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Architecture of Smart City Based on IoT and Bigdata

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ABSTRACT
This research paper describes and discusses the concept of Smart City architecture based using latest technologies. Application of internet based technologies of Internet of Things in designing the architecture of Smart cities infrastructure. Proposed infrastructure model of smart city is created on the perception of the Smart City with digital infrastructure having blend of the latest digital technologies like Big Data, cloud computing technologies and Internet of Things (IoT), thereby attaining instinctive control and intelligence governance for public and other related services of cities. Thelatestdeployment of wirelesshardwarenetworksinSmartCitysetuphasledtoveryvoluminousdatabeingcreatedevery dayacrossa varietyofsectors,withapplicationsincluding smart traffic management, environmentalsurveillance, medical healthcarecontrollingand sector specific data. We use Data Centers for storage and monitoring big data of smart cities according to hardware networks in the city. To handle grass root glitches and challenges caused for the storage & management of Big Data of smart cities, we propose a strategy to handle Big Data using architecture of Internet of Things, Data Mining and Cloud Computing. Our proposed study in this paper also includes a basic context for incorporation of variety of services available in smart cities. We also propose the intelligence governance of city administration using Multi-LevelSmartCitysetup.

Keywords: Smart City, Internet of Things, Big Data, Cloud Computing, Digital cities, Intelligent Services

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I. INTRODUCTION

Cyber space is considered as the E- world (Electronic World). As we have given formula of Smart city integrating digital services using latest technologies the digital city and the existing real city shall map to each other; accordingly, the digital city is a technological representation of the city where we live in cyber space [1]. The smart city concept is based on the perception of the digital cyber space. Using a latest ultramodern hardware network of digital gadgets, the smart city is associated with the real city. These all digital devices existing in the city are interconnected through Internet of Things and Cloud Computing podium that handles the gigantic data storage, computation, analysis, and decision-making process and performs the related automated task or desired actions based on the results of those analyses and decisions [2]. Smart cities are linked to the digital and physical cities through Internet of Things and Cloud Computing, thus forming an integrated digital-cyber-physical space. The state and changes in the real world of both humans and services will be monitored robotically in real time in this space. Cloud storage servers handle the enormous data, complex computation and regulation. This structure will provide intelligence governance to public administration for effective governance.

We can derive a justification for Smart cities as follows:

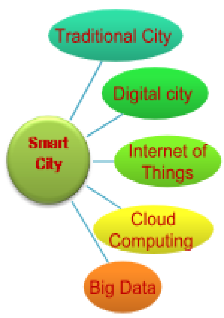

Fig1: Smart City Incorporation

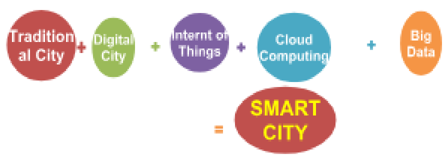

Fig2: Formula of Smart City

We have seen an increasing graph of people drifting towards Cities for their better future prospects and to upgrade living standards. It is estimated that by2030morethan65%ofthe world populationmayliveinancities or rather we could predict metro Cities. These projected population migration towards cities in search of either better lifestyle or better opportunities willprovidethe path towards the growthoftheSmartCity at global level.The SmartCityperceptionoperatesinacomplexmetropolitan environment,integratingseveralcomplexsystemsof infrastructure,humanactivities,digital presence & activities,social,politicalandtheeconomy structures.ASmartCity podium offers anintelligent and efficient waytocontrol the major eight focused components suchastransport,health,local administration, security, smart industry, renewable energy, smart homes& smart buildings andthe environment changes. These components are interconnected with each other using various latest hardware and they keep exchanging data by talking to each other.The digital datageneratedbytheselatest gadgetsareprimarilythroughwireless router networks.Wirelessnetworks of digital gadgetshavebeeninstalledinvariouscommercial,consumer and individualapplicationssuchashealth management system,smarthome management applications, Smart traffic management, Smart governance and administration and other related sub modules of smart cities.

Hardware gadgets associatedwithdifferentSmartCityapplicationsgeneratehuge amountofdatathatare not being efficiently utilized, therefore effective utilization of this enormous data has to be taken care for effective growth of smart cities.UsingexistingInformation Communication Technologysetup,generatedunrelatedinformation has to be covered together in a meaningful knowledge base. TheSmartCityperceptionis hooked on managing ever-growing hardware's ofIoTdevices generating voluminous data for inspection and observation fromacommonplace.

Inordertoenable thecommunicationbetweeninformationandcommunicationtechnologies, internet of things devices, cloud based applications to control devices, data center to handle big data,amodel of SmartCity architectureisprojectedinthroughpaper. We have plannedtoarrange thearchitectureonaservicepodium.Throughthis podium, various existing hardware and software applicationscanbeassociatedandoperatedbywide range ofwebapplicationsforanintelligentoperating environment. Theprojectedmodel of smart cityassistsintaking advantage of gigantic amount ofdataandinformationusingweb technologiesanduncertainreasoningrules.Weshall implement reasoningmechanismfor desired knowledgeabstractionandinformation amalgamation fromdifferentSmartCitysectorssuchas people, transport,medical, administration, homeandenvironmentsector.

Thecontributionsofthispaperinclude Section2describestheLayeredarchitecture of SmartCity, Section 3 Section 4 describes proposed Big Data management center through proposed SCDC, Section 5 concludes and suggests future scope of work.

II. LAYEREDARCHITECTURE OF SMARTCITY

Consideringexisting theories of Smart City,weshall propose to useaLayered systemdesign, whereinitial – level basic data issemanticallyenhanced andinferredbysensible customizableapplicationsinaSmartCitydomain. By using latestwirelesstechnologiesandhardware networks, our perception for theupcomingSmartCity systems that could be providinginfluential,intellectual andadaptive supportforpopulationlivinginurbansocieties.Asshown inFigure 1werecommendaSmartCityarchitecture that includes eight basic services to be initially taken in Smart City.By integratingInternet of Things networks, cloud based applications, Big Dataandavailablewirelesscommunicationservices,thefollowingexploration aimsare targeted:1)customization of services in real time;2)ecofriendly living environments;3)efficientutilizationoftheexistingresources.

Fig. 3. Eight Components of SmartCity

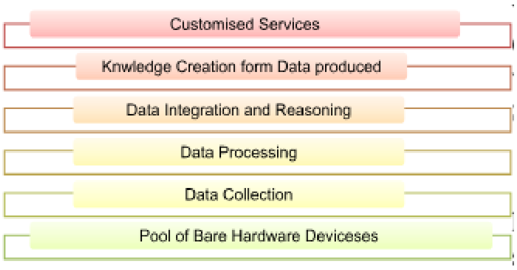

Fig.4. Layered Architecture of Smart City

AsshowninFigure 3,these eight components are main pillars for theSmartCityarchitecturetobesmarthealth,smart environment,smartenergy,smartsecurity,smartoffice &residentialbuildings,smartadministration,smart transportandsmartindustries.Thesensor nodesdeployedineachSmartCitydomainprovidethepr imarydata sourceforheterogeneous informationgeneration. Informationgenerated throughthesensor nodesarecollectedusing theexistingcommunication services. The collected data are then processed and analyzed. The focus is on deploying the architecture on a cloud based platform for use as a software as a service.

The implementation of the architecture will follow the steps outlined below. Firstly the raw data are collected and processed to make them web consumable. Once the data are converted into a common format they are then semantically enriched with OWL concepts based on the knowledge of domain experts. The idea is to recognize activity and learn new rules that are governing an activity. The new rules learned at this level will be used in defining the knowledge of the semantic model. The same approach will be used in defining customized services that will provide feedback to the end users (citizens) in the form of alerts and warnings as mentioned in Level 4 of the Smart City architecture.

- Layered Architecture of Smart City

AsshowninFigure 4, pool of hardware devices are theprimarysourceofdatageneration.Therawdatasensedbythe hardwarenodearetransferredtoLevel1oftheSmartCityarchitectureusingcommunicationservicestoperform furtherinformationprocessing.Adetaileddescription ofeachLevel is explainedbelow.

Level 1:Data collection

Inthislevel,rawdatacollectedfromdifferent hardware isstoredforfurtherprocessing.Thecollectedformats arethenprocessedusingsemanticwebtechnologiesinordertoconvertthemintoacommonformat.Thenextlevel describesthestepsused inconversionofdataintoacommonformat.

Level 2:Data processing

Informationgatheredfromthedatacollection level issummarizedprior totransmission, analysis andfusioninthe furtherlevelsusingsemanticwebtechnologies.Themainobjectiveofthislevelistoconvertthecollected heterogeneousinformationintoacommonformat,e.g. ResourceDescriptionFramework(RDF).RDFisthemost commonwaytoexchangeinformationovertheweband itfacilitatesheterogeneousdatasharingandintegration for differentSmartCitydomains.

Level 3:Dataintegrationand reasoning

Semanticwebtechnologiesenableexploitationofdomainspecificdatabasedontheconceptsandrelationships betweenthoseconcepts.The techniquesusedinthislevelaresummarizedbelow. Thenew ruleslearnedduringtheprocessofextractionofhigh-levelcontextinformationfromrawsensordatacanthen be storedandusedfor buildingup knowledge intheSmartCityarchitecture.

Level 4:Device control and alerts

Dataobtainedfromlevel3canbeutilizedbydifferentwebapplicationsforintelligentoperatingconditions.The inferreddatacanbeutilizedinmanyways suchasinput/output,messaging,alertsandwarnings[13].

III. COMMUNICATION SERVICES

Thecommunicationmediumplaysanimportantroleinachievingthe SmartCity concept.The existingcommunicationservicesthatareutilizedinaSmartCityinfrastructure:3G(3rdgeneration),LTE(Long-termevolution),Wi-Fi(Wirelessfidelity),WiMAX(worldwideinteroperabilityformicrowaveaccess),CATV(cabletelevision)andsatellitecommunication.Themainaimistoconnectallsortsofthings(sensorsand IoT's)thatcanhelpinmaking thelifeofcitizensmorecomfortableandsafer.Anexampleisprovidedby communicationservicesinthehomedomainforconnectingtelephonedevicesandPCthroughtheinternet.InthecaseoftheGovernmentsector,cloudandcommunicationservicesarecombinedtoobtainabettergovernance system.Inthecaseofthehealthsector,communicationtechnologiescanbeusedtoconnecthealthstatistics, medicationandlocationofthepatientfromaremotelocationthushelpstoachieveaSmartHealthsystem.Hence, withSmartCityandcommunicationtechnologieswecanprovideamoresecureandconvenientinfrastructurefor betterliving.

IV. BIG DATA IN SMART CITIES

Thestudies considerbigdatatobethe“oil”ofthefuture world.Themeaningofthisinitiativeiscomparableto20th century’sinformationhighwayplan.Scientists andpoliticianshavecometorealizethatbigdatawillbeat reasureforminininginformationandknowledge. Alongsidethegradualconstructionandimplementatio nofsmartcities,humanbeingsandvarioustypes ofsensorswillproducemoreandmoredata.Therewillb eanincreasingamountofdatadeposited,and thescaleofdatawillgraduallyincreasefromthecurrent Gigabyte(GB)andTerabyte(TB)magnitude toPetabyte(PB)orevenExabyte(EB) or even Yotabyte(YB) or may be Zetabyte(ZB).Ifwecan effectively and thoroughlyanalyzethesedataandintegratetheanalysis throughcloudcomputing,wewillbeable toquicklyconvertthedataintovaluableinformationand toextractthelawsofchangesinnatureand society.

- Theincreasingamountofbigdata

The smart city links the city with a digital city through the ubiquitous Internet of Things. Around the world, an increasing amount of big data is being produced, the total amount of which is beyond imagination. At all times, people exchange ideas, data, and information on the Web. Within a minute, Google receives two million search queries, Facebook has 680000 new posts, and more than 200 million e-mails are sent. Every day. Currently, the total number of Internet pages is nearly 1 trillion, and the amount of data is close to 1000 PB. Every day, the Internet receives hundreds of billions of time queries and adds more than 200 TB of data. Two- and three-dimensional data in the space of digital Earth grow rapidly and will reach the TB to PB level. A single high-definition (HD) webcam produces 3.6 GB of data per hour. Because the number of webcams throughout smart city is more than 200 hundred, the amount of data produced will reach a PB to an EB level. According to a research report of Symantec Inc in 2012, the total enterprise data storage around the world reached 2.2 Zettabyte (ZB), with an annual growth rate of 67%.

4.2 Challenges of BigData in smart cities

In the smart city, the Internet of Things will continue to collect a vast amount of data using a vast number of sensors. Big data must undergo storage, processing, post queries, and analysis to be used for all types of intelligent applications and services. Moreover, there is an increasing need to conduct real-time storage, processing, query, and analysis for big data. This will bring a series of problems and challenges.

The high cost of big data storage. The rate at which the data storage costs decrease, brought about by the development of storage technology, falls short of the growth rate of the data. Currently, cost is a challenge to all who store big data in accordance with the ideal standard for the storage and preservation of large data.

In the era of big data, the rapid expansion of large-scale data, such as spatial information and video further exposes the limitations of traditional methods. Different types of remote sensing observation satellite send PBs of data to the ground every day. Municipal video capture systems collect EB-level data every day. Currently, there remain difficulties in conducting a complex automatic semantic analysis and interpretation. In addition, municipal big data contains data related to important abnormal behaviors, events, and characteristics, such as those of falling, scuffles, climbing walls, hovering, vehicle collisions, and retrograde. Big data can be used for identification and warning. For example, major robberies are often accompanied by prior wanderings.

Byefficientlyusingautomationtechnologies forobjectandbehavioridentification,itispossibleto retrievesemanticinformationfrommunicipalbigdata,c onductpriorwarnings,andeffectivelydeter criminalactivities.Thiswillallowforpreventiveaction s,informationretrievalduringthecourseofan action,andpost-eventmeasurements.Ultimately,thiswillensureafullra ngeofprotectionofpeople’s life,andproperty,aswellasdailyproductionduringinci dents.

Mining for knowledge from big data is very difficult. Big data contains not only data and information but also a wealth of rules and knowledge. Such rules and knowledge are not given directly. Instead, to obtain them one must conduct in-depth data mining and analysis. However, the major characteristics of big data make it difficult for effective integration and management as well as automatically process and analyze. It is particularly difficult to conduct data mining on a dataset containing spatial information. To mine rules and knowledge from big data, in addition to solving issues related to data heterogeneity and retrieval, in-depth data mining also must address a series of issues such as data selection, semantic description, semantic interpretation, uncertainty, knowledge representation, etc. [13]. Currently effective and feasible techniques for data selection, semantic description, and semantic interpretation cannot be directly applied to big data. Accordingly, the rules and knowledge related to big data cannot be fully utilized. The nine issues for sustainable human development, including human health, energy, weather forecasting, climate change, disaster emergency forecasting, water resources, sustainable agriculture, the environment, and biodiversity, have not been effectively addressed.

V. SMART CITY DATA CENTER

- Asmartcityneedsanoperation Data center

AfterestablishingtheMulti-level smart city architecture for InternetofThings,cloudcomputingplatforms,thedigitalcitygeospatialframe-work,andotherrelatedinfrastructureinacity,forthatinfrastructuretobetterplayitsfullroleinthe city'soperation,thereisaneedforaSmartCityData Center(SCDC).TheSCDCisaninstitute thatintegratesalltypesofreal-timedata,information,andservices.Asthe"heart"ofasmartcity,the SCDCcollectsandmonitorsafullrangeofdataandinformation,generatedbythecity'soperation.It thenprovidescustomizedservicestothegovernment,businesses,andindividuals. This data center helps local administration in intelligent governance; it shall also be helpful in planning and effective utilization of resources in efficient manner.

- TheCompositionoftheSCDC

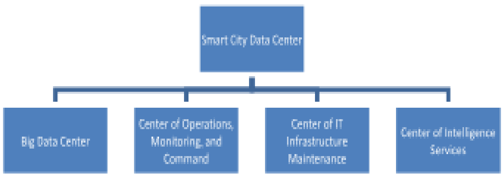

Fig: Composition of SCDC

AnSCDCgenerallyconsistsoffourparts:
a)bigdatacenter: Thebigdatacenterwillbecomeahubbetweentheresourcepoolofcityoperationandthe Internetof Things.Itwillallowforcomprehensiveandreal-timeawarenessofdatarelevanttocityoperations.
b)municipalcenterofoperations,monitoring, andcommand: The centerofoperation,monitoring,andcommandwillbebasedoncomprehensiveandreal-timeawareness andcarriesoutcross-sectoral,cross-regional,andcross-systemcollaboration,alongwithefficientemergencyresponses.
c) municipalcenterofITinfrastructuremaintenance:The centerofITinfrastructuremaintenanceisresponsibleformaintainingtheupdating oftheSCDC'sinfrastructuresandensuringthesecureandstableoperationoftheSCDCatalltimes.
d)centerofintelligenceservices: The center of intelligence services provides services not only to the government but also to all types of enterprises and to the public.

Thetraditionalgovernmentinformationtechnology(IT)infrastructurewillgraduallybereplacedby the"cloud"andtheinteractivesmartcity,whichwillreducethecostsofestablishingandmaintaining thecity'sIT,minimizeadministrativecosts,andenhanceoperationalefficiency.ThroughtheSCDC,the modeofgovernancewillbetrulyswitchedfromcitymanagementtourbanoperationsandservices.

- FunctionsoftheSCDC

Through the SCDC, a city can provide operations and services[d]. The city can also use big data as the basis for governance and major decisions. Based on data and empirical facts, the influence of subjective individual opinions and various business interest groups can be avoided. City operation will achieve visibility, controllability, intelligence, predictability, quantifiable assessment, and continuous optimization. Consequently, the government will become more open, accountable, and efficient, thus minimizing the administrative risks.

VI. CONCLUSION

TheSmartCityconcepthasbeenrevolutionizedandhasevolvedintoanewerawithrecentdevelopmentsin ICTthatcombinewirelesssensornetworks,computernetworks, Cloud Computing Internet of Things Big Data and all other related technologies. We aim to develop prototype architecture of Smart cities that incorporate the utilization of various policies and services included for the betterment and up gradation of the life expectancy of humans living in these smart cities. We tried to cover the main eight themes for Intelligent Governance of smart cities. Althoughitisverydifficulttocovereachandeveryaspectofthe SmartCity,throughour architecturewe aimtofocus onthemost important areas ofthe Smart Cityenvironment. Our proposed SCDC shall be utilized for intelligent governance and planning.

Futureworkisplannedtoperformexperimentsontheideasdiscussed,whichincludesimplementation of smart transport system, intelligent governance using smart application, proposingacommon framework of smart cities services for the Smart cities network and further proposing a integrated platform of these smart cities at national level to monitor and implement direct benefit schemes for common public welfare.

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