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Analysing the Critical Quality Factors in IOT-Based Service Implementation: A Systematic Evaluation

Norliza binti Sidek, Nor'ashikin binti Ali

***Abstract:** The emergence of InternetofThings offers opportunities for public services to deliver efficient and high-quality smart services. At present, the IoT-based services (IoTbS)are still at an initial stage of the journey to Government's digital transformation. Although the success of IoTbSimplementation depends on users' behaviour and their willingness to use, little attention has been paid to explore the critical quality factors (CQFs) of IoTbSthat may influence the usage and performance. This article presents the currentstate of IoTbSimplementation and will answer these questions: 1) What are the CQFsthat influence the usage and performance of IoTbSimplementation?; and2) What are the research types and research contribution types in this area? In this study, a systematic literature reviewwas performed using specific search string to obtain papers recently published from four relevant electronic databases. As a result, the systematic search yielded 10,066 hits and 11 papers were selected presenting CQFs in this context. Besides identifying the CQFs, research types and contribution types in IoTbSimplementation, this paper reports the identified research gaps that have led the author to recommend potential future directions on this topic.*

***Keywords:** IoT, Quality Factors,e-Government, Systematic Literature Review, IS Success Model*

I. INTRODUCTION

Governments around the world are beginning to realise the benefits of Internet of Things-based Services (IoTbS) implementation. TheIoTbS delivers a new value to citizens, enhances capabilities, increases service delivery, and solves many chronic problems plaguing their management, economies, and environment (Group, 2017; Obi, 2017; Talavera et al., 2017). Thus, various types of wireless technology connected to the Internet are increasing, which in turn realises the vision of Internet of Things (IoT). It is reported that the latest worldwide spending on the IoT is forecasting high growth rate from US$737 billion in 2016 to US$1.29 trillion in 2020 (Masse & Beaudry, 2017). In 2018, the number of IoT connected devices in use worldwide have reached 23.14 billion (Statista, 2018). Governments implementing IoTbS may face challenges in ensuring the products and services are of better quality with improved performance standards. Low quality in services may influence the users' perceptions, which than can lead to non-optimal use and high failure rates of the services(Ali et al., 2017).

An unexpected outcome during implementingIoTbS may trigger security breaks and physical accidents (Alaa et al., 2017; Asir, 2016; Hussein et al., 2018; Samant et al., 2017; United Nations Department of Economic and Social Affairs, 2018). To ensure the success of Government'sdigital transformation and to provide guaranteed services, it is essential to address the critical quality factors (CQFs) of IoTbS.

Following the work by Petersen, Vakkalanka, and Kuzniarz (2015), this paper presents systematic review by considering the CQFsthat have been used to gauge the IoTbS success implementation andidentifies thefactors that need more attention. The findings will be useful for a more comprehensive assessment of CQFs. The paper is organised into four sections: Section 2 explains the research methodology adopted to conduct SLM. Section 3 explains the findings and results of the SLM, followed by Section 4that presents the research conclusions, limitations, and suggestions for future research.

II. REVIEW METHOD

This study usesSystematic Literature Review (SLR) to capture the current state of research relating to IoTbS in Digital Government. Compared to traditional literature reviews, a SLR offers an approach that assists the investigation in great breadth (Petersen et al., 2008). This study adopts SLR guidelines by Kitchenham & Charters (2007)to identify CQFs that may affect the usage and IoTbS performance.

This SLR aimed to find which of the CQFs have been considered and not when validating users' satisfaction, and IoTbSperformance. We also identified research types and research contributionhave been proposed and have been underutilised. The process is adopted from (Ahmad et al., 2018).Figure 1 presented the main phases of SLR, while Table 1 shows details of planning review.

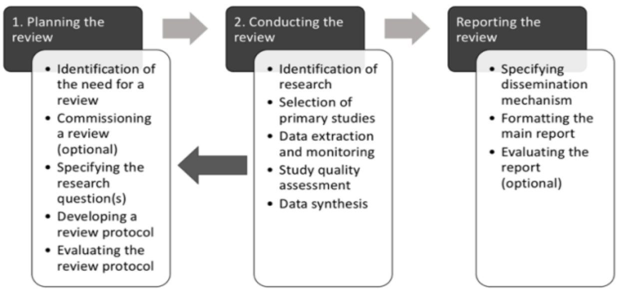

Fig. 1 The Main Phases of SLR

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Norliza binti Sidek,Tenaga Nasional University
Nor'ashikin binti Ali,Tenaga Nasional University

Table. 1 Details of Planning Review

Categories	Details
Research Questions (RQs)	1) What are the CQFs that influence the usage and performance of IoTbS implementation? 2) What are the research types and research contribution types in this area?
Database Sources	Five (5) online databases subscribed by the University Tenaga Nasional's digital library (Taylor and Francis Group, Scopus, Science Direct, and IEEE Explore). Applied an advanced search strings with a combination of Boolean operations and concentration on the TAK fields (Title, Abstract, and Keywords) to gain additional significant results as suggested by White, Nallur, & Clarke (2017).
Keywords Used	The search were extracted using PICO technique by Kitchenham et al. (2010) to formulate search strings from RQs and to identify keywords. 1) P=Population: IoTbS 2) I=Intervention: CQFs 3) C=Comparison: Applicability of CQFs in IoTbS ecosystem. 4) O=Outcomes: List of CQFs, research types and research contribution.
Final simplified query string	((“IoT Service?” OR “IoT Application?” OR “IoT System?” OR “Internet of Things Service?” OR “Internet of Things Application?” OR “Internet of Things System?” OR “Smart Services?” OR “Smart Application?” OR “Smart System?”) AND (‘‘quality factor?’’ OR “quality element?” OR “quality aspect?” OR “quality component?”))
Study Selection	To filter out irrelevant results, this study used five (5) selection criteria: 1) Advanced Filters: by automatic filtering technique to ensure the inclusion and exclusion criteria applied. 2) Removal of duplicates based on the title of the articles, author names and year. 3) Preference title by remove the articles with the title unrelated to CQFs and IoT. 4) Abstract Selection by remove the articles which do not present a CQFs as an output of research. 5) Full paper selection (fast reading) by remove the articles which did not present a CQFs as one of the contributions and does not define the CQFs considered. 6) Related references (snowballing) as the final stage to include other works through the process of snowballing. This stage identified an additional paper in the references. The selected papers then added to the final list of papers.
Inclusion Criteria	Studies published online from 01/03/2014 to 01/03/2019 in the field of computer science, future generation computer systems, and computer applications. Studies are presenting quality factors as one of the contributions of the paper and using quality factors to evaluate their IoTbS implementation.
Exclusion Criteria	Studies were presenting non-peer reviewed material and not presented in English. Studies not accessible in full-text and duplicates of other studies.

III. RESULTS AND DISCUSSION

It can be difficult to determine the keywords that contribute to most documents especially when long string keyword is used. This research conducted some keywords using the SCOPUS database to find which predefined keywords contributed the most articles as seen in Figure 2. From this diagram, the highest percentage (37.88%) or 50 of our returned results were from the ((“IoT” OR “Internet of Things”) AND “quality factor”) keyword searches. As it would takes a lot of time to conduct a SLR with over millions of documents, this useful information described the coverage of the final search string and allowed to revise the current keywords to be more precise. This research decided to focus keywords on ‘IoT’, ‘Internet of Things’ and ‘quality factor’ to provide exploration of the particular areas that we wanted to map. Figure 3 shows the results removed from each stage and the selection of articles. The complete list of all articles can be found in Appendix A.

SCOPUS 01.01.2019	IoT, "Internet of Things"	"IoT Services"	"IoT System"	"IoT Application"	"Smart Services"	"Smart System"	"Smart Application"	Count	Percentage
CQF, "Critical Quality Factor"	0	0	0	0	0	0	0	0	0
"Quality Factor"	42	1	1	6	1	3	0	54	40.91
"Quality Element"	1	0	0	0	0	0	0	1	0.76
"Quality Aspect"	7	0	2	0	0	1	1	11	8.33
"Quality Component"	0	0	0	0	0	0	0	0	0.00
Count	50	1	3	6	1	4	1	132	
Percentage	37.88	0.76	2.27	4.55	0.76	3.03	0.76	100%	

Fig. 2 Keywords used on search engines

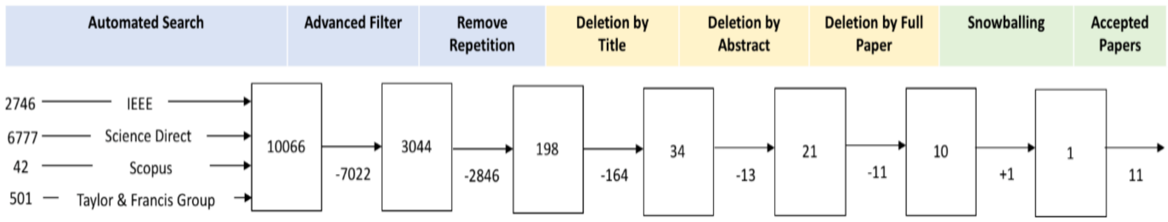

Fig. 3 Selection of articles

RQ1: What are the CQFs that influence the usage and performance of IoTbS implementation?

Larrucea et al., (2017) argued that a new approach to standard software engineering techniques needed to resolve several issues such as user satisfaction of quality of IoTbS implementation.This approach allows us to map each quality factors addressed by DeLone & McLean (2003) as a critical factor for information system success with other quality approached proposed by IoT researches.Table 3 showsthe classification of the CQF addressed by IoT researchers.

Table. 3 Classifications of Critical Quality Factors

Quality Factor	Definition & Source	Study	Article
Information Quality			
Accuracy*	The degree of user's perception to which the IoTbS data are correct, reliable, and certified free of error (Bailey & Pearson, 1983; Wang & Strong, 1996).	A3, A5, A7, A8, A10	5
Timeliness*	The degree of user's perception to which the IoTbS offers timely responses to the request for information or action (Bailey & Pearson, 1983; Wang & Strong, 1996; Wixom & Todd, 2005).	A3, A5, A6, A7, A9, A10	6
Completeness*	The degree of user's perception to which the IoTbS data are sufficient, comprehensive, breadth, depth, scope and provide all the necessary information for the task at hand (Bailey & Pearson, 1983; Wang & Strong, 1996; Wixom & Todd, 2005).	A3, A8	2
Relevance*	The degree of user's perception to which the IoTbS data are applicable and helpful for the task at hand (Bailey & Pearson, 1983; Wang & Strong, 1996; Wixom & Todd, 2005).	A6, A8	2
Consistency*	The degree of user's perception to which the data values are the same for all instances of IoT-based services (Gusmeroli et al., 2009).	A3	1
Security:	The user's perception of the degree the system preserving the confidentiality, integrity, and availability (CIA) of information (Farooq et al. , 2015).	A1, A2, A3, A4, A7, A9, A10	7
System Quality			
Easy to Use / Usability*	The degree of user's perception to which the IoTbS are easy to use (Rai, Lang, & Welker, 2002).	A1, A2, A3, A4, A10, A11	6
System Functionality*	The degree of user's perception to which the information IoTbS functionalities match the needs of the task (Lu, Wang, & Hayes, 2012).	A1, A2, A6, A7	4
System Reliability*	The degree of user's perception to which the dependability of the IoTbS operation (W. H. DeLone & McLean, 2016; Nelson, Todd, & Wixom, 2005).	A1, A2, A4, A5, A6, A7, A9, A10, A11	9
System Flexibility*	The degree of user's perception to which the IoTbS adapts to the changing demands of the user (Bailey & Pearson, 1983; Nelson et al., 2005).	-	0
Portability*	The degree of user's perception to which the capability of the system to change another environment system such as install ability, co-existence, and replaceability (Kim, 2016).	A1, A2, A7	3
Integration*	The degree of user's perception to which the ability of the sensors to communicate with heterogeneous devices and network protocol for information exchange (S. Singh & Tiwari, 2018).	A10	1
Performance Efficiency	The scale of data existing in the IoTbS as it collects data from sensors, connected devices, cloud performance where it stores, network, signal strength and the frequency of the collection (Kiruthika & Khaddaj, 2015).	A1, A2, A4, A10	4
Compatibility	The degree to which an innovation perceived as being consistent with the potential adopters' existing values, past experiences, and needs (Rogers, 2002).	A1, A2, A8	3
Maintainability	The degree of user's perception to which a software system or component can be easily modified to correct faults, improve the performance or other attributes, or adapt to a changed environment (Riaz, Mendes, & Tempero, 2009).	A1, A2, A10	3
Robustness	The ability of IoTbS to maintain its performance under undue pressure and changes (Kiruthika & Khaddaj, 2015).	A4, A10	2
Interoperability	The ability for IoTbS to communicate and exchange information between each other and external systems of different structure (Kiruthika & Khaddaj, 2015).	A4, A10	2
Scalability	The ability to increase IoTbS without affecting the level of performance of a system (Kiruthika & Khaddaj, 2015).	A4, A10	2
Service Quality			
Tangibles*	The physical facilities, hardware and software, and appearance of personnel (William H. DeLone & McLean, 2003; F.Pitt, Watson, & Kavan, 1995; Pitt, Watson, Kavan, & Watson, 2011).	A11	1
Reliability*	The ability of a service provider to perform the promised service dependably and accurately (William H. DeLone & McLean, 2003; F.Pitt et al., 1995; Pitt et al., 2011).	A11	1
Responsiveness*	The willingness to help customers and provide prompt service (William H. DeLone & McLean, 2003; F.Pitt et al., 1995; Pitt et al., 2011).	A11	1
Assurance*	The knowledge and courtesy of the service provider and their ability to inspire trust and confidence (William H. DeLone & McLean, 2003; F.Pitt et al., 1995; Pitt et al., 2011).	A11	1
Empathy*	The caring attitude and individualized attention the service provider gives its customers (William H. DeLone & McLean, 2003; F.Pitt et al., 1995; Pitt et al., 2011).	A11	1

This research used the D&M ISSM as a reference framework to analyse the most CQF of the presented quality model. This model classified three main quality dimensions where each dimension contains several quality factors to measure. 1) Information quality takes into account many factors such as accuracy, timeliness, completeness, relevance, consistency, and security. The result shows that information quality covered 29.5% of the overall quality approaches. The most addressed quality factor in a quality model for IoTbS is security. Security is a new critical quality factor under information quality. As a non-functional quality aspect, security needs to be tuned and should be traceable for the IoTbS in order to protect data privacy and confidentiality (Kiruthika&Khaddaj, 2015). 2) System quality is one of the essential quality dimensions and is addressed in 64.1% of the articles. It contains many important factors such as usability, functionality, reliability, portability, integration, importance, performance efficiency, compatibility, maintainability, robustness, interoperability, and scalability. Reliability is the most used quality factor as seen in Table 3 and is often the primary goal of many of the approaches. Reliability has been considered the most critical factor in IoT system quality as services are offered across Platforms and operate in diverse contexts (D. H. Shin, 2017). It is also one of the aspects thatneed to be addressed at each layer of the IoT architecture (White et al., 2017). 3) Service quality is essential in increasing usage as user expectations have a substantial effect on overall satisfaction. Surprisingly, as seen in Table 3, only 6.4% of the articles addressed the importance of service quality dimensions such as tangibles, reliability, responsiveness, assurance, and empathy. Together these results provide valuable insights into other quality factors that determine the success of IoTbSimplementation such as trustworthiness, adaptability, faults tolerance, throughput, latency, sustainability, and auditability (Batista et al. 2018; Hoyos et al., 2016; Singh & Tiwari, 2018).

The most frequent CQF applied are maintainability, reliability, security, usability, and timeliness as shown in Table 3.Table 3 also presents essential factors deemed critical to influence user satisfaction and the success of the IoTbS implementation but are rarely taken into consideration namely, flexibility, integration, consistency, tangibles, responsiveness, assurance, and empathy. The present research is expected to highlight the use of DeLone& McLean Information System Success Model. This research also providesa list of quality factors that must be taken into considerationwhen implementingIoTbS.

RQ2: What are the research types and research contribution types in this area?

This study uses the classification structure recommended by Wieringa et al. (2006) to characterize the research approaches. Table 4 shows the research approach used by IoT researchers. The result suggests that more studies on experience and opinion papers are needed because IoTbS are still at an early and primitive level (Bi et al., 2016; Miorandi et al., 2012). Although the use of IoT technology is rapidly evolving with many benefits mentioned in the paper, very few IoTbS are being developed in industries (L. Da Xu, He, & Li, 2014). Most frequent types of research in this area have focused on evaluation and validation research. This study has identified the need for further research on experience reports or opinion papers.Evaluation research is the most utilised research facet to determine theresearchmodel orresearch method,resulting in less on other substitute contribution facets such as metrics, processes, and tools.The contribution types of research were developed by accessing relevant quality approaches through SLR(Abdelmaboud et al., 2015; Oriol, Marco, &Franch, 2014). Table 5 presents the significant contributions types in these selected papers.The model contribution is the most common throughout all the research compared to other contributions. The contribution of models is useful as it allows to explore the quality factor relationships and identify challenges. This research also identified the second highest research contribution type is method. Method refers to an algorithm or a specific approach to improve quality in IoTbS. However, there are other contribution types with lower scores such as tools, processes, and metrics. Interestingly, this result is correlated to a recent study by Salahshour, Mehrbakhsh, and Dahlan (2018) in their reviewed papers on IS adoption. The authors claim that the 'actual system use' is recorded as the lowest frequency of use due to the complexities involved in measuring the dependent variables. Since the study on the IoTbS usage is low, it affects research contribution because researchers need to compare pre and post IoTbS implementation results in order to come up with new tools, processes, or metrics.

Table. 4 Types of Research Approach

Research Approach	Definition	Study	Article
Evaluation Research	This is the investigation of an empirical solution proposal in practice. In general, research results in new knowledge of causal relationships among phenomena, or new knowledge of logical relationships among propositions. Casual properties are studied empirically such as by survey, field study, field experiment or case study. Logical properties are studied conceptually, means such as mathematics or logic.	A5, A6, A8, A11	4
Validation Research	This investigates the properties of a solution proposal that has not yet implemented in practice. The solution may be proposed elsewhere by another author. The investigation uses a complete methodologically research setup. Possible research methods are mathematical analysis, simulation, experiments, mathematical proof of properties, etc.	A1, A2, A3	3
Solution Proposal	This is the proposal of technology solution for a problem, which must be a novel or significant improvement of an existing technique. A proof of concept may be offered by a logical argument or a small example.	A4, A7	2
Philosophical Papers	This is a proposal which is usually performed a new conceptual framework or structuring a new way of looking at things.	A9, A10	2
Opinion Papers	This is the author's opinion about whether a technique is right or wrong and how we should do something. These papers usually not contain research methodologies or related work.	-	0
Experience Papers	This is the author's personal experience of an actual project including what was performed and how it has done but not on why it happens. The paper usually contains a list of lessons learned without a discussion of research methods.	-	0

Table. 5 Types of Research Contribution

Contribution Type	Research Output	Study	Articles
Tool	Contribution of applications or software tools to increase quality in IoTbS.	A11	1
Method	Contribution of specific approach or an algorithm to increase quality in IoTbS.	A1, A2, A3	3
Process	Contribution of specific activities or architecture to improve quality in IoTbS.	A8	2
Models	Contribution of relationships with different CQFs in IoTbS.	A4, A5, A6, A9, A10	4
Metrics	Contribution of reporting measurements which calculated the CQFs in IoTbS.	A7	1

IV. CONCLUSION

The goal of this SLR was to specify the CQFs in IoTbS. The suitable CQFs on user satisfaction is to ensure the success of IoTbS implementation in Digital Government. This research used the SLR process to identify 11 articles as main studies. The answers to the research questions are consideredthe primary outcome of this study.Our contribution to the research is the potential future research directions. Directions for future research have been identified based on the results in the previous subsections. We believe the results help practitioners to increase the level of user satisfaction and to achieve a successful implementation of IoTbS.

There are some limitations of the study.First, the review process of the previous literature could use meta-analysis software to examine the potential causal effects and interrelationshipbetween them. Second, future research could also involve Government IoT Experts in order to increase results reliability and validity.

Appendix A. Complete list of all articles included in the SLR study.

[A1] Tambotoh et al. (2016), [A2] (White, Nallur, & Clarke, 2017), [A3] (Karkouch, Mousannif, Al Moatassime, & Noel, 2016), [A4] (Kiruthika&Khaddaj, 2015), [A5] (Banerjee &Sheth, 2017), [A6] (Shin, 2017), [A7] (Bello &Zeadally, 2017), [A8] (Hoyos, García-Molina, Botía, &Preuveneers, 2016), [A9] (Batista, Kuehne, Frinhani, Filho, &Peixoto, 2018), [A10] (Singh & Kumar, 2018), and [A11] (Zheng, Martin, Brohman, & Xu, 2014).

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