International Journal on Advanced Science Engineering Information Technology

Vol.8 (2018) No. 4
ISSN: 2088-5334

An Architecture for Facilitating Two-Way G2C Relationships in Public Service Delivery

Lukito Edi Nugroho[#], Sayuri Egaravanda[*], Kusuma Adi Achmad[#]

[#] *Department of Electrical Engineering and Information Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia*
E-mail: lukito@ugm.ac.id, kadia.s3te14@mail.ugm.ac.id

**Dinas Komunikasi dan Informatika Daerah Istimewa Yogyakarta, Indonesia*
E-mail: sayuri.egaravanda@gmail.com

***Abstract*— Public service delivery is typically managed and executed by government institutions. While government institutions have employed specific measures to provide the best possible services, expected level of service still cannot be met at specific points. E-government applications have been used to remedy the situation, but their inability to capture specific and temporary user needs renders them ineffective in handling the situation posed by the specific needs. We propose an e-government application architecture that provides a structured way of accommodating specific and temporary needs out of standard service. The architecture is built based on the principle of free-flowing information between citizens and government. It allows a particular user request to be made during a normal service, acknowledges it as an intervention that needs specific attention from the service provider, and processes accordingly. We also describe how automation of G2C (government-to-citizen) mechanism can be designed in a cleaner and modular way.**

***Keywords*— e-government; G2C relationship; decision making; public services.**

I. INTRODUCTION

ICT has been penetrating very deep in the delivery of public services provided by governments to citizens. ICT, in the form of hardware, network infrastructure, and software applications has not only been serving as a communicating tool that sets up a direct link between a government service provider and its users but also integrating resources and bureaucratic processes behind services. It even pushes its limit further to enable a new breed of capabilities and services, such as creating digital place making [1] and personalized travel time estimator in an urban environment [2].

When used in the delivery of public service, the operation of ICT, most notably the software/application components, is governed by procedures behind the service designed and implemented by government institutions that own or manage the service. The interests and aspirations of citizens are captured, either using a direct or indirect mechanism to create a service that serves the need of citizens.

The importance of involving citizens in public service delivery is well known (e.g., in [3]). With the involvement of the citizen in its design, the implementation of service would typically satisfy the general need of the citizens. However, some temporary, “irregular” needs require different service settings. Some of these needs are of high importance, so the ability to adjust the settings is critical. Consider emergency travel of an ambulance for example. When this event occurs, the standard traffic light arrangement cannot serve its urgent demand, so some manual intervention (e.g., by a policeman) is necessary. This manual action can be avoided if we can determine the ambulance trip a priori; this information is used to temporarily adjust traffic light duration in intersections to allow free traffic flow for the ambulance when the ambulance arrives at each intersection.

Similar situations can also be found in less critical cases. For example, a prominent music show attracts a large number of public attendances. When this show concludes, there is a surge of public transportation need when people are rushing out of the stadium almost at the same time, trying to catch buses. When this rush is known in advance, a proper arrangement of public transport can be made (e.g., the temporary addition of buses) to avoid long service delays.

The previous cases show that in general, when citizen needs can be predicted or planned before the event that raises the needs takes place, a decision can be made to meet the requirement, improving the quality of the service to the user. The illustrations also show that public service delivery can be improved when we can establish two-way relationships between a government institution (as the service provider) and the public (as the customer). This G2C/C2G (government-to-citizens, and vice versa) channels allow 'joined-up' services, whose importance has been known for long to provide more convenience to citizens instead of to the government [4]. The prominent feature of such relationships is that it allows inputs representing citizen needs to be timely captured. Citizen inputs not only become part of the service delivered by the government institution, but they are used for making decisions optimized for the satisfaction of the users. Overall, this scheme can be viewed as a co-production of services involving both government institutions (as the service producer) and citizens (as the user) [5]. Co-production takes citizen participation beyond engagement: citizens stand on the same side of the government in running a service.

Supporting two-way relationship using ICT is not tricky, the simple client-server model can do it fine. However, providing uniform support for 'equal' relationship where citizen inputs have the same importance as the government's and are used as the primary consideration in adjusting public services is not a trivial task. The difficulties arise from the facts that: 1) citizen inputs can come from any source, in any form, and consequently, 2) their capturing and computing processes will also vary.

The Internet has been used as a media for engaging citizens in political processes, although people are not too interested in using the Internet for political purposes, even in western countries like the UK [6]. Various Internet-based media are used to acquire user inputs: Facebook [7], Twitter (for example, for gathering information from public regarding reactions during earthquakes [8]), and specific platforms for attracting public participation, such as Qlue (www.qlue.co.id), Accela (www.accela.com), and CitizenLab (www.citizenlab.co). In using these tools, the process of acquiring user inputs entirely rely on the tools' fundamental mechanism. This represents a disjointed perspective: user inputs and decision making associated with the inputs are considered separated processes. In our case, when decision making is to be automated to improve public service quality, the disjointed perspective may block the information flow and therefore reduce the effectiveness of the public service delivery.

A direct implication of disjoined perspective is that data processing is highly dependent on the platform used. Applications can be developed to process user data to construct meaningful information, but to do that they have to read the input data from the platform. For example, citizen tweets may be quite easy to extract using Twitter API, but it may be hard to develop an application that can read what citizens post in a government Facebook page. Delivering decisions computed from the inputs back to the platform is even more difficult, even not possible in some cases.

Disjoined two-way processes are due to the 'bottom-up' approach to viewing meaningful citizen participation in government processes. A two-way process is divided into disjoined activities which are then combined to form a continuous process. While this approach works fine for high-level and macro decision making (e.g., on general public policies), its disjointed nature poses a serious drawback when applied to a more delicate and micro level, especially if the overall process is to be automated by ICT processes. In this situation, a comprehensive perspective of the overall process is essential. Therefore a more structured approach is needed.

This paper describes our work on providing architectural support for realizing the two-way relationship between a government service provider and citizens. The architectural approach was chosen to achieve the requirement mentioned above: it provides a comprehensive view of a service delivery process. Some other works on the communication aspect of public service delivery have also focused on the architecture level, such as described in [9] and [10]. However, since they were designed in the context of smart city development, they are more application oriented and does not cover high-level, human-oriented communication.

The purpose of our work is to make integration of activities easier through a uniform conceptual perspective for various means of acquiring user inputs, their processing, and computing decisions. The work explained in this paper extends the work described in [11] by generalizing the concept of two-way relationship and promoting it to an abstract level.

II. Material and Method

The research described in this paper is analytical work. It did not use any physical material nor data gathered from any source. Our research is a direct extension of a Ph.D. research work fully described in [11]. The Ph.D. research proposed a model for technology intervention to improve the quality of public service delivery through mutual, two-way relationship between government and citizens. ICT is used to strengthen the C2G (citizen-to-government) channel by allowing citizens to express their needs or intentions that can be used by the government to adjust the service. In the experiment, an ad-hoc mechanism was developed to capture user inputs in a public transportation scenario and use the inputs to intervene existing decisions (traffic light duration, in this case) to favor for a planned emergency ambulance trip. Our research takes the two-way concept to a higher, more abstract level. Instead of leaving an application to define its architecture in constructing the intervened channel, we provide a generic architecture model to allow cleaner design and implementation.

The proposed architecture is then analyzed by comparing it to some existing platforms that have a similarity to the purpose of our architecture. We use criteria that are important in promoting the equal relationship between government and citizens: automating the mechanism, handling communication blocking, and handling the dynamics of user needs.

III. Results and Discussion

A. *Problem Analysis*

Ideally, a two-way G2C relationship concerning a public service should be balanced. Both sides have equal control over the service. The quality of the service is defined by the combination of both sides' roles, instead of only one of them. However, such an ideal situation rarely exists. In most cases, the relationships are unbalanced. Citizens have less control over the service compared to the government. When they have specific needs related to the service, the government cannot meet their needs because the citizens are not able to inform the government about their needs. Such blocking is shown in Fig. 1.

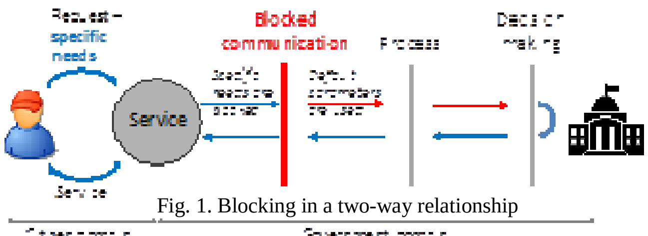


Fig. 1. Blocking in a two-way relationship

When specific citizen needs cannot reach the government, default or predefined service parameters are used, creating a minimum performance of the service.

Blocking in a two-way relationship occurs due to the following causes. At the service's business process level, business process blocking may take place when some form of bureaucracy does not allow citizen inputs to pass on. Blocking can also happen when technical problems arise, creating system incompatibilities that prevent information flow through communication channels connecting citizens and the government. Finally, architectural blocking arises when soloed or nonintegrated system design creates barriers to information exchange between client and server applications representing both sides.

B. Underlying Principles

To overcome blocking problems, we examine the overall two-way interaction concept to identify its most critical parts. By identifying the most important factors, we expect to redraw a more structured and reliable approach. We found out the critical parts to be: 1) the ability to capture citizen inputs, 2) input identification and processing, and 3) recommendation and decision making. The sequence is quite generic and has been adopted by similar reasoning-based systems such as described in [12].

Inputs can be individual (from a single person) or collective (from a group of people). Both represent the interest or needs of the source. Inputs can also be associated with current events or those that will happen in the future. This temporal attribute determines the urgency of the inputs, as shown in Table I.

TABLE I
TYPES OF INPUTS

	Current Events	Future Events
Expected response	Prompt decision/action due to critical importance	Prediction and preparation for optimal performance or better experience
Individual inputs	Emergency or urgent needs (e.g., traffic accidents)	Priority events (e.g., trip planning of an ambulance carrying a patient)
Collective inputs	Priority events associated with social or community needs (e.g., natural disasters, severe traffic jams)	Social or community intention (e.g., big events attracting mass viewer)

Identification of inputs is another challenge due to variability in their form. The input may come in a natural form which can be processed directly, like a user's geographical position. However, some inputs may have more subtle forms, and its original format has to be revealed through some preprocessing. The latter kind of inputs usually represent group intentions or sentiments, and come in the forms of behavioral patterns (e.g., trending topics in Twitter or mobility patterns of a large number of people). Different forms of input will need different acquisition and preparation methods, and subtle forms will undoubtedly require more complex treatments than simpler ones. Tweets as input, for example, will require substantial text preprocessing before they can be converted into useful information.

Finally, inputs are computed to produce decisions or recommendations. Depending on the application, this is where algorithms are applied. In some cases, decisions are in the form of actions that are channeled back to citizens to the same system (e.g., in traffic light management, where a decision to give priority to emergency trips is executed through the same system). In other cases, decisions or recommendations are brought to some other (usually at a higher level) systems.

C. The Architecture

Following the basic principles in constructing two-way G2C relationships, we present our proposed architecture. The architecture has 3 main components that represent the essential activities in the two-way relationships: capturing citizen inputs, identifying and processing the inputs, and computing decisions. Fig. 2 describes the architecture.

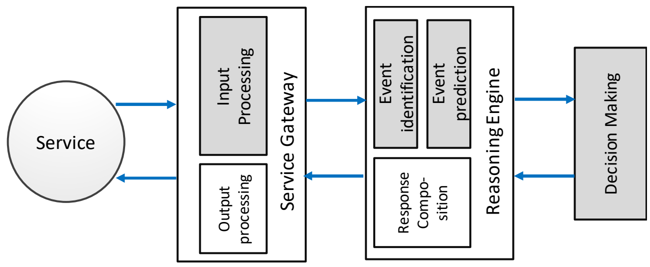


Fig. 2. The architecture for two-way G2C relationships

The development of public service does not only focus on the specification of the service but also the way it will be delivered and communicated to citizens. The architecture in Fig. 2 proposes a structured two-way mechanism that can be used as a platform for computing decisions required to adjust the service in response to the dynamics of citizen needs regarding the service.

The primary function of the architecture as a platform is to connect citizens requesting specific needs and the government who has the decision making authority through allowing request messages to be transferred to the government side in a proper form for decision computation. As explained in the previous sections, the issue lies in the heterogeneity of citizen inputs and the complexity of the computation. Our architecture overcomes this difficulty is by dividing the overall process into clear and separated activities so that technical solutions can be formulated with a clearer scope.

The proposed architecture has 3 main parts; each is associated with the corresponding activity in the two-way mechanism. Each part has both input and output functions. It should be noted that the architecture only defines components and their boundaries, and is independent of any implementation details. The components are described below.

1) Service Gateway (SG): SG is the front end of the two-way mechanism, it directly connects to citizens. A citizen user will use SG to channel his or her needs to the government (SG's input function). Conversely, SG may also play the role of delivering decisions or actions to the user. The essential characteristic of SG is that it takes the heterogeneity of user inputs and provides interoperability to the Reasoning Engine (RE). The specification of SG is given in Table II.

TABLE II
SPECIFICATION OF SG

From Citizen to Government		
Input	Process	Output
Raw data indicating, directly or indirectly, user needs or intentions	Transforming raw data into a format suitable for computation to identify or predict user needs or intentions	Data ready for identification or prediction of user needs or intentions
From Government to Citizen		
Input	Process	Output
Information to be delivered to citizens, or data to trigger response actions	Presenting the information to citizens, or sending the triggering data to the automation process	Delivered response information or recommendation, or trigger actions,

2) Reasoning Engine (RE): RE takes input from SG and processes the data to determine citizen needs. It can handle two types of data: data related to current events and those related to future events. The focus of current events is to identify the needs, while for future events, it is interested to predict what will be the needs when the events take place in the future. It is the responsibility of the implementing system/application to select whether RE will carry out need identification or prediction. On the other direction, RE may serve as response composer or decision decomposer. As a composer, it takes high-level decisions in their native format, then transforms them into information in user-oriented presentation format. As a decomposer, RE may decompose decisions reflected regarding actions into data that will trigger the automation process. The specification of RE is shown in Table III.

TABLE III
SPECIFICATION OF RE

From Citizen to Government		
Input	Process	Output
Data ready for analysis for identification or prediction of user needs or intentions	Identifying data messages and patterns and preparing information required for decision making	Information ready for the decision-making process
From Government to Citizen		
Input	Process	Output
High-level decisions or actions in their native format	Transforming high-level decisions into a presentation format, or actions into data to trigger the automated process	Composed information, or triggering data

Regarding computation, RE may come in various forms. It can be as simple as monitoring a single variable's value, or as complex as identifying data patterns out of a huge pool of citizen data. Techniques that can be used in RE include data mining, machine learning, and prediction analysis.

3) Decision Engine (DE): DE implements the decision logic behind a service. It receives data required to calculate a decision and produces decisions in its native format. The native format is determined by the application or tool that is used to produce a decision. It is the responsibility of the implementing system to choose the method or algorithm to calculate decisions. Decisions can be in the high-level format (e.g., the decision on a city development policy that takes into consideration citizen voices expressed using tweets), or low level and specific action (e.g., extend the duration of all green lights in a specific route).

D. Using the Architecture as an Integrating Platform

In this subsection, we demonstrate how to use the proposed architecture to facilitate two-way interactions between government and citizens. Since the primary purpose is to improve the flow of communications, first we present how existing platforms handle G2C interaction problems, namely: automating the mechanism, handling communication blocking, and handling the dynamics of user needs. We analyze three platforms: common social media applications (such as Facebook), specific G2C platform (such as Citizen Lab), and particular purpose web/mobile applications (such as crime reporting or citizen complaint applications). The social media application is selected because it is a widely known generic platform that can be used to facilitate G2C interaction. The specific G2C platform is similar to the social media platform, except that is tailored to facilitate the government-public relationship. The web or mobile application is chosen to represent an application-level approach to facilitate citizen feedback. Table IV describes the analysis.

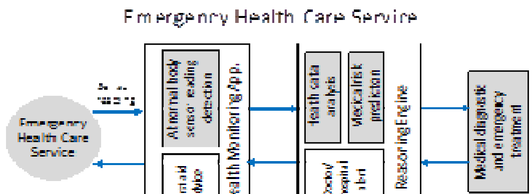
TABLE IV
ANALYSIS OF G2C COMMUNICATION PLATFORMS

	Automating the mechanism	Handling communication blocking	Handling the dynamics of user needs
Social media	Very limited due to the difficulty in extracting user posting as input, except for a few social media that work with simple messages (such as texts in Twitter)	Very good for high-level communication due to its 'flat' and open structure. A potential block will be quickly identified and resolved using community mechanism	Very good for high-level user needs since FB does not impose any restriction on the types and forms of postings representing user need dynamics
G2C platform	Unless the platform offers application-level tools for extracting user input, the ability will be very limited	Very effective since the platform is owned and managed by the government. A potential block will be quickly spotted due to continuous monitoring of the government	Very effective since specific need or request message will be quickly identified and responded. However, this only works for high-level, human-oriented messages.
Web or mobile application	Native support can be provided by connecting the application to the other software components in the processing stream	Since user need messages are encoded in application data, explicit software mechanism has to be built to detect communication blocks	Changes in user needs are implicitly encoded in application data; explicit software mechanism has to be built to detect such changes

Table IV shows that different platforms have different targets. Social media and specific G2C platforms are suitable for handling high-level, human-oriented communication, while web or mobile applications have their strength on automating the two-way communication mechanism. We will use this characteristic as the basis to describe how the proposed architecture can be used to lay down an integrated approach to overcome the problems.

In the first scenario, we present a personalized health service (PHS). The PHS is designed for older adults whose health condition has to be monitored at all-time using wearable sensors. The data read by the sensors are sent to hospitals where the central monitoring system (CMS) is installed. When an anomaly data reading is detected, the CMS will alert doctors or hospitals so that emergency treatments can be initiated.

Using our approach, the architecture of the PHS is shown in Fig. 3. In this architecture, the elderly are represented by a health monitoring application (HMA) that does the reading of the sensors. It converts electrical pulses into significant numbers, and when the numbers exceed some limits, the application sends some health-related data to the CMS in the hospital. The CMS analyzes the data set to determine what is happening and predict the risk if the situation prolongs, then send the analysis to a medical diagnostic tool that provides a preliminary diagnostic. When this diagnostic indicates something critical, doctors and medical alerts are issued as well as first aid advice to the elderly through the HMA.

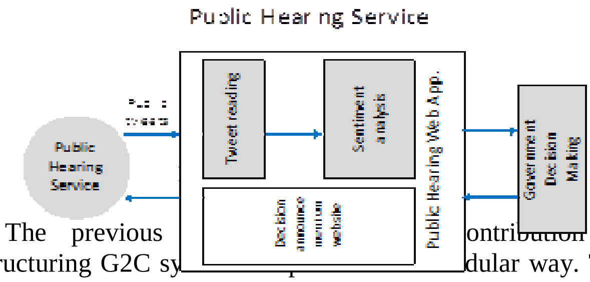


Fi... rgenc... ervice

As seen from the example in Fig. 3, the architecture integrates different components by removing boundaries between a citizen (i.e., the elderly in this case) and the government (i.e., the hospital). In the health care example, the HMA belongs to the citizen, and two-way interactions take place in the form of communication between HMA and the hospital's CMS. Automation of the two-way mechanism is carried out by merely sending data from HMA to CMS and vice versa.

In a different scenario that works with human-oriented communication, the different setting may apply. In the second example shown in Fig. 4, we describe a public hearing scenario. When a local government proposes a policy strongly related to the community in town, they usually arrange a public hearing to gather opinions of the community. In our example, the government wants to hear the public's voice through their tweets, so they develop a web application that tracks tweets related to the policy, extract them and feed them to a sentiment analysis tool, and finally calculate the pros-and-cons to make a decision. When the decision is formally approved, it is uploaded to the web.

In the public hearing service scenario, all the architecture components: the service gateway (tweet reader), the reasoning engine (sentiment analyzer), and decision making computation reside in one single system, and the government fully manages the system.



The previous ... ontri... to structuring G2C sy... dular way. The architecture sets up clear boundaries between system functions. Interfaces between components can be defined more clearly, improving the cohesiveness of the components. In effect, modifications can be performed more efficiently (e.g., replacing algorithms with better ones), hence improving system maintainability.

The proposed architecture does not impose any implementation-related requirement. However, it does require that a service system can be mapped into three distinct elements: input acquisition, input processing and reasoning, and decision computation. Mapping is necessary to define the boundaries for the ICT intervention clearly.

E. Planned Anticipation for Optimized Service

While a seamless two-way relationship can improve the delivery of public services by responding current citizen needs, its main strength lies in its ability to provide a better quality of service through anticipation of citizen needs. From a citizen perspective, anticipation is considered more valuable than responding, because anticipation expresses the willingness of the government to serve the public proactively. Reactive responses, on the contrary, exhibit passive behavior, which is not in line with the underlying purpose of any government: to serve the citizens actively.

We argue that if at time t we understand citizen needs or their intentions at time $t+n$ in the future, we can provide better services to them. This has been proved in a study reported in [11], using the case of ambulance trip planning. The scenario was built based on actual traffic management infrastructure owned by the Special Province of Yogyakarta, notably the Automatic Traffic Control System (ATCS). In a simulation, the ATCS, together with a citizen-side application called Travel Information System (TIS), can shorten the travel time of an ambulance carrying a patient up to 29.21% [11]. It is done by predicting its travel time given its planned route and adjusting the traffic light duration accordingly when the event takes place.

In our architecture, user intention or plan is captured as input at time t. The output produced by the decision-making engine is the anticipation decision that will be executed at time $t+n$.

IV. Conclusions

We have presented our work in improving the quality of public service delivery by developing an architecture that provides a unified perspective on the two-way relationship between government and citizens. This unified perspective allows integration of software components that implement different stages and functions of two-way communication processes. We have also demonstrated that the architecture has wide applicability. It can be applied to both high-level, human-oriented G2C communications and low-level, application-oriented communications. The latter is especially useful when the two-way relationships are to be automated.

For our future work, we are planning to implement the architecture in some cases. One of the projects that are currently running is the development of a tourist recommender system that allows a tourist to specify his or her visit plan. The system will provide the best possible recommendation based on the plan, and adjust the recommendation should specific event occurrences in the future may cause an impact on the plan.

References

[1] A.A. Abdel-Aziz, H. Abdel-Salam, and Z. El-Sayad, "The role of ICTs in creating the new social public place of the digital era," Alexandria Engineering Journal, vol. 55, no. 1, pp 487-493, March 2016.

[2] K. Tang, S. Chen, and A.J. Khattak, "Personalized travel time estimation for urban road networks: A tensor-based context-aware approach," Expert Systems with Applications, vol. 103, pp 118-132, August 2018.

[3] OECD,"Focus on Citizens: Public Engagement for Better Policies and Services", OECD, 2009.

[4] D. Pappa and L. K. Stergioulas, "G2C and C2G: Emerging principles and architectures in e-government and e-participation", eGovernment Workshop '06, Brunel University, West London, 11 September 2006.

[5] T. Bovaird, "Beyond engagement and participation: User and community co-production of public services," Public Administration Review, September-October 2007.

[6] C. Di Gennaro and W. Dutton,"The Internet and the Public: Online and Offline Political Participation in the United Kingdom," Parliamentary Affairs, vol. 59, no. 2, pp 299-313, April 2006.

[7] E. Bonson, S. Royo, and M. Ratkai,"Citizens' engagement on local governments' Facebook sites. An empirical analysis: The impact of different media and content types in Western Europe", Government Information Quarterly, vol. 32, no. 1, pp 52-62, 2015.

[8] P. Earle, M. Guy, R. Buckmaster, C. Ostrum, S. Horvath, and A. Vaughan, "OMG earthquake! Can Twitter improve earthquake response?", Seismological Research Letters, vol. 81, no. 2, pp 246–251, 2010.

[9] J. Wan, D. Li, C. Zou, K. Zhou, "M2M communications for the smart city: An event-based architecture", IEEE 12th International Conference on Computer and Information Technology, 2012.

[10] N. Uribe-Perez and C. Pous, "A novel communication system approach for a Smart City, based on the human nervous system," Future Generation Computer Systems, vol. 76, pp 314-328, 2017.

[11] S. Egaravanda, "Development of Two-Way G2C/C2G Relationships with ICT Intervention in Public Services" (in Indonesian), Ph.D. Dissertation, Department of Electrical Engineering and Information Technology Universitas Gadjah Mada, 2017.

[12] J. Aguilar, P. Valdiviezo-Diaz, and G. Riofrio," A general framework for intelligent recommender systems," Applied Computing and Informatics, vol. 13, pp 147-160, 2017.