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Digital Citizen Engagement Framework: An Approach to Citizen Centric Smart Cities of the Future

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Abstract. Smart city capabilities are currently realized in a staggered fashion or they exist in silos. However continuous improvement and personalization is expected by citizen for sustained engagements. This is possible only if the service enabling platform is able to continuously learn about the citizen persona and her need. This enables a platform to transform the way the services are delivered to an individual citizen. The current study provides insights to develop Digital Citizen Engagement Framework (DCEF) to build a platform for citizen to personalize the engagements with smart city services. The framework is arrived at through Content Analysis, a qualitative research methodology identifying various categories and themes to manage technical components and features that need to be part of DCEF that can be deployed in a Smart City to make it future ready. Our initial experiments on an Ambient Assisted Living (AAL) use-case for geriatric care proves the effectiveness of our proposed framework.

Keywords. Human-centric system, service orchestration, framework for citizen engagement, ambient assisted living, Personalization, Contextual Enrichment, Localization, Smart Cities.

1. Introduction

In this section, we try to capture the motivation behind our work, the objectives of the current study, and a brief survey of related works and enumerate the key scientific contributions of our current work.

Digital citizen is a person who continuously engage using the power of digital technologies with the required services offered by the City based on her needs. The

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"smartness" or "Intelligence" is not a measure of how advanced or complex the technology being adopted is, but how well a service uses technology to improve the QoL (Quality of Life) of citizen. DCEF is designed to make the citizen smart by continuous, sustainable personalized engagement with the smart services offered by the city/service providers.

Figure 1 captures how typically a smart citizen can get engaged in with the DCEF a personalized way. Beyond smartness provided in the services, the framework has to ensure the way the services are rendered and how the citizen is enabled to have sustainable interaction with the smart services. This requires sensing of the environment, sensing the behavior, her engagements, physiological parameters, her need and feedback. Sensing through citizen by onboarding her own assets and sensing the citizen by various other means like wearables, video images, activities are required to personalized the services to her. The below diagram depicts the sensing, information abstraction, contextualization and business enrichment of data, and intelligent orchestration of services to render personalized services to citizen. The data needs to be enriched with contextual information for businesses to provide highly personalized services to the citizen.

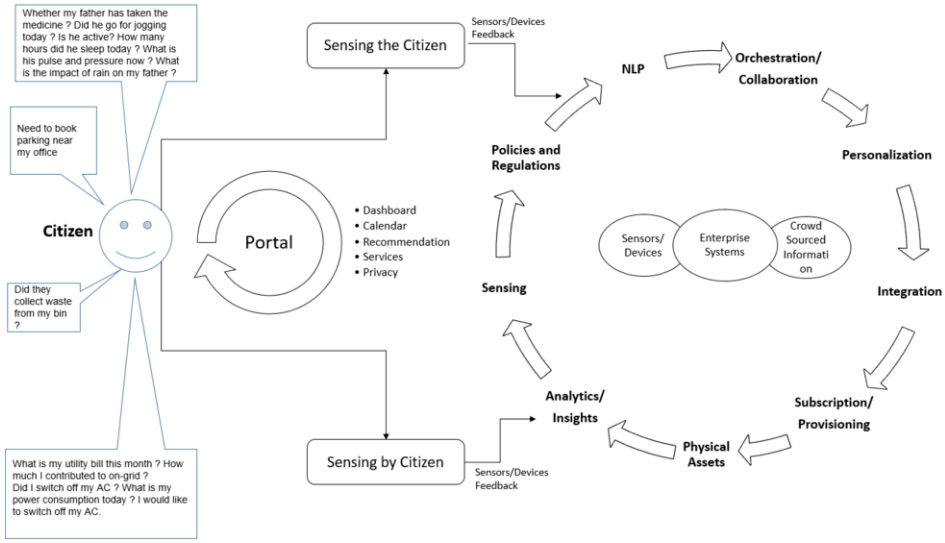

Figure 1. Smart Citizen Personalized Services

1.1. Motivation

Current smart city deployments are infrastructure centric and managed in silos. Citizens get confused in the journey due to multitude technologies and challenges in citizen experience. Although it is well known that the major stakeholder in the smart city context is the citizen. Hence, instead of approaching the smart city paradigm from technological angle or e-governance perspective, we approach the smart city paradigm from a human information interaction (HII) [Albers, 1] perspective. This enables us to understand the

key value metrics that is appreciated by a citizen when she is either contributing to a service like in the case of participatory sensing; or engaging with a smart service as in the case ambient assisted living.

1.2. Objectives

The central objectives of the study are:

- To arrive at the key factors influencing the design of a Digital Citizen Engagement framework that is future ready;
- Ideal digital framework for citizen to engage with smart services offered by a smart city/provider?
- Personalize the engagement there by the quality of life is maximized?

1.3. Related Works

[P. Vlacheas et al,2] proposes a cognitive management framework for Internet of Things (IoT), in which dynamically changing real-world objects are represented in a virtualized environment, and where cognition and proximity are used to select the most relevant objects for the purpose of an application in an intelligent and autonomic way. This practical need impels us to develop a new paradigm, named cognitive Internet of Things (CIoT), to empower the current IoT with a "brain" for high-level intelligence [Wu, Qihui et al, 3]. [Cretu, Liviu-Gabriel, 4] provides an event driven architecture for smart city solutions that enables a kind of city where digital artifacts enable the interoperability between Internet of Services, Internet of Things and Internet of Humans. [Hoseini-Tabatabaei et al, 5] provides insights into how todays smartphones have become increasingly multipurpose platforms, it is still a challenging task to add opportunistic sensing and context processing capabilities without jeopardizing the users overall mobile phone experience. [Uckelmann, Dieter et al, 6] proposes a design framework for service-oriented interactive systems integrating the concept of persona. This enables to extract relevant elements towards deriving the design of main functionality of a user interface. [Eloff, J. H. P et al, 7] discusses important aspects of dealing with human data in the context of smart cities; like security and privacy etc. [Robson, Karen et al, 14] extends the idea to wearable devices, grid for wearable provides information on contextual self-awareness and other situation awareness using wearable devices. [Spector, Yishay, 8, berg, Christina et al, 9] provide viable business models for user centric smart cities of the future.

We find that there is gap related to defining digital citizen engagement framework focusing on human personas and the factors that are needed to make it operational. [Marco Conti, 17] defines Internet of People as all networking functions take into consideration that Internet devices can be users' personal devices, and therefore exploit models of the human behavior to determine the way these devices should operate in the network.

We next delve into the particular application of Ambient Assisted Living (AAL) which is an important aspect for human information interaction (in fact Internet of People (IoP)) with IoT. [Augusto, J, 10] shows that there are different types of caregivers that are needed to be considered to provide assisted life-cycles for Night Optimized Care

technology. This means that the framework for assisted living also needs to adapt itself for providing night care for subjects suffering from insomnia and nocturia. [Schultz, Joseph S et al,11] conducted studies to list the Distinguishing Elderly Needs across factors like: a) Health b) Safety c) Independence d) Mobility & e) Participation. The findings of [Fowler, Jie G, 12] show that Chinese Older People, at-least those who are part of Internet chat groups, exhibit higher levels of happiness through consumption, though consumption is not the key to happiness. In the front of IoT based healthcare, Najafi hopes he and his group will be able to build devices that could be safely implanted in children with severe heart problems and last 30 to 50 years [Najafi, Nader et al, 13].

[Diego Reforgiato Recupero et al, 16], worked on the paper that introduces an open, interoperable and cloud based citizen engagement framework for the management of administrative process of public administrations, which also increases the engagement of citizens. However the mentioned framework does not address how it would manage personalization and human centric aspects which would be possible through citizen persona and human intelligence that are required for cognitive and sustained engagements.

1.4. Key Contributions

The key contributions of this paper are as follows:

An indication at the reference architecture for a future ready framework for digital citizen which is not addressed in earlier studies and literature:

- An interoperable data model which enriches and stores IoT data with business context is needed. Mere IoT data is insufficient;
- Identification of components needed in a DCEF to make it citizen centric.

The rest of the paper is organized as follows: Section 2 provides an overview of the proposed system. We elucidate the effectiveness of our design through real-life case studies based on field deployments, in Section 3. Section 4 provides insights into Implementation of the framework along with performance and scalability analysis through instances of Ambient Assisted living and Activity tracking sensor (Actrack) applications. Finally, In Section 5 we draw the conclusions of our study and also provide a road-map for future work.

2. System Overview

In this section we illustrate our system architecture and the rationale behind our design principles.

2.1. Theory of Design

We begin our study with the study of existing literature as illustrated in section 1.3. A summary of key findings in provided in table 1. Based on the key attributes mined, we proceed to detail our philosophy of design.

The research methodologies that were used by us include content analysis as research methodology using coding the variables and case study analysis.

Table 1. Analysis of State-of-the-Art

Literature Reference	**Variables**	
Citations	**Themes or Category**	**Attributes Learned**
[2,3,4,6]	Management Framework	Cognitive IoT and IoP
[5,14]	Technology Framework	Contextual data Modeling, Service orchestration
[7,8,9,10,11,12,13]	Technology Features	Device configuration, semantic web, security & privacy

Our Content analysis pointed to the frameworks and the features that can be part of the Digital Citizen Engagement framework where AAL is a primary use case. These facts were corroborated through the case study analysis on AAL platform. Our findings are provided in section 4.

2.2. Architecture Overview

The architecture of DCEP is illustrated in Figure 2. DCEP employs a micro services architecture providing engagement as a service to citizen. The service is profiled, personalized and provisioned by learning citizen personas by contextualization and correlating of data from variety of sensors. The sensed information includes but not limited to activity, behavior, feedback and physiology measurement helping multi-dimensional analytics to personalize the services to citizen.

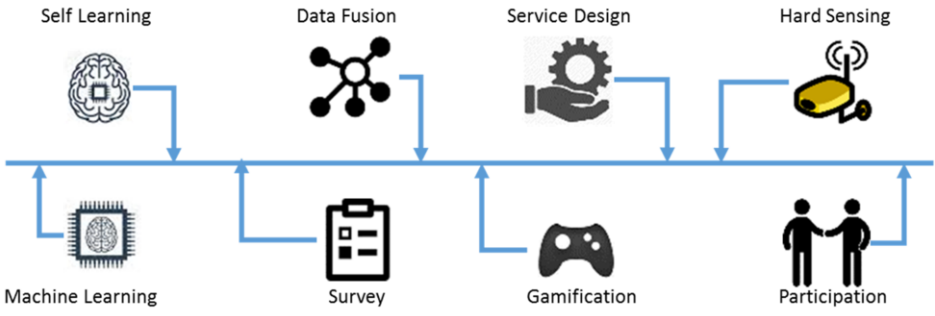

Figure 2. Features of DCEF

The architecture would also aspire to take care of the attributes arrived through literature review in table 1. Human sensing provides low and high level inferences based on multitude of sensor data which enables understanding of both persistent and transient context. Personalized services are those services which are rendered to citizen knowing her persona, her engagements and the context. This is illustrated in figure 3.

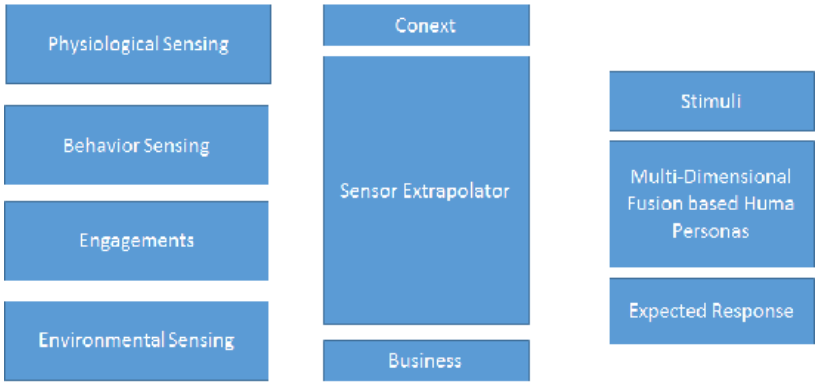

Figure 3. Human Sensing Architecture for Personalization

3. Snapshots of Implementation

In this section, we provide an example of Ambient Assisted Living Framework highlighting some of the concepts presented so far. This framework is primarily targeted at a specific group of citizens namely Elderly citizens interact with AAL platform hosted in DCEF. The AAL platform not only enables sensing of the elderly citizen and alerts that caregiver but also learns about the citizen and her various personalization parameters which will also be fed into DCEP. The services provided by AAL platform is not only through traditional services like authorization, profiling and subscription but also learning about the individual through physiological sensing, behavioral sensing, sensing the various engagement opportunities of the elderly citizen with the system. This helps us to learn about the person across various service paradigms, creates various opportunities for engaging with him and, alerts the rights and services recommended for them.

Another means of personalizing the service is by monitoring the activities of the citizen by using the Actrack application which can be used in AAL platform. We use the above notion to show how an activity recognition application Actrak [Chandel, Vivek et al, 15] can be implemented using the same. In case of Actrak, the sensor being used is the three axis accelerometer on user's mobile or wearable device and is able to provide data on her physiological movements for her personal factors. Citizen decides to on onboard her own device and the device provides meta data like age, height, weight and

gender for accurate estimation of Body Metabolic Index (BMI). Based on this, day-long activity, calorie burnt using various steps and calorie charts can be generated.

4. Case Study

4.1. Ambient Assisted Living for elderly

The AAL scenario for elderly citizen is monitoring enabled by sensor enabled home for motion, activity sensing, utility sensing and physiological sensing with the help of wearables.

Some of the sensors and their features that are used in the rooms for the AAL platform are:
- Passive infrared (PIR) for detecting motion;
- Door Contact (two piece magnetic sensor) for detecting door open/close activity;
- Smart Plug to meter electricity consumption;
- Medibox sensor to monitor medicine intake;
- Bed contact (accelerator sensor) for detecting sleep activity on bed.

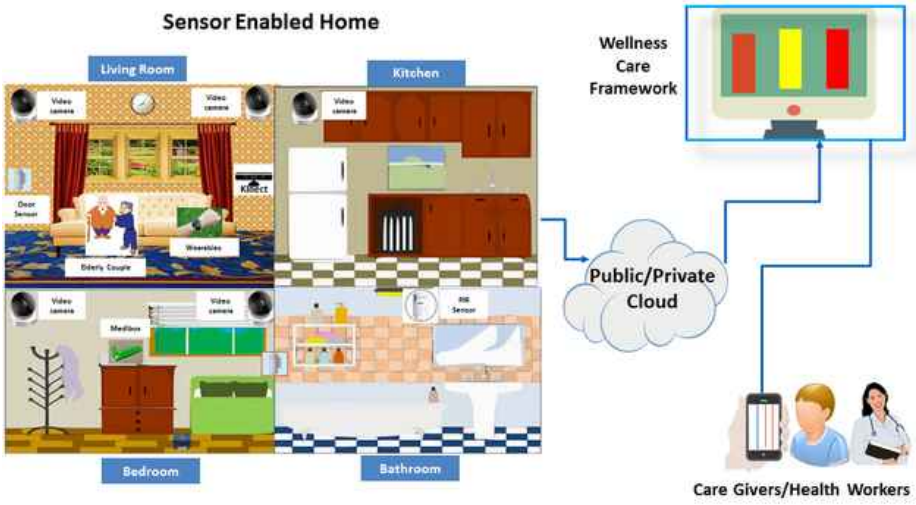

Figure 4. AAL Overview

Figure 4 depicts the layout and type of sensing and services for tracking activities of Daily Living (ADL) and creating quantified life charts of individual subjects. Figure 5 shows how personalized services are enabled using an assisted living

framework on the DCEP. It also provides details of how sensor data is analyzed to understand both behavior and wellness parameters of the elderly citizen.

Recommendation and personalization of citizen engagements would require defining citizen personas. Continuous learning of attributes which influence/impact the definition of citizen personas can be categorized into following:

- Profile
- Behavior
- Physiological
- Location
- Engagement
- Feedback
- Culture/Community
- Environment
- Activity

Many of these inputs are dynamic and state dependent. Contextual enrichment of the personas will help the take decision on what, when, where and how part of the services. For example, recommendation to citizen to adhere to special medication, when he is diagnosed with an ailment like dementia which would need different method of reminding the citizen, when there are chances of citizen missing medication.

Following is the brief description on some of the key components for the Citizen persona in figure 5:

- Citizen persona listener: It is a listener component looking at the data which has dependency to attribute of the citizen, which is being learnt as part of defining citizen personas.

- Citizen persona manager: This component implements a factory type of pattern matching, which in turn will call attribute specific citizen persona processors to learn and define the persona attributes.

- Citizen persona [attribute] processor: This component manages attribute specific processors which in turn calls algorithms/process for learning, in order to categorize the persona attributes.

- Citizen persona APIs: Once the citizen personas are defined, the orchestrator (business processes) and the recommender will leverage the citizen persona services to personalize and recommend the services to citizen.

To illustrate how citizen persona can help in providing personalized service, we can look at an example – The AAL personalized service can help in sending reminder to medication box and also to the care giver to alert and ensure elderly medicine intake

after 1 PM and before 1:30 PM, if the elderly citizen has not taken the medicine. The system also knows that she has sleeping pattern between 1:30 PM and 3:30 PM. In the event of elderly citizen hasn't taken the medication in spite of the alerts from the service and if we are able to monitor and notice that there is down trend in her pulse, then immediate alert to caregiver and reporting to hospital and paramedical care can help the patient, a great deal.

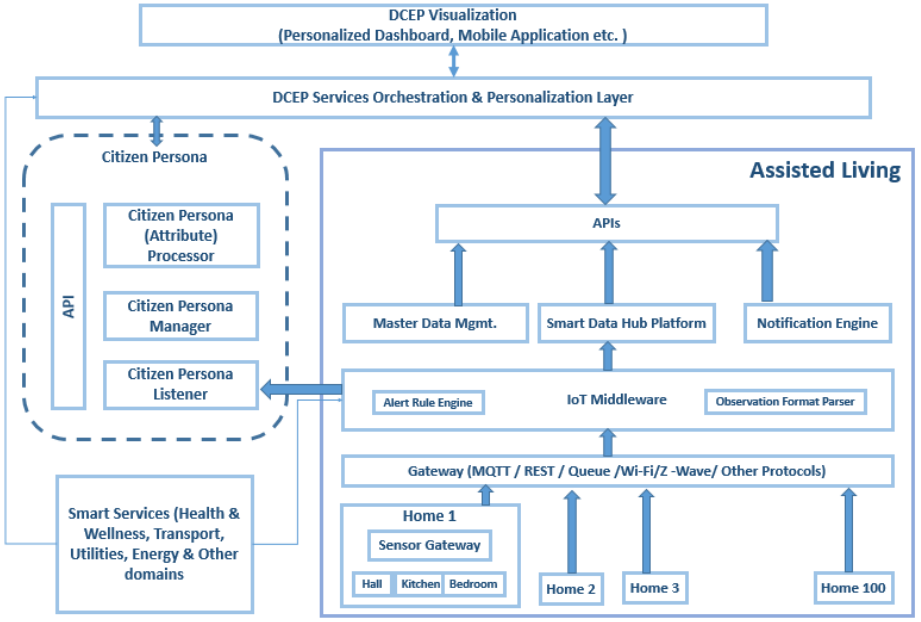

Figure 5. AAL Framework

5. Conclusion and Future Work

In this paper, we have shown how sensor driven context can lead to rendering of personalized services to citizens. We further show that sensor driven applications and associated algorithms can be uniformly implemented on a conceptual DCEF and we also showed how this works for an AAL scenario. As a future work, we plan to implement novel algorithms to build citizen personas through the data and enhance its features to achieve further personalization. We show in our current paper that understanding of human individuality and community uniqueness is key to effective assimilation of information, orchestration of services as well as effective citizen participation and becoming mascots for government initiatives. The future work can also cover privacy and security aspects of the personalized services through DCEP.

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