A Design of Technological Infrastructure for Citizen Participation in Public Value Co-creation

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Abstract. Along with the disruptive development of ICTs such as social media and Internet of Things (IoT), attempts to use them for citizen participation in public values co-creation are also accelerating. While attempts to use social media-based citizen participation for public value creation are actively going on, despite the growing penetration of IoT into our daily lives, IoT use is limited to ad hoc processing and attempts to use it for insights extraction to create public value are still passive. Then, several scholars argue that combining social media and IoT can be one alternative to overcome practical limitations in applying social media to citizen participation in public value co-creation. In this background, we have conducted a study to construct a technological infrastructure that can integrate data from citizen participation through social media and the IoT, using it for the public value co-creation process. The proposed design can provide realistic conditions for a solution that can support decision-makers suffering from a lack of citizen participation in the process of co-creating public value.

Keywords: Public value · Co-creation · Citizen participation · Internet of Things (IoT) · Social media

1 Introduction

Attempts to introduce entities other than the public sectors into the public value creation process have begun long ago. However, it was considered difficult to realize, or at least economically inefficient, because it consumes a lot of work costs to involve numerous geographically widespread entities in the public value creation process [16]. Along with the disruptive development of ICTs, especially Internet technology, since the end of the last century, it has significantly reduced the work costs to involve entities other than public sectors in the public values creation process, becoming the co-creation of the public values as a hot topic again. The initial approach to co-creating the public values was to present topics related to issues of the public interest to government-owned digital platforms and request to participate in discussions or suggest ideas for them [19]. This

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initiative can be regarded as a government-led approach in that it raises the topics of discussion and requires citizens to participate. However, these platform-based initiatives were not very successful due to a lack of citizen participation [15]. Meanwhile, the emergence of social media has created a new channel for citizens to include in the public values creation process. The social media approach that governments initially used to co-create the public values was crowdsourcing, which also raised topics and required citizens to suggest opinions on the topics, there was no fundamental difference with platform-based approaches in mechanisms. Meanwhile, social media allowed citizens to voluntarily discuss various topics on their social media without government interference [15]. Citizens' discussions on social media attracted the attention of scholars and practitioners as they encompass diverse topics and include insights that would be very valuable if mined. The term social media monitoring (SMM) has emerged under the efforts of practitioners and researchers to harness citizens' voluntary discussions on social media for value creation. SMM was initially used in the private sector and then transferred to the public sector. SMM is to systematically and continuously monitor citizens' discussions conducted on social media to harness insights from citizens in public values creation [7]. SMM approach, given that citizens discuss on their social media without external interference and the government obtains insights from citizens' voluntary discussions to create public values, has been regarded as a citizen-led approach. In [18], it is argued that social media-based citizen participation plays a role in further strengthening citizens' role in determining what is needed for society under the prerequisite of the government's recognition of citizens' knowledgeability. Other researchers have also described that the introduction of social media in the public sector promotes communication between government and citizens, opening the way for the government to more grasp the needs of citizens and allowing stakeholders to expect that public values 'for citizens, by citizens' would be created [5, 13, 17]. Despite these expectations from scholars and practitioners, socio-technological challenges such as privacy, digital divide, participation inequality, and intentional manipulation hinder social media from becoming an excellent means for public value co-creation [1, 3, 4, 6, 11, 12, 14]. Meanwhile, with the disruptive development of the IoT in recent years, it is rapidly emerging as a new means to include citizens in the public value creation process. IoT based participation is not about expressing citizens' thoughts but about being included in public value creation by contributing to generate insights necessary for formulating public policies and providing public services by routinely using IoT infrastructure [9]. The IoT approach can also be regarded as a citizen-led approach in that it uses data obtained from citizens' daily use of infrastructure without external interference in the public value co-creation process. It becomes an important part of the public value creation process to analyze the data resulting from citizens' daily use of public and private infrastructure embedded with IoT, predicting citizens' demands and future trends. Combining social media and IoT approaches in the public value co-creation process is an alternative to overcome some practical challenges of social media, making public policy and public service citizen-friendly and further enhancing the role of citizens in urban governance [10].

Several scholars have studied to use the social media approach and the IoT approach separately from the perspective of the public value co-creation, but previous studies to

combine these two approaches are few or have rarely been conducted [10, 11, 13]. In addition, most IoT-based approaches are inclined only to ad hoc processing [9]. Thus, in this article, we, based on our previous studies to incorporate the potentials of social media-based and IoT-based citizen participation to create public value, aim to design the technical infrastructure necessary to integrate the two approaches [22]. The proposed infrastructure can serve as the basis for a new way to co-create public value by combining social media-based participation and IoT-based citizen participation, more reinforcing the role of citizens in urban governance.

2 Theoretical Framwork

The citizen participation for public value co-creation can be considered to be a social system consisting of citizens and decision-makers, communication channels, such as e-participation platforms and social media to support dialogue between them, and rules to operate the system. With the rapid development of IoT, introducing IoT in citizen participation for public value co-creation resulted in the expansion of the social system. Motivated by the need to re-conceptualize the expanded citizen participation system, a new model of citizen participation for public value co-creation has been proposed in our preceding study (Fig. 1) [22].

This model is based on Giddins' structuration theory and dynamic capability [8, 20, 21]. Giddens' structuration theory provides a good framework for understanding the interaction between social structure and actors. Furthermore, in the context of citizen participation, this theory allows us to investigate how the power between administration and citizens can be redistributed due to the introduction of IoT, and what new rules are needed to harness IoT in citizen participation.

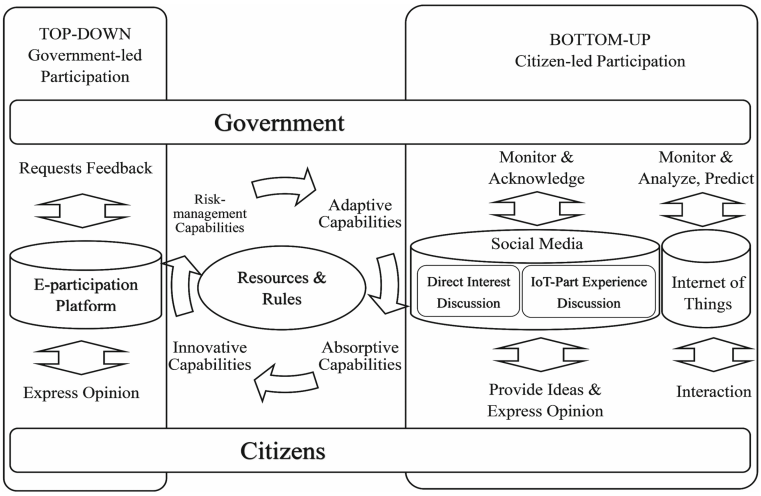

Fig. 1. Citizen participation model for public value co-production in smart city (Notes: Photo credit: Original)

Citizen participation process for the co-creation of public value is dynamic. The dynamic process proceeds in drastically changing environment surrounding it. Under changing environment, it is needed to examine the capabilities of government required to citizens exercise sufficiently their agency in the social process. Although structuration theory discusses the shape and reproduction of rules and resources, it does not enable a fine-grained analysis of the human agent's ability required to sustain the dynamic social process. Structuration theory also fails to explain the mechanisms by which an organization's internal and external functions are assigned to its rules and routines [18]. Given that the dynamic capability theory reveals how to continuously improve an organization's performance by integrating and reconfiguring resources in a dynamic environment [20], to examine the government's capabilities to allow for citizens to exercise their agency in changing environment, dynamic capability theory is applicable. Furthermore, the dynamic capability theory enables a more in-depth analysis of the capabilities and resources required for organizational change. Meanwhile, all activities of organizations are conducted in a dynamic, complex, and interconnected environment. This environment surrounding the organization raises the possibility that the organization may face an immeasurable number of potential risks. The number of potential risks attributed to rapid change and complexity of the environment is immeasurable and it is almost impossible or at least uneconomic to deal with all of these risks [2]. Also, how the organization responds to the sudden occurrence of unforeseen risks plays an important role in ensuring its continued competitive advantage. Against this background, Bogodistov and Wohlgemuth have proposed the concept of risk management capability as part of an organization's dynamic capability. According to the authors, risk management capability is an organization's capability to repeatedly avoid, mitigate, transfer, or intentionally accept risks in rapidly changing environments, thereby eliminating or mitigating the risk of internal and external environmental change, allowing the organization to create value.

Therefore, in this study, considering Bogodistove and Wohlgemuth's argument, it is argued that dynamic capabilities consist of adaptive, absorptive, innovative, and risk management capability.

3 Infrastructure Design

3.1 Approach

The goal of our study is to design a technological infrastructure for citizen participation in public value co-creation. The infrastructure should collect, process, and analyzes data resulting from IoT and social media-based citizen participation and integrate these results with those obtained from e-participation platforms, ultimately assisting decision-makers to formulate citizen-friendly public policy and increase efficiency and effectiveness of public service. Therefore, we first elicit the technological infrastructure requirements for citizen participation in public value co-creation based on the citizen participation model raised in our previous study and map these requirements to specific system components. Next, technological infrastructure is designed based on them. Finally, the possibility of implementing the proposed design by existing technology has been examined.

3.2 Infrastructure Requirements

Based on the citizen participation model for public value co-creation, we first elicit the requirements for the technological infrastructure of citizen participation (Table 1) and map them to specific components of infrastructure design. In our previous study, the proposed citizen participation model for public value co-creation is composed of two parts, one of which is a government-led approach and the other is a citizen-led approach. The infrastructure for government-led participation has been already widely implemented in the form of a dedicated e-participation platform. In this scenario, decision-makers present specific topics such as social issues that attract public attention and topics related to public service delivery on government dedicated e-participation platforms and demand feedback from citizens. In the government-led approach, the goal is to allow citizens to fully utilize allocative resources, in other words, to utilize e-participation platforms without being restricted by time and place in the public value co-creation process. Currently, the citizen-led approach exists in the form of voluntary debate of citizens in social media and IoT-based participation. The topics of citizens' debates in social media are very various, and the amounts of data are vast, so it is impossible to use them-raw data for policymaking and public service provision. Therefore, it is necessary to utilize the potential of social media monitoring (SMM) to extract insights used to create public value. Generally, IoT-based processing is implemented as an ad hoc process, and processed data is stored for future use. Our technical infrastructure is designed to extract insights necessary for creating public value by analyzing the secondary data stored after primary processing. The implementation of citizen-led participation mentioned above allows the government to use insights resulting from SMM and IoT-based citizen participation in policymaking and public service provision, and at the same time, citizens' contributions in the public value creation process are officially recognized by the government. When sufficient insights for policymaking and decision making are not derived from SMM and IoT-based citizen participation, citizens are invited for discussions on the topics using communication channels such as e-participation platforms, social media. This process contrasts with the current IoT-based solution, in which the government focuses only on ad hoc processing without clearly including citizens' contributions through IoT in the process of policymaking or decision making. To ensure that citizens' contributions are recognized by the government and harnessed constructively, it requires absorptive capability including continuously monitoring, processing and storage of data resulting from IoT-based participation, participation framing process, and personalized information service to citizens. The infrastructure should also support adaptive capability to ensure that citizens are engaged in the public value creation process. This is provided to citizens in a form of platforms. Next, the infrastructure should include innovative capabilities to ensure that citizen participation is ubiquitous. Finally, infrastructure should support risk management capabilities to manage potential risks inherent in citizen participation. The government should routinely monitor potential risks resulting from rapidly changing and complex environments, conduct a regular assessment of the priority of risk treatment, treat with them according to the priority criteria, and notify the treatment results public. The risk management toolkit of infrastructure should be designed so that the functions mentioned above can be performed.

Table 1. Requirements

	Dynamic capabilities				
		Adaptive	*Absorptive*	*Innovative*	*Risk management*
	Empower	R13.	R14.	R15.	R16.
CleP	*Process*	.	R10.	R11.	R12.
	Frame	R5.	R6.	R7..	R8.
	Listen & look	R1.	R2.	R3.	R4.

* For reading comfortably, R1-R16 are written table below.

R1. Government needs tools to monitor social media data and to gather data resulting from IoT-based citizen participation.
R2. Government needs to acknowledge the citizens' knowledgeability.
R3. Government needs to build ubiquitous IoT infrastructure and construct means that could capture faster and more widely citizens' discussion on multi social media channels.
R4. Government should routinely monitor the potential risks.
R5. Government needs tools to interact with citizens and frame debates.
R6. Government should analyze citizens' debates and provide frequently the guideline to direct the citizens' debates.
R7. Government should exploit new technologies enabling faster and more relevant interaction with citizens.
R8. Government should regularly inspect the priority of risks treatment, according to changing environment, and redetermine risk priorities.
R9. Government needs tools to process data gathered in IoT infrastructure and spontaneous discussions by citizens on social media.
R10. Government should analyze IoT and social media data, and recognize valuable citizens' contributions.
R11. Government should exploit new technologies for better and faster processing of IoT and social media data.
R12. Government should treat the risks, corresponding to the priority of ones.
R13. Government needs to delivery tools that enable citizens to impact directly the creation of public value.
R14. Government needs to establish an approach where citizens' contributions are reflected directly in policymaking.
R15. Government should constantly seek new ways of co-creating public value with citizens.
R16. Government should constantly broadcast the results of treating risks, and information related to the potential risks to the public.

It is derived the components of design necessary to implement the technological infrastructure requirements as follows.

TR1. Participation Means Monitoring and Exploring tool
TR2. Participation Means Monitoring and Exploring tool

TR3. Participation Means Monitoring and Exploring tool
TR4. Risk management tool
TR5. Debate Control tool
TR6. Debate Control tool
TR7. Debate Control tool
TR8. Risk management tool
TR9. Multi-source Data Analysis & Management tool
TR10. Multi-source Data Analysis & Management tool
TR11. Multi-source Data Analysis & Management tool
TR12. Risk management tool
TR13. Policymaking Agenda Setting tool
TR14. Policymaking Agenda Setting tool
TR15. Policymaking Agenda Setting tool
TR16. Risk management tool

3.3 Design

We derived the necessary components based on a detailed analysis of the requirements and designed the technological infrastructure for citizen participation (Fig. 2). In infrastructure, adaptive capability has been realized as technological tools for citizen participation, and these also serve as the means to realize absorptive and innovative capability. Risk management capability has been implemented by the risk management tool. The names of the design components have been simplified for the clarity of the model.

The technological infrastructure consists of Information Processing Area, including Decision-Maker Interface Toolkit, Data Analysis and Management component, Risk Management component, and Information Mining and Publishing Area where government leads the direction of citizens' debates as experts and publish various information

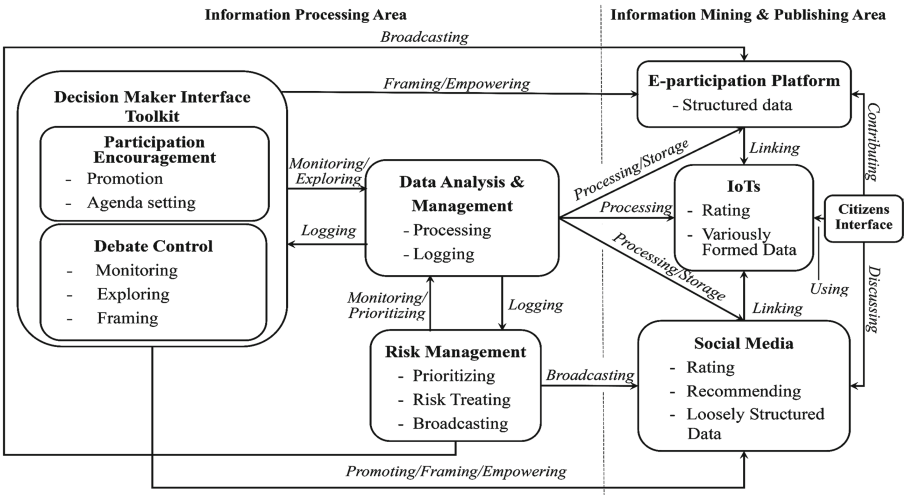

Fig. 2. Technological infrastructure of citizen participation for public value co-production (Notes: Photo credit: Original)

related to participation. We have grouped the infrastructure components according to works performed in the citizen participation process. Decision Maker Interface toolkit includes Participation Encouragement tool and Debate Control tool. Here, Participation Encouragement tool has grouped the functions to promote citizens' participation and enable citizens direct policy agenda setting, a part of citizen empowerment in urban governance. Debate Control tool performs the functions to monitor and explore continuously process conducted in Data Analysis & Management component, and government as an expert in public area participates in spontaneous citizens' debates on social media, leading the direction of citizens' discussions and recommending to citizens if necessary. In addition, the Debate Control tool also performs the function to raise topics on e-participation platforms and social media to engage citizens in discussions related to those when sufficient insights for policymaking have been not found from analysis of IoT data conducted in data analysis and management elements.

The Risk Management tool conducts the functions to determine regularly risk priorities according to the changing environment; continuously monitor Data Analysis & Management components, cooperate with decision-makers to treat them according to risk priorities once occur risks; and inform citizens of risk treatment results through communication channels such as government platforms and social media.

One of the most important functions of the Data Analysis & Management tool, which are core components in the technological infrastructure, is to search and analyze data resulting from e-participation platforms, social media, and IoT. In addition, this component determines priorities of insights, related to policy agendas, extracted from social media and IoT and records their metadata to connect with the origin of contributions in the future. Another function of this component is to create and maintain logs of other tools, such as Participation Encouragement, Debate Control, and Risk Management, provide feedback on them, and analyze log content.

Eventually, under the premise of recognition of citizens' knowledgeability, decision-makers will be able to harness the proposed infrastructure to integrate insights from citizens into the public value creation process.

Given the obligation of designers to provide the correctness and validity of created design, we must show that the proposed infrastructure design is valid for the requirements in Table 1. Considering the design components were directly mapped based on a detailed analysis of the requirements, it is argued that the design would satisfy the requirements. The requirements elicited from the citizen participation model for the public value co-creation are assigned to the corresponding design components as follows;

R1-Debate Control, Monitoring
R2-Debate Control, Monitoring and Exploring
R3-Data Analysis & Management, Logging
R4-Risk Management, Monitoring
R5-Debate Control, Shaping
R6-Debate Control, Shaping; Participation Encouragement, Promotion
R7-Data Analysis & Management, Logging
R8-Risk Management, Prioritizing
R9-Data Analysis & Management, Processing
R10-Data Analysis & Management, Processing; Debate Control, Exploring

R11-Data Analysis & Management, Logging
R12- Risk Management, Treating
R13- Participation Encouragement, Agenda Setting
R14-Participation Encouragement, Agenda Setting and Promotion
R15-Dada Analysis & Management, Logging
R16-Risk Management, Broadcasting

The proposed infrastructure design enables the synergy () of citizen-led participation, including IoT and social media-based participation, and government-led participation based on e-participation platforms.

The following section describes the implementation possibility of the proposed design.

3.4 Implementation

In this section, we discuss how the components of the proposed infrastructure are implemented using existing technologies.

The Participation Encouragement and Debate Control components can be implemented directly through dedicated e-participation platforms, government portals, and government social media pages. The functions performed in these components can be significantly improved by applying targeted participation advertising such as Facebook Targeted Additions (for details see Appendix, the following is so) or Promoted Twitter. RDF-based Linked Data technologies can be used for metadata and information inference with detailed information on the origin of contributors and debates. The Risk Management component can be implemented through dedicated risk management tools such as nTask, Resolver, TimeCamp, and Integrum. In particular, nTask is considered an excellent risk management tool widely promoted for its characteristics such as Professional Risk Reporting, Easy Visibility, Demine Risk Impact, Risk Matrix, Custom Fields, and Risk Assessment Graph. Data Analysis & Management component can be implemented using automatic or semi-automatic content summarization tools such as Open Text Summarizer (OTS) and MEAD, or natural language processing tools such as NLTK and Stanford Core NLP. Citizen-led participation requires analysis tools (Debate Control and Data Analysis & Management) for social media and IoT data. In terms of social media, Bottlenose, SproutSocial, UberVU, Visible, NetBase, and NUVI can be used for this. Linked Data technologies can be used to structure debates in multi-platforms and integrate them into a single knowledge base. This technology further enables decision-makers to directly contact authors of valuable contributions. Analysis of data collected from the IoT can be implemented using IoT data analysis and visualization tools such as AWS IoT Analysis, SAP Analysis Cloud, and IBM Watson IoT Platform. AWS IoT Analysis is a completely managed service that automates the most difficult tasks related to IoT data and makes it easy to execute complex data analysis algorithms. It is one of the easiest IoT analysis platforms, allowing analysis to be performed at the edge and accurate insights to be extracted. SAP Analysis Cloud has the option of integrating IoT data into analysis solutions and better analyzing and visualizing data. SAP Analysis Cloud has been improved by prediction analysis and machine learning technology. Users can easily analyze and visualize IoT data by using IBM Watson IoT Platform's Analytics

solution and conduct a detailed analysis of data produced from various IoT devices. IBM Watson provides natural language processing, machine learning, image and text analysis, which enrich IoT apps. For Monitoring capability implementation, dedicated ontology such as SIOC Ontology, which is enhanced with an Argument Extension that combines content summary tools such as OTS, can be applied.

4 Conclusion

In this article, a study has been conducted to construct a technological infrastructure for realizing them, based on our previous research, which re-conceptualized citizen participation system expanded by the introduction of IoT from the perspective of structures and agents. To this end, it has been elicited the requirements of technological infrastructure necessary to integrate social media and IoT-based citizen participation from the citizen participation model for public value co-creation proposed in our previous studies and identified the components of infrastructure necessary to realize them. Based on this, a technological infrastructure has been designed to integrate citizen-led participation, including social media and IoT-based citizen participation and government-led participation. Finally, its implementation possibility has been examined by existing technologies.

In our opinion, harnessing the proposed technological infrastructure could be improved the role of citizens in the public value creation process and further empower citizens in urban governance. There are several attempts to use IoT in the public sectors, but they are mainly limited to ad hoc processing and few attempts to analyze them to predict citizens' demand, utilize them for policymaking. Moreover, few attempts have been made to combine social media and IoT as an alternative to overcome the practical limitations of the social media approach in public value co-creation.

In addition, existing solutions are considered simple social media-based or IoT-based solutions without an in-depth consideration of the unique attributes of citizen participation and the theoretical basis. In this article, using Giddens' structuration theory, one of the most powerful and most widely used social theories in interpreting changes arising from the introduction of the social system of ICT means, and dynamic capacity theory, which is a remarkable theoretical framework in the field of management, citizen participation for public value co-creation has examined. In this sense, it is argued that the proposed technological infrastructure is more general than other solutions. We have designed our infrastructure based on the fact that IoT is one of the key technology tools used in smart cities and is a very flexible digital means for information exchange with other ICT tools.

Overall, the proposed technological infrastructure could be seen as a good alternative for public institutions suffering from overlapping citizen participation in public value co-creation.

The limitation of this study is the lack of research on its implementation cases. In the future, we intend to provide evidence for the practical validity and effectiveness of the proposed design model through case studies.

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Appendix

Facebook Targeted Additions: https://www.facebook.com/about/ads/
Promoted Twitter: https://business.twitter.com/products/promoted-tweets-selfservice
RDF-based Linked Data: http://www.w3.org/standards/semanticweb/data
nTask: https://www.ntaskmanager.com/blog/best-risk-management-software/
Resolver: https://www.resolver.com/
TimeCamp: https://www.timecamp.com/applications/
Integrum: https://www.integrumws.com/
Open Text Summarizer (OTS): http://libots.sourceforge.net/
MEAD: http://www.summarization.com/mead/
NLTK: http://nltk.org/
Stanford Core NLP: http://nlp.stanford.edu/software/corenlp.shtml
Bottlenose: http://bottlenose.com/
SproutSocial: http://sproutsocial.com/
UberVU: http://www.ubervu.com/
Visible: http://www.visibletechnologies.com/
NetBase: http://www.netbase.com/
NUVI: http://www.nuviapp.com/
AWS IoT Analysis: https://aws.amazon.com/iot-analytics/?nc=sn&loc=0
SAP Analysis Cloud: https://www.sap.com/products/cloud-analytics.html
IBM Watson IoT Platform: https://internetofthings.ibmcloud.com/
SIOC Ontology: http://www.w3.org/Submission/sioc-spec/

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