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Sustainable Industrial Revolution Competency Framework for 5G Technology Applications using TRIZ

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ABSTRACT

The Malaysian industrial revolution strategy, also known as Industry4WRD, has been the driving force behind the transformation of the industrial sectors by accepting and implementing modern technology. The initial phase of the Industry4WRD initiative focuses on the readiness assessment of industrial businesses to determine their level of adoption of Industry 4.0. However, the second phase challenges firms to advance and increase their readiness index. According to data collected from 473 firms, the 'People' shift element has the most significant obstacle for companies to overcome, particularly for small and medium-sized businesses (SMEs). In the 'people' dimensions of Industry4WRD, the research emphasised the importance of competency in developing human capital for 5G technology applications. The benchmarking technique revealed five skill levels, the competency unit and work activities associated with 5G telecommunications and system networks. The theory of creative problem solving (TRIZ) was applied to a system-based idea to develop a conceptual competence framework. Twenty-five firms were selected and contributed to this research by designing and verifying a conceptual competence framework for 5G technology implementation. With a 0.81 concordance coefficient, the study's objective has been accomplished by obtaining a high level of unanimity across 25 organisations in three rounds of the Delphi poll. As a guideline, the conceptual competency framework may be utilised to create other technology competencies, such as automation and artificial intelligence workforce. It would benefit the country to conduct more research on the specifics of competence units depending on the needs of industrial sectors.

1. Introduction

Over the past decade, Malaysia focused on developing its technology capabilities in the telecommunication sector. Various initiatives and strategic planning have been developed and executed by the government of Malaysia with the growth of industrial sectors and community development towards digital literacy [1]. In the context of the industrial revolution, telecommunication sectors have become a vital element for connectivity and digital information

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applications. Malaysia has started a proactive action plan to accelerate the adoption of the industrial revolution concept in various industry sectors through a national policy called Industry4WRD, launched in 2018 [2]. In the Industry4WRD policy, telecommunication and system networks are the critical technologies measured in the Industry4WRD readiness assessment under the shift factor technology-connectivity [3]. In 2019, the demand for telecommunication and system networks increased, with 45 million users, especially in the wireless network [4]. Furthermore, the market trend is projected to increase with rapid growth in the telecommunication sectors for the next five years.

However, several challenges have been faced by the industrialist with the fast growth of technology evolution. The technological progress from 4G to 5G network is providing advantages to the adoption of the industrial revolution in an organisation and, at the same time, creates a disruption to the business value chains with some operational risks [5,6]. Besides the transition of network to 5G infrastructure, there is an impact on the workforce and job functions that is significant to adopting the technology at the organisational level. Consequently, there is a demand for expertise and competency in designing, developing, and operating the 5G technologies in a particular segment of the business value chain. In addition, there is a limited talent pool in 5G technologies that is skilled and experienced enough to support and embrace the high performance of communications and system network applications [7]. Therefore, Malaysia should prepare talent development in 5G technology applications with the specialized skill set and competencies that may accelerate the deployment of 5G system network applications and fulfil the essential objective of the Industry4WRD strategy, vision, and mission.

2. Methodology

There are various categories of telecommunication systems in the Malaysian sector of telecommunication and system networks. Wire, wireless and satellite telecommunication systems exist in different vertical industrial sectors [8]. In this study, our scope will focus on the 5G wireless telecommunication system that is starting to increase the demand for adopting the industrial revolution concept at the industrial level. Through the Industry4WRD program, the study has engaged and collected data from 473 companies on the shift factor technology of connectivity. The assessment areas of connectivity technology cover the operation, the facilities and the enterprise level. The general outcome of the assessment will analyse the data from multiple aspects of the industrial revolution, such as 'technology', 'process' and 'people' shift factors [9]. From the analyzed data, we identified the organisation Industry4WRD profiles in 5 categories; 'conventional', 'newcomer', 'learner', 'experienced', and 'leader', as shown in Table 1 [10]. The 'conventional' profile is an established industry representing the traditional organisation that maintains low or no technology in their business value chain and wants to stay the same or the same as the industrial revolution concept. The 'newcomer' profile shows the minimum level of industrial revolution elements in their technology, process and people. The 'learner' profile indicates the sufficient level of program or project related to the industrial revolution that the organisation has initiated. The 'experienced' profile is for an organisation that has already adopted the industrial revolution concept at a specific department and division as a solution for problem-solving or continuous improvement. Lastly, the 'leader' profile achieved mature organisational characteristics in adopting the industrial revolution concept for company-wide profitability, cost saving, market competitiveness and business sustainability.

Table 1
The Industry4WRD readiness profiles [10]

Industry4WRD Readiness Profile	Percentage of readiness	Descriptions
Conventional	0% - 20%	The operation remains "as is" with no intention or initiative into Industry 4.0 adoption
Newcomer	21% - 40%	Has the interest to pursue Industry 4.0 but with none or very minimal efforts or initiatives
Learner	41% - 60%	Has the interest in pursuing pilot line Industry 4.0 adoption in operation, with the existence of planning and strategies, efforts or simple and patches of initiatives being implemented.
Experienced	61% - 90%	Has pursued small to medium-scale Industry 4.0 adoption initiatives in operation and horizontal integration and is ready for large-scale system adoption
Leader	91% - 100%	Has implemented large-scale Industry 4.0 adoption initiatives (company-wide) and system integration

With the Industry4WRD profiling, this study extracted specific data from the assessed organisations on connectivity technology as a sub-profile. In addition, the study gathers qualitative data through an interview session with selected organisations identified under learner, experience and leader profile categories, as shown in Figure 1. This selection is based on the criteria that the company is just starting or operating or even executing a connectivity technology in their organisation, as a part of an industrial revolution project. As a result, three categories of companies have been shortlisted for each of the Industry4WRD profiles: the 'leader', 'experienced' and 'learner'.

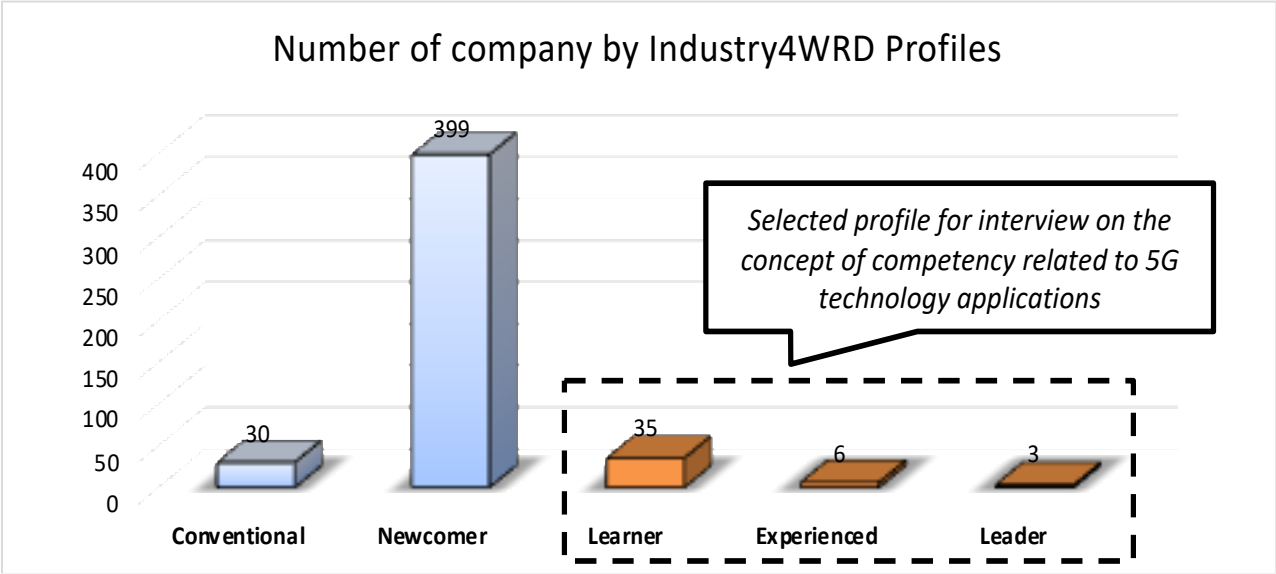

Fig. 1. The number of companies participating in the Industry4WRD program by profiles

This selected profile has already started a program or project related to the industrial revolution concept at their operation, facility, or enterprise levels. This indicates that the company have at least started the initiative and acquired knowledge to plan a project related to the industrial revolution in manufacturing or an indirect project related to the energy optimization of green building [11]. The 'experienced' profile company has planned to adopt an industrial revolution technology system. For the 'leader' profile, they go beyond taking the initiative to innovate their process to optimize their output and customize their industrial revolution technology system. The company representative has

been interviewed on the challenges and issues related to connectivity technology and 5G applications.

The selected Industry4WRD companies provide the context of connectivity technology into three categories; the operation, facilities, and enterprise levels [12]. Figure 2 shows the theme of the organisation's technical challenges during the industrial revolution project design and development phase. The technical difficulties require technological solutions developed by the talent to resolve the issue effectively. This study analyzed the theme of the technical requirement from the perspective of talent in connectivity technology applications and 5G system networks. The technical condition can be translated to competency units and skills critical for the industrial revolution project. The listed competencies will be shared within the selected companies to get their feedback and consensus to form a conceptual competency framework and validation purposes.

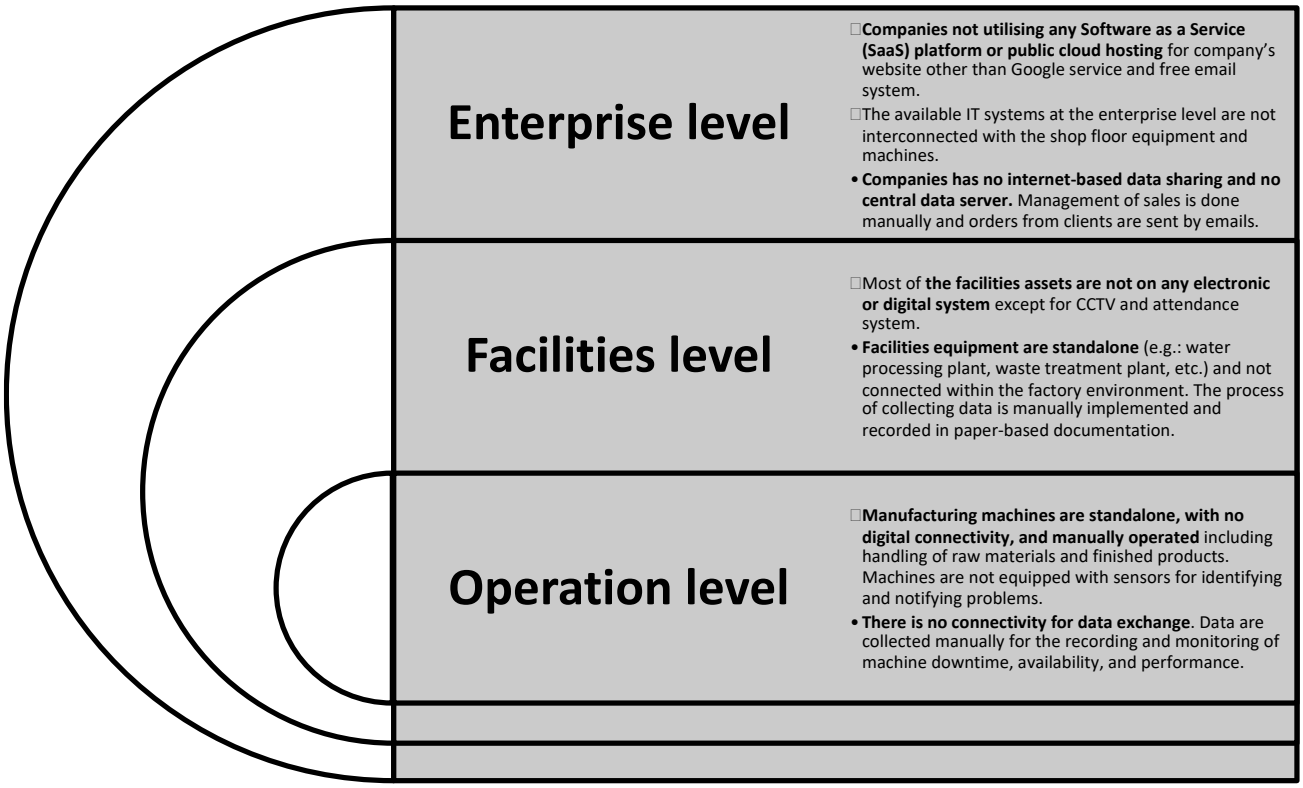

Fig. 2. The number of companies participating in the Industry4WRD program by profiles

3. The Competency of Telecommunication and System Network

Competency development is significant for the application of advanced technology application through the value chain of the organisation. In Malaysia, we have categorized the level of competencies into five groups, as shown in Figure 3 [13]. For competencies in telecommunication and system networks, level 1 will focus on the competency in work activities that have the nature of repeatability, following routine and standard operating procedures related to telecommunication and system networks. For level 2, the competency will be covered in the same scope available in level 1 and with additional responsibilities and autonomy, which introduce empowerment to address non-routine work activities related to telecommunication and system networks—for example, troubleshooting errors in the system network. Next, the level 3 competency has a medium complexity in their work activities compared to level 2. It requires particular competency that involves diagnosis skills, risk and more accountability in the work activities. Level 4 involved a high-

level complexity in the work activities related to telecommunication and system networks. The high complexity involved high responsibility for technical risk at the operation and facility levels. Finally, level 5 refers to the competency comprising a significant range of fundamental principles and complex techniques across a wide and often unpredictable variety of contexts. Very substantial personal autonomy and often considerable responsibility for the work of others and the allocation of significant resources feature strongly, as do individual accountabilities for analysis, diagnosis, planning, execution and evaluation. This level has been successfully adopted in Malaysian technical institutes, especially for Technical and Vocational Education and Training (TVET) [14].

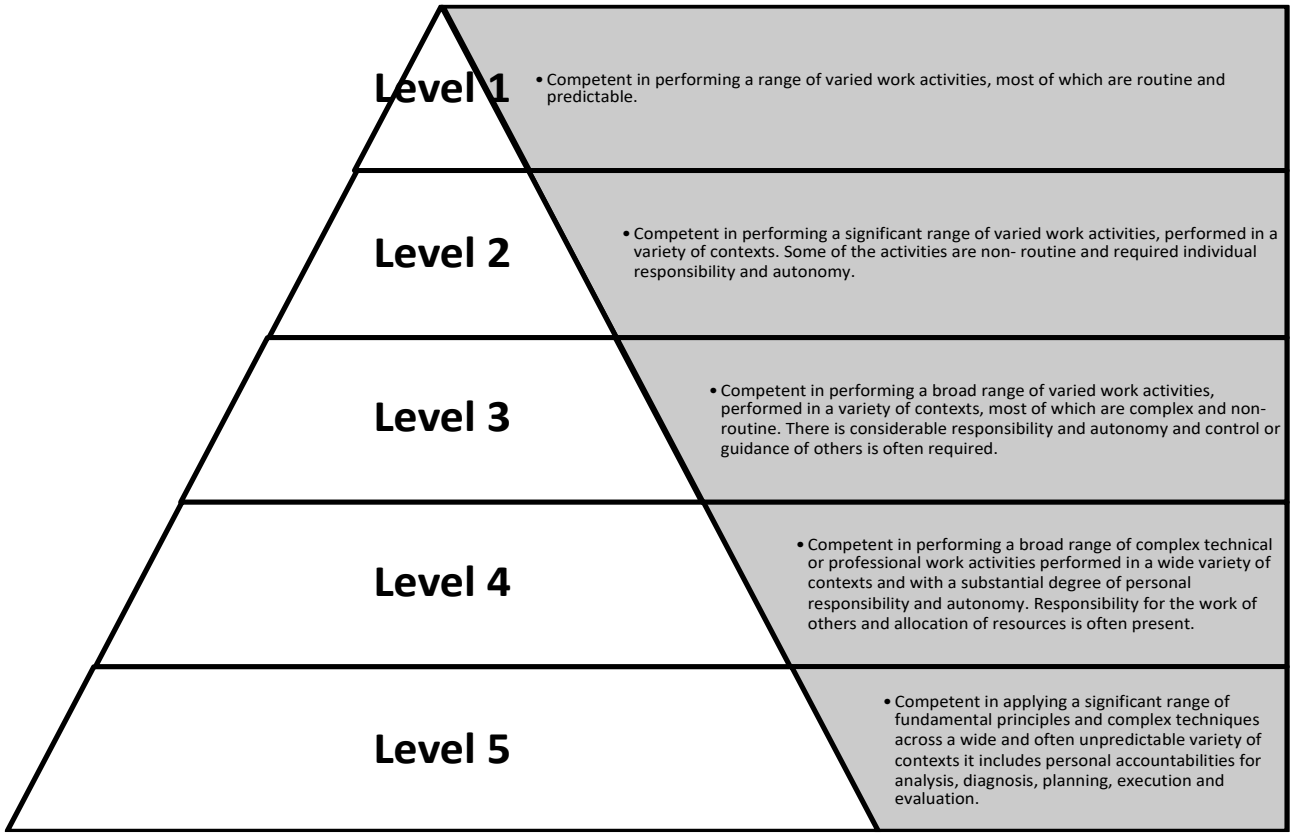

Fig. 3. The overview of Malaysia's standard competency levels [13]

In the context of telecommunication and system network sectors, the work condition will highly depend on the size of the organisation and the type of network used for the organisation's functions. The critical challenges for this area of work will be the focus on the performance of connectivity and the reliability of the telecommunication signals [15]. The nature of the work also depends on the internal and external function of the organisation, which is not timebound and relies on the operability of the system network. The place of work also may vary according to the job functions, for example, the system network development that involves internal servers and external cloud system networks. The most critical focus related to competency is delivering availability and connections. They also must be adaptable to new technologies and provide a mandated level of reliable networking services [16]. In Figure 4, the example shows the standard competency profile related to the telecommunication and system network highlighted by the IndustryWRD selected companies. The competency unit is the core element in developing telecommunication and system network policy, which is critical in carrying out the work activities such as preparation, producing documentation, management and system improvement.

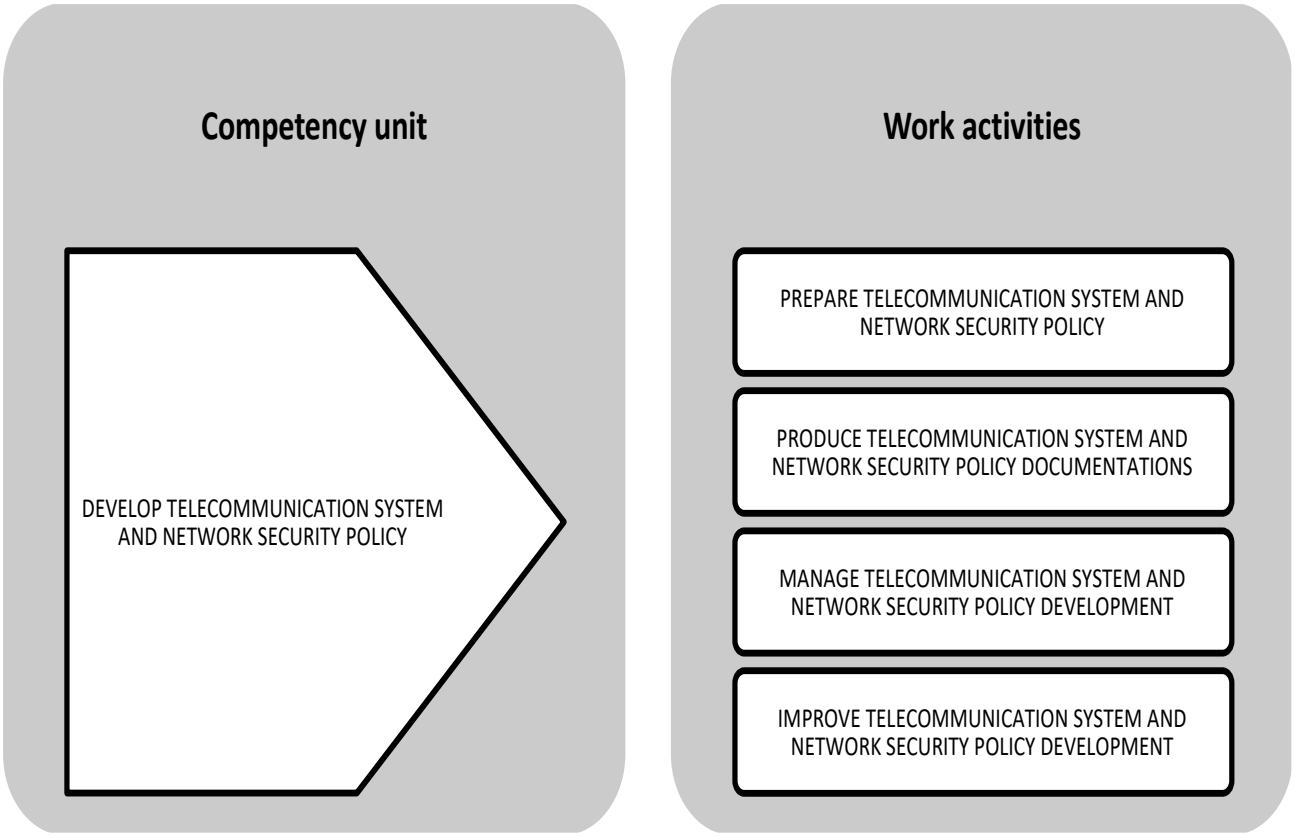

Fig. 4. The competency profile for telecommunication and system network

4. The Conceptual Competency Framework of 5G Technology Applications Using TRIZ

According to the analyzed data of Industry4WRD readiness assessment companies, talent competencies development is critical in the shift factor connectivity technology. From the data, 25 companies do not conduct competency requirements; training needs analysis and learning & development plans for their employees regarding the 'Industry 4.0' technology pillars. The employees must attend training on Industry 4.0, which limits their exposure, knowledge and skill about the technology. Most employees need to be more knowledgeable in Industry 4.0 as most activities are based on their job scopes/required skillset. Most executives in the industrial revolution project have been hired since 2019, and they are still new to their roles and working in a silo with less coordination. Therefore, recruiting the workforce with the appropriate skills, knowledge, and desirable attitude for the 'Industry 4.0' transformation is increasingly difficult. Recruitment of force with the proper skills, expertise and attitude for the 'Industry 4.0' transformation project is increasingly challenging in Sarawak. Another company finds it challenging to employ or recruit employees to design and customize 5G technology systems as there is a limited supply of knowledgeable and skilled personnel and graduate in these areas. Companies have informed on the lack of dedicated IT personnel as a hindrance factor in the competency of personnel 'In Industry 4.0'. This challenge requires a solution for developing adequate competency and skill set, especially in assisting the 5G technology applications.

A conceptual framework is proposed to support the organisation in developing strategic competency and skill sets for 5G technology applications, as shown in Figure 5. The conceptual framework used the system-based theory of inventive problem solving or TRIZ. The framework comprises job functions as sub-systems or components for the competency unit representing the workforce system [17]. Meanwhile, the job title of 5G talent refers to the super-system of the

workforce, which differ according to the nature of the 5G application and type of industrial sectors. At the sub-system level, two key components represent the technical and organisation components. The technical component carried the function of technical work activities, such as design, development, analysis, calculation, etc. The organisation component moved the position of organisation roles and authority, such as supervising, managing, leading, reviewing, endorsing, authorizing, etc.

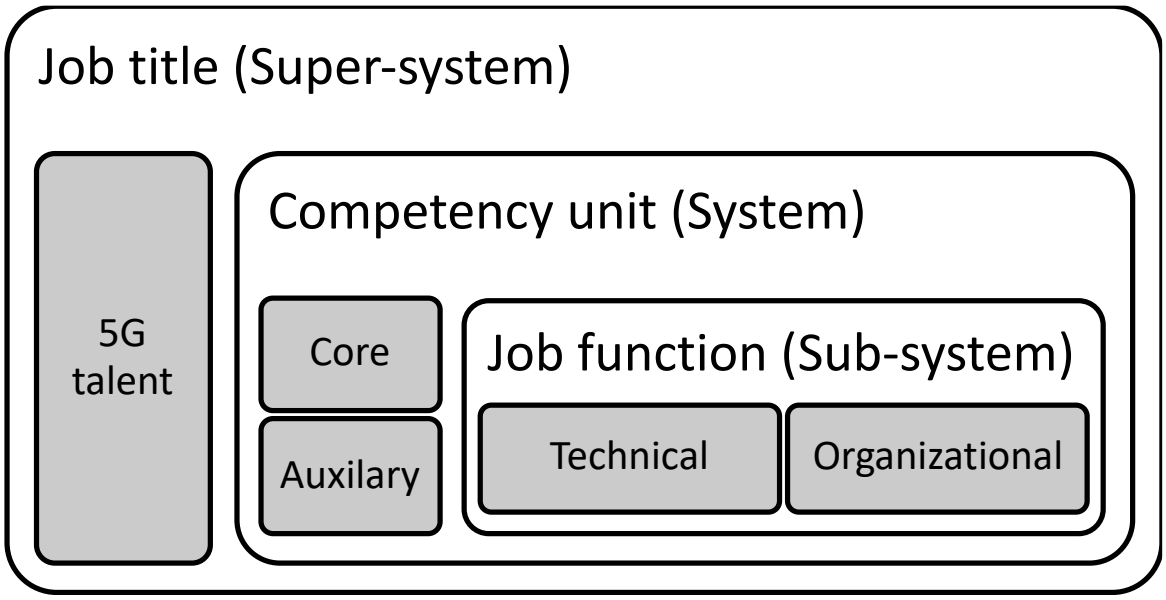

Fig. 5. The conceptual competency framework of 5G talent using TRIZ system-based theory

Each function becomes the building block of the competency unit, which is critical for 5G technology applications. At the system level of competency unit, 5G core competency units are related to the 5G application. The 5G core skills set, such as programming, operating system, system optimization, etc., is supported by another 5G auxiliary competency unit. The additional competency unit will complement the 5G core competency in executing the job functions, such as analytical skills, problem-solving skills, project skills, management skills, etc. The super-system level is established based on a specific set of competency units required for the organisation to achieve its goals using 5G technology. The organisation will create their personalize job title with selected competency units to carry out the job functions, such as 5G specialist, 5G system developer, 5G digital data processing engineer, 5G test engineer, 5G subject matter expert, 5G marketing manager, 5G solution engineer, 5G technical project manager, etc.

The 25 experts from each selected company have validated the conceptual framework for adopting a 5G system network in their organisation for the Industry4WRD program. The consensus has been achieved sufficiently with a concordance coefficient (w) of 0.81 in the third round of the Delphi survey. This indicates a strong agreement between industries that agreed with significant the concept of the framework in designing, developing and executing 5G competency for their industrial revolution project related to 5G technology applications. Various industrial sectors can use the conceptual framework, especially in setting up new talent for the organisation that focuses on developing and growing its human resource capabilities. The detailed element in the job functions and competency units can become the building block for the organisation to establish influential job roles and responsibilities according to the project's needs and future operation such as automotive, chemical and construction industries [18-20].

5. Conclusions

The study produced the conceptual competence framework for 5G technology applications with significant consensus among 25 Industry4WRD programme participants. The framework's structure can aid the corporation in determining the essential criteria for the organisation's effective adoption of 5G technology. Instead of emphasizing traditional administrative positions, the framework will give strategic balance to the technical competency unit's personnel development and acquisition efforts. The basis of the five competency levels assists businesses in customizing their competency unit and work activities per the needs of their industrial revolution projects and programmes. This can enhance the efficacy of the second phase of the Industry4WRD intervention programme, particularly in the competency development dimension. The verified framework is utilized for industrial sectors and formulating policy for the Malaysian human capital programme, supporting the national skills standard and concentrating on human resource management for the industrial revolution programme.

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