# Emerging Smart World: Technologies, Concerns and Challenges

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***Abstract* – The penetration of smart solutions for ICT industry has revolutionized the outlook of modern society. Technology is in access of humans regardless of their knowledge and expertise level and beyond the social barriers. Advances in mobile communications and web engineering tools have given rise to a new social setup called Smart world. The smart cities support layered architecture abstracting the physical spaces and devices into virtual domains interconnected through ubiquitous infrastructure for information sharing and response systems. Social networking has been a widely accepted platform for communication and information sharing. The information regarding human behavior, requirements, likes and dislikes etc., collected through such networks, can be used for statistical analysis and taking intelligent marketing decisions by analysts and planners. Internet of Things has been the result of wireless sensor networks and intelligent devices. Big data analytics is needed to handle huge amount of data being generated continuously. The smart city projects have been intelligently designed to extract and present information to users through internet. While these new developments are interesting they pose a host of new challenges. Being human centric, the sensitivity and the concerns regarding information propagation and usage have to be carefully handled. We propose services architecture for a ubiquitous smart city built on SOA and cloud computing paradigms. The virtualization by core, essential and extended service layers will be used to address the issues like security, flexible information management, multi-tenant/ multi-dimensional activities, ubiquitous data analysis and presentation for users in normal and emergency situations.**

***Keywords- Internet of Things; Internet of Everything; Service Oriented Architecture; Ubiquitous city; Home Area Network; Service Level Agreement***

## I. INTRODUCTION

Historically, the cities and urbanization of human population was a result of innovative solutions to carry out business, cultural, social, economic or technical activities. For example, rail, roads, trains, automobiles, etc., facilitated communities to flourish in big cities. The driving force in the society today is ICT, having an important role in everyday life for education, business, leisure time, healthcare, entertainment, etc. The innovative growth in technologies has moved the data centers from physical to virtual cloud domain and human interactivity has become boundless due to social media and web based activities. We have smart phones, PDAS, all time available services and smart solutions which have affected our daily activities in all Sections of society.

The concept of global village has engulfed entire society into a virtual reality. As a natural consequence of these developments, smart cities a new vision is rapidly emerging. It is a human centric concept starting with an interface device connecting to a large domain of electronically accessible information useful for interactive decision-making / planning for daily routine to any specialized and data / computation centric professional requirement. The driving forces for smart city development are:

- Resource conservation and optimization
- Peak demand management
- Public safety and emergency services
- Smart transport system
- Smart parking system
- Traffic intelligence sharing and management
- E-tolling for seam less revenue collection

A smart city can be visualized into a layered architecture where physical spaces, buildings, enterprises, transport utilities etc., are abstracted into city systems layer through ICT infrastructure [1]. The multidisciplinary and multi domain connectivity over the internet is used for information sharing, analyzing and decision support systems. The concept of Internet of Things (IOT) coupled with wide adoption of web technologies by communities of users [2] has led to smart solutions manageable through remote connectivity. Internet of Everything (IOE) is the new concept of future development.

Service Oriented Architecture (SOA) has helped in making city systems ubiquitous and pervasive [3]. Smart homes are equipped with intelligent electronic and web aware systems to handle routine matters along with emergency situations. The smart city data contains a variety of information which has to be maintained in big repositories accessible through searching and browsing tools. The service model for systems involved requires features of discovery, security and service engagement through a service level agreement (SLA) [4].

World Health Organization (WHO) reported that half of world population is residing in cities or urban areas. The cities are rapidly becoming crowded and projections show that 60% of world population will be residing in urban areas in 2030 expected to rise to 70% in the year 2050 [1]. The metropolitan managers and municipalities are trying to overhaul their systems for every walk of life to meet the challenges and demands of an intelligent world. Various technologies available in ICT domain are being used for this etc., while portable solutions through mobile devices provide fast and easy access; big data analytics [5] are being developed to intelligently service user requests through cloud services [6]. The proposed solutions provide anytime anywhere connectivity for voice video and text processing.

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Urban mashups combine various data and technologies to enable smart city projects for transport, health, sanitation, tourism, etc. The innovators customize these solutions to meet local cultural and geographical needs of a community [7]. Many model city authorities are releasing open data for interaction with individuals, community organizations and businesses. For this purpose, APIs are developed to enable technologists and developers to interact with open databases [8]. Initially, they are focusing on machine-readable access to static data held by city authorities. To make the systems interactive, transactional APIs are expected to come into play soon. Such APIs will require the properties like atomicity, consistency, isolation and durability (ACID).

In Section 2 we review the related work, followed by technologies and foundations of a smart city in Section 3. The challenges faced by developers are discussed in Section 4. The technical vision of the smart city project for Islamabad, capital of Pakistan, has been presented in Section 5. We conclude the paper in Section 6 emphasizing the requirement of regulation and forensic data management in smart city project.

## II. RELATED WORK

Digital cities have evolved with the growth of web applications, broadband networks and information systems providing the knowledge base. The urban environments are highly demanding hence the evolution of smart city concept has become the rapidly developing need of human society. The Home Area Networks (HAN) are common in many cities [9]. They provide all time connectivity and management capability while at home or from a remote location. While it is a luxury for normal citizens it is a big advantage for the aging or handicapped citizens to manage their day to day activities without full time support. Most of them have server based connectivity to the data centers, which pose problems of scalability and interoperability. It is more appropriate to use Wireless Local Area Network (WLAN) and Internet connectivity through WiFi or WiMax support [10].

Smart grid concept is based on three layers of activities, i.e. infrastructure, communications and applications [11]. The metering of various utilities is done through smart meters and grids. Service Oriented Architectures [12] are evolving to take intelligent decisions autonomously to feed the smart grids. Such solutions are scalable and interoperable due to intermediate software layers to provide flexibility in implementation of services across hardware and software platforms. These services can be used to integrate applications with low development costs. The ubiquitous networking and internet enabled devices have promoted developers to provide smart solutions for our day to day activities [13]. Hence, a new name U-cities is often used for smart cities [14]. These services require interoperability, scalability, extendibility and seamless mobility features.

However a number of concerns are yet to be addressed; for example, vulnerability of software services is critical. Some of the weak areas in software deployment may pose serious security problems in smart city projects [15]. A few of these issues are as under:

- Wide exposure of community systems in smart city projects may be a source of malicious activities
- Lack of exhaustive security testing of software components by all the participants
- Lack of emergency response team to handle problems

Intelligent devices can communicate freely generating large amount of data in the wake of new technologies under the Internet of things (IOT) concept [2]. The variation in data collected and its presentation requires multi modal handling through intelligent data presentation services [16]. The data is aggregated, processed for knowledge and event extraction before forwarding to other federating active nodes

## III. FOUNDATIONS OF A SMART CITY

A smart city is composed of systems deployed with multiple technologies in hardware and software. The ubiquitous availability of information is expected to improve quality of life by providing knowledge-based data collection and presentation through various devices ranging from cell phone, tablet to laptop [17].

A smart city is capable of monitoring and managing critical resource parameters through ubiquitous services. These parameters may be related to physical domains like airports, bridges, roads, railway stations, subways, sea ports, etc. The aim is to optimize resource utilization, increase efficiency and security [18] [19]. Beside normal operation, disaster management aspects along with service delivery form an important component of a smart city [20]. The software architecture and enabling technologies for smart city projects discussed in various research papers and reports referred have been used to form conceptual outlay presented in Figures 1-3. For this purpose we propose to use agent based model using SOA and ubiquitous cloud services.

| | | | | | |
|---|---|---|---|---|---|
| Goals | Eco system development, Sustainability, Ubiquitous services, Information management, storage and presentation through APIs, Support Chatting, Audio Visual communication Data recording and navigation tools | | | | |
| People | E-government, Education, Health, Traffic management, energy management, emergency and security | | | | |
| Software Services | Community / Social Networking, Data Collection and archiving, Competitive advertising of services and utilities | | | | |
| Enabling Technologies | Mobility and Network Infrastructure, SOA / Cloud services, Big Data analytics | | | | |
| City Systems | Communication<br>• Roads<br>• Airports<br>• Railway Stations<br>• Buses<br>• Taxis etc | Residential<br>• Homes<br>• Shopping area<br>• hospitals Community parks | Healthcare<br>• Hospitals<br>• Nursing homes<br>• Pharmacies<br>• Emergency | Utilities<br>• Gas<br>• Water<br>• Electricity | Security<br>• Police<br>• Emergency Response |
| City Infrastructure | Buildings and spaces, Utilities: Transport, Electric, Networks, Emergency systems.... | | | | |

Figure 1. Smart City concept

| | | |
|---|---|---|
| Smart City Abstract Level | Interfaces, Users, Interfaces and other networked sources | GUI, API for Data Visualization |
| Smart City Support | Transformation of requirements to invoke services model: Deals with security services for accessibility and disposition | Data sharing and analysis |
| Middleware | Healthcare, Education, Safety, Social Networking and Interoperability | Data Services for storage and retrieval |
| Interconnectivity | Telecommunications, Informatics, Telephony, Electronics and communication protocols | Data Collection |
| Data Acquisition through sensor networks | Local connectivity in enterprise, home, office and public systems WiFi, WiMax, Bluetooth, adhoc network, LAN, WAN, WLAN, SCADA and WSN | Data Generation |

Figure 2. Functional layout of smart city systems and components

The availability of smart phones and network aware devices has changed the outlook of human society substantially. To lay the foundation of a smart city ubiquitous data management is a core concept. Data is dynamically collected through wireless sensors, meters, personal devices, etc. [21]. Success of a smart city architecture hinges on sustainability under various internal and external factors. The citizens are connected through social networks who share knowledge of common interest [22]. They form digital communities which eventually lead to the smart city concept. Some of the requirements of a smart city are [23] [24]:

**a)** Development of broadband infrastructure to provide integrated solutions

**b)** Deployment of embedded systems for data acquisition from smart sensors, activators, etc.

**c)** Continuous, real time data propagation, management and issuing alerts when required

**d)** Web based and social network applications providing collaborative data collection and sharing

**e)** Intelligent sharing of resources and self-decision making capability

Innovative smart home and office management techniques have been used for lights, fans, air-conditioning along with finger print sensors, smart windows, doors, etc. [25]. Home security systems including urgent response in case of fire or medical emergency are the basic community requirements of modern living [26]. The complexity of human behavior in various cross Sections of population require smart solutions which range from intellectuals, workers, children at schools and citizens requiring medical care [27]. Some aged persons require continuous monitoring and healthcare remotely managed from the caring hospital through smart sensors and ubiquitous connectivity. Some of the inputs required for this purpose include:

- Network infrastructure
- Information propagation
- Data management and privacy
- Collective intelligence
- Interoperability
- System safety

The infrastructure requires sensor networks, mobile communications, digital imaging devices and cameras, remote monitoring and servicing, replacement of conventional hardware with innovative new generation of smart devices [28] [29].

## IV. SMART CITIES AND THE CHALLENGES

Digital systems and Information Communication Technologies (ICT) are being extensively used in the enterprise systems today. These systems have been implemented using different platforms using different data types and structures. The biggest challenge for developers of smart city is to provide a platform from where these systems can be seamlessly accessed. Distributed object oriented technologies like CORBA, J2EE, COM / DCOM verses Service Oriented Architecture (SOA) are the two main approaches to lay the framework for a smart city. The loose coupling between participating systems under SOA is significant because it allows their interaction without the consideration of software platform and its physical location. SOA has much higher efficiency in integration of information systems hence it is the most favored technology used in the smart cities projects like Berlin, Boston, Toronto, New York and Dubai.

Smart cities combine ICT and Web 2.0 technologies to allow interaction in the society which are above the closed city management domains. Innovative solutions are being designed to improve sustainability and quality of life. The fast moving social systems and job commitment bind the humans to regular schedules with little flexibility. In this situation social networking has brought human society in closer ties and social engagement, often termed as digital society. However, lack of awareness among participating communities regarding security, social issues and potential misuse of information by intruders pose serious problems. For example using e-Healthcare services may require a patient to provide his personal information beyond the basic identity leading to a number of problems. Firstly the user may not be aware of the vulnerability of information and secondly the service provider may mismanage or expose it to other parties leading to security issues. To handle such situations regulatory procedures have to be carefully designed.

The basic issues to be considered for smart city are energy consumption, waste management, pollution, control urban traffic congestion, security, social integration and healthcare especially for elderly population. In the modern cities where the population concentration is increasing, the disaster and emergency handling has assumed great importance [33]. Smart city concept has caught the eye of developers and solution providers and a number of big cities are investing a lot to build smart systems. The ICT experts are working hard to provide widely acceptable solutions to the following issues:

- Smart city should provide ubiquitous services through sustainable, trustworthy and secure model

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- A wide agreement on commercial and service invocation procedures is required
- To overcome institutional resistance particularly in current bureaucratic city management systems [31].
- User friendly discovery, identification and use of services
- Interoperability of services with possibility of reuse, combining into new services and creating mashups [32]
- Information management with suitable measures to avoid misuse [33].
- Customer privacy management with suitable forensic data [36]

Enterprise Resource Planning (ERP) systems are the requirement for building a viable smart city. Figure 3 shows service layers of a smart city using a model ERP system.

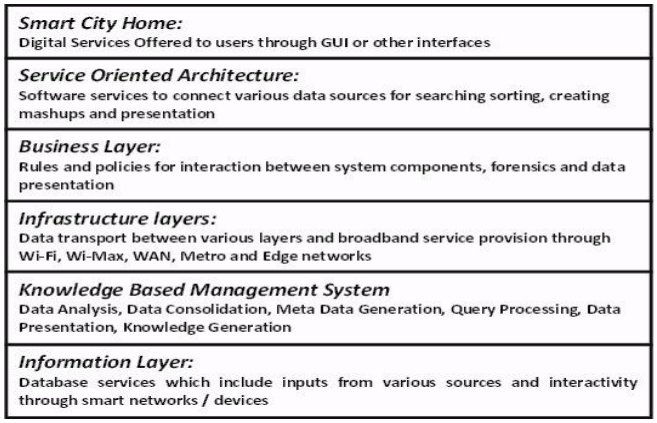


Figure 3. Service layers of a smart city to model an ERP system

The data management in various factions like vehicle registration, resident's registration, Electronic Patient Records (EPR) in hospitals /clinics are not easily accessible with a single window operation [34] [35]. Instead they require institutional verification to access sharable resources. Some methods have to be evolved through a Certificate Authority (CA) at city level to allow access to sharable resources through one level of authentication. So that the smart solutions do not end up with unnecessary delays defeating the purpose of smart solutions. At the same time it is important that suitable forensic data should be generated so that the information misuse may be avoided [36].

## V. AGENT BASED MODELLING OF A SMART CITY

Service oriented architecture provides location independence, mobility, scalability and efficient integration of services model. The SOA uses a registry through which the services are offered to the clients under a policy. Ubiquitous intelligent services architecture for smart cities is built using agent based modeling techniques feeding the federated and abstracted cloud servers [3]. The web based Service Oriented Architecture is used to knit the dynamic requirements of clients with the dynamic databases. In a smart city agent-based modeling methodology is used to simulate behavior of people, business, weather, traffic, etc., Agents exhibit features like autonomy, heterogeneity, reactive or proactive behavior. They enjoy bounded rationality, instructiveness, mobility and capability to adapt to dynamic variations of data, environments along with taking suitable decisions under a policy. Development strategy for smart city project components using SOA is presented as under. We conclude the Section with a smart city model proposed

### *A. Requirements of a smart city*

The smart city projects are being built by using ICT and Web 2.0 tools. Some of the requirements for purpose are:

- Information mobility
- Knowledge sharing and sustainable life cycle
- Collaboration between participating systems.

### *B. Smart City Data Flow model*

Typical data flow model in a U-city can be visualized as under:

- Registry management for services offered
- Data acquisition, analysis and presentation
- Data sharing through interactive tools
- Data archiving and security management
- Data transport across various domains
- Data collection and aggregation
- Data acquisition classification and recording

### *C. Technologies available Cloud and SOA*

NIST has defined Cloud computing as a model to enable ubiquitous, convenient, on demand network access to shared resource pool that can be rapidly provisioned and released with minimum overheads [37]. The virtualization of resources has led to the IaaS, PaaS, SaaS etc., as the building blocks. SOA is based on enterprise system approach, the benefits offered include:

- Language neutral integration
- Component reuse
- Organizational agility
- Layered system approach for system integration, i.e., abstraction, loose coupling, encapsulation through clear / unambiguous interface specifications

While both the Cloud and SOA approaches have an overlap they are different in many ways for example:

- SOA is fundamentally enterprise integration technique making system integration easier
- SOA offers language neutral software layers
- Cloud computing covers the entire stack of hardware through presentation layer. SOA is often used for software services within cloud framework
- Cloud computing offers many IT functions as commodities and are less costly
- SOA can be pursued independently or concurrently with cloud to complement each other

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### *D. SOA for a model smart city - Our Proposal*

We propose a service based smart city architecture; the services are classified into core, essential and extended services. Our proposal is shown in Figure 4. A smart city must provide healthcare services in a manner that data regarding all major infirmaries and hospitals with specialties is available online. Any city council registered person can visit a doctor online by booking an appointment and getting his medical advice. He can also arrange an appointment and physically visit the doctors in case physical examination / assistance is required. In the prior case, general practitioner (GP) can order prescribed medicine for the patient, which gets delivered automatically.


Figure 4. Proposed service based smart city model

We propose education services such that the users, i.e., the habitants can find out catchment areas, consult teachers and view progress of their children online, see which of the schools are doing better. This would pose a requirement on the city council of smart city to provide such interfaces for healthcare and education services. Moreover, council would also require managing basic amenities of life such as electricity, water management and providing an interface where the users would be able to make use of such services. We propose a component based architecture in such a way that a mobile interface as well as a web interface is provided through responsive web system that interacts with services that are launched. A block diagram is shown in Figure 5.

Once core services are provided in a smart city application, essential services including traffic management, complaints and waste management will be considered. The travelers can find out, which traffic routes are facing congestion at a certain time? Similarly traffic may be managed avoiding places of congestion in an automated manner. Another aspect of this service is to provide interface for geo-tagging where incidents could be automatically reported. Complaints management would also be supported in a manner that an automatic complaint registered is to be provided with a comprehensive tracking system. This system would also provide task management system such that the remedy providing sectors can view the complaint, take action and log their results.

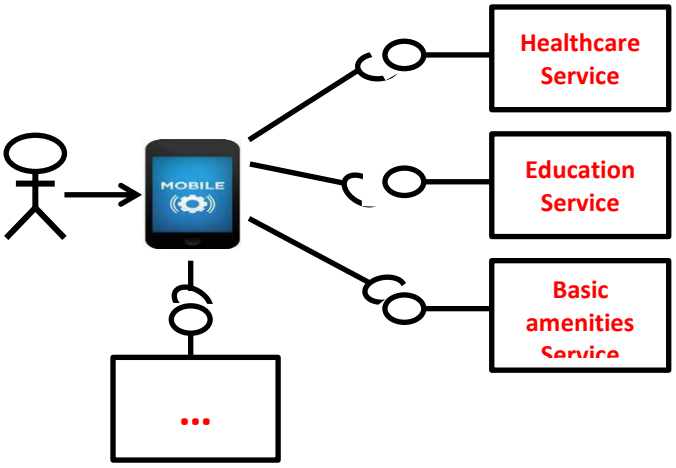


Figure 5. Component-based architecture of proposed services

Finally, a set of services called extended services include security provision with the help of monitoring through cameras. The system would allow the users to log issues and see what safety measures are there in all parts of the smart city. We also propose a set of revenue services, which allow payment of utility bills such system and service providers use same frontend. This set also includes interfaces for social services such as hiring of taxis, booking of places in hotels etc. Our proposal would also provide a set of services where users would also be able to choose from a range of services. Figure 6 shows a conceptual view of the ubiquitous services architecture for a model Smart city.

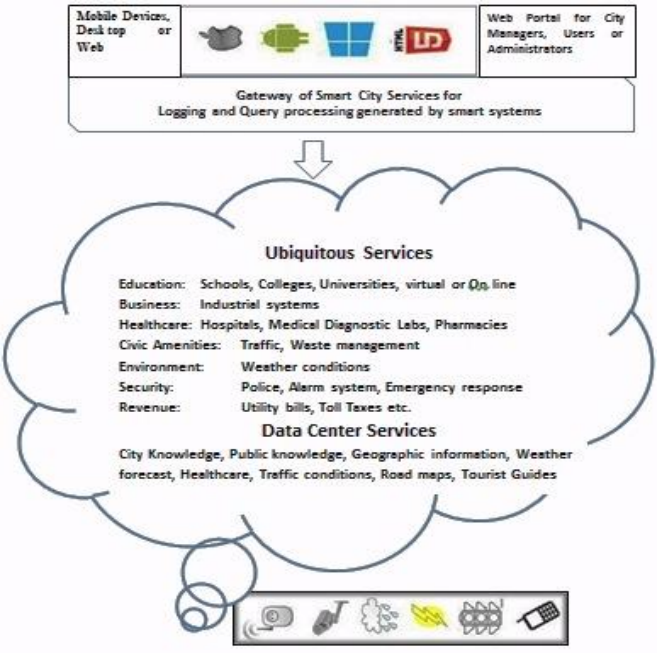


Figure 6. Smart city model with ubiquitous services architecture

We plan to develop a prototype of smart city project for Islamabad, Pakistan to exploit the initiatives taken for IT infrastructure of the country. Some of the Sections we will cover initially include:

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- e-Government
- e-Healthcare
- e-Utility services and revenue collection
- e-Disaster management
- e-Education
- e-Traffic management
- e-Municipal management and civic services

A mobile application ISPAK will be developed to access the smart city, Islamabad through an internet aware device. The session will start with city information and important announcements. For example a request for blood donation may be displayed to catch immediate attention.

Our approach is to develop a software framework at Bahria University, to demonstrate the functionality and then proceed for full scope development. For this purpose the government departments and software developers will be invited to deliberate SLA to provide inputs for data sharing and aggregation, security, availability and other important issues. On the technology side we will use the SOA and ubiquitous cloud services as shown in Figure 6.

## VI. CONCLUSION

The implementations of smart city projects have energy saving in operational and capital investment. The SOA will support management and maintenance of city systems and activities in a widely acceptable perspective. To have a good impact of smart solutions the system integration in service-oriented architecture will allow information access and secure data exchange with forensic data bypassing the legacy protocols. The smart city projects are expected to increase productivity as the human interactivity with them has become ubiquitous and boundless. They are accessible through mobile applications available on mobile devices as well as through conventional Internet access through LANs.

The issue of integrating ICT solutions for technical and non-technical communities of users across various live activities is of prime importance in a smart city project. The privacy and regulatory mechanisms required in various factions may be significantly different. For example healthcare, smart grid or traffic management may have very different logistics to handle. Hence, bureaucratic, privacy and regulatory challenges for disparate services to be presented to various communities in service oriented architecture has to be addressed to meet the expectations of end users.

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