Government Approaches to Requirements Gathering in Smart Cities: Lessons Learned for Southeast Asia

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***Abstract*—Smart city is frequently regarded as an effective approach that leverages technological solutions to address urban challenges. However, due to the complex nature of smart city projects, requirements engineering plays a crucial role in providing a structured method to gather, analyze, and manage the needs of various stakeholders. This ensures that technological solutions are properly aligned with urban development goals. However, it's important to note that most of the current requirements engineering (RE) theories originate from the Global North. Given the significant socio-cultural differences between the Global North and the Global South, it is essential to investigate the existing policies regarding requirements engineering in smart city projects in both regions. This will help to understand how these techniques are adapted or need to be tailored to suit the unique contexts of each region. This study aims to explore the government's perspective on requirements engineering in the Global South compared to those in high-ranked smart cities from the Global North. Considering the diverse cultural backgrounds in the Global South countries, we select Southeast Asia cities in the 2024 IMD Smart Cities Index as case studies. We conducted comprehensive reviews of government policy documents and smart city websites from 23 cities in 20 countries; 15 cities from the Global North and 8 cities from Southeast Asia. The policy documents and official websites were selected to represent the official government stance on requirements engineering. We observed that each city has different perspectives and employs various requirements-gathering techniques for smart city projects. Based on the result, we propose community-based requirements engineering for smart cities in Southeast Asia countries.**

***Index Terms*—smart city, global north, global south, requirements engineering, community-based**

I. Introduction

According to the UN [1], the world urban population is projected to be 68.8% by 2050. In more developed regions, 86.6% of the population is expected to live in cities, compared to 65.6% in the less developed regions. This increasing population has the potential to intensify urban challenges, including sanitation, pollution, transportation and various other urban problems. To address these challenges, diverse solutions have been designed and implemented. One of the solutions involves the application of the smart city concept, which aims to improve the citizen's quality of life through the use of information and communication technology.

Until now, there have been various definitions of smart cities. As a comparison, The International Telecommunication Union (ITU), an agency under the United Nations specialising in information and communication technologies (ICTs), defines a smart sustainable city as *an innovative city that uses information and communication technologies (ICT) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects* [2]. Meanwhile, the European Commission defines a smart city as *a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business*. From the various definitions available, it is clear that different organizations may have distinct focuses and strategies in implementing smart cities. Therefore, it is crucial to understand smart cities from the perspective of the government, as a key stakeholder in these initiatives. However, amidst the diversity of smart city definitions, one common thing is that all these definitions emphasize the use of ICT solutions in solving urban problems.

Similar to other ICT projects, smart city initiatives require requirements engineering to align technological developments with the specific needs and expectations of stakeholders. Effective requirements engineering practices in the context of smart city is crucial for minimizing risks and achieving successful implementation of smart city projects. However, despite the importance, requirements engineering for smart cities remains a relatively under-studied subject [3].

This research aims to explore the requirements engineering practices, especially in the requirements gathering phase, conducted by cities around the world. To understand the characteristics of smart cities implemented in various cities, we compared the policy documents and official smart city websites from selected countries in the Global North and the Global South, focusing on Southeast Asia. Considering the diverse situation among the Global South countries, Southeast Asia was chosen as a regional representative as countries in this region share similar cultures and socio-political situations.

To achieve our goal, we conducted a comprehensive review of smart city policy documents and official smart city websites from 23 cities in the Global North and the Global South. The process includes a comparative analysis of the requirements-gathering practices among selected cities. The main contributions of our works are: (1) providing a comparative analysis of smart cities implemented by governments around the world, and (2) proposing a novel approach to requirements engineering for smart cities in Southeast Asia.

II. Related Works

Research into requirements engineering has been conducted for many years. However, there has been limited research focusing specifically on requirements engineering within the context of smart cities. In 2018, Bastisdas, Helfert and Bezbradica [4] conducted literature study that identified a set of requirements by analyzing 10 selected research articles. This study presented 12 functional requirements and 16 non-functional requirements for the design of smart city reference architectures. Daneva and Lazarov [3] conducted a similar study, which resulted in a set of smart city requirements that categorized into four classes: end-to-end experience, architectural, security, and infrastructure requirements. However, both of these studies focus on identifying requirements for smart cities, without addressing the issue of how these requirements are gathered.

Meanwhile, research on smart city policy documents was conducted by Micozzi and Yigitcanlar in 2022, who investigated smart city policy of 52 local government from 17 countries [5]. The research focused on comparing key planning issues, goals, and priorities outlined in these policy documents. Another study on smart city policies was conducted by Estevez [6], who explored various smart city policies and standards issued by international organizations such as ISO, ITU, and the European Commission. This exploratory research focused on comparing government policies related to smart cities and highlighting common themes for the development of smart cities.

From the existing research, it is evident that while there are studies focusing on smart city policies and requirements engineering, there is a notable gap in research specifically addressing government strategies for gathering requirements for smart cities. Therefore, this study is important as it aims to examine current government policies related to requirements engineering and identify necessary steps to improve our understanding of the requirements from diverse stakeholders involved in smart cities.

III. Study Design

We construct a comparative analysis of the requirements gathering practices in the smart cities of Global North and Global South by extracting information from governments' policy documents, or from the official websites for smart cities in the absence of information from such formal policy documents. Our study is driven by the following research questions:

(RQ1) What are the characteristics of smart city projects in Southeast Asia and how do they differ from smart city projects in the Global North?

(RQ2) How are requirements gathered for the smart city projects in Southeast Asia and the Global North cities?

We adopted a structured approach [7] to answer these questions. This approach consists of following four-step process:

(i) Selection of relevant literature: We follow the International Monetary Fund (IMF) categorization [8] for the differentiation between Global North and Global South. IMF, in the World Economic Outlook, divides the world into two main groups: (1) advanced economies, denoted as the Global North, and (2) emerging and developing economies, referred to as the Global South. We then used the IMD Smart City Index (SCI) to select cities as subjects of this study [9]. The IMD Smart City Index ranks 142 cities globally by assessing the perception of city residents on issues related to smart cities. From these 142 cities, we decided to pick top 15 cities and chose only one city from the one country in the Global North This choice is made to gain insight into policy differences across various countries.

Global South broadly consists of countries from Africa, Asia except Singapore, Japan and South Korea, Latin America and even a few countries from Europe such as Bulgaria and Ukraine. The government style, political structure, culture and geo-strategic position vary a lot among these countries and even within each country. For this reason, it is quite hard to draw a straight and fair comparison among smart city projects of these countries. Therefore, we restrict our analysis to the Global South countries in Southeast Asia region in the IMD Smart City Index which comprises Indonesia, Malaysia, Thailand, Vietnam, and Philippines. We draw a comparative study of eight cities in the Southeast Asia with fifteen cities from the Global North countries, all of which are listed in Table I.

(ii) Organization and preparation for analysis: The strategic document for smart cities issued by the municipality serves as the primary source for this analysis. However, in instances where this document is unavailable or not accessible to the public, we examined the strategic document for smart cities issued by the National Government. These strategic documents might be in the form of a guideline, master plan, digital strategy, or standard. Additionally, to complement our investigation, we also investigated the official smart city website developed by the city administration.

(iii) Detailed coding and analysis: Upon acquiring the documents, we organize the literature and conducted a coding process in Atlas.ti. We use the combination of predefined code, which consists of three specific codes including *definitions, themes, and requirements gathering*, and in-vivo coding to capture relevant information in the documents.

(iv) Reporting our findings: In this phase, we summarize our main findings emerging from the data analysis and report them in Section IV. We perform narrative synthesis, which is a systematic method resulting in a textual narrative summary explaining the emerging from the content analysis and identifying emerging patterns and trends [10].

IV. Results

A. RQ1: Characteristics

The results of analysis on policy documents and official smart city websites show that there are differences in the characteristics of smart cities in the selected countries. To find out the basic differences between smart cities, we discovered the characteristics of smart cities by analyzing official definitions

TABLE I
SELECTED CITIES FOR POLICY REVIEWS

No	City	Country	Smart City Rank	Country Categories
1	Zurich	Switzerland	1	Global North
2	Oslo	Norway	2	Global North
3	Canberra	Australia	3	Global North
4	Singapore	Singapore	5	Global North
5	Copenhagen	Denmark	6	Global North
6	London	UK	8	Global North
7	Helsinki	Finland	9	Global North
8	Stockholm	Sweden	11	Global North
9	Hamburg	Germany	14	Global North
10	Prague	Czech Rep.	15	Global North
11	Seoul	South Korea	17	Global North
12	Amsterdam	Netherlands	18	Global North
13	Vienna	Austria	23	Global North
14	Tallinn	Estonia	24	Global North
15	Reykjavik	Iceland	26	Global North
16	Kuala Lumpur	Malaysia	73	Global South
17	Bangkok	Thailand	84	Global South
18	Hanoi	Vietnam	97	Global South
19	Jakarta	Indonesia	103	Global South
20	Ho Chi Minh City	Vietnam	105	Global South
21	Medan	Indonesia	112	Global South
22	Makassar	Indonesia	115	Global South
23	Manila	Philippines	121	Global South

and identifying the common themes of smart city projects. Several cities uses different term, including 'smart city dimensions', 'solution categories', 'smart city components', 'field of activity', and 'priority projects', to describe categories of their smart city initiatives. However, we used the term 'themes' in this article for the purpose of standardizing and ensuring consistency in this study.

Our investigation reveals that not all policy documents provide an official definition of smart city or 'themes' for smart city projects. In some instances, the information is either unavailable, inaccessible, or only presented in a local language. From the accessible information, we identified 11 definitions from 11 policy documents and 19 sets of themes from 19 smart cities.

Comparing the definitions of a smart city provides insight into how different governments perceive and approach the concept of a smart city. Analysis was conducted by investigating smart city definitions in policy documents or government websites and extracting words from the definition. For instance, the Vienna Municipality define that smart city *means high quality of life for everyone in Vienna through social and technical innovation in all areas while maximising conservation of resources*. Based on the definition, we extracted the following key words and phrases: *high quality of life, everyone, social innovation, technical innovation,* and *conservation of resources*. Subsequently, we compare the extracted words and phrases for each smart city definition and identify commonalities among them.

Table II provides information on the definition comparison of smart city. Several words are often found in this definition, namely *people or citizens, technology, business, participation, quality of life, sustainable,* and *innovation*. Based on our observation, all available policy documents included *people and technology* as part of the definition of a smart city. We found that most of the cities included *the quality of life* as part of smart city goals in the definition. However, several cities such as Zurich, Singapore and Manila also mention improving *business* as part of the smart city goals.

An additional notable observation from these findings is that three cities in the Global South—Bangkok, Medan, and Makassar—include *participation"* as a part of their definitions of a smart city. In contrast, only one city in the Global North, Oslo, incorporates this aspect into its definition. This finding may indicate that, for these cities, public participation is a crucial element, as it is integrated into their definitions of a smart city. Meanwhile, the word *sustainable* is exclusively present in the definition provided by Medan and Makassar municipalities, which are cities in the Global South.

TABLE II
SMART CITY DEFINITIONS

No	City	people/citizens	technology	business	participation	quality of life	sustainable	innovation
1	Zurich	x	x	x				
2	Oslo	x	x		x			x
3	Canberra	x	x			x		
4	Singapore	x	x	x		x		
5	Copenhagen							
6	London							
7	Helsinki							
8	Stockholm							
9	Hamburg							
10	Prague	x	x					
11	Seoul							
12	Amsterdam							
13	Vienna	x	x			x		x
14	Tallinn							
15	Reykjavik							
16	Kuala Lumpur	x	x			x		
17	Bangkok	x	x		x	x		x
18	Hanoi							
19	Jakarta							
20	Ho Chi Minh City							
21	Medan	x	x		x	x	x	x
22	Makassar	x	x		x	x	x	x
23	Manila	x	x	x				

Based on the analysis of definitions, smart cities in the Global South share more commonalities compared to their counterpart in the Global North. Additionally, smart cities in the Global South tend to incorporate more keywords in their definitions than those in the Global North. This may suggest that smart cities in the Global South have more objectives or challenges compared to the Global North cities. However, further research is necessary to confirm this observation.

The next characteristic is *themes* for smart city projects. Themes is a categorization of smart city projects based on the goals or general characteristics of the project. For generalisation purposes, we did not include unique themes in some smart cities, including *smart participation* in Zurich or *the*

urban landscape in Tallinn. 'Unique themes' refer to those that are present exclusively in a specific city and are not found in the themes of other cities. Upon collecting all themes, we interpreted these themes and classified them into eight general themes. A themes comparison was conducted to observe the similarities of themes in the selected cities.

TABLE III
THEMES FOR SMART CITY PROJECTS

No	City	Transport	Health	Education	Environment	Climate	Digital Infrastructure	Energy	Economy
1	Zurich	x							
2	Oslo								
3	Canberra					x	x	x	
4	Singapore	x	x	x					x
5	Copenhagen	x			x	x	x		
6	London	x	x		x				x
7	Helsinki				x	x			x
8	Stockholm	x					x	x	
9	Hamburg	x	x	x				x	x
10	Prague	x			x			x	
11	Seoul	x	x						x
12	Amsterdam	x			x			x	
13	Vienna	x	x	x	x	x		x	x
14	Tallinn	x	x	x	x		x		x
15	Reykjavik								x
16	Kuala Lumpur	x	x	x	x		x		x
17	Bangkok	x	x	x	x			x	x
18	Hanoi								
19	Jakarta								
20	Ho Chi Minh City								
21	Medan		x	x	x				x
22	Makassar		x	x	x				x
23	Manila			x	x		x	x	x

In Table III, it can be observed that the most common themes are transport, present in 13 cities, economy in 13 cities, environment in 12 cities, and health in 10 cities. On the other hand, the least common themes are climate, found in 4 cities, and digital infrastructure, found in 6 cities.

We can also observe that the most common themes used in the Global North are transport in 11 cities, economy in 8 cities, and environment in 7 cities. Meanwhile, the most common themes in the Global South cities are education, environment, and economy which are present in 5 cities. It is noteworthy that the climate theme appears exclusively in smart cities in the Global North. Additionally, the themes of transport, energy, and digital infrastructure are each represented in only two cities in the Global South.

In terms of quantity, it can be observed that most of the cities in the Global North have less common themes that those in the Global South. Most of the smart cities in the Global North have four or less common themes, with the exception for Vienna which has seven common themes, Tallinn with six common themes, and Hamburg with five common themes. Meanwhile, cities in the Global South share four or more common themes. For example, Kuala Lumpur and Bangkok each have six common themes, Manila has five, and Medan and Makassar each have four.

B. RQ2: Requirements Gathering

Each city has a different strategy for gathering requirements from the stakeholder. However, based on the policy documents collected and websites investigated, no city referred to *requirements gathering* or *requirements elicitation* in their official sources. Therefore, we interpreted all techniques that could be employed for requirements gathering in smart city projects. Through investigation, we managed to obtain requirements-gathering techniques from 19 out of 23 smart cities.

Based on document investigation, we classified requirements gathering techniques in smart cities into 11 classifications, including innovation grants, hackathons or innovation challenges, workshops and focus groups, interviews, living labs, surveys, and participation portals. However, we found that participation portals can serve various purposes. Hence, we divided the participation portals into five types such as sharing ideas, complaints, opinions, feedback and voting ideas. We have categorized participation portals into five types to clarify in detail the types of requirements collection techniques used by the selected cities. Sharing ideas is used to share ideas between citizens or propose ideas to the government. Complaints are used to report problems to the government. Feedback are used to give suggestion about specific problems or projects. Meanwhile voting ideas are used to vote ideas from citizens to be implemented in smart city projects. The 'Sharing Ideas' portals facilitate the exchange of ideas between citizens or the submission of idea proposals to the government. 'Complaints' portals are designated for reporting issues or problems. 'Feedback' portals provide a platform for citizens to offer suggestions on specific problems or projects. Additionally, 'Voting Ideas' portals enable citizens to cast votes on which ideas should be prioritized for implementation in smart city projects.

As observed from Table IV, the most widely used methods to gather requirements are participation portals for sharing ideas and feedback, living labs, and workshop/focus group, all of which are employed by 6 smart cities in the Global North. In contrast, these methods are not mentioned in the policy documents of any smart cities in the Global South. Meanwhile, innovation grants and interviews are the least widely used methods, each being applied in only one city: Zurich and Reykjavik, respectively.

It is noteworthy that the most commonly used methods in the Global South are participation portals for complaints. Additionally, all documents from these cities mention only one or two methods for gathering requirements.

It is evident that the majority of smart cities in the Global North have more than one requirements-gathering technique. Reykjavik, for instance, utilizes various functions, such as participation portals, workshops, and interviews. This contrasts with cities in the Global South, which have fewer methods for collecting requirements.

TABLE IV
REQUIREMENTS GATHERING FOR SMART CITY PROJECTS

No	City	innovation grants	hackathons/innovation challenge	participation portal (share ideas)	participation portal (complaints)	participation portal (opinion)	participation portal (feedback)	participation portal (vote ideas)	workshop/focus group	interviews	living labs	surveys
1	Zurich	x		x								
2	Oslo											
3	Canberra			x		x	x	x	x			x
4	Singapore		x	x					x			
5	Copenhagen										x	
6	London		x				x		x		x	
7	Helsinki										x	
8	Stockholm								x			
9	Hamburg						x		x		x	
10	Prague		x	x			x					
11	Seoul				x	x		x				
12	Amsterdam											
13	Vienna			x		x					x	
14	Tallinn		x								x	
15	Reykjavik			x		x	x		x	x		
16	Kuala Lumpur				x							
17	Bangkok											
18	Hanoi					x	x					
19	Jakarta		x		x							x
20	Ho Chi Minh City											
21	Medan				x							
22	Makassar				x							
23	Manila											

V. DISCUSSION

A. Distinguishing the Differences

In the definitions of smart cities, most cities in the Global North do not explicitly mention 'public participation'. However, in practice, these cities utilize various methods to engage citizens in smart city projects, employing digital methods such as participation portals and traditional methods like workshops and interviews. In contrast, while several smart cities in the Global South explicitly mention 'participation' in their definitions of a smart city, they employ fewer requirements-gathering techniques compared to their counterparts in the Global North. This situation might be the results of different socio-political and cultural context of the Global North and the Global South, especially Southeast Asia, which influence how the governments gather requirements for smart city projects.

The differences are also observed in themes of smart city projects. Smart cities in the Global North are inclined to use unique and fewer common themes compared to those in the Global South. Since the themes often originate from priority issues faced by a city, it can be inferred that cities in the Global North are more focused on addressing the specific problems in their cities. Each city has distinct priority challenges, which is reflected in the narrower range of common themes among smart cities in the Global North. In contrast, smart cities in the Global South have more common themes, indicating a focus on a wider range of projects. This suggests that cities in the Global South are engaged in more diverse projects compared to the Global North.

B. Community-based Requirements Engineering

Requirements gathering is one of the important activities in a smart city project. Therefore, identifying the correct requirements is one of the determining factors for the success of smart city projects. As observed on Table IV, smart cities in Southeast Asia adopt fewer strategies to gather requirements compare to the smart cities in Global North. This situation often caused by various factors including limited financial resources, limited digital infrastructure, and limited human resources. To address these issues, we proposed a community-based requirements engineering approach for smart cities in Southeast Asia. We illustrated the complete process in Fig. 1.

As stated by Kung Phoak, Deputy Secretary General of ASEAN, people in Southeast Asia share common values of caring for family and community [11]. Collectivism is highly valued among the people of Southeast Asia, compared to the individualism value in the West. The smallest administrative divisions, such as neighborhood associations including Rukun Tetangga (RT) in Indonesia and Malaysia, Barangay in the Philippines, Muban in Thailand, or villages in other regions, can serve as examples of communities from which requirements may originate.

In addition to community, the government also serves as the key stakeholder of smart cities. The hierarchical nature of leadership structures in Southeast Asia positions leaders as the highest policymakers within government organizations [12]. It is impractical to gather all stakeholders for requirements gathering. However, relying solely on leaders' opinions during the requirements-gathering process carries the risk of producing incomplete or incorrect requirements. Therefore, designated representatives of stakeholders are necessary. To gather requirements, we propose that government agencies discuss requirements internally and communicate their opinions with these representatives.

The objectives of smart cities are to address urban problems and to increase the citizens' quality of life. Hence, it is imperative to accurately identify **urban problems** that require resolution and prioritize them accordingly. Mistakes in determining priority problems can result in the ineffectiveness of the resulting smart city solutions.

After determining priority problems, the smart city team may explore **possible solutions** that can be employed to address the priority problems. In addition to the recommendation of the smart city team, solutions can originate from the government or community representatives. After selecting several solutions, the smart city team will seek approval from the government representatives to implement the chosen solutions. Seeking approval from the government is crucial, given that the government typically owns this smart city project.

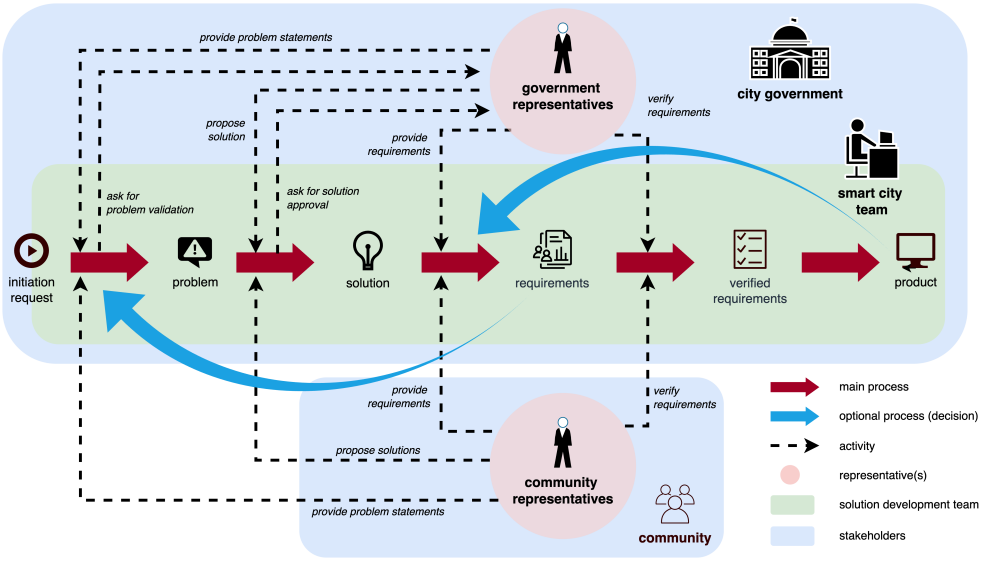

Fig. 1. Community-based Requirements Engineering for Smart Cities in Southeast Asia

In the next phase, the smart city team will elicit **requirements** from the government and community representatives. Various tools and techniques can be utilized in this phase. During the requirements elicitation phase, if the smart city team encounter new and unrelated requirements, the team will discuss this to ascertain whether it constitutes a new urban problem.

Upon completing the requirements elicitation phase, the smart city team will conduct a requirements analysis. The smart city team may also create requirements specifications, which will be verified by the representatives to ensure accuracy and alignment with project objectives before proceeding further with the implementation and later the **verified requirements** will serve as the foundation for system design.

Subsequently, the smart city team will design the system and begin implementation. After **product** testing and deployment, the smart city team will ask for feedback from the public and if the team identifies new requirements, the team will initiate the requirements elicitation phase. However, if a new problem arises requiring a different solution, the problem identification stage will be revisited.

VI. Conclusion

In this study, it can be observed that each city might have different smart city concepts compared to other cities. Cities that have long implemented smart cities and are in the category of Global North countries are inclined to define smart cities according to their current context, such as the smart climate city concept applied by Austria or Singapore's smart nation concept. In addition, these countries have more channels for public participation than the Global South countries. While this study conducted a comprehensive review on smart city documents issued by the government, there is a need for empirical research on the implementation of smart cities in these countries. In addition, this study proposed a novel requirements engineering approach for smart cities in Southeast Asia. However, further research is necessary to evaluate this method in practical situation.

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