Modeling Citizen-Centric Services in Smart Cities

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Abstract. Much research about large cities has focused on *policy-level* action for concerns such as infrastructure, basic amenities and education, treating the citizens as a collective of millions. We suggest an alternative, drawing on recent moves towards 'digital era governance.' We argue for and develop a foundation for the design and modeling of services that focus on *individuals*. Drawing on and extending prior work in service modeling and public-sector governance, we develop a formalism for modeling citizen-centric services, illustrate its application, and extract principles that underlie this effort. The paper concludes with pointers to other aspects of the larger iCity project, aimed at building smart cities in the world's rapidly growing regions.

Keywords: Mega-cities, Smart city, Citizen-centric services, Service modeling, Case management, Digital era governance, iCity.

1 Introduction

For the first time in human history, more of us live in urban, not rural areas (Dugger 2007). In the near future, this surge is expected to produce many more mega-cities (with populations of 10 million+). By 2050, urban centers are expected to house 2 out of every 3 individuals on the planet (UN 2012). This change will be particularly extraordinary in Asia where "the accumulated urban growth … during the whole span of history will be duplicated in a single generation" (Dugger 2007). The challenges facing these fast-rising Asian cities are, thus, qualitatively different from those for existing cities (Woetzel et al. 2009).

Challenges that need to be addressed include infrastructure concerns such as transportation (World Bank 2013), provision of utilities such as water (Dobbs et al. 2012), and governance for services such as health and education (WHO 2008; UNESCO 2012). Each has engendered *policy*-level action. Advances in research are, however, pointing out that it is important to create solutions for each *individual* citizen, not just the collective of millions. Work in public administration research has moved past the focus on so-called new public management (with a focus on markets and efficiencies (see Ferlie et al. 1996)) to a focus on services targeted at individuals. This new wave, described as digital era governance or DEG (Dunleavy et al. 2006; Dunleavy et al 2008) provides the inspiration for the work described in this paper.

The *objective* of this research is to develop and demonstrate a meta-model for the design and modeling of citizen-centric services in smart cities. The key motivation

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and precursors to our work are outlined above. The paper begins with a scenario in a narrative style that describes Sam, a citizen with a chronic disease, who provides the focal point for development of the meta-model, which recognizes the interaction between the *specific* individual context and *generic* service offerings from government agencies. The paper uses multiple episodes not only to highlight key constructs in the meta-model but also to surface fundamental principles that can drive the design of such services (Dunleavy et al 2010, Fishenden and Thompson 2012). We acknowledge recent work by Bergholtz et al (2011) and Andersson et al (2012), which provides important precursors to our work. The key *contributions* of the research, therefore, are a formalism that provides the foundation for translation of government programs to citizen-centric services in smart cities.

2 Background and Prior Work

2.1 City Governance: Rethinking the Role of IT and Services

IT-enabled delivery of public services in cities is not new. The last decades of the 20th century have witnessed significant injection of IT in support of public services (Fishenden and Thompson 2012; Gil-Garcia and Martinez-Moyano, 2005). The first generation mirrored advances in the private sector to increase automation and reduce costs (Cordella and Iannacci 2010). Here, IT applications were seen as tools to minimize errors and get things done faster. The second generation (described as new public management or NPM) witnessed the adoption of market-based mechanisms to drive greater efficiencies (Fang 2002; McNulty and Ferlie 2004). IT platforms were seen as facilitators for public-private competition but failed to deliver the anticipated benefits; and instead, lead to administrative complexity as well as difficulties in coordinating service delivery. IT, thus, wrought fossilization of silos making the delivery of citizen-centric service an impossibly difficult outcome to achieve.

The response, the third generation, is characterized by open standards and architectures. Here, IT platforms are seen as enablers of outcomes, made possible by separation of service logic from the supporting applications (see Fishenden and Thompson 2012). Described by Dunleavy et al. (2006) as Digital Era Governance (DEG), this generation aims for "re-aggregation of public services under direct government control around the citizen," made possible by dis-aggregation of previously grouped functionalities for extraction and publication of services, which then might be personalized and re-aggregated. This juxtaposition - between the policy-level efforts and the unique needs of individuals - is at the core of new thinking about IT in the public sector, and provides the inspiration of our work.

2.2 Service Design and Modeling

The notion of services and service design (Goldstein et al. 2002) is at the heart of efforts needed to realize the vision of digital era governance (DEG). Scholars in several disciplines have addressed this area of work. Examples include work related to service-dominant logic (Lusch and Vargo 2006), customer service design

(Segelström 2010), the design of web services (Papazoglou and Yang 2002), exploration of service-product design (Giannini et al. 2002) and exploration of process and use views (Andersson et al. 2012). As a result, the fundamental terminology has remained in flux. For the purpose of this research, we co-opt and extend several efforts (see Wikipedia 2013) to define a service as:

- the seeking of an outcome by a citizen,
- where the outcome has a quantifiable value,
- and achieving it requires multiple interactions across different agencies,
- drawing upon specific capabilities of these agencies
- in a manner that takes place over time and repeated as necessary

This definition emphasizes several properties including the co-construction of outcomes (Gebauer et al. 2010), suggesting specific actions that the recipient must take to realize the outcome of value; and the primacy of an individual case for the realization of benefits. Using these as starting points, we develop our proposal as a meta-model for the design and modeling of citizen-centric services.

3 A Foundation for Modeling Citizen-Centric Services

The development of the formalism is grounded in several scenarios that were obtained via discussions and interviews, and distilled through multiple revisions. Here, we begin with a condensed scenario that describes Sam, an individual dealing with a chronic disease.

> **Scenario**: Sam, a 45-year old cab driver has been living alone. He has been diagnosed with type-2 diabetes. Following the diagnosis, he has been enrolled in a home care system to manage the chronic disease. A nurse-educator has taught him how to administer the three insulin injections a day and watch for onset of other problems. Sam has worked with a dietician for a personalized diet plan, and a physiotherapist for an exercise regimen. Sam's smart phone is able to access his history, prescriptions and plans. His calendar alerts him for administering medication and tracks his exercise and diet actions. A social worker helps Sam to connect with support groups and social activities. After a year, when Sam's condition deteriorates; he cannot perform his job as a cab driver. He is admitted to the hospital. The social worker helps Sam apply for financial assistance, respecting his privacy. Doctors at the hospital are able to access, with Sam's consent, not only his medical history but also other details of his case.

A number of observations can be made from the narrative. A City will have several agencies that provide the services Sam will need. Sam will consume these services over a period of time, as needed. The provision of services will require personalization, when the services are enacted during specific encounters. Many will need follow-ups from Sam. A holistic view of an individual case will then be a combination of service performance and actions from the individual. Figure 1 captures these concepts.

Agencies and Capabilities

$a_1..a_i \in A$	set of agencies
$c_1..c_j \in C$	set of capabilities
capable-of (a_i, c_j)	capability c_i is provided by agency a_i {0,1}
$\forall\ c_j \in C\ \exists\ a_i \in A \mid$ *capable-of* $(a_i, c_j) = 1$	a capability is provided by at least one agency

Individual Citizens and Agency Representatives

$d_1..d_k \in D$	set of citizens
$b_1..b_y \in B$	set of abilities
able-to (d_k, b_y)	ability b_y is available for citizen d_k {0,1}
$r_1..r_z \in R$	set of representatives
agent-of (a_i, r_z)	representative r_z represents agency a_i {0,1}
$\forall\ r_z \in R\ \exists\ a_i \in A \mid$ *agent-of* $(a_i, r_z) = 1$	a representative represents at least one agency

Service Offerings, Encounters, Actions

$s_1..s_l \in S$	set of potential service offerings
$s_l =$ *bundle-of* $\{c_1..c_j\}$	service s_l is offered by bundling capabilities c_1 to c_j
$e_1..e_m \in E$	set of encounters
$e_m =$ *performance* (s_l, d_k, r_z, t)	encounter as enactment of s_l for d_k by r_z at time t {0,1}
$g_1..g_n \in G$	set of actions (preceding or following an encounter)
$g_n =$ *enactment* (d_k, b_y, t)	action as exercise of b_y by citizen d_k at time t {0,1}
precedes (e_1, e_2)	encounter e_1 precedes action e_2
follows (e_1, e_2)	encounter e_1 follows action e_2
linked (e_m, g_n)	encounter e_m and action g_n are linked {0,1}

Episodes and Cases

$f_1..f_v \in F$	set of episodes
$f_v = \{<e_m, \{g_n\}>\} \mid [t]$	episode as a set of encounters and actions in timespan t
episode-of (f_v, d_k)	episode f_v belongs to citizen d_k {0,1}
$h_1..h_w \in H$	set of cases
$h_w \in \{f_v\}$	case as an ordered set of episodes
belongs-to (h_w, d_k)	case h_w belongs to citizen d_k {0,1}
visible (f_v, r_z)	episode f_v is visible to representative r_z {0,1}
access (h_w, r_z)	case h_w is visible to representative r_z {0,1}
visible $(f_v, r_z) = 1\ \forall\ f_v \in h_w \Leftrightarrow$ *access* $(h_w, r_z) = 1$	visibility on all episodes in a case implies case access

Fig. 1.A Set of Formalisms for the Designing Citizen-centric Services

The formalism and the accompanying meta-model (not shown here) provide the foundation for defining service-offerings, customizing these for individual citizens, ensuring cross-agency coordination within the context of the individual, and creating and sustaining the longitudinal case for the citizen. It is important to draw parallels with and distinctions from the formalisms described above and the concepts developed by Bergholz et al (2011) and Andersson et al (2012). For example, ideas related to capability, service offering and specific instances they call event have parallels in our formalism respectively as: capability, service offering and action. Our work also introduces concepts such as encounter and case, similar to but not identical to the ideas of process in theirs. The differences are driven by our context (smart cities) compared to the context (business) implicit in the work by Andersson et al (2011). Although it is possible to engage in these comparisons further, we move to demonstrating application of the model in light of space constraints. Our intent in this effort is both, demonstration of the formalism as well as an initial evaluation of feasibility in the context of smart cities.

4 Application and Evaluation

The scenario earlier is a condensed version of a larger narrative obtained from agency representatives and individual citizens. To demonstrate application of the formalisms, we decomposed it in several episodes, of which one is elaborated here. Table 1 summarizes the episodes. The episode and the model appear after the table.

Table 1. Episodes derived from the scenario

Episode	Description	This Paper
Diagnosis	Sam's initial diagnosis after the onset of symptoms	
Home Care	Sam's enrollment into Home Care system with instructions	X
Self-care	Personalized services direct Sam towards diet and exercise	
Management	Sam's efforts to manage the chronic disease	
Escalation	Escalation of the disease and Sam's loss of job	
Case Analysis	Analyzing Sam's case for ongoing help	
Analytics	Analysis of multiple cases, including Sam's	

Episode: Home Care. Sam was enrolled in home care to manage his diseases. A summary of his case notes, clinical information and prescriptions were transferred to his smart phone. He was offered education sessions via prompts on his smart phone and email. Based on his driving schedule, Sam selected a session. During the first appointment, a nurse interviewed Sam on his lifestyle, diet preference, habits and addiction to measure his baselines. During his second appointment, the nurse trained him on the disease and how it can be managed. He now knew how to look for signs of complications, was taught insulin injection technique and made aware of symptoms so he may recognize the onset of problems like hypoglycemia or hyperglycemia. The nurse asked him for an emergency contact; Sam shared information about his brother.

Figure 2 shows the interaction diagram for Episode 2, keeping extraneous information to a minimum (based on our intent of demonstration and evaluation).

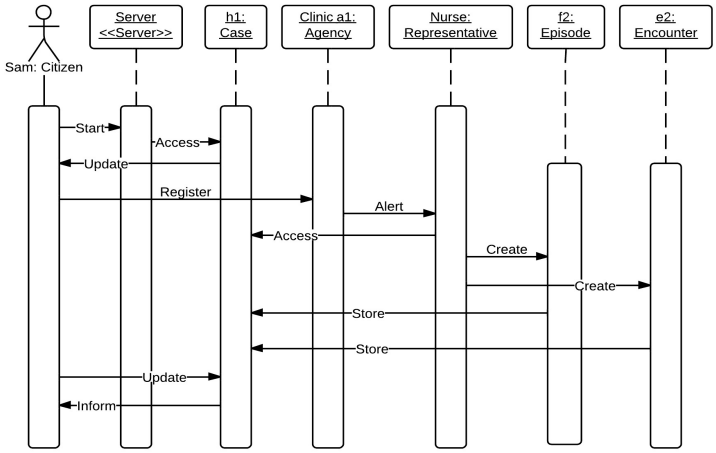

Fig. 2. Interaction Diagram for the Home Care Episode

The episode demonstrates how the formalism (see Figure 1) may be used to design and activate service offerings and encounters. The interactions (example shown in Figure 2) describe how the episodes can be operationalized. The set of interaction models (or all episodes) also provide a vehicle to discover principles that underlie the formalisms. Table 3 describes the outcomes of this investigation and reflection.

Table 2. Key Principles for Design of Citizen-centric Services

Principle	Description
Bridging Abstractions	Bridging from the abstraction of agency policies to specific service offerings for individuals
Aggregation Levels	Aggregation of different agency capabilities to different service offerings
Personalization of Services	Personalization of services to the needs of individual citizens at different times
Independent Action	Independent follow-up actions from citizens based on the services performed by the agency
Accumulation to Cases	Longitudinal accumulation of encounters and actions to episodes; Accumulation of episodes to cases

5 Discussion and Concluding Remarks

This research builds upon prior work related to digital era governance (Dunleavy et al. 2006; Fishenden and Thompson 2012) and service modeling and design (Bergholtz et al. 2011; Andersson et al. 2011). The key contribution of work is a formalism that can act as the foundation for the design and modeling of citizen-centric services in smart cities. Application to multiple episodes has allowed us the opportunity to uncover principles that can underlie service design and modeling for citien-centric services. These are a core contribution of our work.

The key motivation for this work is the rise of mega-cities around the globe, and the resulting demands on ensuring digital era governance (DEG). Appropriate design and modeling of services is of primary importance in this context. The formalisms we have developed stand *in contrast* to the previous generations (such as NPM). Practical applications of our model are, therefore, direct and straightforward. We acknowledge that effective citizen-centric services will require more than a set of formalisms (see Peters and Savoie 1995). These concerns, such as coordination challenges and incentives for changing practices, remain concerns that need to be addressed.

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