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Service Oriented Smart City Management Framework

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Abstract: *The concept of a smart city is relatively new strategy to alleviate the problems generated by the rapid urbanization. The Integration of Information and Communication Technologies into administration, availability of data, proliferation of mobile devices and real-time information systems provide new opportunities to offer better services and to make cities of the future more competent, resilient and sustainable. Yet little academic research has discussed the phenomenon. This paper proposes a framework to understand the concept of smart cities in response to the increasing use of the concept in India. Based on the principles of Service Oriented Architecture we identify some critical factors of smart city initiatives: Smart governance, Smart economy, Smart mobility, Smart environment, Smart people and Smart living. These factors along with Service Oriented Architecture form the basis of an integrative framework that can be used to examine smart city initiatives. The framework suggests directions and agendas for smart city research and outlines practical implications.*

Keywords: *Smart City, SOA, ICT, Smart Governance, Smart Economy.*

1. INTRODUCTION

As the global population continues to grow at a steady pace, more and more people are moving to cities every single day. The 2014 revision of the world urbanization prospectus by United Nations Department of Economic and Social Affairs (UN DESA) population division notes that the largest urban growth will take place in India, China and Nigeria [1]. By 2050, India is projected to add 404 million urban dwellers, China 292 million and Nigeria 212 million. As a result these countries will face numerous challenges in serving the needs of their growing urban population including for housing, infrastructure, transportation, energy and employment, as well as for basic services such as education and health care.

Managing urban areas has become one of the most important development challenges of the 21st century. In India the urban population is currently 31% of the total population, which contributes over 60% of India's GDP. It is projected that the urban India will contribute nearly 75% of the national GDP in the next 15 years [2]. Cities are accordingly referred to as the engines of economic growth. There is accordingly a crying need for the cities to be intelligent to handle this large scale urbanization and finding new ways to manage complexity, increase efficiency, reduce expenses and improve quality of life and all that explores a smart city.

The key feature of a smart city is in the intersect between competitiveness, capital and sustainability [2]. The smart cities should be able to provide good infrastructure such as water, sanitation, reliable utility services and health care, attract investments, transparent processes that make it easy to run commercial activities, simple and online processes for obtaining approvals and various citizen centric services to make citizens feel safe and happy.

Information and Communication Technology (ICT) plays a critical role in conceptualizing a smart city as an icon of sustainable and liveable city. ICT tools have the ability to afford eco-friendly and economically sensible solutions for cities for example in the form of efficient water management, conserving public transport systems with the help of satellite data, exploring solutions to air quality monitoring and electromagnetic fields, among others [3]. Smart cities are looking increasingly to Service Oriented Architecture (SOA) for better align business processes and I.T systems to improve agility, maximize reuse of SOA assets and reduce maintenance costs.

1.1. Conceptualizing a Smart City

The idea of smart city is rooted in the creation and connection of Human capital, Social capital and ICT infrastructure in order to generate greater and more sustainable economic development and a better quality of life.

Although there is an increasing usage of the phrase, there is no absolute definition of a smart city, but it is a process by which cities become more "liveable" and resilient and hence, able to respond quicker to

new challenges [4]. Thus a smart city should enable every citizen to engage with all the services on offer including the next generation services, in a way best suited to his or her needs.

In any case, a Smart City is a city aspiring to address public issues via ICT based solutions on the basis of a multi-stakeholder, municipally based partnership. These solutions are developed and refined through smart city initiatives either as discrete projects or as a network of overlapping services [5].

As presented above, the definition reflects that a smart city is one that is able to:

- Benefit from the innovative developments of citizens, Small and Medium sized Enterprises (SMEs) and other actors from across the country.
- Leverage a service infrastructure that is capable of delivering 'one stop government' through the integration of services, interoperability and use of actionable intelligence in service delivery.
- Contribute to a multi-national Service Oriented Ecosystem (SOE) by providing and sharing open business processes as services with other cities.

2. SMART CITY INITIATIVES

In this section we take a look on some factors that make a city smart. More over a city to be classified as a Smart City, it must contain at least one initiative that address one or more of the following key factors [5]:

2.1. Smart Governance

Smart governance is a process of ameliorate in the way government works and shares information with the public to deliver services in order to function efficiently and effectively as one organism. It is all about improved governance and transforming the ways of delivering public services in which the quality of governance is enhanced with the integration of ICT applications, enabled by smart processes and interoperability.

2.2. Smart Economy

Smart Economy is a major initiative that shows a city as a center of excellence in commerce and economic development. It builds local expertise and supports continued growth. Smart economy is related to economic competitiveness and involves innovation, entrepreneurship that connects local and global markets with heterogeneous services and knowledge with an ability to transform.

2.3. Smart Mobility

Mobility plays an intrinsic role in the planning and development of smart cities. Smart mobility refers to ICT supported and integrated transport and logistics system. It offers the citizens with access to technologies and the use of these in everyday life that facilitates the access of relevant and real-time information by the citizens in order to save time and improves commuting efficiency.

2.4. Smart Environment

Smart environment refers to the extended use of ICT for sustainability and for the smart management of natural resources through re-use and resource substitution. It includes smart energy, ICT enabled grids, pollution control and monitoring, improve water quality, renovation of buildings and historical monuments, green buildings and particularly green urban planning.

2.5. Smart People

Smart people are a key element in smart cities. Smart people are the active users in terms of their skills and education levels, as well as the quality of social interaction. It includes e-skills and ICT enabled working, having access to education and training within an inclusive society that improves creativity and fosters innovation.

2.6. Smart Living

Smart living refers to ICT enabled life style, behaviour and consumption. Smart living includes the smart devices of today and tomorrow, letting them talk and work in sync and take autonomous decisions to save time and conserve energy for a better world. It is also healthy and safe living in a culturally vibrant city with diverse cultural facilities and incorporates good quality housing and accommodation.

As services become pervasive and ubiquitous, the matter of opening up databases will become more important. The use of open data is an opportunity to trigger innovative Internet enabled services in Smart Cities [6]. The Public Sector Information re-use will help creating a better and more efficient public administration, as well as opening new ways for the administration and citizen centric societal processes.

In order to realize these opportunities, there is a need for an integrated framework, which should be built on top of three fundamental architecture principles [7]:

- *Modularization*: The framework should be flexible with the creation of multi-purpose and extensible constructive components.
- *Normalization*: The framework should be designed through normalizing the system data from participating services and sub systems.
- *Standardization/Unification*: The common functions should be standardized in a unified fashion.

A framework bundled with these principles can present a high level view within a set of domains.

3. SERVICE ORIENTED ARCHITECTURE

Poor interoperability and adaptability are serious issues for many of today's infrastructure components. Service Oriented approach resolves this issue by embedding interoperability and adaptability within the ICT architecture [12]. SOA integration is essential to deliver business agility and IT flexibility. These benefits require the deployment of a service oriented environment. In this section we examine the definition, the elements and key principles of service oriented architecture which can reinforce and strengthen service management in a smart city.

3.1. Defining SOA

Service Oriented Architecture (SOA) is a paradigm, refers to a set of components that provides a model of creating, assembling and utilizing the distributed capabilities via well published and discoverable interfaces.

3.2. Elements of SOA

Service is the central concept in SOA. It enables access to one or more capabilities by means of a service interface that follow the policies specified by its service description. There are three core elements in SOA: A Service Provider, who allows access to services, creates a description of services and publishes it to the Service Registry. A Service Consumer is the service requester, who is responsible for discovering and binding to the services through their descriptions. A Service Registry is a repository of service descriptions which acts as an interface between the Service Consumer and the Service Provider as depicted in Figure 1:

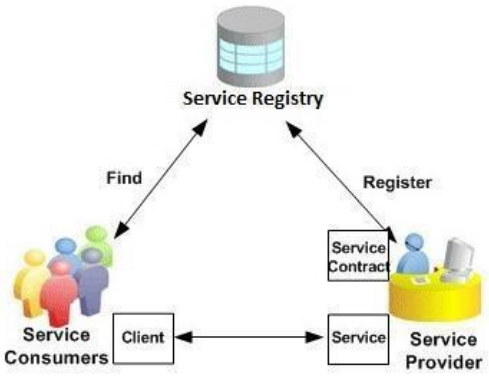

Figure: *Basic Service Oriented Architecture*

Visibility, Interaction and Effect are three key concepts for understanding SOA model in a dynamic perspective [8]. Visibility refers to the capacity for the service consumers and service providers to be able to see each other, which can be realized by service descriptions. Interaction is the activity of using a capability. It proceeds by the exchange of messages. Effect is the result of an interaction which might be a change in the state of the entities that are involved in the interaction.

3.3. Key Principles of SOA

In this section we provide an overview of the key principles [9] of the Service Oriented Architecture. Service loose coupling is the core principle of SOA that promotes the design and evolution of a service's logic. Service autonomy is another principle that provides services to have control over their logic. The principle of service contract states that the services should accept the service agreement as specified by the service description. Service abstraction is a principle that hides a service's implementation details from the outside world. The principle of service composition allows a collection of services to be integrated to form a composite service. The principle of Service statelessness ensures that a service become stateful only when it is required. The principle of Service discoverability allows the services to be found easily. The service reusability principle is the core aspect of SOA that maximizes the reuse of a service's logic.

4. SMART CITY PLATFORM COMPONENT MODEL

Drawing on the conceptual literature on smart cities, their initiatives and the principles of SOA outlined above, we proposed an integrated framework for a highly optimized and interactive service provision in smart cities. This model helps in constructing a smart city, which is both highly efficient and sustainable, as well as generating economic prosperity and social wellbeing on the other hand. Our smart city integrated framework model is based on SOA as depicted in Figure 1, which implements the core components needed in any smart city service. This approach builds on five layers: (1) Resource Layer. (2) Transmission Layer. (3) Database Layer. (4) Process Layer and (5) Service Layer. In the following section we describe the details of each of these layers and their functions.

The Resource Layer: The Resource layer is the physical layer of the model. It includes the physical infrastructure and devices such as sensors, webcams, smart meters, PDA's and smart phones, etc. This layer envisions a large network of embedded sensors or smart devices throughout the city that measure everything from traffic conditions to environmental monitoring and recording desired parameters at the field levels.

The Transmission Layer: The Transmission Layer is the transport layer of the model. It transmits data from resource layer to the database layer. It includes different transmission infrastructures and various communication technologies such as Ethernet, Wi-Fi, WiMAX, hotspots and cellular access for the accurate transmission of the information obtained in the resource layer.

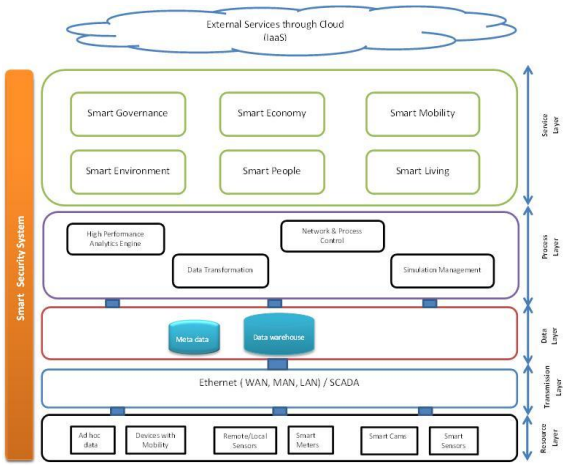

Figure1. *Smart City Component Model*

The Database Layer: The database layer constitutes data management and serves as the basis for service delivery. It presents all the data and information, which is collected, produced and is necessary for further analysis and decision support. All the sensors in the smart city are connected to the database layer, where data can be captured, compiled and analysed by using business intelligence to provide efficient and effective services to the citizens.

The Process Layer: The process layer processes relevant smart city data in a broader context to analyse the inherent meaning in it. Data analytics, data transformation, simulation management, network and process control is the major function of this layer.

***The Service Layer*:** The service layer incorporates all the smart services being offered. These services include smart governance, smart economy, smart transportation, health care, smart education, food safety, public safety and security, etc. A Service Oriented Architecture (SOA) based model can be used to offer these services with an objective of re-use and repurpose. An Enterprise Service Bus and a service registry are used to find the right information at the right time.

5. SERVICE ORIENTATION IN SMART CITIES

We identified that SOA's core principles can reinforce and strengthen a city to become 'smart'. The characteristics of service orientation need to be fully embedded in to this model to achieve interoperability and to deliver a portfolio of efficient services to its citizens.

The European Interoperability Framework (EIF) underlying principle 10- 'Reusability', which is a core aspect of SOA signifies that public administrations must be willing to share their concepts, solutions, frameworks and specifications with others. This can be possible with the application of the EIF principle 9- 'Openness'. It is well known that "Reuse and sharing of the services lead to mutual benefits and agreed common goals ". Accordingly 'Reuse' becomes a key to the efficient development of public services and a way to publish reusable components and services [10].

According to the EIF underlying principle 11- 'Technological neutrality and adaptability', another characteristic of SOA denotes that the access to public services is independent of any specific technology.

When establishing public services, it is crucial to implement a unified scheme to interconnect loosely coupled service components. The SOA principle of 'Loose Coupling' facilitates the separation of system components, with a consequence of reducing the dependencies while guaranteeing interoperability and component replacement with minimum disruption.

6. CONCLUSION AND FUTURE WORK

This paper proposed an SOA integrated Smart City framework, which enable open, scalable and efficient service delivery for smart cities. We have further briefly elaborated the core features of the model including service discoverability, service autonomy, service reusability, openness, technological neutrality and loose coupling that empowers the smart cities to connect to the right information at the right time to deliver scalable and extensible smart city services to its citizens.

The proposed SOA integrated smart city management framework is being further developed into an industrial grade framework. Further in-depth work should be continued to identify the available data sources, data definitions, dimensionality, cleansing, enrichment and proper methods for organizing the unstructured data as well. At the same time research work on SOA integration in Smart Cities will be conducted to evaluate and model the resource consumption of ICT applications and smart approaches of real-time access to information in order to effectively deliver services. It should also scope further standard activities in relation to performance assessment methodologies and asses the issue relating to smart data risk and resilience.

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