An Examination of the Skills Framework for the Information Age (SFIA) Version 7

Abstract

The Skills Framework for the Information Age (SFIA) is a popular international skills framework for the Information and Communications Technology (ICT) sector for which version 7 was released in June 2018. This paper provides an overview of this most recent version of the framework and compares it to the previous version, version 6. Some potential issues with the framework are then discussed, perhaps the most important of which is that version 7 is not backwards compatible with version 6, which can lead to undesirable results when two users of the framework (e.g. an employer and job applicant) interact with one using version 6 and the other using version 7. Other issues examined are the lack of universal certification criteria for objective assessment of skills (which affects the portability of the framework between users), the complexity of the framework in terms of skill/proficiency mapping, the representation of soft or transferable skills and the limited scope for automating skill management tasks. Some solutions to these issues are offered, including structuring the skill definitions to include mappings between different SFIA versions and creating mappings to recognised formal qualifications, industry certifications and job experience.

Keywords: SFIA; ICT; technical skills; transferable skills

1 Introduction

A skills framework provides a common terminology and model for skills or competencies in a specific sector in order to facilitate skills management, and the automation thereof, by the users of the framework e.g. individuals and organisations. This generally includes both ‘hard’ or ‘technical’ skills, which are discipline specific and so not transferable across disciplines, and ‘soft’ or ‘transferable’ skills such as communication, leadership and teamwork (Andrews and Higson, 2008; Eisner, 2010; Robles, 2012). Many employers cite the importance of transferable skills in particular, but also claim that graduates typically lack such skills when they first enter the workforce (Raybould and Sheedy, 2005). Therefore, a skills framework should include, if not emphasise, transferable skills.

A typical use case for skills frameworks by organisations is assessing current skill proficiencies and planning future skill upgrades. This may include the provision of self service applications for employees to manage their skills profile and enrol in training and certification programs. A skills framework can be regarded as a type of standard, whether formal or ad-hoc, and thereby, in principle, it affords some of the usual advantages of standards such as reduced costs, greater efficiency and portability due to the same framework being used across organisations. In addition, a skills framework can facilitate new economic opportunities for its users e.g. by allowing an individual to prove they have certain skills at a designated proficiency level through experience even without formal qualifications. Moreover, it can, in principle, enable the automation of common skills management tasks.

The Skills Framework for the Information Age (SFIA) is a skills framework for the Information and Communications Technology (ICT) sector, which has been developed incrementally over the past few decades to assist individuals and

organisations with skills management. SFIA was driven initially by the British Computer Society (BCS) and a consortium of organisations as a UK only initiative. The objective was to develop a common ICT skills framework incorporating the best features of various existing industry frameworks. Today, its development is managed by the not-for-profit SFIA Foundation, but is still collaborative in nature. It is perhaps the mostly widely adopted ICT skills framework on a global basis, although there are prominent alternatives such as:

- the European e-Competence Framework, otherwise known as e-CF (CEN, 2016; CEN, 2019)
- the Skills Framework for ICT, otherwise known as SFw for ICT (SkillsFuture, 2019), from Singapore
- the i-Competency Dictionary, otherwise known as iCD (IPA, 2019), from Japan

SFIA Version 7 (SFIA, 2019a), the most recent version and sometimes known simply as SFIA 7, was published recently in June 2018 and so it is an appropriate time to examine the current status of the framework. This paper:

1. summarizes the SFIA v7 framework including the updates from SFIA v6 (SFIA, 2019b), and examines some compatibility issues between the versions;
2. identifies potentially important features which are absent;
3. discusses existing aspects of the framework which are open to criticism;
4. provides possible solutions for all these issues.

In regards to the first item, perhaps the most important issue we focus on is the lack of backward compatibility in the upgrade from SFIA v6 to v7, which might deter users of

the framework from upgrading because it can lead to problems when two users of the framework (e.g. an employer and job applicant) interact, with one using v6 and the other using v7. With respect to the second item, absent features, we identify and discuss the lack of universal certification criteria for objective assessment of skills, which affects the portability of the framework between users. For the third item, discussion of existing features, we examine the complexity of the framework in terms of skill/proficiency mapping, the representation of soft or transferable skills and the limited scope for automating skill management tasks. The aim of the paper is to stimulate wider visibility and discussion about these issues with a view to solving them collaboratively in a future release of SFIA.

The remainder of the paper is structured as follows. Section 2 discusses related work from the literature. The methodology is provided in Section 3. An overview of SFIA v7 (SFIA, 2019a) is presented in Section 4.1. The differences with respect to SFIA v6 (SFIA, 2019b) are then highlighted in Section 4.2. In Section 5, the paper focuses on potential issues with the current status and direction of the SFIA framework. This is based upon the overview and informed by the literature. Some possible solutions to these issues are also proposed. Conclusions are drawn in Section 6.

2 Related Work

Concerning previous academic contributions on the subject of SFIA, these have so far been limited to earlier versions of SFIA, since v7 is relatively new at the time of writing, having been released in 2018. These contributions generally can be classified according to whether they are concerned with the applicability of SFIA to ICT curriculum design in higher education, the suitability of SFIA for defining specific skills (e.g. software engineering, data science) or the place of SFIA and other ICT skill frameworks in government policy and regulation. There have been very few studies on

the design choices of the complete SFIA framework, which is the scope of the present paper.

With respect to the academic literature that examines the applicability of SFIA to ICT curriculum design in higher education, there are a significant number of contributions. von Konsky, Jones and Miller (2013, 2014) used extended radar diagrams and other visualisation techniques to show how SFIA v5 skill sets could be used to inform ICT curriculum design in higher education. Later, von Konsky, Jones and Miller (2016) also investigated the use of SFIA v6 in ICT curriculum design, and highlighted the standard model and nomenclature as particularly important in this regard. However, they also found there was room for improvement, particularly with respect to the relationship with other frameworks used in curriculum design (e.g. Bloom's Taxonomy) and the limited representation of soft or transferable skills in the framework. This is interesting as this paper reaches similar conclusions about SFIA v7, as will be discussed later. Lewis et al. (2013) have also investigated ICT curriculum design using SFIA skill sets and concluded this has benefits, including aligning better to the needs of industry and reducing costs. More recently, the Computing Curricula 2020 (CC2020) initiative (Impagliazzo and Pears, 2018; Frezza et al., 2018) has been established to summarise and analyse the prevailing curricular guidelines of academic programs for computing related degrees on a global basis, and make recommendations for the future direction of such guidelines. CC2020 defines a competency as a combination of knowledge, skill and disposition in a specific context, whereas in SFIA, the concepts of knowledge and disposition are embodied, to some extent, in the proficiency levels of individual skills.

With respect to the academic literature that examines the suitability of SFIA for defining specific ICT disciplines, von Konsky et al. (2008) investigated the utility of SFIA v3 to describe software engineering skill sets in particular and concluded that it

was an excellent fit at that time, with the caveat that it needed to be complemented with knowledge of commercial products and technologies. However, Orsoni and Colaco (2013) somewhat disagreed with this conclusion when examining SFIA v5. They selected SFIA as the starting point for a software development competency model, but cited limited treatment of transferable skills and the complexity of the skill/proficiency mapping as reasons to develop extensions/modifications to the framework. Related limitations are also discussed in this paper regarding SFIA v7. Costa and Santos (2017) examined the applicability of e-CF v3.0 and SFIA v6 to data science and observed that both frameworks adequately represent the discipline, but there are differences in terminology and scope, and hypothesis testing is not explicitly discussed in either framework. Mason (2018) discusses how the SFIA v6 framework does not cater for the ICT discipline of digital preservation at all, possibly highlighting how SFIA is unlikely to be able to keep pace with a fast moving ICT industry given the relatively infrequent release schedule.

Siekmann and Fowler (2017) provide an overview of existing skill frameworks, including SFIA, as the starting point for a discussion on government policy within Australia regarding education and training. However, they do not analyse the individual skill frameworks in detail or identify their relative advantages and disadvantages. Brown and Parr (2018) compare and contrast three prominent ICT skill frameworks: SFIA v6, e-CF v3.0 and SFw for ICT. They note that SFw for ICT integrates transferable skills explicitly into the framework as standalone skills, whereas the other frameworks do not. In addition, it is concluded that none of the three ICT skill frameworks provide a universal and unambiguous path to skill certification, leading to an issue of portability of skills.

One related topic in the academic literature is the definition of skills and the ontology of skill frameworks. Clarke and Winch (2006) highlight the difficulty of agreeing on a universal definition of skills (and qualifications) due to the different historical meanings in different countries, and, in particular, the UK and Germany. This has some relevance to SFIA, which is promoted as a global and universal skills framework. Lundqvist, Baker and Williams (2008, 2011) and Miranda et.al. (2017) discuss an ontological approach to skill frameworks based partly upon the IEEE draft Reusable Competency Definition (RCD) standard (IEEE, 2007). However, these concepts have not been adopted by SFIA, which relies on natural language skill definitions.

3 Methodology

This paper employs a design science methodology (Hevner, 2007) in the sense of taking an existing artefact, in this case the SFIA skills framework, and evaluating it in a qualitative manner in its target application environment (the 'relevance' cycle) and with respect to underlying technologies, methods and other skills frameworks (the 'rigor' cycle). This results in a new found knowledge that can be used to shape the future direction of SFIA (the 'design' cycle). The paper provides examples of how this future evolution of the SFIA framework might be implemented to cater for use cases which are not currently addressed (such as portability of skill profiles) and to use technologies which are not currently employed (such as XML).

Design science is an appropriate methodology to employ for this study because it is sufficiently general to be applied to a large range of artefacts in the fields of ICT, computer science and engineering, and also is very pragmatic in nature which fits the development of a skills framework designed to aid a number of actors including employees, employers and educational organizations. Additionally, it is iterative in

nature, which melds well with an ICT skills framework which must evolve to incorporate new skills as well as retire obsolete skills.

In terms of the evaluation of the existing SFIA skills framework artefact, the objectives, scope, structure and content of SFIA v7 (SFIA, 2019a) are first examined. The differences with respect to SFIA v6 (SFIA, 2019b) are then extracted, partly by point-by-point comparison of the respective versions and partly be referencing the SFIA change summary document (SFIA, 2019d). The comparison is a qualitative one and based upon:

- Examining the attributes (i.e. name, code, natural language description and level of proficiency descriptions) of each skill represented in the SFIA v6 and v7 frameworks for significant differences
- Examining the framework level definitions of level of proficiency in the SFIA v6 and v7 frameworks for significant differences

This facilitates the identification of new, modified and retired skills, as well as changes to the definition of skill proficiency. The potential impacts on users of the framework under different scenarios (e.g., a single user migrating from v6 to v7, a v6 user interacting with a v7 user) are then assessed, leading to observations of compatibility issues between versions.

Secondly, SFIA is assessed more generally across versions to identify aspects which are potentially absent from the framework, but which could add value, and to highlight existing features which could be modified to improve the utility of the framework. This is achieved partly through comparison with other existing ICT skills frameworks and partly by envisaging features which are not currently supported by any

major skills framework. The comparison with other skills frameworks is also a qualitative one and based upon:

- Examining how transferable skills such as communication and leadership are represented (i.e. which transferable skills are represented and whether they are separate entities or combined in some manner with technical skills)
- Examining how skill proficiency is represented (i.e. number of levels of proficiency, framework or skill specific definitions of proficiency)

The final step, which corresponds to the design phase of the design science methodology, is to propose possible solutions to some of the identified issues with a view to contributing to the evolution of SFIA and possibly other ICT skills frameworks. However, a full evolved artefact is not built because there are many considerations beyond those discussed in this paper (e.g. identification of new professional skills) that need to be addressed in the next version of SFIA (i.e. v9). These need to be addressed according to existing SFIA procedures and processes as a collaborative project.

4 Skills Framework for the Information Age (SFIA) v7

4.1 Overview of SFIA v7

SFIA v7 (SFIA, 2019a) is based around 102 *professional* skills in the ICT sector which, for the most part, equate to 'technical' or 'hard' skills because they are very specific to certain jobs or functions. For example, there is a professional skill for real time/embedded systems development and another for network design. However, a small number of the professional skills might actually be thought of as 'transferable' or 'soft' skills because they can apply to almost any job or function. For example, the professional skill of 'Innovation' is one such case, since an individual can be innovative

in most roles. It is important to stress that there are no professional skills for what might be thought of as traditional or classic transferable skills such as communication, leadership and teamwork. These are incorporated into the framework in a different way, as discussed later in this section.

Each professional skill has a name, 4 letter skill code for easy reference and an overall natural language description. For example, the professional skill 'Real time/embedded systems development' has a skill code 'RESD' and the following overall skill description (SFIA, 2019a):

> 'The architecture, design and development of reliable real time software, operating systems, tools and embedded systems. Embedding computer systems with a dedicated function within a larger mechanical or electronic system, often with real-time, safety, security, and reliability constraints. Typically includes interfacing with hardware, mechanical sensors and actuators for monitoring and control in applications such as industrial, automotive, aerospace and medical machinery, robots and equipment including IoT (Internet of Things) devices.'

There is no formal structure e.g. in terms of an Extensible Markup Language (XML) schema, defining different aspects or attributes of the skill, beyond this.

Professional skills are not dependent upon each other in any way, however they are grouped into 6 colour coded categories (and subcategories thereof) to help facilitate navigation of the SFIA framework by users. For example, the professional skill 'Real time/embedded systems development' belongs to the 'Development and implementation' category (which is associated with the colour 'orange') and the 'Systems development' subcategory.

With respect to the proficiency of professional skills, SFIA v7 defines 7 *levels of responsibility* with level 1 representing the lowest proficiency and level 7 the highest. Each level of responsibility is associated with one or more labels, as illustrated in Figure

1. One of the implications of this labelling is that increasing levels of responsibility represent increasing levels of leadership, a transferable skill, since terms such as ‘enable’, ‘influence’ and ‘inspire’ are commonly associated with leadership (Leonard et al., 2013; Rosenbach, 2018). It might also be argued that increasing levels of responsibility imply increasing seniority and/or supervisory duties due to the use of the word ‘responsibility’.

[Figure 1: The 7 Levels of Responsibility in SFIA v7, near here]

The levels of responsibility are further characterised by 5 *generic attributes* of autonomy, influence, complexity, business skills and knowledge, as summarized in Figure 2. The business skills attribute in particular implies the possession of transferable skills beyond leadership, and specifically communication skills. Therefore, transferable skills are generally not represented in SFIA v7 explicitly, as part of the 102 professional skills, but implicitly as part of the levels of responsibility metric.

[Figure 2: The 5 Generic Attributes Associated with Levels of Responsibility in SFIA v7, near here]

SFIA v7 provides a mapping between each professional skill and a range of proficiencies for that skill, as embodied in the levels of responsibility. However, each professional skill is limited to a specific permissible contiguous range of levels of responsibility rather than the full 7 levels. For example, the professional skill ‘Real time/embedded systems development’ is constrained to levels of responsibility 2 through 6 inclusive. Different professional skills are associated with different permissible contiguous ranges of levels of responsibility, as illustrated in Figure 3, which shows the mapping for a sample of professional skills from the ‘Development and implementation’ category. These mappings are not explained or justified in the publicly accessible SFIA v7 documentation.

[Figure 3: Mapping Between some Professional Skills from the 'Development and Implementation' Category and Permissible Levels of Responsibility in SFIA v7, near here]

For each permissible level of responsibility for a specific professional skill, SFIA provides a natural language description of what capabilities are required to qualify for that specific professional skill at the given level of responsibility. For example, for the professional skill 'Real time/embedded systems development', the level of responsibility 2 capability description, which corresponds to the lowest level of responsibility for this professional skill, is as follows (SFIA, 2019a):

> 'Designs the interactions between simple embedded systems components with hardware and the physical world, through sensors, actuators and I/O ports. Uses low level programming languages to develop simple real-time/embedded components as part of an overall systems design. Applies standard approaches to perform extensive testing of real-time/embedded systems, using specialised tools such as logic analysers, in-circuit emulators or digital storage oscilloscopes.'

The level of responsibility 6 capability description, which corresponds to the highest level of responsibility for this professional skill, is as follows (SFIA, 2019a):

> 'Provides overall direction in the conception and design of real-time/embedded systems. Develops real-time/embedded software architectures in order to exploit new technologies or new uses for existing technologies. Develops effective implementation and procurement strategies, consistent with specified requirements, systems architectures and constraints of performance, cost and feasibility. Sets organisational policies and standards for, and leads on, the development of real-time/embedded systems including how critical non-functional requirements such as performance, safety, security, and reliability are achieved. Drives adoption of and adherence to relevant strategies, policies, standards.'

SFIA is a natural language and technology neutral framework. If a technology vendor implements content management for certain SFIA use cases, the SFIA framework does not mandate any specific technology to be employed.

4.2 Changes from SFIA v6

It is instructive to examine the nature of the changes from SFIA v6 to v7, because how the framework evolves determines how difficult it is to upgrade for both individuals and organisations and the benefits of doing so. SFIA provides a summary of changes resource to facilitate this analysis (SFIA, 2019d) and Figure 4 illustrates the top level differences.

[Figure 4: Overview of Differences Between SFIA v6 and SFIA v7, near here]

One of the most readily observable updates in SFIA v7 is that the number of professional skills has increased in number from 97 to 102. However, this statistic hides some of the complexity of the changes. In fact, 9 new professional skills have been added to SFIA v7, 4 SFIA v6 professional skills have been retired or merged into other SFIA v6 skills and 5 professional skills have been renamed in the transition. Of the 9 new professional skills, some have been formed due to forks or splits of SFIA v6 professional skills. For example, the professional skill ‘Real time/embedded systems development’ is new to SFIA v7, but it does not correspond to a new ICT discipline per se; rather, it has been forked from the SFIA v6 professional skills of ‘Programing/Software development’, ‘Systems design’ and ‘Testing’. Conversely, the professional skill ‘Measurement’ is new to SFIA v7 and was not previously covered in SFIA v6, at least not explicitly.

Of the existing SFIA v6 professional skills that have transitioned into SFIA v7, a significant number have been modified in terms of their overall skill descriptions, the permissible range of levels of responsibility that apply to them and/or the capability

description for each permissible level of responsibility. For example, for the professional skill ‘Methods and tools’, the overall skill description and the permissible range of levels of responsibility have been modified in moving from SFIA v6 to SFIA v7.

Another change in SFIA v7 is that the number of generic attributes associated with levels of responsibility has increased from 4 to 5. The new generic attribute of ‘Knowledge’ in SFIA v7 existed as part of the ‘Business Skills’ generic attribute in SFIA v6, but has now been elevated in stature to be a standalone generic attribute. In addition, security considerations have been added to the ‘Business Skills’ generic attribute in SFIA v7.

These updates and changes from SFIA v6 to SFIA v7 are, in general, not backward compatible and may cause issues for users of the framework when transitioning to the newer version. For example, a dedicated real time systems developer may have listed the SFIA v6 professional skills of ‘Programing/Software development’, ‘Systems design’ and ‘Testing’ on their resume at certain levels of proficiency, but in SFIA v7, the new professional skill ‘Real time/embedded systems development’ would be more appropriate. These concerns are discussed more in the next section on issues and solutions.

5 Discussion of Issues and Potential Solutions

In this section, we discuss:

- the lack of backward compatibility between SFIA v6 and SFIA v7, which is an issue created by the evolution of the framework;

- the lack of universal certification criteria for objective assessment of skills in any version of the SFIA framework, which affects the portability of skill profiles;
- some existing features of SFIA which may potentially be improved: the representation of transferable skills and the scope for automation of skills management tasks.

We also discuss some potential solutions for these issues, which could be adopted in future versions of SFIA.

5.1 Lack of Backward Compatibility

5.1.1 Issues

If the SFIA v7 framework preserved the SFIA v6 framework as-is and only added new professional skills corresponding to:

- new ICT disciplines, which have emerged in the transition period, or:
- existing ICT disciplines, which had previously been overlooked in SFIA v6

then SFIA v7 would be backward compatible with SFIA v6. This would mean that there would be no inherent incompatibility between two interacting users of the framework (e.g. an employer and a potential employee), one using SFIA v6 and one using SFIA v7. Further, users of the framework would be motivated to upgrade to SFIA v7 in order to use the new skill definitions safe in the knowledge that there would not be an incompatibility issue as a result of doing so.

However, as discussed in the SFIA v7 overview (Section 4.1), the updates from SFIA v6 to SFIA v7 are more extensive than this and include the following:

- New professional skills in SFIA v7 which have been forked out from one or more existing SFIA v6 professional skills
- Professional skills, which exist in both SFIA v6 and SFIA v7, and have been changed with respect to name, description and/or the permissible range of levels of responsibility
- Professional skills, which existed in SFIA v6, but have been merged into other professional skills in SFIA v7

These changes have been made at least partly in response to SFIA user community feedback, which is understandable and part of the reason perhaps why the SFIA framework enjoys such popularity. However, they do create the following types of incompatibility between two interacting users of the framework, one using SFIA v6 and one using SFIA v7:

- Invalid values: one user may regard the professional skills or levels of responsibility declared by the other user as invalid, since they are not defined in the version of the SFIA framework being used
- Misinterpretation: because the same ICT discipline can be represented very differently in the two versions of the SFIA framework, one user may regard the professional skills or levels of responsibility declared by the other user as inadequate or unreasonable, when in fact this is not the case

Users of the framework may be discouraged from upgrading to SFIA v7 because of these potential backward compatibility issues.

5.1.2 Solutions

Two solutions to this issue of backward incompatibility between SFIA v6 and SFIA v7 are as follows:

- Users can work with both SFIA v6 and v7 simultaneously for a period until it is deemed that there are no more SFIA v6 only users, at which time SFIA v7 will be used exclusively. For example, an individual may list both their SFIA v6 and v7 skill sets on their resume, so as to maximize their opportunities with different hiring organisations, some of which may be using SFIA v6 and some of which may be using SFIA v7.
- A structured mapping guide between SFIA v6 and SFIA v7 can be constructed such that SFIA v7 users can translate a SFIA v6 skill set into the corresponding v7 skill set (or vice versa) and process it accordingly. Some aspects of such a mapping may be subjective and/or imprecise, however this would still be preferable to the potential of a serious misinterpretation of skill sets that exists now.

Both these solutions require duplication of effort and clear labelling of version information. There is also the potential problem that more than two SFIA versions may be active simultaneously. For example, at the time of writing, the SFIA v5 framework (SFIA, 2019c) is still publicly available, and it must be assumed that some users are still actively using it rather than upgrading to SFIA v6 or SFIA v7.

A summary of changes between SFIA v6 and SFIA v7 is provided in tabular format in (SFIA, 2019d); it allows users to assess the significance of changes (i.e., high, medium or low) for each SFIA professional skill. However, it is not a structured mapping guide, and each user would individually need to explore the detailed nature of changes in concert with the main SFIA v6 and v7 frameworks. In the structured

mapping guide proposed in this paper, a complete set of information would be provided for each professional skill for both SFIA v6 and SFIA v7. Furthermore, it would be beneficial to maintain a history of each SFIA professional skill across all SFIA versions (i.e. dating back to SFIA v5 and before). This could be structured in an XML document that serves as an authoritative lookup whenever there is a mismatch of SFIA versions between users, although there are other valid choices such as a JSON document. In the case of XML, there would be a distinct XML document for each professional skill that has existed across all SFIA versions, irrespective of the birth and/or death versions of the skill, where the birth version is the first SFIA version in which the skill appeared and the death version is the last such SFIA version (for professional skills that have been retired). Such a document for a given professional skill might include the following information about the skill for each SFIA version for which the skill is defined:

- Identifying information such as name and skill code
- Overall natural language skill summary
- Permissible range of levels of responsibility
- Mapping to professional skills in earlier SFIA versions, if appropriate
- Mapping to professional skills in later SFIA versions, if appropriate

A different solution is to use date based tracking instead of version based tracking i.e. skills become deprecated, or are retired, after a certain date. This may be particularly effective when the skills are certified for a given fixed term, as is the case with many industry ICT certifications.

In the longer term, for future versions of SFIA beyond v7, one theoretical (if somewhat unlikely) improvement is to allow the full range of levels of responsibility i.e.

from 1 through 7, for each and every professional skill. This simplifies the framework and means, in future, there will never be a situation where the permissible range of levels of responsibility that apply to a given professional skill needs to change from one version of the framework to the next. This recommendation aligns to some extent with the work of Orsoni and Colaco (2013), who cited the complexity of the skill/proficiency mapping in SFIA v5 as a weakness and indeed a point of confusion among users of the framework, because it is not explained in publicly available documentation. However, Orsoni and Colaco also suggested using less than 7 levels of responsibility for simplicity. While this may have some merit, as classifying according to 7 levels of responsibility will always be subjective, reducing the number of levels downward from 7 would cause another potential backward compatibility issue if it was adopted in future versions of SFIA.

5.1.3 Examples

Some simple examples are now presented to illustrate the nature of the XML documents for the different scenarios discussed in Section 5.1.1/5.1.2. These are not complete examples, since other elements would likely be required, but they serve to illustrate the general concept for illustration and clarification purposes. The scenarios are as follows:

- New professional skills in SFIA v7 which have been forked out from one or more existing SFIA v6 professional skills

  The example XML document depicted in Figure 5 corresponds to the professional skill ‘Real time/embedded systems development’, which is new to SFIA v7, as indicated by the ‘firstSeenInSfiaVersion’ element. However, the ICT discipline of real time and embedded systems development has existed for decades, and previously it was represented implicitly by other professional skills

in SFIA v6 and earlier versions. Therefore, we include a mapping to these other professional skills, specifically ‘Programming/software development’ and ‘Testing’.

[Figure 5: Example XML Based Mapping of Professional Skill ‘Real time/embedded systems development’ for Different SFIA Versions, near here]

- Professional skills, which exist in both SFIA v6 and SFIA v7, and have been changed with respect to name, description and/or the permissible range of levels of responsibility

  The example XML document depicted in Figure 6 corresponds to the professional skill ‘Methods and tools’, which existed prior to SFIA v7, but with a different overall skill summary and a different permissible range of levels of responsibility (3-6 inclusive in SFIA v7, but 4-6 inclusive in SFIA v5 and SFIA v6.

  [Figure 6: Example XML Based Mapping of Professional Skill ‘Methods and tools’ for Different SFIA Versions, near here]

  Another example XML document is depicted in Figure 7. This corresponds to the SFIA v7 professional skill ‘Information governance’ which has undergone a name and skill summary change between SFIA v5 and SFIA v7.

  [Figure 7: Example XML Based Mapping of Professional Skill ‘Information governance’ for Different SFIA Versions, near here]

- Professional skills, which existed in SFIA v6, but have been merged into other professional skills in SFIA v7

The example XML document depicted in Figure 8 corresponds to the professional skill ‘Quality standards’, which existed up to SFIA v6, as indicated by the ‘lastSeenInSfiaVersion’ element, but was merged with ‘Quality management’ in SFIA v7. Therefore, we include a mapping to the SFIA v7 professional skill of ‘Quality management’.

[Figure 8: Example XML Based Mapping of Professional Skill ‘Quality standards’ for Different SFIA Versions, near here]

5.2 Lack of Universal Certification Criteria/Portability

The SFIA v7 professional skill and level of responsibility definitions are based wholly on natural language, and therefore may be interpreted differently by different users of the framework, just as any technical specification based on natural language can be interpreted differently by different readers. For example, determining whether an individual is able to apply, to advise or to set strategy with respect to a particular professional skill, which determines the skill proficiency in terms of the level of responsibility, will always be subjective to some extent unless further qualified.

This type of situation is usually addressed by devising a separate universal (i.e. centrally managed) set of certification criteria to resolve any possible ambiguity in the base specification. In the case of SFIA, such universal certification criteria would allow objective assessment such that a trusted third party could certify the skill profile (levels of responsibility versus professional skills) of an individual. However, SFIA does not define universal certification criteria and instead delegates the assessment/certification process to individual users without any central oversight or direction.

For some use cases of SFIA, this is not a huge issue. For example, an organisation may set its own certification criteria and apply them to determine the SFIA skill profiles of its existing employees e.g. for the purposes of internal skill gap analysis.

This is a closed environment and so private certification criteria are sufficient. However, if an employee of this organisation then applies for a job at a different organisation, or is assigned to a project providing services to a different external organisation, their skill profile, as determined in the original environment, is not necessarily valid, as the second organisation could use totally different certification criteria. This demonstrates the need for universal certification criteria to support *portability* of skill profiles. Without such criteria, the utility of the SFIA framework will always be limited.

The solution to this issue is for universal certification criteria to be defined either within SFIA itself, or by a separate body created by the SFIA user community. Furthermore, such criteria should include defined mappings between formal qualifications, industry certifications and other recognised educational awards and SFIA skills. While this will be an extensive and ongoing exercise, it is the only way to truly unleash the potential of a skills framework in all use cases. It can also be argued that SFIA or a related body should define standard mappings between common job roles such as ‘Software Engineer’ and ‘Senior Software Engineer’ and SFIA skills. While this is problematic (at least initially) because of the different definitions of such roles across organisations, it does create new opportunities and use cases for SFIA. For example, if a resume does not include any claim to SFIA skills, then simply by exercising standard mappings for qualifications, certifications and job roles contained in the resume, it is possible to build a SFIA skills profile automatically. Moreover, such standard mappings between job roles and SFIA skills will encourage organisations to more closely align their job role names with the associated mappings.

The mapping between SFIA professional skills on the one hand, and qualifications, certifications and job roles on the other, can be specified in a structured

document such as an XML document, that serves as an authoritative lookup whenever there is a need to translate education and experience into a SFIA skill profile. A simple example to illustrate the likely nature of such an XML document for the 'Network support' professional skill is presented in Figure 9. With similarity to previous XML examples, this is not intended to be a complete example, since other elements would likely be required, but it serves to show the general concept for illustration and clarification purposes. It can be seen from Figure 9 that there is a mapping from the Cisco certification CCNA (Cisco, 2019) to a level of responsibility 2 for the 'Network support' professional skill, and a mapping from the more advanced Cisco certification CCNP to a level of responsibility 3 for the same skill. Similarly, there is a mapping from the 'Support officer' job role to a level of responsibility 2 and a mapping from the 'Senior support officer' to a level of responsibility 3.

[Figure 9: Example XML Based Mapping of Professional Skill 'Network support' to Industry Certifications and Experience, near here]

Another type of mapping, which may be useful to support portability, is between SFIA professional skills and educational learning objectives, which are sometimes specified in conjunction with Bloom's taxonomy (Anderson et al., 2001). There have been several academic investigations into using SFIA to inform ICT curriculum development, which are summarised in the literature review in the Introduction of this paper.

5.3 Representation of Transferable Skills

The SFIA v7 framework, like previous versions of the framework, does not represent traditional transferable skills such as communication, leadership, ethical decision making and teamwork explicitly as SFIA professional skills. SFIA professional skills are mostly reserved for traditional technical or hard skills. However, as we have noted,

there are some SFIA professional skills such as ‘Innovation’, which may be regarded as transferable skills, since they can apply across disparate job roles.

The traditional transferable skills are instead represented in the proficiency level of SFIA professional skills in terms of the level of responsibility. Certainly, as the level of responsibility for a SFIA professional skills increases, it is assumed that at least the leadership and communication associated with that professional skill are increasing. This differs from some other ICT skill frameworks, which treat technical and transferable skills independently. For example, SFw for ICT represents technical skills as Technical Skills and Competencies (TSCs) and transferable skills as Generic Skills and Competencies (GSCs). The CC2020 initiative (Impagliazzo and Pears, 2018; Frezza et al., 2018) also clearly distinguishes between knowledge, skills and disposition.

The issue surrounding the treatment of transferable skills in SFIA has been touched upon by other researchers (von Konsky, Jones and Miller, 2016; Orsoni and Colaco, 2013). Even if this is recognized as an issue by the wider SFIA community, it will be difficult to resolve without fundamentally changing the representation of skills and proficiencies in a future version of SFIA. Having said this, it is clear that backward compatibility is not a huge concern when moving from one SFIA version to the next based upon the experience of moving from SFIA v6 to v7, so it may be a possibility.

5.4 Limited Scope for Automation

The SFIA framework acts as a skills framework standard in the ICT sector, allowing users of the framework to agree on terminology and a model for skills management. This facilitates automation of certain skill management tasks by interacting users provided they are using the same version of the SFIA framework. For example, when an organisation has advertised a job containing a certain minimum SFIA skill profile as part of the requirements, they can easily scan a large number of resumes

in an automated fashion for candidates purporting to have requisite SFIA skills, provided all users have adopted the same version of the SFIA framework. Another example of SFIA facilitating automation would be an organisation that wishes to aggregate the SFIA skill profiles of one of its departments to understand overall skill coverage and overall skill gaps. Again, provided all the employees had declared their SFIA skill profiles according to the same version of the SFIA framework, this task can easily be automated.

However, as we have seen, problems may arise when:

- Users have adopted different versions of the SFIA framework, since SFIA is not backwards compatible at least when moving from v6 to v7, or:
- When there is a mix of SFIA users, users of a different skills framework and/or actors who do not subscribe to any framework at all

Automation can only be realised in all these cases when there is an agreed mapping between different versions of the SFIA framework, between different skills frameworks and between SFIA and qualifications, certifications and experience. In this paper, we have proposed such a mapping should be undertaken using an XML application, although this is not the only possibility.

It should be noted that, while automation of skill management tasks is possible without the definition of universal certification criteria for the SFIA framework, the real power of automation occurs when there are such criteria in place, since this removes the subjectivity from SFIA definitions, allowing two independent parties to agree unambiguously on a SFIA skills profile for an individual.

6 Conclusions

The SFIA v7 framework introduces new ICT skills, retires/merges others and redefines

some to a greater or lesser extent. This is clearly important in a sector, which is and always has been, subject to rapid change. The common terminology and model afforded by SFIA v7 for ICT skills management certainly provides benefits to users in terms of costs savings, efficiency and new opportunities.

However, the evolution from SFIA v6 to v7 is not backward compatible, which can cause issues when two users, one of whom is using v6 and the other v7, interact. This can be solved by creating and maintaining a standard mapping between the definitions of each professional skill across SFIA versions. In this paper, we proposed using XML for this purpose, since it facilitates automation of skill management tasks, although it is not the only possibility. Another highlighted issue is that SFIA v7 still does not include universal certification criteria for assessing whether someone has attained a certain proficiency in terms of a level of responsibility for a given professional skill. Without this, the assessment will always be somewhat subjective. In this paper, we proposed not only establishing such criteria, but creating a standard mapping to educational qualifications, industry certifications and job experience to increase the utility of the SFIA framework as a whole. Again, this mapping can be implemented via an XML application to facilitate automation. Finally, the representation of soft or transferable skills is somewhat different in SFIA v7 than in some other ICT frameworks such as SFw for ICT; they are not represented as standalone independent skills, but as part of the definition of proficiency in terms of level of responsibility. Other researchers have made similar observations about this aspect for previous versions of SFIA.

Future work will concentrate on formally defining an XML application to represent some of the skill mappings discussed in this paper, including version

mapping, qualifications mapping and experience mapping in order to increase the utility of the framework.

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