obtain their own assessment and tracking without visiting medical facilities or hospitals. Apple's fall detection scenarios were tested more than a decade ago under some circumstances. The COVID-19 virus can be diagnosed using phone and personal data in a few years. Even in industrialized countries such as Australia and Singapore, end users have objected to COVID-19's current diagnosing approach and contract tracing due to privacy issues. As with Google and Facebook's photo features, there are no additional fees associated with the solution, which is discussed in a subsequent section. AI-based apps use speech-to-photo matching to assist patients in tracking and detecting the symptoms of COVID-19 virus; AI-based apps use speech-to-photo matching.

6.1 Image processing with the comparison of selfies

Thermal imaging can be utilized in the same way as high-definition AI to watch crowds and detect those who are sick. Mobile users can self-diagnose and self-identify COVID-19. Google Drive allows users to compare selfies and generate results using an AI-based algorithm. The health sector has benefited from a range of app development platforms [41, 42]. Examples of how AI is being utilized to battle the present global epidemic of infectious diseases include research and development of antibiotics, vaccines, and public policy-related information, such as quarantine and isolation of sick individuals.

Patients with COVID-19 can be identified and diagnosed using AI and DL using mobile data. An accurate and cost-effective diagnostic method with personal devices like mobile for COVID-19 detection is lacking. Despite the fact that the vast majority of patients infected with COVID-19 have only moderate symptoms, they should be separated, treated, and administered follow-up therapy. AI algorithms can be used to help individuals identify three possible COVID-19 patient groups: moderate (80%), severe (15%), and high risk (5%). New COVID-19 treatments can be developed using AI with mobile applications and data stored on a personal cloud. In recent years, DL patterns that are both light and precise have been produced.

Doctors' workloads can be reduced if AI-driven triage systems are implemented. Online chatbots can use mobile devices to help patients recognize early illnesses, teach people of the hand about basic hygiene, and show signals of better healthcare. Patients with mild influenza may benefit from telephonic monitoring of their medical data (e.g., daily temperature and symptoms) [43]. For example, the latest pandemic can be transmitted using this method. Chinese hospitals work with blockchain companies and pharmacies to deliver medication to their patients. Pharmaceuticals can be delivered faster and more reliably using blockchain technology [44].

Mobile device data and AI systems have the potential to improve medical diagnoses in several ways. Currently, coronavirus-infected patients have limited screening options because they are too slow and unreliable. Two DL algorithms were used to identify COVID-19 from chest CT data. Both AI systems have COVID-related sickness detection and diagnostic algorithms. Many studies have demonstrated positive results when DL approaches are used for the analysis of medical images.

Chest CT may be useful in patients with suspected of developing SRS-CoV-2 infections. Therapy and diagnostics are becoming increasingly dependent on COVID-19 imaging. Ground-glass opacity and pleural consolidation are two of the most obvious signs of infection on CT scans. Chest CT has been found to be substantially more sensitive than viral results in diagnosing COVID-19. When the healthcare system is already thin, CT can be used to quickly treat individuals at risk of developing COVID-19. Chest CT has a significant impact on the diagnosis of COVID-19 in individuals with severe and complex respiratory symptoms. This procedure can help doctors track the progress of a sick patient's illness, as well as the extent of damage to the patient's lungs.

It is becoming increasingly common for CT scans to detect COVID-19-induced lung abnormalities for various reasons. CT's ability of CT to detect COVID-19 has been greatly improved by applying an artificial neural network to a large number of patients. To improve CT's ability of CT to detect COVID-19, many patients should be able to swiftly and precisely identify their symptoms using an artificial neural network.

Video safety cameras, facial recognition, credit card records, and a global positioning system (GPS) are some of the technologies that South Korea has developed to provide real-time data and accurate travel routes for individuals (GPS) using mobile data. Individuals infected with COVID 19 are required to self-isolate at testing centers, and those infected with COVID 19 are notified through text messages. Early detection and quarantine have led to low fatality rates among the South Koreans.

Germany's software uses data from wearable sensors, such as pulse, temperature, and sleep patterns, to detect signs of viral infection. These patterns have been widely used to help diagnosis, especially in addition with other signal data like EEG [45]. COVID-19 recurrence can be assessed using the application's map data, found in the United States. Because of the country's extensive use of broad-ranging diagnostics and digital health treatments, Germany has an extraordinarily low death rate per capita.

6.2 Voice Recognition and Comparison for Sneezing and Coughing

Preventive measures were taken to accurately identify pneumonia and asthma before the epidemic began. Therefore, we believe that we have nailed down each algorithm. There are many signs of Alzheimer's disease, including memory loss and neuromuscular deterioration, such as weaker vocal cords, which can be detected using AI. Machine learning system ResNet50 was designed to distinguish sounds with varying levels of vocal cord force. The sound "mmmm" is a good indicator of vocal cord strength and fragility. "Then" and "then" are frequently used in audiobooks; therefore, Subirana trained a neural network to select "The" from these phrases.

COVID-19 patients were interviewed in April by the researchers to obtain as many records of coughing as possible. The recordings of coughs were made using an Internet-enabled phone or gadget and posted online. Individuals participating in the study will be asked to complete a questionnaire on their symptoms and the presence or absence of the COVID-19 gene. In addition, people can indicate their gender, location, and native language to better understand one another. According to reports, there are more than 70,000 records and 200,000 audio samples in Subirana's database of study coughs. COVID-19 individuals who were asymptomatic were included in the study's 2,500 data points.

Regarding diseases such as flu or asthma, Subirana stressed that the AI model is not built to identify people with symptoms. Most importantly, the equipment can distinguish a symptomless cough from a healthy cough. The team is developing prescreening software based on an AI model provided by a corporation. To train and improve the model's accuracy, they collaborated with a number of hospitals around the world to obtain a wider and more diverse collection of tobacco records.

Smartphones can be used to gather information about potential patients. Sensors can be used to monitor the fingertip temperature and speech of a patient. Data were sent to a cloud server powered by AI for disease identification and analysis [46, 47]. Radiologists are unable to complete their investigations because it takes a long time to compare several CT scans. Radiologists benefit from this, as well as people who find themselves in a scenario where they are not sure what they should do.

6.3 Voice Recognition using Recorded Calls from Cloud Sources

For a long time, this has been regarded as a threat to user privacy and security. However, now that everyone can upload their personal data to Google photos for free, it is becoming more common for customers to record their voice calls and save them for later use. Comparing previously recorded sneeze and cough recordings with newly uploaded recordings over time can help identify COVID-19 symptoms. In the future, mobile app users will be able to run reports and identify issues independently.

End-to-end networks and uplink connections strongly rely on 5G networks. They are also incredibly fast in communicating with one another and have a high level of mutual trust. 5G is more secure and faster than Wi-Fi. Owing to its flexibility, coverage, and reduced latency, 5G may allow for more deployments in the lower, mid-, and high-band ranges [48]. Figure 5 depicts IoT, edge computing, web apps used as the edge-to-cloud interface, and clouds for data processing that use coordinated profound knowledge. If you are not in the COVID-19 cohort, this information can be provided. Many IoT formats have been used for data collection. A web application can be used to link a cloud server to specific hospitals and healthcare providers. Using secure online connections, hospitals and doctors may perform remote patient evaluations and plan for future situations [49].

Self-driving vehicles can be used to minimize human contact in healthcare. Images from many vehicle cameras can be retrieved in real-time via control centers. Disinfectants can be dispensed by using automated or semi-autonomous robots. Detecting body temperature and operating touch points can be accomplished using platform recognition and facial recognition software in self-driving automobiles. Mobile apps and computer systems must adhere to established networking standards for automotive systems to operate swiftly and reliably.

Using 5G networks that connect vehicles to the cloud via the customer location and operator control and monitoring device, autonomous vehicles can be installed, enforced, and operated in accordance with end-user and public safety requirements. A wide range of 5G-related activities includes data centers, the Internet, municipal rail systems, electric vehicle charging stations, and higher voltage power grids. In an effort to boost the economy and society, the government has targeted a number of enterprises and institutions. This is especially critical in developing countries, where trade and industry must continue.

ZTE's latest 5G technology in China allows the remote diagnosis of coronavirus pneumonia. In a cloud video environment, ZTE's smart video, AI, and temperature sensors avoid interruptions at all times [50]. The testing and commissioning of ZTE's 5G remote diagnosis and treatment system have reached a vital point in the process. In 5G networks, cutting-edge AI, robots, and other cutting-edge techniques have been employed to restrict the spread of infectious illnesses. As China's 5G network expands, many of the country's subway systems now offer video consultations. The low latency and enormous bandwidth of this technology have made early disease detection and treatment easier. To avoid privacy risks with videos, the voice recognition method can be used to detect infected people.

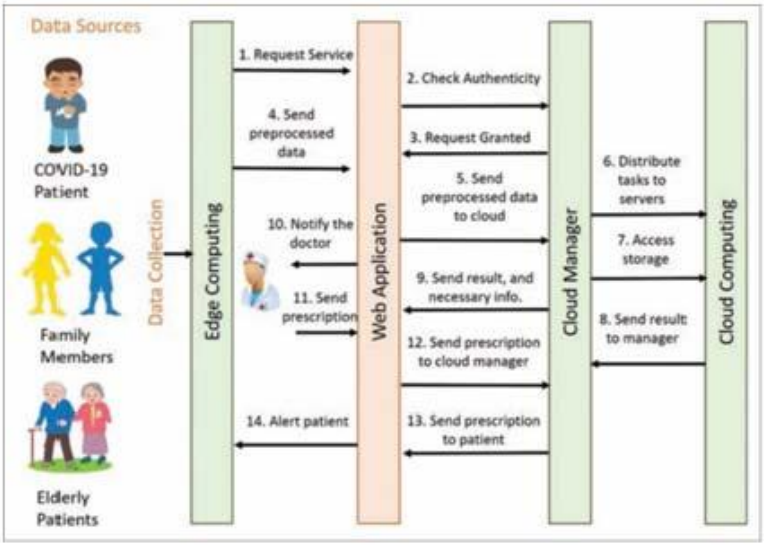

Fig. 5 Depicts the many layers of data sources in a healthcare system

6.4 Temperature Sensing while on Call and Holding the Phones

In healthcare, self-driving cars can be used to reduce the requirement for human touch. Remote control centers can obtain real-time views from a large number of onboard vehicle cameras. Automated or semiautomated robots can dispense disinfectants. Platform recognition and facial recognition software can be used in self-driving cars to detect body temperature and operating touchpoints. Networking requirements must be met by mobile apps and computer systems for automotive systems to operate quickly and reliably [51]. Phones can be used for temperature sensing and recording data in iOS and Android health apps. Data can be collected, especially when a user is not using headphones and holding the phone close to the face. Similar to wearable devices, phones can be used to detect and record temperatures that can be used with AI to investigate COVID-19 symptoms.

6.5 Temperature Sensing from Selfies and Photos

Mobile users will be able to employ thermal image processing to assess temperature variations and track and monitor the COVID-19 virus while photographs and other data will be stored in the cloud. In the COVID-19 crisis, cloud computing aided cooperation, communication, and crucial Internet services. Because of the COVID-19 outbreak, many people have been compelled to work from home. As a result, we consider cloud computing as an essential part of the issue of working productively from home. During lockout, cloud computing allows for the delivery of high-quality healthcare services, which is a comprehensive framework for digital transformation. The importance of cloud computing in today's environment has sparked protracted discussion. Researchers are still looking at COVID-19 pandemic cloud computing, and have identified some of the most important COVID-19 cloud computing applications. Providing Internet services helps to control the virus. To limit the spread of the virus, every country focuses on its efforts. This encourages healthcare workers to become more creative and productive. Newly infected patients can be identified and monitored by this method. This technology will be deployed in the future to save millions of people worldwide. Additionally, this method can be used to predict the impact of SARS-Co-2 in the future.

A Silicon Valley biosensor patch that monitors the electrical activity of the heart can detect COVID-19 at an early stage. The heart rate may be monitored using this biosensor, Patch-1AX, which is water-resistant and can be worn in your pocket. An IoT device or a smartphone app can be used for heart monitoring [21] and to view real-time data from a user's patch. If a patient with COVID-19 develops symptoms, it is possible to submit this patch's data to a cloud system to notify other COVID-19 patients while they are wearing it. Wearing patches for five days at a time prevented the illness from spreading outside the patch, according to the instructions. Biosensor patch 2A Patch 2B will also be released in June by LifeSignals. Critical signals from a clinically qualified patient (ICU) are stored and transmitted to COVID-19 patients in ICUs.

Infrared thermometers (NCITs) and thermal imaging systems use a variety of infrared technologies to measure temperatures. The non-contact infrared thermometer information page contains more information about the NCITs. The ability to accurately measure the skin surface temperature of persons without physically approaching them has been repeatedly proven by thermal imaging technology when used correctly. Methods requiring close proximity or touch to measure the temperature include non-contact thermometers and mouth thermometers (for example, non-contact infrared thermometers or oral thermometers). For example, temperature-based screening is insufficient to determine whether a person has COVID-19 permanently because COVID-19 may not be feverish; for instance, COVID-19 must be diagnosed with a diagnostic test.

6.6 Heartbeat Comparison with a Normal and Infected Person Situation

The blockchain-based platform MiPasa transmits the data. Blockchain and cloud technologies from IBM allow the exchange of medical and geographic data that can be verified. People and organizations from the medical and public health sectors were involved in this effort. According to WHO guidelines (WHO), this software is safe and beneficial for doctors. COVID 19 hospitals may use this platform to better plan for the future and allocate resources to mitigate the impact of the pandemic.

Increasingly, Germans are using smartwatches, fitness trackers, and smartphone software (corona-Datenspende) to monitor their health and assess how many individuals are clinically unwell, a news-release state. As of this writing, more than 160,000 people have signed up for the program. Using the app's data, health professionals and the general public may better understand the prevalence and distribution of infections in the community via an online interactive visual system.

Wearable technology, such as wristwatches, can be used to predict flu outbreaks in the United States according to a study published in early 2020. Nearly the course of the two-year study, researchers examined the heart rates of over 47,000 Fitbit users across five states (California, Texas, New York, Illinois, and Pennsylvania). The 0.84–0.9 statistics from the CDC correlated well with these methods when mapping the prevalence of ILI. Wearable sensors and community health promotion during a pandemic are necessary to "flatten the curve" and reduce disease morbidity and mortality, according to these studies.

Sharing short-range Bluetooth signals between nearby devices has been made possible by a Singaporean initiative. These meetings were recorded and saved on a mobile device for two weeks. A COVID-19 patient's Contact information is available from the Singapore Ministry of Health. Per capita mortality from COVID-19 is lowest in Singapore and South Korea. With the help of mobile and heartbeat data, AI-based apps can be used to detect COVID-19 symptoms, and this method will have fewer implications from the privacy side of personal data use.

6.7 Social Distancing Alarms with Mobiles and Keeping Track of Full-day Reports using Wi-Fi and Cellular Technologies for Connecting to Nearby Devices

People can be counted, their whereabouts tracked, their geographic movements tracked, and even taken abroad, using big data from telecom providers [52]. However, law enforcement and the management of privacy security have an impact on this. With users' individual cloud data, there will be no issues regarding privacy and data security, as users can decide to keep or delete data from the cloud.

Free Internet and cloud-based solutions can be used in China to identify the most relevant materials for an individual's needs. A Taiwanese airport deployed infrared thermal cameras to promptly detect individuals suffering from fevers. Businesses, schools, and public transit in Singapore were surveyed to collect temperature data. Temperature data were collected to identify the illness clusters and hotspots.

The position of an asymptomatic person is thoroughly analyzed in Iceland, as in other countries. To better understand pathological illnesses and viral proliferation, Iceland gathered patient-reported symptom data as well as clinical and genomic sequencing. Using digital thermometers and wristwatch apps, a commercial firm in the United States monitors fever clusters and COVID-19 epidemics in California. There is no place in politics or practice for commercial or intellectual business.

6.7.1 Quarantine and self-isolation

Random infection control locks have resulted in considerable financial loss in several countries. Quarantine for persons who have been exposed to or infected with the virus is made easier using digital technologies. It is now possible for health officials in China to keep track of patients' movements and temperature readings while completing symptom surveys because of the QR technology. Health and travel certificates for COVID-19 can be issued by using QR codes. Both the green and red codes were permitted to travel simultaneously. Drones and digital recorders are used in China to monitor and regulate public gatherings.

In Wuhan, passengers from the Australian mainland were arrested, whereas those from other countries were quarantined at their hotels. As a result of the new regulations, anyone breaking quarantine would have to wear tracking devices and face fines. A quarantine break can lead to personal messages and fines in Taiwan, where those quarantined can electronically monitor their government-issued mobile cell phones. Downloading an app on your smartphone will allow officials to notify you if you leave the exclusive South Korean community. Self-isolators in Hong Kong are obliged to wear cloud-based wristbands to notify authorities if the quarantine is breached. A mobile phone system for COVID-19 soldiers was built in Iceland.

With contact-tracking apps, sunshine and rainbows are not available. Quarantine is not required for all exposures, including those involving personal protective equipment or thin barriers that can be penetrated by mobile signals. People can miss a lot of exposure if they do not have or carry a cell phone. It is possible for authorities to monitor people's health and restrict their movements using the China rapid reaction code system (QR). According to UK experts, more than 60% of a country's population must apply an effective mitigation strategy.

People may avoid using mobile phone solutions for quarantine enforcement if they leave the quarantine region without phones. To use self-reported data (such as the QR code system) effectively, participants must be unwell enough to describe their symptoms accurately. Even if these technological breakthroughs are employed alone, they can be advantageous in combination with other methods. Self-isolation and apps for detecting close contacts will reduce the risk of privacy and government enforcement for the use of contact-tracing apps [53].

6.8 Clinical Management

In China, AI CT services can be used to identify patients with COVID-19 pneumonia. COVID-19 may be distinguished from other lung diseases using our method, which significantly accelerates diagnosis. Thoracic radiograms can be easily searched using COVID-Net, a deep open-source coevolutionary system for clusters worldwide. Machine learning algorithms were created by the Chinese to predict the likelihood that those infected with Ebola will suffer severe respiratory distress and potentially life-threatening illnesses. Using these modeling frameworks, it is possible to improve clinical decision-making and resource allocation, and uncover key care resources, medical supply sites, and institutions. Videoconferencing and digital monitoring in virtual care systems worldwide can limit exposure to SARS-CoV-2 in healthcare facilities. Between February 2020 and May 2020, the number of Canadians seeing a doctor increased significantly.

A Swiss company has developed an AI-powered patient flow management system. It is a cutting-edge learning platform that compiles data from various municipal hospitals [54]. Using this information, it is possible to predict and forecast the demand for hospital beds and other treatment facilities [55]. This technology can be used by hospitals to deliver DL for future patients. Image classification with DL is already effective, and ML and AI can be implemented for COVID-19 detection [56]. A growing number of hospitals, tourism attractions, and sporting events have contributed data to AI solutions that employ these models to improve their algorithms. In research on hospital availability, important hospital availability and AI solution performance are updated every 7 days. As shown in Fig. 6 with regular data from different sources coming in, its platform can help prevent hospital turmoil and keep patient flow in the hospital running smoothly, according to this assertion [56].

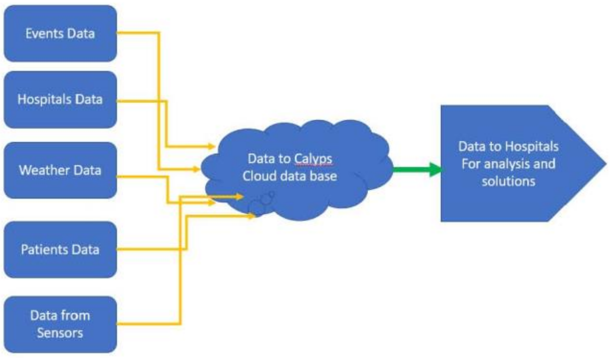

Fig. 6 Chart of the functional block

The curse of COVID-19 has been broken owing to AI in robots. The development of AI-based robotics has curbed the rise of COVID19. The Vici and Tug robot serves as a good example of how robotics can be applied. By using high-tech equipment, Vici and Tug Robot can confine the virus. Healthcare workers were exposed to SARS during the 2003 [57]. Therefore, they were less likely to receive high-quality treatment. Vici, a medical robot, facilitates patient-doctor interactions through visual cues on a screen. Infected patients might utilize a wheeled electronic tablet to connect with healthcare staff. It can be used as a diagnostic tool to measure body temperature. Until a healthy immune system can be developed, doctors, airport employees, and hotel staff can make considerable use of high-tech technology to reduce human contact and the risk of infection. Because support people are not present, the deployment of Vici and Tug robots can significantly minimize the spread of the virus as displayed in Fig. 7.

The "Little Peanut Robot", which has been released in cities across China, has been added to the list. These robots may provide food, medical supplies, and other requirements for persons in quarantine or those suspected of harboring the virus. Medical supplies and patient belongings were saved from a filthy area by similar robots at a hospital in southern China. To stop the spread of this new coronavirus, many robots may be deployed in hotel rooms around the world. Traveling by air was needed during this tough period for many people, both domestic and foreign. Aircraft disinfection is regulated to ensure that passengers are appropriately screened and monitored. This was proven by the "GermFalcon robot" [58], which was created specifically for this purpose. This robot can destroy bacteria, viruses, and superbugs by degrading the UVC light. UVC lights installed in a plane's cabin are intended to shine

Fig. 7 Vici and Tug

all of the cabin's high-touch surfaces. As soon as an airplane becomes infected with the virus, passengers who are unaware of the danger must be protected immediately. With IoT and mobile devices, there is no need to use cameras to reduce security and privacy risks. Movement detection at home for quarantined people can be used with mobile applications, and sensors and robots can take action based on the symptoms. A fall in a locked room for a heart patient can be detected with motion sensors, and the robot can act accordingly to provide critical medicine within a few minutes of an accident. Further research on robots, IoT sensors, and mobile apps is required for self-management at home for COVID-19 infected peoples.

7 Conclusion

Many cutting-edge technologies, such as AI and 5G, are being deployed to ease the consequences of the COVID-19 pandemic on the global population. The core of our effort was to provide the most up-to-date COVID-19 pandemic strategies. COVID-19's clinical features and transmission system are explored in the first phase of this study. The unique therapy attempts to stop the pandemic and preventive measures that can be taken until the pandemic is stopped are also discussed. Post-conversation discussions described a number of COVID-19's innovative treatments. This paper covers the currently employed technologies in different countries for the control of COVID-19 spread. The first world countries are using these technologies while waiting for vaccination as technologies are easy to deploy, whereas vaccine production and certification takes months in some years. The middle sections are all about current solutions with AI and 5G technologies and use cases from different countries. Users decide which data they can upload to the cloud and other applications for self-diagnosis. Similar to thermal cameras for temperature monitoring, mobile devices have the capability to test and monitor temperature from selfies and photos. The data are automatically stored in the cloud in the same manner as Google photos; that is, users can upload their photos to Google photos and can access these photos when needed. Fall detection with mobile applications was a dream, and now IOS have this capability. Voice recognition, coughing and sneezing analysis, heartbeat monitoring, and temperature monitoring are critical for the diagnosis of COVID-19. These novel approaches will produce mature products in the future, and there will be no need for clinical testing in hospitals. Our primary goal was to minimize the impact of the COVID-19 outbreak by employing cutting-edge technologies, such as AI and 5G. This new technology is exclusively responsible for controlling and limiting the consequences of this disease until treatment is established.

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CHAPTER 9: DISCUSSION

5G technology is expected to be rolled out by 2020. Therefore, understanding the technological advancement and research that has made this rollout possible is very important. This research project attempts to provide a detailed analysis of different features, such as cloud-based services, accessibility, and flexibility, which will ensure that mobile communication remains a protocol for global communication for as long as possible. Given the advent of the use of mobile data, existing wireless networks are already performing to extents that warrant the need to explore new horizons and create a next-generation mobile network that can replace existing ones. Research indicates that the 5G focus on IoT is in advanced stages and that all stakeholders, including vendors and operators alike, are eagerly participating in testing and trials. Soon, a finalized standard for 5G will exist. 5G aims to be better than the existing protocol in achieving high data rates, low latency, and power consumption. However, the most important feature is its vast device connectivity. IoT, which stands for Internet of Things, is a system of many related computing and digital devices that are connected over a network that does not require human-to-human or human-to-computer interactions. IoT is considered the most promising research topic in business and other research programs. The belief is that innovations in the lives of people are just resulting from information about technology. Consequently, researchers require different information resources to process information and design systems that are used to obtain accurate positions. IoT is an advanced innovation that offers machine communication and allows physical objects to make contact with others. By using the Internet, IoT has communication and information sharing processes to obtain better implementation when determining locations. Different internal attacks are also affected by the application of IoT, which is connected through the Internet. Initially, Internet use was based on transferring data packages between data sources and users through specific IP addresses. In the present survey, different aspects of IoT are considered, such as fundamentals, architecture, and technologies. Given a forecast of connecting billions of devices to cellular networks, the massive connectivity of the NB-IoT and 5G protocols is critical. The massive connectivity for smart utility tools such as water meters is only possible using NB-IoT and 5G technologies. Typical meter warranties are for 10 to 15 years, which indicates a critical factor—the longevity of the network to support these devices. NB-IoT has been declared as a 5G protocol and will work for the next 10 to 15 years even if a technological advancement such as 6G is realized. A normal cellular network life cycle is 10 to 15 years. For example, 2G and 3G are still operating in developing countries, 3G will be shut down in Australia in 2022 and 2023; however, 4G will continue to work for another five to 10 years. 5G is new, and the full nationwide rollout will take approximately five years before the 6G rollout in urban areas starts. In recent years, sensors and meters have become critical instruments for establishing and updating systems, as well as for reducing costs by boosting utility efficiency. The need to save money is the driving force for the implementation of technology. Water utilities are typically the largest power users in any township because of the size of the impellers, which can range from a small car to a small city square. In addition, water prices have risen faster than wage inflation expectations. Using IoT technology to measure those pumps has been shown to conserve up to 10% in energy costs, representing substantial savings (Ahmadzadeh et al., 2021).

According to do Amaral et al. (2014), to overcome the energy efficiency barrier, this construction needs to be incorporated into buildings. The amount of energy efficiency, which is also used in residential buildings, and the prevailing energy crisis are significant to overcome the various barriers, as is adopting a reasonably simple energy efficiency method (do Amaral et al., 2014). This study reduced the total energy by using flats in smart meters through the factor and provided reduced comfort to a household. Therefore, an energy-saving building used in energy efficiency design to enhance residential energy efficiency could result in reduced energy costs and better electric energy supply, similar to the result from decreasing the use of energy through the residential building sector, which could also play a significant role in lowering greenhouse gas emissions. Droughts cause reservoir levels to plummet, increasing worries over water quality and stressing the need to preserve every last bit of water in a system. Ketos developed a network of interconnected hardware and sensors that uses sensors to provide near-real-time groundwater resources and supply management information. The sensors can identify contaminants such as lead and copper while also providing data on water pressure and flow (Xiao et al., 2021). In a dry spell, every drop of water counts; therefore, Echologics and Syrinix established a sensor-based leakage detection system that will allow utilities to supervise their systems in near real time and respond quickly to occurrences or repair work. Water leakage in the Las Vegas Valley has been reduced from 20–40% to only 5% from the use of Syrinix technology. The energy-efficient protocol overhead reduction methodology considered transmission periods, sources of transmitted data, and distance between the source and receiver, and overlaid the approach with a crossing approach, communication protocol, and optimized flooding process (do Amaral et al., 2014). An entire process is carried out with the maintenance of network connectivity, and a new, reduced topology is created on the basis of the local information. This process makes an assumption related to data delivery by using a query-driven model. Two main approaches exist for interest dissemination. The first is spin, in which all energy nodes demonstrate data availability and then wait for the request to be completed by interested nodes. The second approach is directed diffusion (DD), in which sync nodes are used to deliver data among all energy nodes in networks. Through DD, the data gradients are established between the interested sensors and the sink. Different routing categories, such as cougar, rumor routing, CADR, and gradient-based routing, are considered in the data interpretation role of energy-efficient routing.

Researchers have also provided brief information on the integration of energy efficiency in power systems. A research study that was conducted in Europe analyzed the demand for energy efficiency in 2050. In the study, a significant amount of data was collected, resulting in efficient analyses of demand (Bussar, et al., 2016). The research findings indicated that energy efficiency systems' long-term storage is highly significant. Without long-term energy storage, renewable energy systems might be unable to provide maximum benefits. High-speed 5G, such as Verizon's 5G Ultra Multiband, could allow all of these innovations to collaborate, enabling massive amounts of data to be processed and transmitted from water utility hardware to policymakers. Additionally, having more sensors means having more real-time data, enabling managers to be proactive instead of reactive. In contrast, extreme rainfall events may generate flash floods when precipitation surpasses sewage systems. WaterStart is assisting utilities in the United Kingdom with coping with increased flooding. The most common solution has been to expand the sewage infrastructure; however, of the high cost and a paucity of accessible land, doing so has proven to be more difficult. Water shortages, aging infrastructure, and dwindling funds are all concerns that the water industry is grappling with on a global scale, although in various ways. By 2025, 50% of the world's population will live in water-stressed areas, requiring steps to prevent leaks and protect water quality because filthy water is linked to disease spread, such as typhoid and cholera. Each year, more than 0.8 million people globally are anticipated to die as a consequence of polluted drinking water, underlining the need for large-scale solutions to help with irrigation systems (Chew et al., 2020). The research found a significant number of restrictions in the transmission infrastructure, which increased the demand for long-term storage by a significant extent. The researchers stated that different technologies can help reduce the cost of water.

As the world advances at a rapid speed, and many technologies are being introduced in the market daily, mass notification and weather management is technology that was introduced in the business market and has become the most significant one for the application of IoT in smart cities. Because of the advantages provided by IoT, many executives and managers prefer using mass notification and weather management for their use. The reason for this is that mass notification and weather management provide complete information about the application of IoT. This data analysis helps with making certain decisions that are in the best interest of executives or managers. Mass notification and weather management serve as the best decision maker for any type of business. This article addresses information on the advantages of IoT, how it has served the world of business, and how it benefits mass notification and weather management functions. The research shows that the methods for adopting and utilizing IoT and having successful results from it have been increased over time. These advancements have been observed over the last two decades, and this article makes it evident that organizations have not yet made full use of mass notification technology. They still lack in some places and are attempting to have an impact through the incomplete use of the technology. The articles systematically discussed these points and looked for the areas that have been neglected throughout the process (Huang and Nazir, 2021).

IT development and the progressive digitization of activities have made adequate technological transformations in the business environment indispensable. Companies that invest in innovation and business technologies increase productivity and gain a competitive advantage. Future automation provides companies with know-how, tools, and highly specialized personnel to address change in the simplest way. An integrated but versatile system can assist customers in meeting their specific needs—from consultancy and the design of technological systems to a "turnkey" service for installing and configuring hardware and software platforms.

An AMI is a meter configuration that enables two-way communication between different applications and their respective service providers. Applications typically have an IP address through which they connect to a server and send status information. Although many energy metering applications have been developed, AMI is unique in that it can accurately display the amount of energy consumed and the associated cost in near-real time.

Smart meters are increasingly used in the electrical industry. Smart meters are no longer simple devices that just record and transmit data for billing purposes. Functions such as remote disconnection and reconnection are planned in advance to take into account changes in the household. In addition, smart meters are intended for use as a customer communication tool to encourage efficient water use. Trolley patrols alone can cost millions of dollars a year to fix faults (Hansen et al., 2017).

Hydro One is one of the largest electricity transmission and distribution companies in North America. It serves 1.3 million customers over a large territory, mostly in rural areas. Ontario was one of the first countries to deploy smart meters on a large scale as a result of a provincial government decision in 2010. According to Vaz, the platform's various tools can be tailored to the business needs of each company, its AMI network, and its topology. For example, PLC and RF networks are the most common network architecture in Europe and North America, respectively.

In addition, it is a "completely neutral solution that combines Information Technology (IT) and Operations (OT), merging data and providing a single view of the LV network." Regarding fault management use cases, Bettencourt explained that a fault management application is based on the “last event” principle, for which a faulty meter sends a “last event” signal that can be used to determine the current state of the network in real time.

Bettencourt noted that this process helps determine the extent of the fault—whether behind a fuse or repeater or just within the customer’s territory. He noted that the average recovery time when unmetered is approximately 42 seconds, whereas the average recovery time is eight seconds when metered. In addition, the Hydro One smart meter is a first-generation model, and the second-generation model should perform better.

This smart meter detects faults more quickly, often before the customer is aware of them, and more accurately guides personnel to the fault location. Bettencourt also noted that another benefit is better customer service. When a customer calls about a fault, Ping can determine whether the cause is a system failure or something else, such as a breaker in the home (Mohassel et al., 2014).

“This way, we can communicate differently with our customers. Before, we had to send a command to the site.” The system is the core of the Holley AMI solution. ESEP uses a hybrid B / S and C / S system based on .NET / Java architecture and a topology graph and integrates data management over the Internet as its core business. The ESEP system measures, collects, and analyzes energy consumption and communicates with metering devices on demand or on schedule. The meter data management system (MDMS) is used to collect data from smart meters and store them in a database through process meter demand, energy, snapshot, and billing data, and provides data analysis and line loss analysis results or a report to the customer. The MDMS data are always transferred from the digital meter via a wireless network such as NB-IoT. The meter data is first transferred to a head end system and then to the MDMS through an API or direct connectivity. The MDMS normally uses an application enablement platform and a dashboard to report the data.

Utilities will use different dashboard reports to monitor the status of the meters, alarms, and events, and battery-related issues.

A prepayment system is a flexible vending system that supports different vending and medium channels. This system helps the tool improve the route of the meter for billing and settlement in cash, improves their liquidity, and guarantees the investment. Over time, 5G may become an important factor in ground-breaking solutions to these problems, allowing distant job opportunities to assist troubled governments in improving productivity and lowering costs by providing more data on environmental quality and leaks and enabling remote job opportunities to assist troubled governments to improve productivity and reduce expenses. In terms of increased water security, cost savings, and global health, 5G's prospects in the water market remain bright. The influence of 5G technology on our everyday lives will be substantial. The management of the water cycle and the manner in which this technology may aid with water resource management is one of the most critical, if not the most visible, applications of 5G (Gohar and Nencioni, 2021). Holley AMI can be integrated with third party interfaces (APIs), such as banks or clearing firms, to provide value-added services through various sales methods and 24/7 services. The interface enables access to the data, charging, relay checking, and meter data management.

A phenomenon of such a transformational nature is big data. In the first place, big data is associated with a flood of data from intelligent networks and an advanced measurement infrastructure. However, the essence of big data is the ability to process huge amounts of unstructured content, such as from, for example, the social media domain. In this area, a significant extension of the functionality of UCIS (Utility Customer Information Systems) should be expected. Analyzing data from social media, even if the sender of the information is not identified, can help with the effective monitoring of customer feedback and detecting significant changes in customer preferences. Using data to develop personality profiles of end recipients, who themselves are eager to publish on websites, such as Facebook or Twitter, and combining them with detailed data on water consumption obtained through an advanced measurement infrastructure will allow CRM systems to achieve unprecedented functionality and will most likely translate into advanced personalization of product offerings. In turn, this possibility raises the question of whether the billing systems will keep pace with the creativity of commercial services.

Therefore, in our work, we identify a new area of development in which UCIS systems will evolve. The introduction of personalized offers targeted at mass customers creates the need to develop "advanced billing," in which the paradigm of batch settlements is abandoned in favor of real-time settlements or, more precisely, settlements "on demand." Advanced billing means not only the need to settle new products, such as through interval settlements, previously reserved for large collection but also the necessity to support various billing models for consumers and, above all, the possibility of using individual billing cycles for each—also individual—final recipient. The implementation of new billing systems will be a significant challenge for both the energy and water industries and for most suppliers of this type of solution (Kalogridis et al., 2010).

To date, the most spectacular case of big data adoption in the energy sector is related not to sales and marketing but to network maintenance. The network operator in New York state (NYISO - New York Independent System Operator) used software during the removal of the effects of Hurricane Sandy, and it searched on Twitter for information on power outages, network failures, and transformer station failures. Using geolocation data automatically added to the photos posted on the website, the key points of network damage were identified, which allowed for a significant reduction in the time needed to restore everything to full functionality.

IoT is another phenomenon that will have a significant impact on the development of UCIS systems. The possibility of identifying the receiver already makes it possible to implement the concept of “energy roaming,” which is used, for example, in the billing of energy collected when charging electric cars. A “side effect” will be the creation of temporary alliances of energy sellers and suppliers of energy receivers, which will enable the construction of combined offers (e.g., buy an X freezer, and you will get a 50% discount on the energy it consumes). However, before this happens, a discussion is necessary that will allow for the re-establishment of the devices that can be the source of billing data, how to protect the privacy of end user data, and how to divide the responsibility for the implementation and maintenance of IoT in the utility sector between distribution and sales. These questions are being asked all over the world right now. The role of regulators seems to be to find answers to them. Unfortunately, discussions on the protection of customer data are conducted in response to the sometimes-controversial activities of companies such as Google or Facebook instead of being initiated by entities with high public trust, operating, for example, in the power sector.

In only a few years, technological advancements have resulted in significant benefits in a variety of social and economic activities. More complicated, quicker, and better problem solving is possible with 5G. Networks will become much more adaptive in the future, allowing us to connect more low-complexity devices to IoT and maintain more steady connections. They will also make it easier for us to swiftly process data. The flexibility of 5G, along with advancements in other areas, such as sensorization, results in circumstances that provide a wide range of alternatives, many of which are positive. Many of the 5G applications and enhancements to water resource management will be related to any device that can connect to a sensor and provide data. Essential infrastructure companies, such as water utilities, will be able to build their own communications infrastructures utilizing the concept of "network slices," which will be critical for planning and monitoring use cases for these communications networks (Guevara and Auat Cheein, 2020). Electrical measurements, apart from measurements of mechanical quantities and temperature, are one of the most frequently performed measurements of physical quantities in industry. On their basis, knowing the technical condition of the tested devices and determining the energy consumption and the correctness of the technological processes carried out is possible.

Often, the measurement of the phase shift can also be important. These parameters allow for the determination not only of the technical condition of individual devices but also the correctness of their operation in relation to the production cycle or technological process. Too high energy consumption or anomalous power consumption may indicate, among others, upcoming failures or the incorrect selection of devices for the needs of the technological process. Thanks to this, any irregularities can be reacted to very quickly, and breakdowns can be prevented. "Edge computing" will enable us to create decision-making algorithms and employ sensors to detect water leaks, anticipate water quality readings, and give processes such as machine learning and artificial intelligence some autonomy as they grow more efficient over time. Operators may now provide remote technical help using augmented reality calls, eliminating the need to travel. Autonomous vehicles might be utilized for planting and harvesting in the agriculture industry. Many lives will be changed in the medium future by smart 5G adaption with the stated goal of strengthening water infrastructures and ensuring safe access to drinking water and sanitation systems (Zhou et al., 2021).

From the point of view of an energy company, measurements of the aforementioned parameters allow for the determination of not only the energy consumption necessary to calculate "water" charges but also to plan energy supplies on an ongoing basis or anticipate for at least a dozen or so months in advance the need to expand the power network related to the constantly growing demand of individual water customers in a given region. Using this knowledge, power grids can be dynamically managed in a way that does not cause blackouts, that is, extensive power failures.

The COVID-19 pandemic has shown how connection has grown in importance as a crucial component of essential infrastructure, allowing people to work, learn, and interact in new ways. Last year, household broadband service use increased by two and a half hours each day, whereas mobile usage jumped by one hour. Variables related to high usage included the 490% growth in telemedical acute medical visits in healthcare, a 75% increase in online gaming during the socialization process, and a 74% growth of retail online money transfers globally, as per the World Economic Forum's first 5G Outlook Series study. Sixty percent of white-collar workers have expanded their use of video calls at work, as per Ericsson's Mobility Survey (Micallef et al., 2020). Currently, practically all industrial electrical measurements are made using digital measuring devices; however, this does not mean that analog devices have completely disappeared from the market. For practical reasons, their use has been reduced almost exclusively to scientific and research laboratory measurements, for which the work requires no external power source, exceptional simplicity of construction, and many years of reliability.

The most significant disadvantage of analog devices is the inability to cooperate and exchange data with industrial automation and computer measuring systems. The "analog" exceptions include the commonly used analog water consumption meters that, until recently, were used on a mass scale by energy companies, primarily for individual consumers. The reason was their simple construction, low price, and long-term operational reliability. However, given changing regulations and the automation of energy readings without human intervention, they are now being gradually replaced with intelligent digital devices (McLaughlin et al., 2010). The networks performed successfully despite the unforeseen and quick traffic patterns and requirements, with providers offering appropriate connection speeds in the vast majority of situations. Users appreciated the excellent level of performance, with 83% saying that ICT assisted them in some way in dealing with the lockdowns. Without investments in 4G and 5G, none of the services, such as telemedicine, video conversations, and entertainment, could have been supplied to the extent shown during the outbreak. With vaccines, the chance is that society may attempt to pick up where it left off before the outbreak. However, the world clearly cannot advance if the globe returns to pre-pandemic circumstances. We must not only continue but also further accelerate the digital transformation, with 5G at the vanguard, if the world is to escape stronger from COVID-19 and face deeper challenges, such as changing climate.

Digital measuring instruments are based on processing a continuous analog input signal into a numerical value of the measured quantity, which can be displayed in decimal form on the display and / or binary transmitted to the automation system via an integrated communication interface. When measuring electrical values with a digital instrument, the accuracy of the measurement depends on its digital resolution related to the measuring range and weight of the last digit and its basic error. The basic error of a digital device consists of two elements: the error of the analog part, indications of which are sampled to the digital value, and the error of the digital part, which is related to, for example, accuracy (resolution) and the sampling rate, as with analog instruments (Liu et al., 2011).

As a reminder, the accuracy class of a measuring instrument defines the maximum absolute error calculated as a percentage error in the full measuring range of the instrument. Therefore, for example, the indications of a class 0.5 electric meter in rated conditions are affected by an error not greater than 0.5% of the maximum value of the measuring range. Currently, measuring instruments are classified into one of eight standardized classes: 0.05; 0.1; 0.2; 0.5; 1; 1.5; 2.5; and 5. The vast majority of digital meters used in industrial conditions are classified in the 0.5 class.

Different technologies work for different purposes, and the choice made is based on specific needs. Subsequently, a comparison of the most popular technologies and a summary of how they meet different smart metering needs in a network of 16-year meters is provided.

Smart water management systems are becoming increasingly important in water utilities around the world. See why these utilities are updating their system to improve meter reading efficiency and accuracy, reduce non-revenue water, improve customer service, and more.

Smart water management systems are gaining prominence in water utilities around the world. These systems are believed to improve meter reading efficiency and accuracy, reduce non-revenue water sources, strengthen customer service processes, and much more. Compared with other AMI systems that require network infrastructure to be deployed and maintained, Badger Meter's Infrastructure-Free AMI is a preferred choice for utilities. Authorities still take the long approach in assisting with the implementation of 5G if they want to leverage technology to ease environmental and economic concerns while concurrently lessening inequality. With features such as high speed and low latency, 5G is intended as a framework for enterprises to go forward with efficient, low-cost, low-emission usage, and to promote other technology, such as IoT and cloud computing. 5G applications in manufacturing settings include automatic warming, ventilating, climate control, lighting levels, and infrastructure solutions. Many of these 5G possibilities, as well as the accompanying economic and environmental advantages, are addressed by Ericsson's 5G Smart Manufacturing (More et al., 2020).

Badger Meter realized that the market needed an alternative to traditional fixed network systems and invented an AMI solution that eliminates the need to deploy a gateway infrastructure using existing cellular networks. Utilities no longer need to obtain permits to build expensive radio towers or lease infrastructure to third parties. Instead, they deploy cellular networks as a service (NaaS) from a single provider, which provides the superior network performance and data security that any utility requires.

With cellular NaaS, utilities realize the benefits of an AMI solution as soon as the devices are deployed. This flexibility allows them to focus their efforts on providing quality drinking water and improving their operational efficiency, while the network operator provides continuous monitoring of the network to ensure that it runs smoothly without intermittent outages, manages the network 24/7 to repair problems and outages immediately to avoid service interruptions, and maintains the network and system (absolutely no maintenance is required from the utility).

Because cellular networks are designed to meet or exceed 99.9% reliability, potential reading failures and interruptions are virtually eliminated. In addition, the utility does not need to deal with contracts and negotiations with the cellular provider, which is already included in its deployment costs and annual subscription.

Fortunately, innovative engineering and construction companies around the world are already addressing the issue. By leveraging digital water management strategies, they are improving utility operations to ensure greater sustainability and service resilience. The combination of building information modeling (BIM) and the cloud helps water treatment plants modernize and better manage municipal water treatment infrastructures from Brazil to Bordeaux. Existing resources are optimized, and new stations are built to address extreme weather conditions and reinforce wastewater treatment.

Although ubiquitous, the amount useful for human activities is extremely unevenly distributed. Of the approximately 1,300 million km³ of water on the planet, 97.2% is made up of salt water that is unusable for human activities; of the remaining 2.8%, 2.15% is "trapped" in polar ice. The remaining 0.65% includes 0.62% in underground form. The water cycle ensures a level of terrestrial precipitation of approximately 113,000 km³ per year, from which 72,000 km³ of evaporation must be subtracted to obtain the net flow available; of the remaining total, 32,900 km³ are considered geographically accessible; however, the timing of this precipitation must also be considered. Most of the precipitation is concentrated in short periods and results in flooding; 9,000 km³ remain effectively accessible. If precipitation water retained in dams is added, 12,500 km³ of fresh water are available each year for human use, representing more than 5,000 liters per person per day worldwide, and the largest users (the Americans) withdrawing "only" 1,800 liters daily. These figures could give the impression that water is overabundant; however, its unequal distribution at the inter- or intra-national level makes water an inaccessible resource for a large part of the world's population: nine countries share 60% of the freshwater resources (Brazil, Colombia, Russia, India, Canada, United States, Indonesia, Congo, and China). Some countries considered to be water-abundant have regions devastated by the lack of water (for example, in India) (Finkle, 2016).

The third characteristic of water, the availability in fixed quantities on a planetary scale, obliges us to consider the notion of water supply as a geophysical and economic reality. The geophysical reality is dictated by the laws of conservation, which means that the resource cannot be destroyed or created and that its "infinite" renewal is ensured by the water cycle. To this, we must add that water can be conserved in evolving forms and that the latter can modify the accessibility to water. From this point of view, climate change will very probably play a decisive (and negative) role in the future availability of water insofar as the water cycle is one of the most sensitive systems to the phenomenon, with impacts on accessibility to fresh water. The economic reality is that the water supply cannot react to market signals, as is the case for all other primary resources: adjusting the water supply can only be done at the margin through less wastage and better use of the available resource (increase in the productivity of water use). Furthermore, a number of 5G use cases exist in farmland, where the combination of monitors and other compatible devices allows farms to produce more while using fewer precious resources, such as water. Agroscope, a Swiss agricultural research organization, is one of the examples offered. Real-time sensors detect soil moisture, crop growth, weather information, and animal behavior in the facility. Farmers have been able to reduce nitrogen fertilizer use by 10% without a commensurate loss in crop output because of these monitors. Broadband and 5G, as per the European Commission, offer the foundation for the economy's ecological and technological advancements irrespective of whether people are talking about mobility and electricity, education and health care, or manufacturing and transport. However, an exception exists to this economic "law" dictated by geophysical constraints: the desalination of water, which effectively makes it possible to increase the availability of fresh water almost indefinitely (and which would, in a way, play the same role as the development of renewable energies in another field).

If the water supply can be considered in many respects as fixed, we find the main explanations for the scarcity of the resource on the demand side. This situation has evolved during the past few decades mainly under the impact of population growth and rising standards of living. Population growth has been authorized by—and has at the same time led to—a sharp increase in irrigated areas for agricultural activities: these have doubled in 60 years, whereas the quantity of water used by agricultural activities agriculture has tripled. In addition, an increasing number of consumers have become increasingly water-intensive—in rich countries, of course—

but also increasingly in emerging countries with the development of the middle classes: with nearly two billion people on the verge of middle-class status, water consumption is bound to increase even for a stagnant population because of changing diets. Four times more water is needed to produce a kilogram of beef than a kilogram of chicken, and five times more water is needed to produce a glass of orange juice than a cup of tea.

Agriculture is still by far the most water-intensive sector and contributes to 70% of withdrawals and 93% of overall consumption, mainly in developing countries in which agriculture remains a major activity. From this point of view, agriculture is the most problematic sector for the management of water resources: the growing demand in the agricultural sector is less and less satisfied by the use of rain and surface water but more and more by underground withdrawals, often leading to the depletion of the resource.

However, given an increase in living standards almost everywhere in the world, the two other categories of levies—for industry and domestic activities—are seeing their shares increase. They account respectively for only 22% and 8% of global levies, but their increase was twice as rapid as for agriculture during the second half of the 20th century.

The result of these changes is that water withdrawals increased twice as fast as the world population during the 20th century. Moreover, given trends in economic growth and improving water use productivity globally, the gap between supply and demand is predicted to be 40% by 2030. There is no Kuznets curve for accessibility to water resources; however, in contrast, an ecological footprint in this area is very closely linked to the level of development (Hahn and Govindarasu, 2011).

To speak of the scarcity of water resources in general does not make much sense. Among the characteristics of water and the issues that arise from it, one of the most significant is the local and temporal nature of its availability, which is a function of very contextual parameters, a mixture of geophysical, climatic, demographic, and socio-economic characteristics, which contribute to making water an extraordinarily badly distributed resource globally and whose management is based on essentially local parameters, as previously indicated.

This infrastructure integrates hardware (advanced meters, measurement management centers, routers, concentrators, antennas, and others), software, architectures, and communications networks, allowing the operation of the infrastructure and the management of the energy distribution system data. In other words, this modern infrastructure measures electrical energy consumption, which takes advantage of communications systems and technological advances. Traditional electrical networks are in a gradual evolutionary process because of the linking of new technologies and are becoming Smart Grids. Thus, the electric power chain obtains added values by creating new markets and services to solve the current needs of the systems. A key element within this transformation is the smart meter, which allows articulating the relationship between the electrical system and the final energy consumer and determines the type of commercial and technical relationship between the agents involved. An AMI can be defined as the integration of several technologies that create an intelligent connection between system operators and consumers to provide the latter with the information, they need to make decisions that result in greater benefits.

Projects and initiatives associated with AMI systems are the focus of the electricity sector worldwide, especially in developed countries in which success stories exist related to the implementation of these technologies. In Colombia, pilots involving smart meters are being developed. Some energy distribution and marketing companies have made initial deployments with different levels of development in cities, such as Bogotá, Medellín, and Cali. However, they are isolated projects that are not framed within national guidelines. A route map also defines gradual implementation phases for AMIS systems in Colombia by 2030 and with the first regulatory initiatives through a draft decree to establish public policies that encourage small-scale self-generation, demand management, and smart metering. Many pieces of the puzzle still need to be specified to allow the implementation of AMIS systems in Colombia (Li et al., 2012).

This article's purpose of contributing to the construction of a global panorama in Colombia enables it to present a general conceptual framework associated with AMI systems and a review of relevant international experiences (Zabaloy et al., 2019). From this, the priority functionalities for the measurement systems in Colombia and the benefits associated with their use for all actors of the system are established. The current panorama of Colombia in the face of this technology and some future scenarios of the mass use of smart meters are also presented. The existing barriers to obtaining the proposed futures are analyzed, and general guidelines are proposed for the solution to these obstacles. Finally, some cases of the use of AMI technology are considered that are associated with the generation of new markets.

Measurement accuracy depends on the accuracy class of the measuring instruments used, the selection of the appropriate measurement method, and the consideration of the conditions resulting from the specificity of the tested object and its parameters. Measurements should be made with the highest possible reasonable accuracy. Using expensive laboratory class instruments (classes from 0.05 to 0.2) for measurements in industrial conditions makes no sense, as well as relying on the indications of class 2.5 or 5 instruments, which will be burdened with too large an error that could affect the correct interpretation of the results and the decisions made on their basis regardless of whether it will result in the incorrect charging of fees (Mo et al., 2012).

Also worth remembering is that the applied method of making measurements should be the simplest method that will ensure the achievement of the required measurement accuracy. The choice of the method itself and the necessary measuring instruments should be dictated by the knowledge of the construction of the device, the technologies used in it, and the electrical installation infrastructure used. Therefore, before choosing the measurement method, reading the technical documentation of the device and the technical documentation of the electrical infrastructure of the facility, as well as comply with all of the requirements of the relevant standards, is absolutely necessary.

The latest generation measurement systems used in the power industry enable not only automatic measurements of electrical values but also two-way, digital communication—including sending measurement data with a given frequency, data visualization, and full scalability of the system, enabling its expansion at any time. The most visible elements of the smart metering system are smart water meters that, according to Directive 2009/72 / EC of the European Parliament and the European Council of July 13, 2009, are to become part of the so-called third climate package and must be operational by 2020 in 80% of European countries, including Polish water consumers. In this way, the provisions of the aforementioned Directive were fulfilled in the scope of providing the European Commission with information on the benefits and costs of implementing smart meters and the use of smart metering technology.

The mentioned latest generation of water metering systems that enable two-way, remote data transmission from meters is the so-called smart metering technology. This technology It is part of the Smart system and the advanced metering infrastructure AMI. AMI is a system that includes metering devices (smart meters), networks, computer systems, communication protocols, and organizational processes that allow obtaining data on energy consumption and parameters for each recipient. In the Polish literature, the term Intelligent Energy Network (ISE) is also used very often, which is narrowed down to the technical elements of

AMI without considering the organizational and decision-making processes related to the management of electricity transmission.

From the point of view of the power grid operator, the introduction of intelligent energy meters allows for reacting to changes in energy demand for a given region and more efficient use of renewable energy sources. Research carried out in Europe showed that such an increased awareness of expenditures among society and entrepreneurs and the possibility of checking one's balance on a current basis result in greater self-control and generates further savings of water metering expenditures.

One of the comprehensive IT energy management systems is the moniTorus system, available from the Apator group. MoniTorus allows for energy consumption to be optimized and expenses to be rationalized in the future. The system not only informs about energy consumption exceedances at individual measuring points but also reports energy losses by comparing the input meter indications with submeters indications. Also possible is determining the level of energy losses and internal flow and the costs of unused ordered power. The technical reports module allows for the creation of charts, summaries, and comparisons, as well as an analysis of the percentage share of the department or process consumption relative to the consumption of other organizational units of the company. An interesting option is the ability to visualize the operation of devices.

The moniTorus information and measurement system cooperates with a number of smart meter models. Apator offers its users intelligent meters from the smartEMU, ESOX, EQUS and CANGU series to cooperate with this system and allows for direct bi-directional and reverse active energy measurements in a multi-tariff prepayment mode or fully autonomous credit mode. In addition to energy measurements, the following electrical network parameters are measured: RMS values of currents and voltages, frequency, power factor, and instantaneous and maximum power. The device is designed for two-way communication. Depending on the customer’s needs, removable PLC, GSM, RS-232, RS-485, SRD, or other communication modules are used. The new billing process reduces meter reading errors and the resources required for its execution. Through the management of historical consumption, anomalies can be detected, and fraud maps of the network can be created. Specific sectorized services can also be offered according to the type of end user. The AMI infrastructure enables markets, such as the inclusion of electric vehicles and the sale of prepaid energy, to expand their service coverage (Mohassel, 2014).

CHAPTER 10: CONCLUSION

The profound insights into smart water management and the seamless integration of energy efficiency technologies are truly enlightening. Advanced Metering Infrastructure (AMI) technology boasts a plethora of advantageous outcomes for water systems. Smart water grids, in addition to efficiently managing water distribution, also exhibit advanced monitoring and conservation capabilities. The integration of energy efficiency systems with smart metering technology not only promises enhanced water management efficiency and cost-effectiveness, but also augurs well for optimizing the overall performance of the water system mechanism.. The integration of energy efficiency sources in smart metering is analyzed critically. Smart metering technology integrated with energy efficiency resources provides various opportunities to power systems. A power system with these technologies can provide better water distribution. In short, the traditional water distribution mechanism can be made more efficient and beneficial through smart meter technology. The latest technologies can not only improve the power system but also significantly reduce the costs associated with power systems. Such changes have the potential to revolutionize power systems (Liu & Su, 2008).

The authors also elaborated on energy efficiency in smart metering. In this study, the researchers performed an economic assessment of smart meters and how smart metering can be utilized more economically. The researchers also analyzed the stochastic traits of PV, wind, and other renewable energy resources that are modeled using the Markov approach (Adefarati and Bansal, 2017). An intelligent gadget known as a wireless sensor performs the same functions as a GPS unit. Even sensor technology in electric cars is preferable to a GPS gadget in terms of efficiency. In the proposed work, the goal is to develop an IoT-based solution to regulate charges in cars, as well as to investigate its use in the external environment by transferring data over long distances. Individuals' lives are being saved through the employment of this predictive approach because this system may result in a shortcut, which will cause significant harm to human life. To achieve this goal, the major conclusion of the proposed study is to investigate the maximum charge potential range with respect to established voltage limitations. These parameters will be computed using a gradient boosting technique, which will result in low inaccuracy in the forecast. Because this technology considers the data transmission method, in which the evaluated information will be sent to the control center, utilizing IoT-based technology with a cheap installation cost to achieve the desired results is important (Martins et al., 2019).

By having information from the AMI system, the marketer can implement a rate system that takes into account not only the electrical power but also the energy, which represents income for the energy consumed and for that contracted in the retail market. The inelasticity of demand can also be modified, and the aggregator role can be enabled, which is responsible for grouping multiple users to present them to the distribution system as a single entity. The increase in the energy efficiency of the electricity system has a positive impact on the environment by reducing CO_2 emissions from thermal plants and enabling participation to renewable energy sources. The appropriation and use of new technologies promote the need for trained human resources and raises the educational and technological level of society.

With data analysis from the BOM report the conclusion was made that the leakage is resulting in non-revenue water and the cost of non-revenue water is almost 3% to 8% for residential users(Bureau of Meteorology, 2022).

The cost of smart water meter deployment can be recovered from the saving of non-revenue water leakage.

Below hypothesis and calculation methodology was used to find out the total cost of the project for different sizes of utilities, for example, a utility with 10,000 meters connection or 100,000-meter connection will have different total cost of the project over 10 years.

There are total 85 water utilities suppliers with more than 10k Meters

Out of 85 there are 53 water utility suppliers with complete billing information for last 10 years from 2010-2011 till 2019-2020(Bureau of Meteorology, 2022). Average bill of these 53 water utilities supplier per meter is $1308 an increase of 2.29% bill per house which equates to $5.53 per year, average of last 10 years bill was taken for 53 water utilities assumptions were made to calculate the average saving per year per house. Starting from 1% up to 8% water leakage saving per month. Assuming 1% saving and using that saving to pay for the project rollout and distributing it in 10 different cost items of the project, these can vary for each utility but for assumption purpose we can use 10 variables.

For example, hardware will cost 20% of the total project cost and project management will cost 5%.

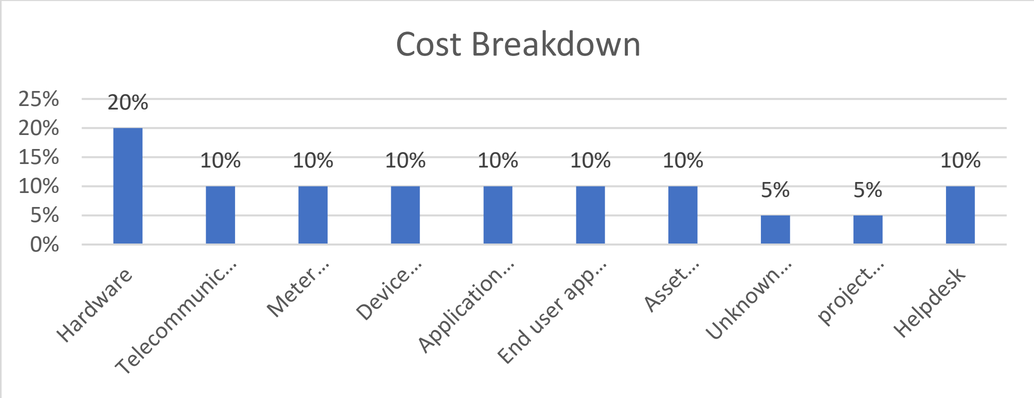

Figure 14 Cost Breakdown

On average, for 1000 000 meters and a 10-year project plan, a council should expect to pay between $36 million and $60 million based on these assumptions and calculations for 3% saving up to 5% leakage saving.

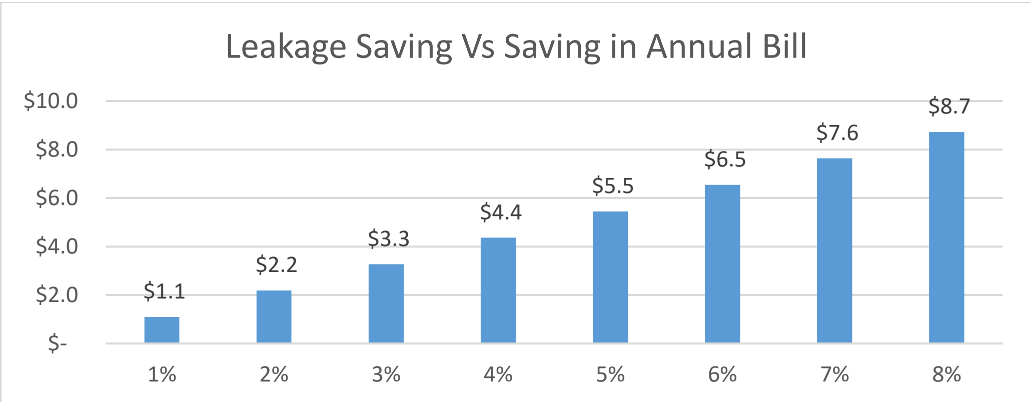

Figure 15 Leakage Saving

A saving of 5% water will result in $5.5 monthly saving in water bill. The cost of project over 10 years with $5.5 per household per month will be enough to complete the project.

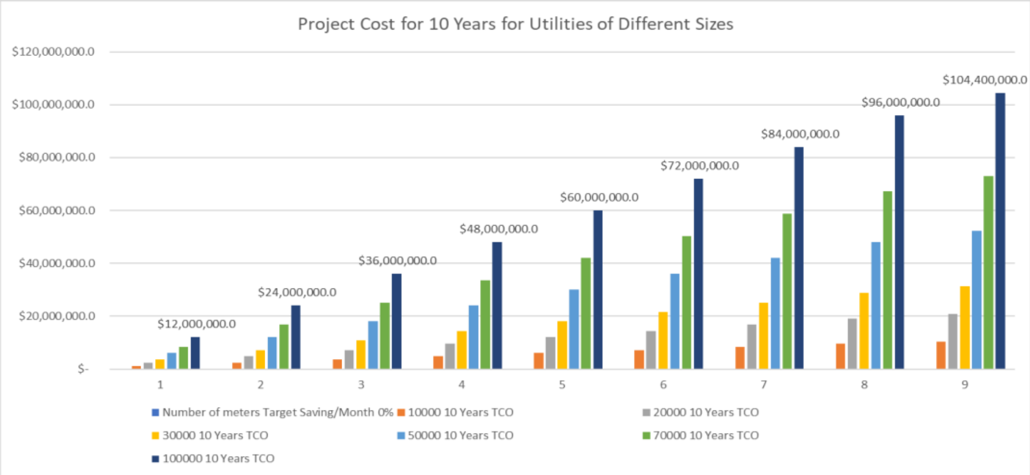

Figure 16 Total project Cost

The proposed solution and framework have been implemented in Australia, albeit still in its early stages of development as compared to the comprehensive end-to-end solution discussed and proposed in this thesis. Over the next two to three years, the infrastructure and digitization efforts are expected to progress towards aligning with the innovative approach presented in this thesis. The successful implementation of this approach serves as evidence of the significance of this thesis and the value of the research work conducted.

The characteristic feature of the meters is the extensive possibilities of measuring and recording voltage, current, instantaneous power, and maximum power. The meters have a built-in PLC communication module compatible with PRIME or OSGP technology. Models also exist with a GSM / 3G communication module that allows the meter to be installed in remote locations. Importantly, the DLMS / COSEM communication protocol is supported here, enabling fully secure and encrypted data transmission between measuring devices and the data acquisition system (Sullivan and Kamensky, 2017).

Worth paying attention to is the fact that this type of device has other names, such as power network analyzer, power quality analyzer, network parameters analyzer, or network parameters recorder. They all inform that the device is equipped with a non-volatile memory that stores the measurement results and a communication module that allows for bi-directional data exchange. Most often, Modbus RTU (RS-485), Modbus TCP (Ethernet), Profibus, Profinet, M-bus, and BACnet IP are found that also support the http protocol.

Power quality analyzers, unlike energy meters, in addition to the amount of active energy (sometimes also reactive), can also precisely measure voltage and current in real time. On the basis of these data, they calculate active, reactive, apparent power, active and reactive energy delivered, higher harmonics, leakage current, voltage frequency, voltage flicker, voltage imbalance, transients, and many other indicators. The direct reading of data from the analyzers, as well as from energy meters, is possible because of the LCD display. However, the number of parameters read from the energy analyzer is much higher.

Often, devices are equipped with communication interfaces that allow for remote reading. An advanced electric energy analyzer, Janitza UMG 104, available from Elmark Automatyka, is such a device. This analyzer enables the measurement and analysis of active and reactive power, higher harmonics, THD, and an unbalance in the network. The device can be communicated with using the popular Modbus RTU or Profibus DP serial protocol.

Another interesting device that can constitute a solid measurement basis for an intelligent power grid is the Lumel ND40 power grid quality analyzer. This analyzer allows for the registration of more than 500 power network quality parameters in accordance with the PN-EN 50160, PN-EN 61000-4-30, and PN-EN 6100-4-7 standards. This analyzer can aggregate measurement results in three-second, ten-minute, or two-hour intervals. The device can work in a three-wire or four-wire, three-phase, symmetrical, or unbalanced power network. Interestingly, the analyzer allows for the recording of up to 51 current and voltage harmonics from 1 to 51, as well as harmonic distortion factors. The basic aggregated values include phase and phase-to-phase voltages and currents and active, reactive, and apparent phase powers,

The device has a fully configurable archive of instantaneous values and an event recording system. Data archiving is possible on the SD card. RS-485 Modbus Slave, Ethernet 100 Base-T (Modbus TCP server), and USB interfaces can be used for communication with the Smart Grid system. To access the collected data, the embedded web server, FTP server, or the touch screen can be used. In an emergency, the device can send information about the event by e-mail.

As indicated previously, water conflicts can be perceived as situations of competition over the allocation of the resource that cannot be managed peacefully for political reasons and whose origins are not necessarily related to the water problem. These conflicts generally arise during the exploitation of the resources of transboundary river basins or aquifers. Either way, these situations require some form of international or interregional cooperation to avoid violent conflicts. This cooperation is by definition difficult to obtain because the situations generally resemble zero-sum games (when a country exploits the hydroelectric potential of a river upstream to the detriment of another country downstream) or cases of tragedy of the commons (when it comes to exploiting a transboundary aquifer) for which the incentives to cooperate are weak. However, a number of relative successes exist in this area, as in the cases of the Nile or the Mekong. The entire issue of negotiations in these conflicting situations rests on the means of increasing and sharing the benefits of the exploitation of the resource. In some cases, that appropriate management of the resources concerned makes it possible to generate gains that can be shared by the potential partners of an international agreement can be demonstrated. In many other cases, conflict and cooperation are closely intertwined and make the situation more difficult to manage.

According to the WHO, the COVID-19 pandemic is the most significant public health disaster since the 1918 influenza pandemic. This thesis and the COVID-19 paper in this thesis examined digital healthcare in-depth to better understand the area and aid in the fight against the COVID-19 pandemic. This paper provides context and an overview of research on digital healthcare. Regarding the COVID-19 pandemic, it examines applications and problems and concludes with the future potential of digital healthcare. Initially, on the page dedicated to background material, the essential principles, important development methodologies, and typical application scenarios for incorporating electronic health records and digital healthcare were explained. Researchers conducted a bibliometric analysis to examine the significant research done, including geographical and interdisciplinary distribution and collaboration networks before and after the COVID-19 outbreak. We found that the COVID-19 epidemic has pushed the study of digital healthcare and healthcare systems research. Additionally, we identified, collected, and examined research papers from China, the EU, and the United States. Researchers stated that COVID-19 can be defeated using big data, AI, cloud technology, IoT, and 5G. The mobile handset and data captured by mobile-like photos, selfies, and voice recordings can be used for the self-diagnosis of COVID-19. The use of these technologies in real-world situations shows their value in minimizing COVID-19 virus propagation. If China is to avoid the second COVID-19 epidemic wave, it will need to successfully integrate digital media and public health on a massive scale. In the fourth segment, digital technology can be used in public health. One of the primary reasons for these problems is the lag time and data fragmentation, as well as privacy and data security problems. Finally, this research examines how digital healthcare will be used in the future. Other countries battling COVID-19 with digital technologies can benefit from our policy ideas and novel-based approach proposed in the COVID-19 self-management research paper. COVID-19 is gaining traction around the world, with an alarming rise in infection cases. According to several studies (Swan, 2013), the global pandemic is expected to reappear in the fall and winter. More than a quarter of the total number of people who died because of the pandemic were in the United States (Swan, 2013). The pandemic situation is getting worse as new cases are discovered daily (Karthika & Kalaiselvi, 2021). The COVID-19 outbreak was initially detected in China, which was the first country to eradicate it. Chinese non-pharmaceutical intervention measures throughout the first wave of COVID-19 were successful in controlling pandemic transmission and reducing the magnitude of the pandemic (Radanliev et al., 2020). Within 50 days of the outbreak, at least 744,000 COVID-19 cases were projected and were confirmed outside of Wuhan (156,000). On February 19, 29,839 verified cases were found outside of Wuhan, a 96% reduction in cases compared with the situation before the interventions. Infections were also reported in Beijing (Karthika & Kalaiselvi, 2021; Radanliev et al., 2020; Abulibdeh, 2020). Non-pharmaceutical interventions (NPIs) were utilized in China to quickly contain localized infections while minimizing economic disruption (Silveira et al., 2020). Many studies linked China's successful NPIs to obvious initiatives such as "city lockdown"; however, little research has examined the technological components that contribute to this accomplishment (Zhang et al., 2021). To fil gaps in the research, this endeavor will analyze the technological measures that enable China's NPIs to use digital technologies, including big data, machine learning, and 5G communications. The Chinese government's successful COVID-19 management will be examined in this study, as well as the obstacles and future trends that digital technologies will face. This research may help in the fight against a potential second pandemic outbreak. The remainder of the sections are structured as follows. A brief history of digital health is presented in Section 2, which is followed by an analysis of digital medical research statistics in Section 3. Section 5 explains how digital technologies can help China fight COVID-19, and Section 6 talks about how they will grow and what that means for China's policies.

Since the beginning of COVID-19 in April 2020, the global social, economic, religious, and cultural frameworks and timetables have been thrown off balance and altered. In addition, the fear and panic associated with the new disease, which was only recently discovered by the rest of the globe, compounded the problem. Scientists, more specifically, epidemiologists were able to trace the first COVID-19 infection back to Wuhan, China, as the source. When the virus's genomic makeup was thoroughly investigated, it was discovered to be zoonotic, which indicates that it has moved from animals to humans through the transmission of genetic material. One key factor in the world's coming to a complete and absolute standstill was the widespread worldwide panic caused by the ambiguity associated with the virus's previously mentioned features and attributes, as well as the increased mortality that was reported in various places of the world at the time. Many different techniques and tactics were utilized by public safety authorities and agencies to restrict the transmission of the virus while scientists and medical professionals found a treatment to prevent COVID-19 from spreading even further. Given the diverse demography of various parts of the world, various attempts were made to properly utilize locally available resources to fight and reduce the harmful consequences associated with a COVID-19 pandemic. Resources and skills have been used to implement or modify the WHO's basic framework for reducing the effects of COVID-19, allowing the virus to have an effective impact in diverse parts of the world. COVID-19 is a disease that currently lacks a vaccine. However, novel technologies that can be deployed within weeks to stem the spread of COVID-19 are being developed; regarding current methods of disease control with respect to the security of users' data and the expense of cloud-based analytics, the proposed self-diagnosis method is a better option for end users than traditional methods such as contact tracing and testing (Radanliev et al., 2020). End users will have better control over their personal data and no privacy issues will exist with the proposed solution in this COVID-19 research paper. Self-management and self-diagnostics using mobile data will make it easy for the individual to control the spread of the disease and get their results at home without visiting medical centers for testing.

COVID-19 is the ancestor of all Corona viride viruses and is also the most common. An RNA virus has only one strand of DNA that is positive. When a person is exposed to this virus, he or she will have symptoms such as a fever, tiredness, coughing, and difficulty breathing, among others. Even though this virus has not been traced back to a known source, researchers have recognized it as a member of the COVID-19 family of viruses. Most of its DNA is taken from rodents and bats. On December 19, 2019, the Chinese city of Wuhan in the province of Hubei reported a human infected with this virus. According to the most recent estimates, COVID-19 has resulted in the isolation of at least 213 countries and independent territories. As of November 2, 2019, more than 60.5 million confirmed cases of COVID-19 were documented, with 566,355 deaths as a result. With the help of photographs 1 through 3, we can observe how many people have been killed and injured in the countries that have been most severely affected. Immediate action is essential to prevent a global pandemic triggered by COVID-19 from occurring. Following the publication of this article, these technologies will be crucial to reducing the detrimental consequences of this condition and aiding in its recovery. The economic consequences of COVID-19 should be known before modern technology and its potential remedies are learned (Karthika & Kalaiselvi, 2021).

According to the WHO, the spread of the coronavirus poses a threat to the general public’s health. According to scientific terminology, coronaviruses are RNA viruses with a diameter ranging from 600 to 1,400 nanometers. Recent years have seen an increase in the number of coronavirus epidemics that have occurred. During 2002–2004, a SARS-CoV epidemic occurred in the United States, and a MERS-CoV outbreak was detected in the Middle East the following year. It was only a matter of time until the SARS-CoV virus spread to the other thirty-seven countries on the planet. Recent statistics show that approximately 750 people died out of 8,000 cases, according to the most recent data. A virus called MERS-CoV has killed more than 850 people in the Middle East; infections began in Saudi Arabia and spread across the region (Radanliev et al., 2020).

There has never been a period like this in the history of humans. Everyone understands that coronavirus poses a risk to everyone, and everyone is concerned about it. Those who have been immunized against this strain of influenza and who are following regular operating procedures account for a considerable proportion of the population. Humans have developed resistance to the coronavirus, even though it has evolved to become more harmful and potent over time. A decline in coronavirus-related mortality has resulted in a reduction in the social fear of the disease around the world. Every day, an alarming number of people die in various parts of the world. Despite this, population growth does not always follow a straight upward line. Cloud computing using 5G has numerous benefits, and these are just a few. Because of the widespread usage of wired and wireless connections, the COVID-19 pandemic has had a significant impact on health care, education, transportation, and business. If these methods of communication had not been in place, the outbreak would have been more severe and widespread. Therefore, 5G networks are essential to our inquiry into COVID-19. The initial selection of firms affected by pandemics was done to provide an indication of the magnitude and complexity of the problem. These firms are now reliant on telecommunications networks to support their remote activities, putting a strain on the capacity of existing networks. That existing networks be thoroughly reviewed as soon as possible was critical to ensuring that business as usual could continue in the afflicted industries because of an increase in the demand for services. The greater bandwidth and improved technology of 5G networks will allow for the resolution of most pandemic-related difficulties. For COVID-

19, we stressed the importance of 5G and comparable technologies, as well as the limits of the current network architecture. 5G networks have the potential to aid in the prediction of future epidemics as well as the development of a civilization that is prepared to deal with pandemics by boosting digitalization and implementing large-scale automation. We can avoid being taken completely by surprise. Also discussed was how the outbreak affected the architecture of network infrastructure (Abulibdeh, 2020).

According to the data, twenty-eight instances of pneumonia caused by an unknown agent were discovered in December of this year. Several of these cases, which have been reported to the WHO, originated in China. In recent years, the rapid spread of COVID-19 has been linked to the outbreak of SARS. A person who has been infected with this virus may go for up to 14 days without showing any signs of illness. This virus has enormous potential for spreading across a population in a short period. If an infected individual becomes a silent carrier, the virus's potential to reproduce will be strengthened. The WHO says that after 2020, it will no longer allow certain medicines or Ebola vaccines to be used in developing countries (Silveira et al., 2020).

Symptoms might vary from an undiscovered ailment to potentially life-threatening respiratory distress syndrome (MODS). Patients with COVID-19 commonly experience symptoms, such as conjunctivitis, breathing difficulties, and sore throats. However, symptoms such as nasal congestion, diarrhea, and hemoptysis, as well as nausea and vomiting, are only seen in a small number of patients with the infection. The vast majority of those who were infected did not exhibit any signs or symptoms of illness. Only 6% of patients were assessed to be in critical condition by the attending physicians. Adults over the age of sixty, those with pre-existing medical conditions such as hypertension or cardiovascular disease, and those suffering from asthma are most vulnerable to COVID-19. Despite numerous studies that demonstrated the origins of COVID-19, it is still unclear how the virus travels from one person to another. Given the association between the outbreak and contact with sick animals or the consumption of their products, researchers are particularly interested in whether this virus can be transmitted from person to person. Coughing and sneezing are the most common ways in which this sickness is transferred among people. Even though asymptomatic individuals are still capable of spreading the virus, they do so at a lower rate than those who are ill. Depending on the circumstances, a droplet can fly up to a height of six feet. People who live near someone who has COVID-19 are more prone to contracting the disease, even if they do not display any signs or symptoms of the illness. Apart from direct or indirect contact with infected surfaces, researchers have uncovered several other modes of transmission. An investigation has found that steel, plastic, and copper surfaces make people susceptible to infection by this virus for up to three days. On cardboard, the virus has a short shelf life of a few hours. The nose is a typical entry site for infectious microorganisms that connect to cell receptors in the body. Through their ability to penetrate cell membranes, spikes on the SAR-surface Cov-2 incite cells to replicate the SAR-surface Cov-2. When a virus escapes from a damaged host cell and infects uninfected cells, the number of infected cells increases dramatically. Following that, the virus targets the air sacs in the lungs with ferocity, traveling through the bronchial tubes on its way. The remainder of the paper is organized in the same fashion as the introduction. In the following section is a list of individuals who have conducted research into the current COVID-19 outbreak and have offered an update on their findings. The last century has seen a number of epidemics. If a pandemic occurs, Section IV explains what to do. In the event of a crisis, emerging technologies such as AI and 5G networks can assist first responders. The subject of the paper will be returned to at its conclusion (Radanliev et al., 2020).

Many innovative technologies, such as AI and 5G, are being implemented to mitigate the effects of the COVID-19 epidemic on the worldwide population. Providing the most up to date COVID-19 pandemic methods is at the heart of our endeavors. The clinical characteristics of COVID-19, as well as its transmission mechanism, are investigated in the first phase of this study's examination. One-of-a-kind therapies that attempt to halt the epidemic, as well as the preventative measures that can be implemented until the pandemic is halted, are also discussed. A number of COVID-19's revolutionary cures were shattered during the post-conversation debates. Our major goal is to mitigate the consequences of the COVID-19 breakout by utilizing innovative technologies, such as AI and 5G. While a cure for this disease is being sought, modern technology will be the only thing that can control and limit the effects of the disease until a cure is found (Radanliev et al., 2020).

Water monitoring, water control, water quality testing, pressure and flow measurement, and a variety of other applications are being facilitated by IoT-based smart water technologies, which are beneficial to both utilities and consumers. Drinking water monitoring systems are used to keep track of chemicals and contaminants in water, as well as the level of the water, to avoid flood situations, pollution of drinking water, and poor water quality, which can negatively affect human health. The water quality measurement system described in this study was used to determine the quality of drinking water and of spa or pool water. Also advantageous are the pressure and flow measurement devices, which help reduce the likelihood of pipe ruptures and protect water transmission lines. Remote meter reading is aided by web-based services and computer vision, and the use of a mobile application for showing the water usage makes it simple to obtain data from anywhere in the world. By utilizing mobile monitoring sensors and IoT technologies, the user can rapidly identify and resolve the problem from any location on the planet. Many of the applications created by the developer make use of a mobile application that is compatible with all Android-based smartphones. The aforementioned IoT-based smart water technologies are advantageous for both utilities and consumers in terms of cost reduction, health implications, environmental impact, water quality monitoring, accuracy, increased system efficiency, fast data transfer, and mobile data transfer, among other aspects. Water monitoring, water control, water quality measurement, pressure, flow measurement, and many more applications are classified into categories on the basis of the application for which they are used (Radanliev et al., 2020). The use of mobile in the water industry for monitoring water usage and water quality will make a significant difference in individuals' health. Disasters such as cyclone and flooding can impact water quality; without real-time monitoring with IoT devices, notifying end users for any water quality issues is difficult. The future of water quality monitoring is more toward residential end users instead of running lab tests from a water reservoir because the quality impact can occur from distribution lines instead of water reservoirs. This paper discussed the methodology of using water quality meters in distribution lines or at residential meters.

"Digital health" encompasses all things eHealth, mobile health, and related. MHealth is a term used to describe the delivery of healthcare services and communication via communication devices. Before digital health, eHealth existed. In the health care sector, eHealth is the cost-effective and safe use of communication and information technology. Despite its roots in eHealth, digital health now encompasses a far broader range of issues. A growing number of smart and interconnected devices are being developed for digital users as part of digital health. Technology such as IoT and AI is increasingly being utilized in the healthcare industry (Rahimi et al., 2014). Digital media and mobile communications are examples of technologically enabled care, which encompasses telehealth, telemedicine, mobile health, digital health, and eHealth. For the first time, "digital health," according to Sonnier, now includes genetics. He views the future of medicine as being shaped by the convergence of the digital and genomic revolutionary movements, with advances in health care, medical treatment, and the quality of human life and society. "Digital health" was defined by Rowland as "healthcare given digitally." Data from all social activities are collected in real time, and complex analysis is performed on the data to extract knowledge that may be used for a wide range of social and economic activities (Mustapha et al., 2021). In 2019, the WHO produced a new term for "digital health" that combined items such as medical digitalization, mobile medical, telemedicine, and digital medical into a single term. Digital health is the use of healthcare technology to support people's quality of life and to ensure they have access to important things. Digital health is a field that combines all of the diverse types of medical research. The term "digital health" refers to the full use of computer programming and digital technology to make new discoveries and produce innovative ideas in clinical medicine (Chase, 2020). Advancements in digital health and the role of mobile are critical for the future. With robots replacing nurses and centralized control rooms and remote surgeries accessible through 5G, low latency technology is making it possible to remotely treat patients.

IoT, AI, and cloud computing are all critical components in the development of new digital health technologies. Rather than simply being there, these advances occur during the application process. For digital universal health care, some of the most crucial data technologies are listed (Pouttu et al., 2018).

In 1999, Ashton at MIT proposed the concept of IoT (Makhlouf et al., 2017). IoT is the connecting of all ordinary goods that can operate autonomously using various information-detecting devices (such as cameras). The medical industry can benefit from IoT as can a hospital's intelligent administration, which can collect and disseminate pharmaceutical and medical data. IoTs' drug identification system may reduce human-induced pharmaceutical errors while enhancing medical staff productivity (Zahra et al., 2020). IoT can also reduce medical costs. Chronic disease patients are increasing because of the aging of the population. Long-term care work for people with chronic illnesses places a major financial and time drain on their families. IoT can automatically monitor patients' health and keep an eye on them from a distance. Using the Internet, medical professionals can track their patients' health from a distance. If the patient's overall data are out of the ordinary, the emergency alert system can alert the medical staff who can quickly check the patient's health (Gill et al., 2019).

In 1956, McCarthy proposed artificial intelligence. Simulating human decision making and thinking processes is possible with the help of AI and constant machine learning. AI is a broad discipline that integrates computer science, math, cognitive science, neurophysiology, computational complexity, and many other fields. AI applications range from expert systems to machine learning to natural language processing, autonomous planning to image processing, and more. When a lot of data exist, machine intelligence can learn from that and make good predictions on the basis of what it learns. AI can assist doctors in diagnosing and treating patients, reducing their workload, and increasing work efficiency and quality. Image inspection is the most widely used intelligent system based on AI. Images and diagnostic data may be analyzed using an AI medical image recognition algorithm at a wide number of hospitals and can also be used to detect, classify, and identify lesions in the body—all of which aid in the diagnostic process. The development of a medical robot powered by AI is a big step forward in the field of medicine. Robotic surgery has come a long way since the Da Vinci system was first introduced. A 3D vision system can collect photographs of surgical procedures and perform operations that are impossible to execute manually (Qureshi et al., 2021).

Some instances include electronic medical documentation, the supply chain for drugs and health data analysis. New technologies such as blockchain are also used in these areas. An autonomous database system, blockchain technology is used in Bitcoin. The blockchain’s qualities include decentralization, transparency, anonymity, and immutability. The volume of medical health data has increased through advances in electronic health technology, posing obstacles such as data exchange across medical organizations and privacy issues. Securely storing and sharing medical data using blockchain technology and smart contracts using mobile devices is possible, and a need exists for future uses of mobile devices with AI, blockchain, IoT, and ML. The decentralization feature of blockchain ensures that all nodes have equal rights and responsibilities, making it difficult to tamper with data. The blockchain cannot be changed, which makes medical data more secure and manageable by end users through their mobile devices. The tamper-proof and decentralized nature of the blockchain safeguards electronic care and psychiatric records, as well as user privacy. The personal privacy and accountability of the blockchain make it easier to access medical data because real names are not needed to build trust. A consensus mechanism on the blockchain protects users’ personal information control rights while giving them the best ways and services to store and retrieve their data. In a blockchain system, only people who are supposed to have direct connections to a participant’s confidential data can see them, which gives patients complete control over their medical data and ensures that the data are valid and accurate. Blockchain technology could change how medicine is practices and will be practiced through a high level of security and control with handsets and personal data. Documents are also used to make it easier for medical associations and their patients to pay each other. Smart contracts can reduce claims fraud and make it easier to trust each other without using third-party intermediaries (Chase, 2020).

Cloud computing is currently receiving significant attention because it is new and different. Cloud technology is a common way to get computer resources and engage in distributed computing. Through cloud computing technologies, servers, apps, data sets, and other resources can be combined to create virtual resources delivered over the network. Cloud computing may be broken down into the following several layers: data centers, infrastructure, platforms, and applications. Using cloud computing technology allows individuals to access and work with data from any location at any time. Using personal handsets, data can be uploaded to the cloud server and be downloaded from the servers to mobile devices. The same data can used for self-diagnosis purposes, and self-management of the data reduces risks related to privacy and security. The extensive use of cloud resources, which can be accomplished for free, results in reduced costs and greater efficiency. Because cloud computing may be utilized more frequently in the future, individuals could receive better treatment and conduct more medical research in the future. Using cloud computing is less expensive because keeping data secure requires less hardware, software, personnel, and financial resources. As a result, cloud providers can store copies of their customers' data in numerous locations, decreasing the chance of human error while also reducing the costs associated with collecting information and minimizing security and privacy risk by giving more control to mobile users to manage their data. Because the cloud allows for real-time data sharing, users can share information with one another. For IoT to obtain and process data when they are stored in the cloud is quicker. By combining cloud-based applications and IoT, creating a range of new types of medical services is feasible. Because medical data, such as electronic medical records, can be stored in the cloud, cloud services can ensure that these data can be accessed and shared from any location at any time. Cloud services can also be extremely effective at managing the knowledge that sensors generate (Mustapha et al., 2021).

Big data refers to a collection of information that cannot be collected, processed, or examined using conventional computing methods. Big data has five distinguishing characteristics: volume, diversity, velocity, low value density (quality), and a high degree of validity in the information it contains (veracity). Big data software is a form of information technology that swiftly collects essential information from a variety of sources, and it is becoming increasingly popular. Among the most potential business industries for big data applications is healthcare. Data from big data has helped change traditional health treatments into digital ones, as per the WHO. The significance of clinical data is experiencing exponential growth as we move toward the era of big data. Because medical data must be stored for a long time, more storage is required. Providers of medical information services need to analyze and process a lot of data online or in real time, which means that they need to be able to generate more information faster. Using big data technologies to solve these problems is possible. Big data technology can be used to access the data from patients' health records and medical equipment and to create virtual clients, diagnoses, and potential treatments for real people. Big data analysis can help doctors produce personalized treatment plans on the basis of a person's specific needs, patients can be interacted with through their mobile devices, and patient data can be stored and made available from the cloud to mobile devices. Big data technologies can enable reviews of personal health, prognoses, and effects on people's health to find ways to keep them from getting diseases. Using big data technology to run a hospital and improve the quality of its medical care is important. Doctors can use big data technology to help them more accurately diagnose and treat service users, which can reduce the risk of misinterpretations. Information retrieval technologies can help hospital managers make good management decisions by reviewing a variety of indicators and values in an objective and scientific manner, which helps them make good decisions. Setting up a large information medical science data center could be beneficial for hospitals and could accelerate data gathering and processing, making it easier for scientists to share information and improve medical science (Abulibdeh, 2020).

5G networks, the most recent form of cellular mobile communication technology, are defined as offering high data transmission rates, wide broadband coverage, and minimal latency. 5G devices send data a lot faster than other cell phones. At its peak speed, 5G technology will be ten times faster than 4G technology at its peak. 5G technologies are already being used in some medical fields. 4G networks have a lot of problems, such as slow real-time signal propagation, bad visual field clarity, and long remote-control delays. 5G can help solve these problems given that its low latency, high bandwidth, and URLLC will play a critical role in remote surgeries. Doctors can now view a patient’s operation, gather real-time data, and perform the surgery from afar. The 5G network’s high-speed transmission allows professionals to understand the progress of an operation and the patient's real-time status, allowing them to be assured of the operation’s stability, reliability, safety, and lower risk. Rural medical care is difficult to come by. Experts can use 5G technology to conduct remote consultations and make clinical diagnoses, which saves patients both time and money (Rahimi et al., 2014).

A lot of people use mobile devices to help them access digital medical care. For this reason, computers and mobile devices are often referred to as being the same thing, and both offer many electronic health benefits. Given the portability of mobile devices, medical treatment may now be provided at any time and from any location, which is quite convenient. The applications available on mobile devices influence their position in the medical industry. As digital medical care becomes more prevalent, the number of health applications is rapidly increasing. Sensors are used in mobile apps to determine and collect information about individuals’ health. For example, smart phones can collect user data while a person is working out and monitor their sleep and eating habits to prevent disease. Mobile devices are increasingly being used to share medical knowledge and practical experience via the Internet. Mobile medical apps educate and empower people to control their health.

The government and medical organizations use apps to distribute medical information to citizens. Various mobile applications keep citizens informed about the COVID-19 pandemic and the latest government actions. These apps also help doctors track their patients' health. Many hospitals now offer online services, including outpatient appointments and diagnoses. Patients can use an app on their phones to set up diagnostic tests in advance, which saves time for both patients and doctors and improves treatment efficiency(Rajeswari et al., 2017).

Health data can be gathered, analyzed, and managed via wearable biosensors that can be worn on the body and connected to the Internet. These new types of wearable sensors can retrieve information about the body's health and keep an eye on how well individuals are doing over time. When monitoring data is combined with other technologies, users can better understand how changes in physiological reference points happen and make better clinical diagnoses. This documentation can also be used to predict diseases, diagnose diseases earlier, and reduce medical costs for both individuals and the entire country. The most common wearable device is a smart watch, which can monitor and analyze data. The Apple Watch is a smartwatch with health-related functionality that can monitor sleep, heart rates, blood oxygen levels, activities, and falls. The smart watch must have a user's authorization before sharing health data with third-party medical care providers, such as hospitals or clinics. The smart wristband's data can be used to improve users' healthy lifestyles. A smart belt is another popular wearable medical gadget. The intelligent belt can track the wearer's activities, sleep, and sitting posture. For example, Active Protective has developed a smart belt that detects falls and incorporates a micro airbag to cushion falls and avoid hip fractures. Using a wearable glucose monitor makes it possible for diabetics to better monitor and manage their blood glucose levels. The user's serum glucose is always being checked by this wearable device, which can help to prevent long-term problems and diseases. The smart pill is a vital digital medical application. Small ingestible sensors called “smart pills” could automatically release the medication’s contents into the patient’s body while simultaneously generating feedback signals. Smart tablets are being used to ensure that patients take their medications as directed. Smart pills use tiny sensors to do their jobs. The Helius pill is an intelligent pill and includes a device on a patient’s skin that sends out a signal when the pill is swallowed. Helius tracks when and how much medicine is given, as well as the heart metabolism and respiration temperature of the person taking it (Radanliev et al., 2020). Smart watches and sensors can send data to mobile handsets, and mobile data can be stored on the cloud for self-diagnosis and self-management of medical data. Few nations have acted as quickly as Switzerland in recognizing the advantages of 5G and committing to it. Swisscom launched Europe’s first commercial 5G network in 2019, and 90% of the population already has access. They will now witness increases in global prosperity as businesses receive first-mover benefits, educational achievements as virtual reality enhances online learning, and green infrastructure as emissions are decreased. 5G is adaptable, and the global advantages are significant if additional nations follow Switzerland’s lead.

Digital technology has made it easier to monitor people from afar, and surveillance footage is becoming increasingly important in telemedicine. In the future, a smart medical monitoring system could help solve the problem of unequal access to medical resources. Remote monitoring allows clinicians to monitor patients’ health outside of the clinical setting, improving job efficiency and quality while saving patients time and money. Digitally reconstructing medical images using surveillance camera technology allows medical institutions and specialists to remotely gather, store, transmit, and analyze images. Monitoring equipment can help nurses better do their jobs. Remote monitoring not only improves care quality but also allows patients to be more self-sufficient. The monitoring equipment collects and analyses physiological data from patients and sends them to physicians and other systems for further processing. Medical practitioners diagnose problems and recommend treatment plans using physiological data, contributing to better medical care. Crowd cameras can be used for temperature sensing and notifying the authorities of abnormal cases—the same can be done with mobile cameras in the future to self-diagnose COVID-19. Digital innovation has the capacity to expedite decreases in total emissions by up to 15% by 2030, although representing just 1.4% of the world’s pollutants. “Industry professionals have forecasted that 5G would create $3.8T in gross production by 2035, generating 22.8M new employment,” as per industry experts. In contrast, risks offer benefits. One of these worries is the risk of increased inequality as a result of different levels of digital technology use. As per Ericsson, 3.5 billion 5G subscribers will exist worldwide by 2026, with North America responsible for 80% of subscribers and Sub-Saharan Africa accounting for just 5%. Given that two-thirds of the world’s labor force will be linked through 5G by 2030, individuals must fight to close the global skill shortage and promote an innovation support agenda, which is a recurring subject across the study series (van der Linden et al., 2020).

The future of smart utilities and smart cities will change through 6G technologies.

The 3GPP roadmap for 6G makes it clear that IoT will change to Internet of intelligence (IoI), and all of the devices connected to the network will be more intelligent. Automation will replace humans’ efforts. Beyond 5G (B5G) and 6G, millions of devices will be connected to the networks, and bandwidth and latency will further improve (Soldani, 2021). Cloud native 5G networks, AI, and centralized platforms will have a significant impact on utilities, smart cities, and health sectors.

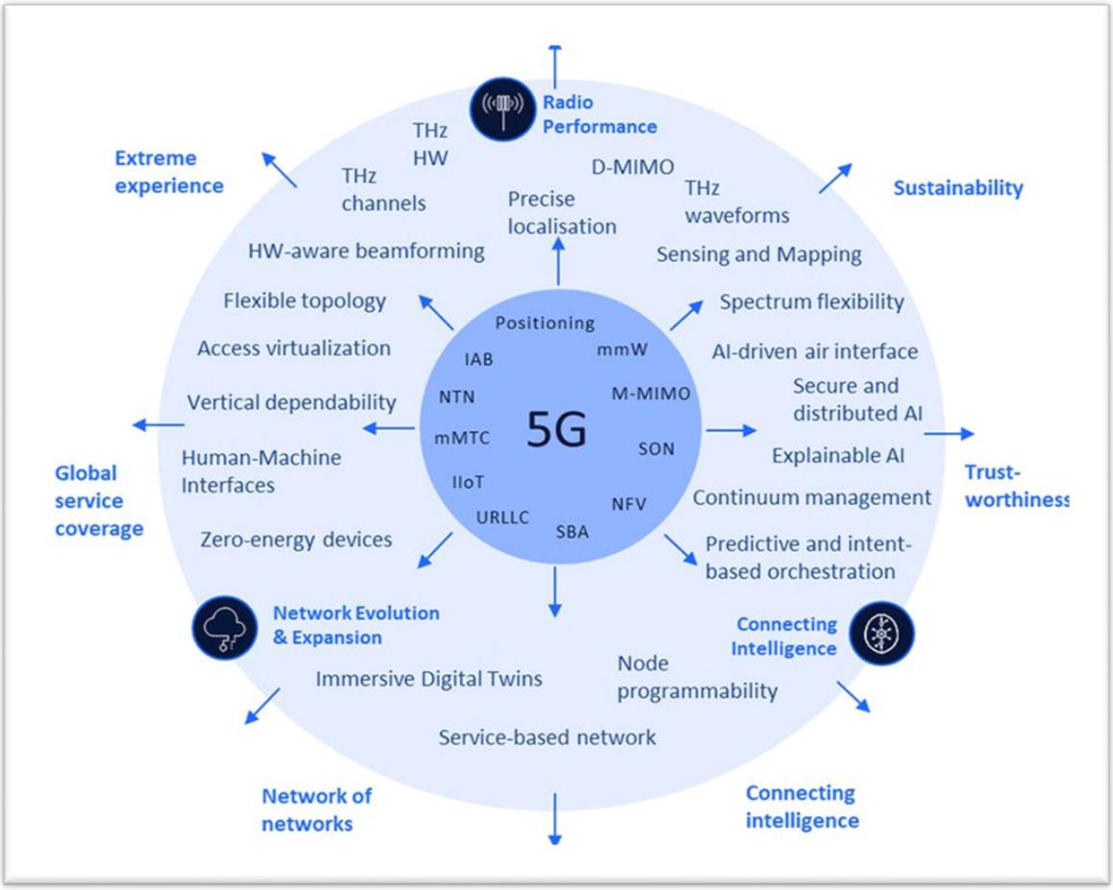

Figure 17 6G use cases

https://www.6gworld.com/exclusives/6g-gains-momentum-with-initiatives-launched-across-the-world/

Global coverage is the most significant challenge for farms and remote locations with no cellular coverage. NB-IoT roaming with low orbit satellite technologies will be a game changer because devices will have seamless connectivity from anywhere in the world, including deserts, open seas, the Great Barrier Reef in Queensland, and agriculture farms.

With the emergence of non-terrestrials' network and 6G, no coverage gaps and blackspots for connecting IoT devices will exist anywhere across the globe. 6G can provide high bandwidth requirements for use cases, such as holographic type communication (HTC), multi-sense networks for immersive experiences, including taste and smell, critical infrastructure, such as water and autonomous vehicles, and heavy sensor networks with time engineered application (Rinaldi et al., 2020).

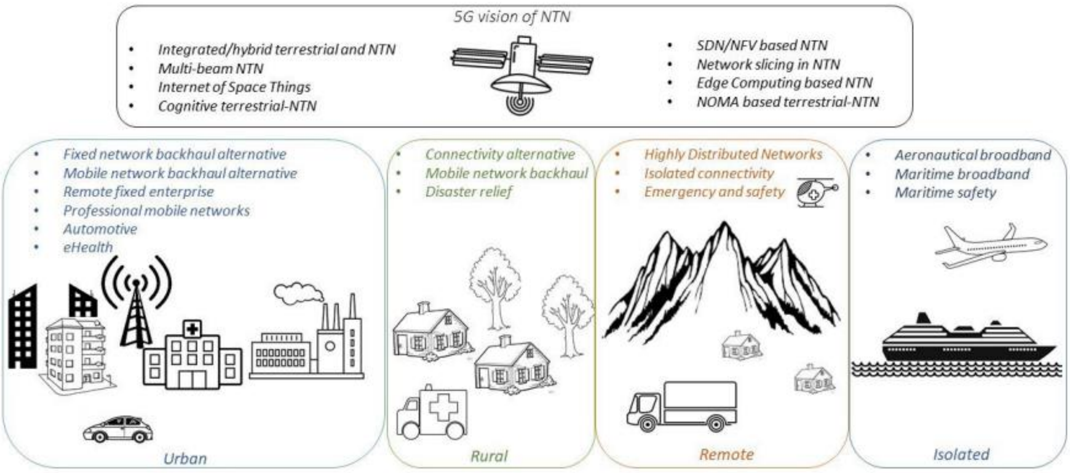

Figure 18 5G NTN Use case:

NTN can be used for remote meters connectivity with no 4G coverage; however, it can connect devices to satellites using the 5G protocol (Rinaldi et al., 2020).

Infrastructure and irrigation water consumption in agriculture will be constantly examined in the near future. Remote metering and smart irrigation will be two critical components to establishing successful water resource management in irrigation organizations. Using these technologies increases the quantity of the data that can be analyzed, which is important for making decisions. 5G-NR is predicted to revolutionize water management because it is a substantially faster technology. This, together with reduced latency, enables high-speed, real-time data processing. 5G-NR can also work with millions of sensors per square kilometer, allowing smart metering to coexist along with the deployment of other smart devices. According to the multinational Idrica, this technology is especially useful in rural areas where real-time data collection is typically difficult.

With respect to implementing EU water policy, the adoption of new technological solutions on the basis of ICT presents numerous options.

This innovative management system encourages the implementation of programmed water management and the conservation of potable water. Energy consumption elements and water supply factors are linked together in this software solution to make the water distribution system more straightforward and effective. The technology not only delivers advantages in terms of cost reduction but also contributes to environmental and socio-economic strategies. Global population growth, climate change, and a significant increase in irrigated land are all current concerns. According to the FAO, agriculture is the most water-intensive industry on the globe, accounting for 70% of total use. According to Idrica's Irrigation Specialist, Begoa Tarrazona, technology helps us "analyze information and react more quickly, so that any network issue may be addressed as soon as feasible." She emphasized the fact that "It's vital to digitally transform irrigation distribution networks to obtain real-time insights into what is going on and to detect system breaches and fraud early on. We will be able to drastically reduce the quantity of non-revenue water, slash manufacturing costs, and increase environmental sustainability by lowering water and energy use." The use of ICT has also benefited the transformation of the utility market and the formulation of useful policies for improving water management systems. Because operational costs have decreased, users can now receive clean water at a lower cost. Because the water delivery system can now be operated at a low cost, poor countries can gain access to water resources quickly and easily. The system benefits from the reduction in its CO_2 footprint that is made feasible by improved energy efficiency measures. As well as these benefits, the technology is transforming the market by creating opportunities for blockchain technology platforms to connect renewable producers and utility companies (Silveira et al., 2020). This control is required because of the presence of critical elements in the irrigation system. An alarm in one of these critical systems that is not detected in a timely manner might cause significant personal and material damage. Furthermore, for process control, infrastructure sensors in remote locations need reliable communication and low latency. Only very fast data transmission systems, such as those provided by 5G-NR, are capable of doing this. Residential users can monitor their water usage, compare their usage with other households of the same size, and set their goals for reducing water usage using a mobile application. The use of a mobile app for demand management and gamification can help reduce the overall water usage, which will ultimately reduce residential users' annual bill. Because of water scarcity, these AMI technologies and IWN can be useful for better water management.

The use of a water level sensor provides the ability to determine how much water is available and how frequently users use this resource. The sensor sends out alerts when the water level gets to a certain point and sends out a signal when the water level changes faster than expected. Finally, the water cycle solutions and multinational services point out that the installation of 5G telecommunications infrastructure has skipped a generation in certain countries and rural areas. In other circumstances, 4G was launched without the deployment of 3G, and 2G and 4G networks coexisted in the same area. Because certain areas will benefit from post-pandemic recovery plans, this might be an excellent opportunity for them to install 5G-NR technology sooner than expected.

Flood warning systems communicate with the host network using cellular, radar, lightning-watching systems, or satellite telemetry. The inevitable digital revolution in integrated water management is predicted to be significantly influenced by 5G technology. This technology has tremendous strategic potential to transform global industries, especially agriculture. 5G wireless technologies have the ability to link billions of devices through IOT if they are released. To drastically accelerate communications across massive networks of digital devices, 5G combines wireless technologies such as 4G and Wi-Fi with new computer approaches such as network functions, virtualization, and software-defined networking. Although flood alarm systems operate on radio frequencies, they can be subjected to interference from weather conditions and electrical noise, which can cause the systems to malfunction. These devices are used to find storms and excessive rain that could cause flooding.

Among the components of the river monitoring system are a stilling well, an integrated data logging system, a multiparameter sonde, a submersible pressure transducer, telemetry, and real-time data. Stilling wells are constructed on the riverbank or may be attached to a still structure, which is used to regulate the amount of water that flows in and out of the river. Data logging includes a real-time observation station and multiparameter sondes that can be used to group a lot of different sensors together in one place, such as in a forest. Cities that cannot handle their resource restrictions are in a particularly difficult situation. In certain locations, poor water and air quality is a direct danger to public health, whereas the continuous dependence on fossil fuels adds to global warming. Wirelessly linked sensors may be able to detect contaminants in water and provide recommendations for waste reduction. Water leaks in American homes lose 1 trillion gallons of water per year, enough to fill 1.5 million Olympic-sized swimming pools, according to the Environmental Protection Agency. Water sensors may also aid agriculture and industry in making more accurate water usage decisions. Agriculture consumes 80% of the water utilized in the United States, implying significant water savings.

SMM devices provide information on the amount of water present in the soil. This information is useful in determining how much water should be applied and when it should be applied. Suction-based sensors and volumetric SMM sensors are the two types of sensors that are routinely accessible. Suction-based monitoring systems offer information on the tightness of water in the soil, whereas volumetric monitoring systems provide information on the quantity of water in the soil.

A meteorological instrument measures the amount of precipitating rain that falls per unit area of land in a certain period. The instrument set consists of a container that is put in an open environment for a specified period and a measuring device that measures the precipitated water in millimeters. Even though the size of the container has no bearing on the results, it should be of medium size to achieve the best results (Swan, et al., 2013). Through all of these new sensors and technologies, the data will be pushed through a mobile app and API integration with an application enablement platform to a mobile handset, allowing residential users, utility staff, and emergency response teams to act promptly with real-time monitoring of water usage, quality issues, and water level of dams and reservoirs. By implementing improved traffic management systems, 5G technology has the potential to enhance air quality and reduce energy consumption. Traffic congestion costs cities a lot of money in terms of lost fuel and time. Drivers in Washington, D.C. spend an average of 82 hours a year sitting in traffic; vehicles in China and India use even more fuel but do not go anywhere. Fine particle air pollution from idle cars and other causes kills nearly 3 million people per year, according to the WHO. Instead of depending on fixed traffic signal cycles, dynamic traffic management systems using cameras and sensors may save energy usage, lost time, and mortality.

Briefly stated, IoT-based smart water solutions are beneficial to both utilities and consumers. Because of technological improvements, IoT is currently being used for a variety of applications, such as water monitoring, water control, water quality testing, pressure, and flow measurement, and many more. The most significant advantages supplied by these technologies are cost reduction, accuracy, increased system efficiency, quick data transfer, and mobile data transfer, to name a few examples. The accuracy and effectiveness of the system can be improved in other ways, such as using blockchain, AI, and data analytics, as well as IoT.

In rural areas with the primary problem being the exploitation of water for agricultural or domestic uses, the involvement of local actors is essential, especially because they are the ones who hold the knowledge related to the most effective techniques to manage the resource. In the field of water, studying local solutions imagined by the populations concerned is necessary to manage the problems related to accessing the resource and whether they are institutional or technical solutions to draw inspiration from successful experiences in other comparable contexts. Buildings use a significant amount of energy for lighting, heating, cooling, and other activities, accounting for up to 42% of the world's total energy consumption. The amount of energy required to sustain acceptable temperatures throughout the year may be reduced if buildings were designed more efficiently. Dynamic systems may also adjust temperature and lighting in response to occupancy changes, ensuring that energy is only used when it is beneficial to the building's occupants. Smart power meters also provide extensive data on home usage habits and cost-cutting advice. The Empire State Building installed meters to track energy use for each of the building's 100 tenants, resulting in a 38% reduction in energy expenses and $4.4 million in annual savings.

This path is increasingly being taken by international development organizations and non-governmental organizations to improve the connection between local behavior and the interventions of the public authorities for water management. West offers a number of suggestions to assist communities in fully realizing the benefits of sound resource management. City authorities should collaborate to purchase large quantities of 5G technology inexpensively. Cities might also use their buying power to press for more interoperability and innovation. Governments must allocate enough wireless spectrum to meet the demand for new technologies and create international standards for which frequencies will convey 5G communications to pave the road for the introduction of 5G. Most critically, these technologies must be protected from cyber-attacks because they are integrated with essential infrastructure. Cities may leverage 5G technology to enhance environmental quality, conserve energy, and save money by adopting these intermediary steps.

Using Power Line Communication (PLC) technology, which uses the electrical distribution network to transmit radio signals, portable prepaid kiosks can be operated. The advantage of this system is that it uses the same channel for the transmission of all signals, thus reducing communications infrastructure costs. The kiosks can be used as mobile commerce spaces in which ICT is used: closed circuit television for surveillance, use of wireless dataphones for the payment of products and services, linking of cards through Radio Frequency Identification (RFID) to apply customer surveys, Internet telephony, and satellite television, among others. Figure 4 illustrates these kiosks.

Changing the current energy paradigm requires confronting the following aspects.

Regulatory barriers: No regulatory framework or complete set of regulations regulate the participation of the associated actors. The regulatory framework must change to: 1) recognize all investments of the AMI system and define adequate investment recovery terms, 2) adapt a methodology that considers investment costs, and 3) enable the development of new businesses.

Differentiated rates: Unregulated users must have hourly rates to ensure that they modify their consumption according to price signals and incentive schemes offered by the marketer to give customers additional incentives to disconnect their loads under agreed conditions.

End-user perception: According to the lessons learned by other countries, such as Brazil, the client may have a bad perception of a change. To address this situation, carrying out awareness and dissemination campaigns is useful for encouraging a change that facilitates the entry and appropriate use of smart meters.

Business models: The guidelines under which energy trading processes are currently carried out do not facilitate the entry of new technologies. Strategies are required to decouple the income of distribution and marketing companies from the energy sold. The fee should reflect the company’s assets.

Meters are considered “smart” because of the various integrated technologies that enable calculations, display, storage, and communication with a central server. Data logging is done hourly (or more frequently), and the data are sent to the utility company for constant monitoring and billing. This two-way communication between the meter and the central system managed by the service provider occurs via cellular telecommunications technologies and facilitates remote reporting and problem solving. Because the water infrastructure is the most critical infrastructure for communities—we can survive without electricity and the Internet for a few days, but we cannot survive without water. Water security is important to understand and must be regulated by authorities by not allowing unlicensed technologies and spectrum. The risk of security breaches with an unlicensed spectrum and network is high relative to the high-level security of 5G, which is mandated by 3GPP. Protecting the environment and addressing environmental issues, such as air pollution and climate change, has evolved into a commercial imperative rather than a CSR effort. There is no denying that the risks and possibilities linked with environmental concerns provide a variety of obstacles to business strategy and operations. On the plus side, an organization’s competitiveness in today’s market will be defined by its larger-scale environmental sustainability plan. Several environmental issues exist and represent one of a company’s top five hazards. As a result, today’s investors and entrepreneurs must incorporate sustainability concepts and strategies into their businesses.

However, in many cases, the financial and technical means and expertise are lacking in local populations, obviously especially in developing countries. Therefore, international cooperation is crucial to initiate the development process. From this perspective, the development of access to clean water features prominently in the Millennium Development Goals of the World Bank. However, international aid without ownership of the policies implemented by local authorities is of little use. Base stations for 4G networks use more energy than base stations for 5G networks. According to Huawei, cooling transmission equipment uses half the energy required by 4G base stations. According to a recent study, 5G technology reduces carbon emissions by 80% and operational expenses by almost one-third. Water is a precious resource because just 3% of it is potable, and only two-thirds is accessible Moreover, the problem does not only arise in the context of aid to developing countries but in general for water policies globally: the problem of water suffers cruelly from a lack attractiveness for politicians and other decision makers and requires a long-term approach, which is not very compatible with the rhythm of electoral cycles. Voters have little interest because they do not perceive water problems or benefit from subsidized access to water. The results of the measures adopted cannot be seen (e.g., underground infrastructures, irrigation systems in rural areas), and their political benefit is meager relative to the costs, which are significant. The issue of water is eminently political and social—much more than technical—and involves long learning processes and the appropriation of good practices. Furthermore, by 2025, water shortages may occur because of a lack of adequate water management. Agriculture uses 70% of the world's freshwater each year, according to the World Bank. Unfortunately, farmers globally employ outdated irrigation techniques that waste water and contribute to climate change. The transmission of information from the meter to the management system can be done in two different ways: 1) directly from the meter to the management center and 2) through a data concentrator that receives the information from a group of meters and transmits it to the management center. In both cases, wired and wireless means of communication are used. The communications infrastructure also includes the necessary tools, resources, and methods to guarantee the cybersecurity of the information in the system.

To establish a general panorama of intelligent metering systems in Colombia, the basic concepts presented in the previous paragraphs were based on key international success stories chosen and criteria for selecting cases that included projects with wide implementation coverage. An analytical review of the experiences was conducted to present, on their basis, the functionalities that the meters in Colombia are expected to fulfill, the agents involved, and the processes that will be implemented. The national context was considered to determine the benefits associated with the implementation of AMI systems, the future scenarios, and the barriers that arise to achieve them. Agricultural data, such as soil moisture levels, pesticide levels, weather conditions, and other essential information, can be shared, monitored, and analyzed at high rates because of IoT devices and 5G technology. Farmers may also utilize 5G to access various technology to better manage crops and water resources, such as GPS systems, chlorophyll sensors, and sprayer control.

AMI systems have an infrastructure made up of software and hardware elements that give a new vision to the distribution and commercialization of electrical energy. Similarly, these systems open a new panorama for the design, operation, and planning of the network.

The massive use of smart meters allows all agents involved to obtain benefits in the execution of their roles, and for the client to actively participate in the value chain of electrical energy, thus generating new markets and business possibilities.

To guarantee the success of programs for the massive implementation of AMI systems, having national policies that direct these initiatives and a normative and regulatory framework that promotes investment in these technologies is necessary. Also essential is to define the functionalities associated with the meters, according to the local context of final use.

Taking as a reference the main initiatives of AMI systems worldwide, the need to give more weight to functionalities associated with information security and synchronization between the different subsystems is evident.

To achieve the development scenario for AMI systems proposed for 2030 in Colombia, all functionalities studied for the meter contribute to achieving the objectives. However, the expected results would not be achieved at the end of the three development phases without some priority functionalities.

Implementing articulated strategies that allow overcoming the regulatory, technical, and market barriers associated with the implementation of smart meters is necessary. The use of new technologies allows solutions to specific problems related to energy consumption according to the local context of each type of end user. The national panorama presents business opportunities, opening energy markets, and innovative applications that can be applied to different types of end users. Farmers and the agricultural industry benefit from 5G-enabled devices that facilitate water management that may also be used in urban areas. Large-scale IoT sensor installations that help with water management are now possible because of 5G technology. These low-cost IoT devices have the potential to identify harmful substances, manage water supplies, warn people about potential health risks, offer early flood warnings, and transform the agricultural business. For heating, lighting, cooling, and other reasons, buildings require up to 40% of all energy used worldwide. Buildings that use automation and are linked to 5G networks will save energy, reduce carbon emissions, and aid in the fight against climate change. When lights are not in use, IoT sensors connected to a 5G network switch them off and change the brightness to simulate natural illumination.

Without a doubt, among the many sustainable development challenges, access to water is among the most crucial because the resource is so vital. The environmental dimension of the challenge is obvious: it is a question of preserving a resource that is threatened not so much by depletion as by a deterioration in its quality, and this with a view to being able to guarantee its access for a world population set to increase in several decades. The economic dimension is no less important: access to water is a key development parameter and, thus, still too often a major obstacle in this area, obviously especially in poor countries whose growth still relies heavily on water-intensive agricultural activities. Finally, the social dimension should not be underestimated: pay for access to the resource between women and men according to the societal methods of managing the resource locally.

In addition to the smart meter, residential users can make use of applications and equipment with Home Display technology to visualize and control in real time the energy consumption of the equipment and elements within the home. This visualization is done through a screen located near the meter and allows for communication between these elements. Thus, the customer can know at all times the water and energy that he or she is consuming, its associated costs, and the amount of CO_2 that he or she is producing. This device can communicate with the elements and equipment that consume energy in the home to allow the user to control their use by managing their consumption in both intensity and time of use. The possibilities for improving water management by demand are based on an overall principle: directing water toward optimal use, which on a strictly theoretical level should lead to equalizing the value of a marginal unit of water for all potential users. Equalizing the marginal values of all the potential uses of water is of course a perfectly utopian objective; however, the principle that flows from this objective and according to which the actors concerned must be encouraged to make the most "productive" use of the resource when it becomes scarce proceeds from simple common sense. Two main ways exist to achieve this: encouraging users to use water more efficiently and encouraging transfers of the resource from the least beneficial uses to those with "yields" that are higher and that can be done by push or pull notification to customers' mobile devices.

A more efficient use of water basically consists of increasing the productivity of the use of the resource, in other words, increasing the capacity to create wealth for a quantity of water used. This can be done by limiting the losses incurred by leakage and percolation when routing water through urban networks or by reducing the waste from the inappropriate use of the resource in agricultural or industrial processes. The most promising avenue in this area seems to be increasing agricultural productivity through better using water by changing irrigation techniques, minimizing the evapotranspiration phenomenon that accompanies plant growth, and creating varieties more resistant to a lack of water. The potential for improvement is greatest in developing countries that are more dependent on agricultural activities and in which agricultural techniques are the least productive. In particular, irrigation techniques can make a significant difference in yields: using irrigation doubles the highest crop yields relative to using rainwater. After the failure of large-scale irrigation projects in developing countries, the emphasis is now on simple technologies at the local level that are easier to appropriate and less expensive.

Agriculture is an essential activity, especially in developing countries, but does not generate the most lucrative uses of water resources: industry creates on average 70 times more value per liter of water than does agriculture. This information explains why agriculture constitutes the bulk of water withdrawals in rich countries. Another characteristic is that water for industry is truly a cost of production insofar as industrialists generally pay for the water they use, unlike farmers who benefit from a free resource. The logical result is that the incentives to improve the productivity of water use are much stronger in industry than in agriculture.

Both IoT and big data are currently at the peak of our expectations regarding the possibility of commercializing these technologies. We will likely soon realize our technological and organizational limitations. However, even if our expectations will be deeply "made real," it will not undermine the transformative impact of these technologies on the functioning of the utility sector. Today, these expectations are primarily a determinant of the development direction for software companies that have the capabilities and ambitions to offer modern products and solutions to customers. Consequently, energy usage is reduced by up to 70%. In addition to lights, automatic temperature management will save energy. Temperature, ventilation, and air conditioning are monitored by sensors linked to a high-speed 5G network, and the temperature is automatically modified. The Empire State Building in New York City is a real-life example of a smart building. Sensors and meters have been placed to monitor each tenant's energy use and allow them to make changes. These automated meters and sensors save approximately 40% on energy expenses and reduce carbon emissions by more than 100,000 tons per year.

The solutions to these many challenges are necessarily multiple and must be coordinated to consider the natural logic of resource reproduction. They must be adapted to the local context, require combining principles that are not always easy to apply (true prices, rights of use, community management), require the participation of all stakeholders (local populations, public authorities, companies, and others), and must never lose sight of the fact that water policies must articulate as much as possible the efficient management of the resource and solidarity with those most in need.

The future is no more about connected things and will be more about connected intelligence— in last decade, we have moved from human-to-human interactions to human-to-machine interactions. Now it is all about machine-to-machine interactions; however, with 6G, it will be Intelligence as a Service, and a major paradigm shift will revolutionize the connected intelligence. Super smart cities and utilities will have intrinsic 6G features, such as massive machine type communication supporting distributed intelligence (MMTCXDI), globally enhanced mobile broadband (GeMBB), and ultra-reliable, low latency computation, communication and control (URLLCCC) (Calvanese Strinati and Barbarossa, 2021).

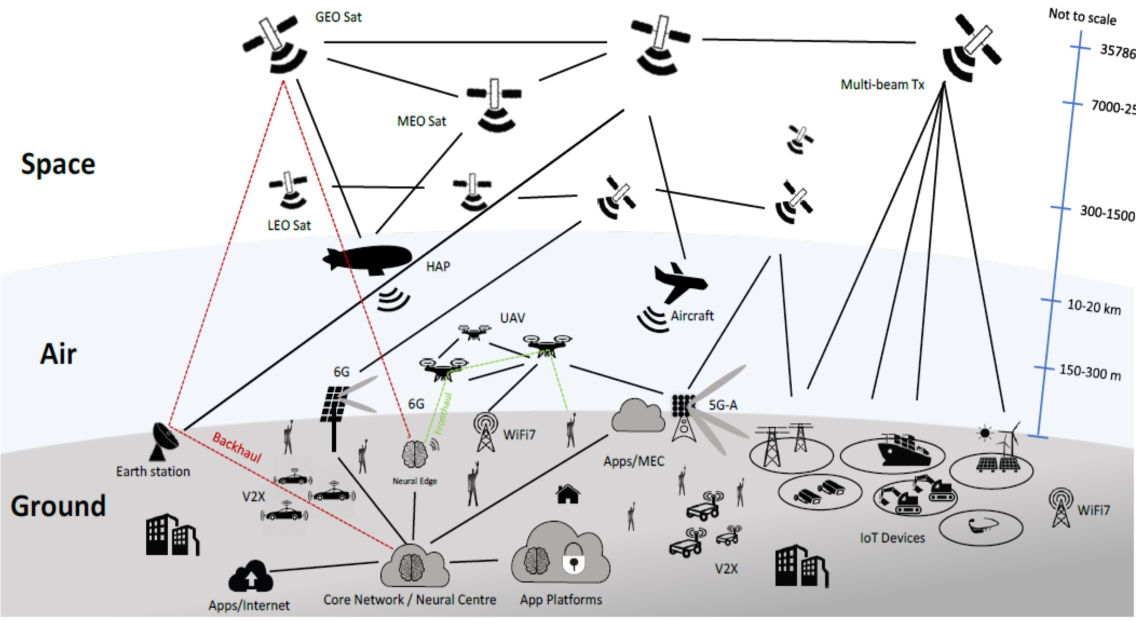

Figure 19 Examples of fronthaul (in red) and backhaul (in green) approaches to ubiquitous connectivity

In this figure, the combination of a cellular and a satellite network will deliver the full connectivity anywhere in the world for IoT devices, and the important use cases are related to critical infrastructure such as water and health (Rinaldi et al., 2020).

The research work to be continued is about the role of mobile with 6G technology; an important aspect of that is URLLCCC. The move away from the desktop to laptops and then to tablets will continue to evolve, and everything will be on figure tips, with mobile access for all data and control. Future mobile technology will be connected to 6G edge computing and decisions, and control will be at the edge of the network that offers very low latency and computational time. Processing speed will be enhanced through edge computing.

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