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Approaches of Information and Communication Technologies (ICT) for Building Smart Cities – A Review

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Abstract: Smart cities are built up with incorporation of Information and communication technologies, which allows the management of urban infrastructure effectively. Sensor networks, Internet of things, digital infrastructure, voluminous generated data from biological websites, social networks, GPS and Geospatial datasets are major sources of database to build the smart city with effective management governance, business, health, transport, resources and energy. Classification of structured and unstructured datasets and integrate them in cloud environment with appropriate hardware, software and interfaces will be cost effective and retrieve the appropriate information as per user requirements, this will assist in long term management of smart cities.

Keywords: Smart city, Bigdata, Data integration, Cloud computing

INTRODUCTION

Migration of more people towards urban zones, increase the burden on the urban infrastructure, civic amenities, resources, pollution rate, health and transport (Borja, 2008; Marceau, 2008; Toppeta, 2010). The ever increase of people's migration has to be contained and managed in such a way that they are able to blend into the urban society, making the integration effective. Hence planning of smart cities based on information and Communication Technologies (ICT) can help management of urban regions effectively and improvise the quality of citizen's life (Shepard, 2011), encourage business to invest and create a sustainable urban environment.

Urban regions which integrate and implement smart combination of ICT technologies such as digital infrastructure, software technologies, sensor networks, interfaces with efficient security, provide better management of economy, people, governance, mobility, environment and activities (Giffinger et al., 2007). ICT also includes characteristics such as openness, dynamic expandability, interoperability of objects, distributed intelligence, and cost and energy-efficiency (Harrison and Donnelly, 2011). These smart cities have been variously labelled as 'wired cities' (Dutton et al., 1987; Hollands, 2008), 'cyber cities' (Graham and Marvin, 1999), Learning city (OECD, 1999), 'digital cities' (Ishida and Isbister 2000,), Virtual city (Schuler, 2002). sustainable city (Batagan, 2004), Knowledge city (Ergazakis et al., 2004), 'intelligent cities' (Komninos 2002), Ubiquitous city, Information city (Anthopouls et al ,2010) , Green city (OECD, 2010) and 'smart cities' (Hollands, 2008) or 'sentient cities'.

Various sensor based devices, meters, personal devices, appliances, cameras, smart phones, implanted medical devices, the web, and other similar data-acquisition systems, including social networks enables the capture of data and integration of live real word (Harrison et al., 2009) that provide smart understanding of city that enhances efficiency and suitability (Hamcke et al, 2013; Townsend, 2013). This real-time insight of structured and unstructured data can be stored as big data and built in a hybrid cloud infrastructure, stored and mined through various software programming and utilized for citizens, business, complex analytics, modelling, prediction of urban processes and visualize them to understand the likely outcomes of future urban development (Schaffers et al. 2011; Batty et al.2012). This paper enlightens and reviews the various components of smart cities, i.e., ICT data requirements to built the smart cities.

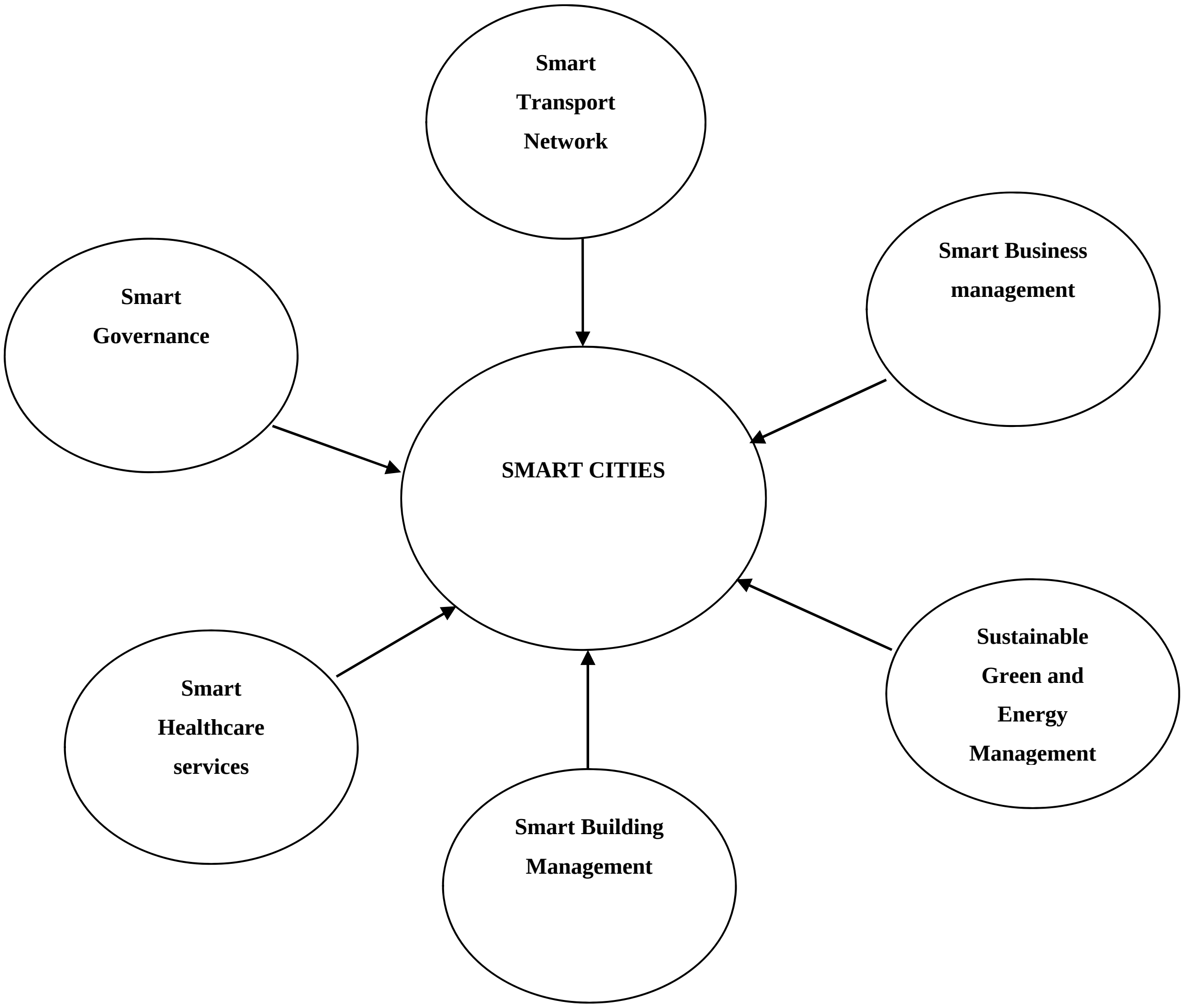
SMART CITY MODEL

Smart City Model describes integration of economic, environmental and social components (Komninos, 2011; Doran et al.,2012) in the smart city system

a) **Economic component** includes public administration and economic actors. It covers governance models, urban regeneration, open data, big data, bandwidth, mobility, cloud computing, security, business intelligence, etc.

b) **Environmental component** includes resources and managerial infrastructures. It covers water, air, energy and waste management, public and alternative transportation, geographical information, green buildings, green spaces, smart growth, climate change measurement, etc.

c) **Social component** includes citizens. It covers community life, urban mediation, participatory democracy, social innovation, human-scale cities, civic participation, proximity services, etc.



SMART GOVERNANCE

ICT-based governance is known as smart governance and core of initiatives which widely represent a collection of technologies, people, policies, practices, resources, social norms and information that interact to support city governing activities (Giffinger et al., 2007; Belissent, 2011). Smart governance includes smart phone based payments (payment taxes, Government services and Bank transections), Immigration passport control, online passport application, accessing property documents, GIS based land records, agriculture information, login based acquiring government documents through internet, this open initiatives will enhance transparency, better empower citizens, foster innovation, and reform public services.

SMART TRANSPORT NETWORK

Sensors, cameras, and global positioning system (GPS) devices, which are attached to street lamps, poles, and building walls, and buried beneath the asphalt of parking lots, provide information on traffic, predicting future congestion and recommending alternate routes. environmental factors, weather, public transport schedule, security and video surveillance system, monitor the state of physical infrastructure such as bridges by detecting vibrations, detect vehicle RFID (Veloso et al., 2009), Automatic Number Plate identification (ANPR) (Kitchin,2014). These data coupled with smart phones technologies provide us with real-time transit information, cultural event schedules, tourist and sightseeing information, and retail offers (Stott, 2013; Van Rijmenam, 2013). Smart transport system significantly contributes to a cleaner, safer and more efficient transport system in urban areas.

SMART BUILDING MANAGEMENT

Smart meters and monitoring devices can help monitor and manage water consumption, heating, air-conditioning, lighting and physical security. Smart meters at customer's homes allow for real-time determination and information on energy consumption and provide the possibility to read consumption both locally and remotely (Siderius and Dijkstra, 2005). Smart phone consumers can also control the consumption of electricity from a remote area. This results in important cost saving and prevents electricity theft (OECD, 2009). Mapping the power grids (Main grid to meters) using Geographical Information Technology (GIT) such as GIS, GPS will help to maintain the energy consumption and reduce electricity theft.

SMART HEALTHCARE SERVICES

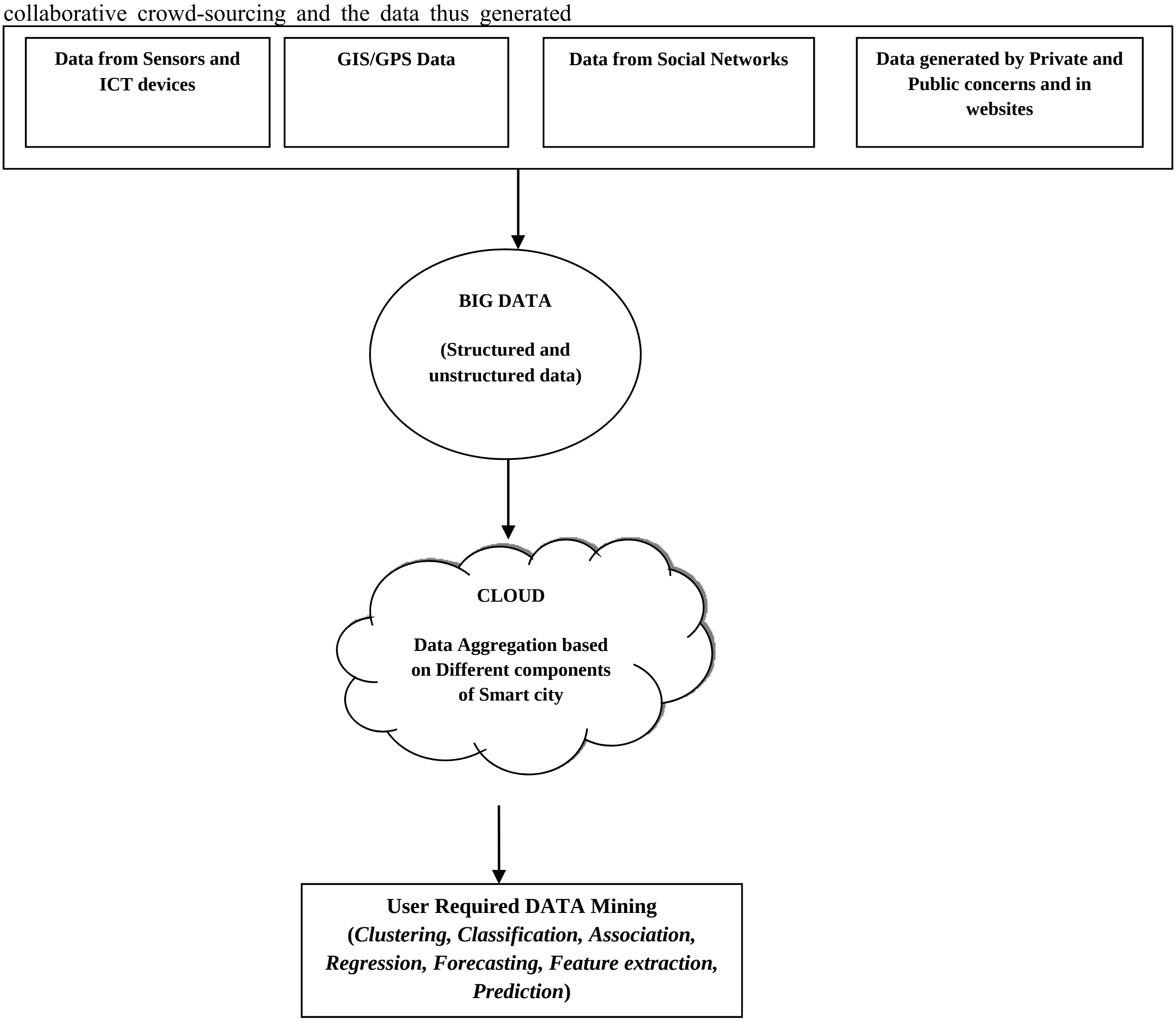
To build a smarter system, healthcare solutions need to be instrumented, interconnected and intelligent i.e., Telemedicine, electronic records, and health information exchanges in remote assistance and medical surveillance for disabled or elderly people (Schaffers et al., 2011). Biomedical engineering, healthcare technologies, health education through satellites, micro and nano-technologies, can greatly contribute to the need for better health care and wellbeing solutions. Bio-sensors techniques contribute very much for Personal health systems, which will be exploited for the prevention and/or early diagnosis of harmful situations and diagnosis and developing target based treatment of diseases using nano-medicines increase the effectiveness of health practices.

SMART BUSINESS MANAGEMENT

Remote working and e-commerce services for businesses, entertainment and communications for individuals based on advanced location based services, social networking and collaborative crowd-sourcing and the data thus generated (Schaffers et al., 2011) will assist integration of ICT applications like data mining and cloud computing will increase the effectiveness of Business management.

SUSTAINABLE GREEN AND ENERGY MANAGEMENT

Core to the concept of a smart city is the use of technology to increase sustainability and to better manage natural resources (Hall, 2000). Smart city initiatives are forward-looking on the environmental front (Giffinger,2007). Of particular interest is the protection of natural resources and the related infrastructure such as waterways, sewers and green spaces such as parks. Bio-based ethanol production for fuel for motor vehicles, LCAs are important for capturing all related environmental impacts, *e.g.* nitrogen use in fertilisers, GHG emissions due to land use for growing the biomass. Sensor-based networks that collect information and software-based interpretation of data can be used to adapt lifestyles, production and commerce in OECD and developing countries to the impacts of climate change (Kalas and Finlay, 2009; FAO, 2010).



Conceptual diagram illustrate to manage data in Smart Cities Geospatial Data

DATA INTEGRATION AND UTILIZATION

Geospatial data and geographic information system (GIS) are essential components for building smart cities in a basic way that maps the physical world into virtual environment as a referencing framework (Wang Tao, 2013). GIS are being used to provide solutions in legal aspects, administration, tourism, street management, parcel management, city management, demography, communication, networking (power and water) recreation, transport, logistics, statistical survey and other government service as well as in businesses and industry. Geoinformation technology is being used in surveying, engineering, planning and logistics for the collection, processing, management and presentation of spatial information through two types of geographic data: vector data and raster data. Vector data (points, lines, polygons etc.) can be linked to a variety of different data types and sources (such as population levels, altitudes, street numbers), while raster data such as high resolution aerial photos, satellite images etc. can be integrated to generate thematic data.

GIS maps, when integrated with other layers of city information, networking systems, and classified high resolution satellite images, create multiple data driven Smart City Platforms involving different stakeholders like the government, private sector, and the civil society. These layers can include building footprint locations, address information, energy consumption, street line markings, railroad and metro rail assets, storm and drinking water management, waterway and wetland areas, surface and volume analysis of roadways, Cadastral survey information, digital topography, encroachments, neighbourhood boundaries, election wards and districts, zoning boundaries, green area cover, etc.

Big Data

The continuous generation of voluminous database of information captured by organizations, such as the rise of social media, Internet of Things (IoT), and multimedia through CCTV, Photographs, Finger prints, Retina id, Unique code for human identity, medical imaging, private and public transactions through digital devices such as mobile phones, web site data from various sensors, communication devices, barcodes, payment registers, travel communication and machine- machine interaction across the internet of things (Kitchin and Dodge, 2011). Government and private Organisations and public are increasingly generating large volumes of data such as historical weather information and forecast, DNA sequencing information, natural resource information, product review and comments posted in social network web and citizen science platforms (Bonney et al, 2014). The data is either in structured or unstructured format , often referred to as Big Data (Bell et al, 2009; McAfee, 2012, Franks 2012). All this accumulated data is potentially aiding useful information for users or clients, which can significantly improve the decision-making.

Big Data computing

The choice of three Vs i.e., variety, velocity, and volume are used to explain Big Data (Russom ,2011). Regarding variety, it can be observed that over the years, substantial amount of data has been made publicly available for scientific and business uses. Examples include repositories with government statistics; historical weather information and forecasts; DNA sequencing; information on traffic conditions in large metropolitan areas; product reviews and comments; demographics ; comments, pictures, and videos posted on social network Web sites; information gathered using citizen-science platforms etc, (Bonney et a, 2014).

Big data are characterized by three aspects: (a) data are numerous, (b) data cannot be categorized into regular relational databases, and (c) data are generated, captured, and processed rapidly. Moreover, big data is transforming healthcare, science, engineering, finance, business, and eventually, the society. The advancements in data storage and mining technologies allow for the preservation of increasing amounts of data described by a change in the nature of data held by organizations (Cumbley, 2013).

Big Data Analytics and Cloud computing

Bigdata offers substantial value to organizations willing to adopt it but at the same time, it has a considerable number of challenges i.e it requires expensive software licenses, employs large computing infrastructure (Schomm et al, 2013; Yu et al, 2013) which is expensive. Performing analytics on large volumes of data (Big Data) requires efficient methods to store, filter, transform, and retrieve the data. Some of the challenges of deploying data management solutions on Cloud environments have been known for some time (Abadi 2009; Sakr, 2011).

Clouds can help organizations from spending money on maintaining peak-provisioned IT infrastructure they are unlikely to use most of the time and provide a platform to manage data using common software online. Cloud is a new class of network based computing that takes over the Internet or a model which relies on large, centralized data centre to store and process a great wealth of information to organise data of all size (Armbrust et al, 2010), minimize the usage cost of computing resources (Amanatullah, 2013), by building proprietary appliances or softwares and, integrating the appliance hardware and access by different company or users from centralized platform (Sun et al, 2011). It also reduces infrastructure maintenance cost, efficient management, and user accessibility (Chih-Wei et al, 2013).

Data mining and Cloud computing

Data mining is the technique to extract hidden predictive information from large databases using clustering, classification, association, attribute importance, anomaly detection, feature extraction techniques, which summarized by Talia et al (2008) as four levels of data mining services in Cloud computing i.e a) Single KDD steps b) Single data mining tasks c) Distributed data mining patterns d) Data mining applications or KDD processes. Ambulkar and Borkar (2012) explained that data mining in cloud computing is the process of extract structured information from unstructured or semi-structured cloud infrastructure. Data mining in the cloud infrastructure is a part of knowledge discovery process and is used to extract human understandable information (Srinivas et al, 2013).

Data integration and Cloud Services

EDW or cloud based data warehouses, however, create certain issues in respect to data integration and the addition of new data sources Standard formats and interfaces can be essential to achieve economics of scale and meet the needs of a large number of customers (Iosup, 2010) and number of models develop for management of cloud data(AssunÇão et al, 2015).

Map Reduce is one of the most popular programming models to process large amounts of data on clusters of computers. Hadoop is the most used open source MapReduce implementation, also available by several cloud providers (Barga et a, 2012). Amazon EMR enables (50) customers to instantiate Hadoop clusters to process large amounts f data using the Amaon EC2 and other Amazon web services. Starfish a data analytics system built atop Hadoop ,focuses on improving the performance of clusters throughout the data life cycle in analytics, without requiring users to understand the available configuration options. Windows Azure's cloud infrastructure relies on master-slave architecture where the master is responsible for scheduling tasks and the slaves for carrying out map and reduce operation(AssunÇão et al, 2014).

Some of basic cloud service types for analytics as a service include infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) (Gunarathne, 2013) are described below;

a) Infrastructure as a Service (IaaS) : Deployed on-premise or via a cloud provider, IaaS enables user to allocate or buy time on shared server resources, which are often virtualized, to handle the computing and storage needs for big data analytics. Cloud operating systems manage high-performance servers, network, and storage resources.

IaaS provides the foundation for many companies' cloud services. However, IaaS also requires greater investment of IT resources in the context of implementing big data analytics. Your organization will be responsible for installing your own software, such as the Hadoop framework, or a NoSQL database, such as Apache Cassandra*, MongoDB, or Couchbase technologies. Your team will also be responsible for managing your assigned resources—which can be made easier with a utomated tools for management and resource orchestration.

b)Platform as a Service (PaaS) : PaaS provides developers with tools and libraries to build, test, deploy, and run applications on cloud infrastructure. PaaS reduces management workload by eliminating the need to configure and scale elements of your Hadoop implementation and serves as a development platform for advanced analytics applications. Force.com , Google App Engine , Red Hat OpenShift, VMware Cloud Foundry , Windows Azure are the some of the PaaS solutions from providers in the cloud technology ecosystem

c)Software as a Service (SaaS) : Specific applications for cloud-based big data analytics can be provisioned with SaaS. You may need to use multiple SaaS applications to cover the range of scenarios business users require. For example, software that works well for sentiment analysis may not work for risk management or asset performance. SaaS can be offered as a standalone application or part of a greater cloud provider solution. Amazon Elastic MapReduce , Cetas by VMWare* analytics solutions , Google BigQuery services , Rackspace Hadoop service , Windows Azure HDInsight are some of SaaS solutions from providers in the cloud technology ecosystem.

There are different types of Cloud computing model , that are a) public cloud : is the pay-as-use-go services available to general public b) private cloud: is the internal data center of a business that is not available to the general public but uses cloud infrastructure c) hybrid cloud: is a combination of both public and private cloud, when a company uses a hybrid cloud, it uses a public cloud for some tasks and a private cloud for other tasks d) community cloud: is a private cloud that is shared by several customers with similar security concerns and the same data and application sensitivity (Iyanda,2014)

CONCLUSION:

Information and communication technologies are key drivers of smart city initiatives. The integration various data components from sensors, GIS, GPS, Imaging, Automated recognizer, social networks, mining the data using the available software and hardware components in the cloud environment would offer better solution to manage the Governance, Transport network, civic amenities, health, energy and business in smart way with cost effective, maintain sustainable environment and benefit of the human kind.

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