IMPORTANCE OF BIG DATA AND ANALYTICS TO THE DEVELOPMENT OF SMART CITIES

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Abstract:
This paper aims to investigate the actual potential of big data analytics in smart cities. In this research, we looked at instances when decision-makers used big data analytics as a tool to create smart cities. The study discusses how the Internet of Things, machine-to-machine communication, big data, and linkages across smart cities might assist in doing predictive analytics that may be beneficial to human wellness. This study focused on two key areas, the Smart Grid and Traffic Congestion Management, where city planners and decision-makers may benefit from Big Data Analytics. The paper details a number of pilot projects being carried out to improve human health while also making cities smarter. The paper also took into account a number of difficulties that may arise while using Big Data to create Smart Cities.
Keywords: *Big Data, IoT, Traffic Congestion*

Introduction

Smart Cities will leverage digital information and communication to enhance urban services in quality, performance, and human welfare. Smart City can save costs and resource use and engage inhabitants. Smart Cities apps improve urban traffic management and enable real-time problem solving.

City dwellers may quadruple by 2050. Several analysts expect six billion people to live in cities by 2050, up from 3.6 billion now, which would strain resources.

Cities account for 31% of India's population and 63% of its GDP. By 2030, half of India's population will reside in cities. Smart Cities prioritize the largest needs and possibilities to enhance citizens' quality of life now and in the future.

India's new Smart Cities Mission enables local development and uses technology to deliver smart results for inhabitants to boost economic growth and quality of life.

Big Data, Internet of Things and Smart Cities

Big Data is a massive amount of organized and unstructured data that is challenging to manage and handle using typical database and software solutions. Gartner defines "Big Data" as high-volume, high-velocity, and high-variety information assets that need cost-effective, creative information processing for better insight and decision-making.

Characteristics of Big Data:

Volume: Volume refers to amount of data.

Variety: Variety is multi-source, structured and unstructured data. Sources vary. Dark data, according Gartner. Dark data like dark matter in physics makes up most of the organizational universe.

Velocity: The speed at which data arrives from multiple sources is what is meant by velocity. The influx of big data is enormous and ongoing.

Veracity: Data validity is doubt. Quality, reliability, and accuracy.

Electronics, software, sensors, and network connections form the Internet of Things (IoT), which collects and shares

data. Remote detection and control through network infrastructure improves efficiency, accuracy, and economic benefit with the IoT. The IoT envisions a future where everything is connected to the Internet and can identify itself. Cisco predicts 50 billion Internet-connected gadgets by 2020.

Smart city definitions vary. The city's development, willingness to change, resources, and people' objectives define it. India and Europe see smart cities differently. Indian smart city definitions differ.

Each Indian city dweller's smart city vision comprises their desired infrastructure and services. Urban planners should build institutional, physical, social, and economic infrastructure for the whole city. Smart Cities generate real-time, large-scale data from sensors, devices, video/audio, networks, log files, transactional applications, online, and social media.

Smart Cities are places where electricity, resources, and urban planning are managed and improved via the use of IoT, machine-to-machine communication, and smart infrastructure.

Data integration, Aggregation, Validation, Cleansing

In smart cities, personal, business, and global data will expand tremendously. Enterprise systems, Website logs, Web Services, Social Media, Mobile devices, Sensors, GPS, etc. will provide structured, semi-structured, and unstructured data. Understanding and organizing data became crucial.

Data integration combines data from several sources housed in different technologies to create a single perspective. A full data integration system discovers, cleanses, monitors, transforms, and delivers data from several sources to an integrated location.

Data aggregation searches, gathers, and summarizes information into reports, dashboards, etc. for analysis.

Data validation prevents faulty or irrelevant data from entering programs. Data validation assures compliance with requirements and quality standards. Hence, linked apps get comprehensive, accurate, secure, and consistent data.

Data cleansing/cleaning/scrubbing removes corrupt or erroneous data. Inaccurate data may lead to faulty analysis and conclusions, particularly with Big Data. Low data quality hinders decision-making.

Data anonymization and visualization

Protecting data during processing and analysis prevents abuse. Right information, right person, right location is the goal. Maintain confidentiality, integrity, and availability. Data anonymization protects privacy. This method anonymizes data sets by encrypting, hiding, or removing personal information. Data anonymization reduces the risk of unintentional disclosure when transferring information between departments or agencies. Data anonymization methods exist. See below.

Data Encryption

Encryption encodes data. The methods protect data and make it unreadable. "SmithTao" becomes "@Tek1ls%&$" when username fields are encrypted. Encryption may cause issues when data input validation or testing requires a certain data type, such as pricing, dates, or income. First decode the data, then validate.

Substitution

Replacement replaces data with predetermined letters or symbols. These characters may be traced to their original

values.

Shuffling

Similar to replacement, shuffling anonymizes data from the column. Data in a column is randomly transferred across rows until there is no meaningful association with the remaining information in the row. If the shuffling method is known, data may be nu-shuffled. This method fails on tiny data sets. If a table has few rows, it should be easy to figure out which scrambled data goes to which row.

Number & date variance

This method adjusts each value in a column by a random percentage to get the precise data to an untraceable point. A salary column may have a ±n% random variance. Some numbers are higher, some lower, but all are within their original range. Dates might also be changed within n days.

Nulling or Truncating

Nulling or truncating deletes or replaces sensitive data with NULL values. This method should not be used to search sensitive data for crucial information. If customer name, address, and other contact data are nil, querying client accounts is difficult.

Masking Data

While protecting sensitive data, the look and feel would remain the same. Visualization aids data analysis and inference. It simplifies complicated data. Patterns may be found fast in vast data sets..

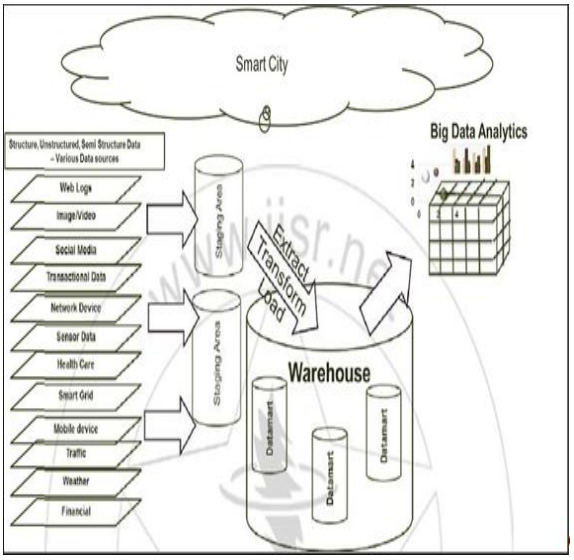


Figure 2: Data Source, Warehouse and Business Analytics – Pictorial View

Big Data Analytics

Big data analytics reveals hidden patterns, correlations, and other decision-making data. Big data analytics uses predictive modeling, text analytics, machine learning, forecasting, and statistics. It identifies trends, weaknesses, and conditions for better and faster future decisions that may be crucial to the concerned region. BigData analytics may filter terabytes to exabytes to inform business decisions. Data comprehension increases.

Use of Big Data Analytics

Smart Grid

Grids transport power from plants to consumers. Substation, switches, cables, transformer, etc.

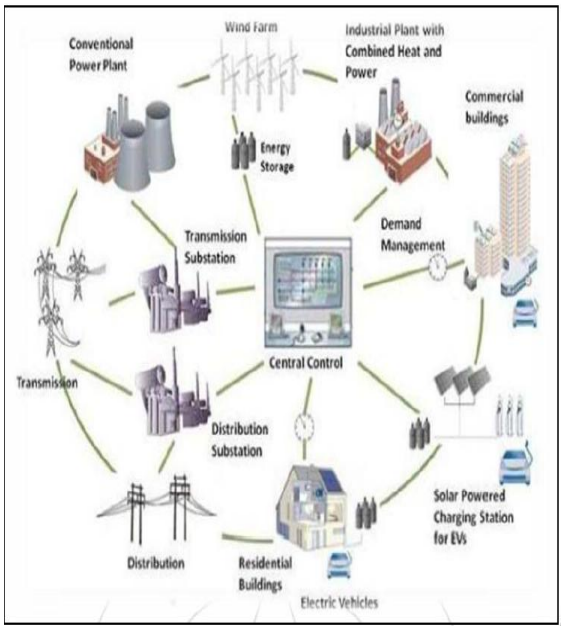
Smart Grid involves computerizing the electric utility grid, like Smart Phone. Smart Grids employ two-way digital communication to deliver power to users. This system monitors, analyzes, controls, and communicates with the supply chain to enhance efficiency, decrease energy consumption, lower costs, and increase energy supply chain transparency and dependability. Smart meters, which may collect data from power meters, voltage

sensors, fault detectors, and other devices on the network, are used in the Smart Grid to improve traditional electrical networks.

Smart Grid view:

It is estimated that by 2020

Figure 3:



Energy Storage:

88,000 MW of additional power generating capacity are added in the 12th five-year plan (2012-17)

By 2030, India must increase its electricity generating capacity by at least 250 to 400 GW. In the next five years, the Electricity Grid Corporation of India plans to spend US$26 billion.

Smart Meters

By 2025, India plans to deploy 130 million smart meters. The power generated (from utilities), distributed, sold, and lost in India.

Indian electricity system has 25% AT&C losses in 2012-13, weak distribution network, huge energy demand-supply imbalance, poor asset management, etc. Several states lost almost 50%.

Energy demand shortfall was 3.6% in 2014-15 and 4.7% during peak time. 300 million Indians need power. Large AT&C losses cause distribution underinvestment and inconsistent demand. Traditional outage management prolongs restoration. Minimizing AT&C losses may reduce deficit. India has started the following smart grid projects to demonstrate its potential for additional cities and states:

Smart Grid Pilot Projects	Benefits/ Objectives
Panipat City Subdivision (Haryana State) Electrical Division No.1, of Agartala town Electricity Department, Government of Puducherry AP CPDCL, Andhra Pradesh - Jeedimetla Industrial Area PSPCL, Punjab - Tech-II Sub-division, SAS Nagar WBSEDCL, West Bengal - Siliguri Town in Darjeeling District	Reduced AT&C Losses Reduced Peak Load Consumption Reduced Cost of Billing
Additional City Area Division (ACAD), Mysore	Reduction in AT&C losses Shifting of load in industrial and domestic consumer during peak hours Reduction in number of transformer failure Reduction in Meter Reading cost

	Reduction in unforeseen outages and also recovery time for unforeseen outages
KSEB, Kerala - Selected Distribution Section offices spread over the geographical area of Kerala State	Reduction in AT&C losses through reduction in loss due to manual error, tampers, thefts, short assessment etc., Savings on employee and travel cost for meter reading Introducing incremental tariff for peak hours through Tariff on Demand
UGVCL, Gujarat Project proposes covering consumers in Naroda and agricultural unmetered consumers in Deesa-II	Reduction in AT&C losses Savings in Peak Power Purchase cost by reduction of peak load Reduction in Transformer failure rate Reduction in number of outages Reduction in Meter Reading cost, Cost of payment collection etc.
APDCL, Assam - Guwahati distribution region	Increased available energy during peak time Revenue increase through Power Quality measurements and power factor penalty Reduction in AT&C Losses Reduction in interest payments due to deferred Capital Investment in sub-transmission networks Improvement of availability (reduction of Customer Minutes Lost) Improved management of power procurement options Unscheduled Interchange using Short Term Load Forecasts
CSPDCL, Chhattisgarh - Siltara – Urla area of Raipur District (Chhattisgarh State)	Reducing Distribution AT&C losses Reducing Peak load consumption through shifting of Peak Load demand to a non-peak time thereby saving UI charges Reducing cost of billing

Himachal Pradesh Location Industrial town of KalaAmb	Shifting peak load Reduction in penalties Reduction in outages
JVVNL, Rajasthan - Sanganer Sub Division, Jaipur City	Reduced AT&C Losses Reduced Peak Load Consumption Reduced Line Outages and DT Failures Increased energy sales due to reduced failures/increased availability
Power Grid Corporation of India with Govt. of Puducherry is developing Smart grid pilot	Indigenization of Technology Common Information sharing platform Scalable and replicable at other places Shall help in demonstration of effectiveness of each functionality Evolving policy advocacy, Regulations, etc. for successful implementation Evolving commercial mechanism
Smart Meter by Tata Power Ltd – Delhi Distribution - Project covers over 100sqkm of industrial and commercial belt in North and North West Delhi The components include AMI, ADR infrastructure, smart meters, radio frequency mesh-based communication, meter data management system and integration with other operational technology and IT systems like outage management system (OMS), SAP, etc.	Analysing of consumption patterns closely and optimize equipment energy consumption. Through customer portal, consumers have options to set threshold values for key parameters, like load, power factor and receive alerts once these thresholds are breached through SMS or email. To improve the reliability of power and manage peak power demand more optimally To Permit Tata Power Delhi Distribution to effectively manage grid emergencies
Smart Grid Pilot Projects	Benefits/ Objectives
Innovari and reliance Infra Project – Automated demand side management expansion project 9 million target in future, currently raghuleela mall, ITC, Blue Dart and Marriott- Consumers	Real time visibility Service Reliability Control of cost and electricity usage Shift in peak load Capacity requirement of the grid

Selected Smart Grid projects acrossthe globe

Projects	Benefits using Analytics
Ontario (Canada) Smart Metering deployment project 4.8 million smart meters , 4.5 million customers Business case – return of $1.6 billion	Demand management Accurate meter reading Timely consumption information Proactive consumer services Reduction in number of crew visits to read and service meters Reduces tempering and theft of electricity Operational benefits
Denmark, Power matching city 240K Customers	Decentralisation distribution Peak load management Better service and efficiency Customer can decide when they can buy electricity Smart App: control indoor climate and save energy Cost saving
Reken(Germany), Uppsala(Sweden), Castellon(Spain), Forli-Cesena(Italy), Virchlabi(Czech Republic) and Carros(France) GRID4EU - Large scale distribution of European smart Distribution Networks	Efficient electricity supply Cost Reduction Reduction in load shedding Voltage control Short recovery time after grid failure Remote control level of the grid Higher reliability Increasedsurveillance
France – Smart electric Lyon 2500 Customers	Consumer Analysis : Tariffs and Segmentations Sectorial Organisation Analysis Real time information about consumptions Getting personalised advice Identification of upstream and downstream services and their behaviours Energy and environment analysis – amount of carbon dioxide emissions Information on technology price. Production, network, quality, continuity on demand
Korea Electric Power Corp – Use of Big Data	In 2014, state-run electric utility Korea Electric Power Corp

	(KEPCO) launched two pilot projects on ways to use big data to improve demand management and risk forecasting. The first pilot set up an energy consulting business based on AMI data while the second established a risk forecasting system analyzing social networking service data. AMI provides extra metering points for spatial awareness of planning requirements
Pacific Northwest Smart Grid – This project will be a unique demonstration of unprecedented geographic breadth across five Pacific Northwest states- Idaho, Montana, Oregon, Washington, and Wyoming. It will involve about 60,000 metered customers, and contain many key functions of the future Smart Grid, ultimately moving the nation closer to establishing a	validate new Smart Grid technologies and business models provide two-way communication between distributed generation, storage, and demand assets and the existing grid infrastructure quantify Smart Grid costs and benefits advance
more efficient and effective electric grid	standards for interoperability (the smooth, seamless integration of all elements of the electric system) and cyber security approaches

Smart Grid allows real-time power system monitoring and control, AT&C loss reduction, demand response and demand side management, power quality management, outage management, smart home energy system, etc. It will allow new business models in Smart Cities, electric cars, smart communities, and more robust and efficient energy systems and tariff structures.

Smart Grids will create unprecedented volumes of data from energy generation through consumption and interact with numerous devices and systems, empowering everyone to improve energy efficiency.

The utility station receives data from smart meters, automated distribution systems, and sensing & measurement equipment for predictive analysis.

Big Data Analytics –Smart Grid

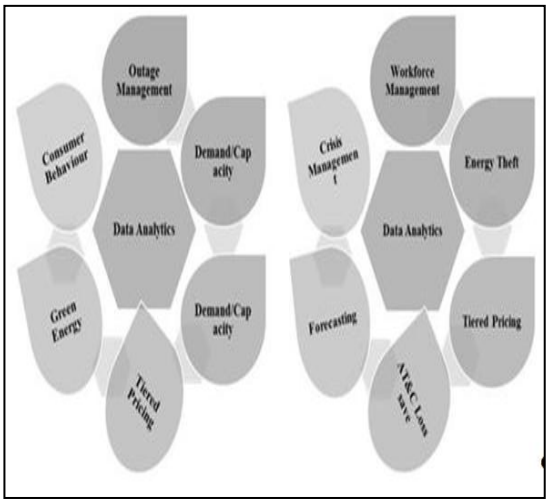


Figure 4: Smart Grid – Data Analytics

Based on some of the pilot projects running and implemented, Big Data Analytics whose main source of data is from IoT (Machine to Machine) can help planners, decision makers and designer of Smart City in following ways:

Outage management - Rather than waiting for customers to report outages, companies can receive reports from the grid itself.The Smart Grid can provide the report on outage, document its recovery in real-time and isolate locations of physical damage.

Demand and Capacity Management- Data gather from both producer and consumer side can help in analyzing demand and capacity. It will help in understanding the peak/non hours of usage.

Better understanding on AT & C Losses –Data collected from each sensor on regular interval from production to consumption will give insight on where the actual loss is happening. Companies can look for how these losses can be reduced based on deep data analysis.

Forecasting based on seasonality – Utilities data collected on regular interval during the years can help analyst in understanding the pattern of usage of the energy. Seasonality pattern can help in looking for when and in which region the demand will be high or low. Companies can act in advance to tackle these situations.

Asset Management–With Big Data Analytics companies can predict how millions of distribution grid assets are about to fail and helps in determining how costly or dangerous those breakdowns are going to be. They can decide which of a thousand different options for asset maintenance, replacement, and procurement strategies is the best. Asset health analytics can help in justify all manner of grid-edge investments -- real-time distribution automation and demand response, strategic deployment of energy storage or grid resiliency projects, and can also help in managing future challenges like the increased threat of storms and natural disasters to grid resiliency.

Crisis Management - Big Data can help in making visual analytics systems which can be place in Smart Grid to help decision makers to perceive and analyze the crisis situations.

Mobile Workforce Management– Decision makers canbetter mobilize their workforce by doing real time monitoring of the systems in place on the Smart Grid. Managers can get accurate information on Fault location, real time load. People can be mobilize accordingly to fix the issue.

Energy Theft - Use real-time metering data can help in discovering unaccounted consumption when energy is being diverted and stolen

Behavioral Analytics of consumers - With so much data available on the consumer utilization of energy at various time interval duration – morning to night, different seasons, across different region, different utility pricing plan - Big Data analytics can help in understanding the Consumer Behavior.

Tiered pricing– Companies can opt for tiered pricing based on the demand and capacity of the energy. Based on large dataset available, Big Data Analytics can help in defining new utility retails rate policy.

360 Degree View - City Planner and organization can get the 360 view of full energy supply chain which enables then to do predictive analysis on various aspect. It can help in improving end user experience, customer loyalty and Demand strategy.

Green Energy - Through predictive

analytics, producer can generate electricity from renewable sources with small plant set up and in incremental way depending upon the needs of a city. Large dataset can help in doing analysis on sources of carbon emission which can be reduced.

Traffic Congestion Management

The urbanization and metropolitan cities trend is fast growing. About 70% of the global population expected to be living in cities by 2050, the execution of smart city technologies will be a focal point for governments in both developed and developing regions. The number of vehicles on the world's roads is expected to double to around 2.5 billion by 2050.

According to national highway authority of India, Indian road carries almost 67% of the freight and 80% of the passengers annually. National highways make up only 2% of the overall road network by length, they are accounted for 40% of the total road traffic.

There is no clear statistic as to how many auto-rickshaws (a three-wheeled vehicle for hire) and two-wheelers (scooters and motorcycles) operate in India's densest urban areas. Some cities have six-passenger motorized vehicles called fat-fat (which describes their exhaust sound). As for two- wheelers, estimates of motorcycles, scooters and bicycles are up to 50 million in India.

The accident rate among cars in India is the highest in the world. India has about 1% of the world's cars (some 4.5 million) manages to kill over 100,000 people in traffic accidents each year. This amounts to 10% of the entire world's traffic fatalities. The U.S., with more than 40% of the world's cars, creates just 43,000 fatalities.

Study suggests China and India will contribute more than one third of the global urban population increase between 2014 and 2050.Between 2014 and 2050, the urban areas are expected to grow by 404million people in India. Rapid urbanisation is concern in India as it is causing traffic congestion, air pollution due to heavy motorisation. Smart cities can help in tackling the rapid urbanisation issue if systematic planning is done along with the use of effective technology and infrastructure.

Smarter cities can new technologies and insights to transform their systems, operations and services. One of the key elements of the plan of Smart Cities is the ability to implement Intelligent Transport Systems (ITS) to deliver city wide mobility services..

A congestion management plan must take into consideration all relevant factors like the ever-exploding vehicle population on the road, geometry of the city roads, travel needs of citizens, and the needs of various administering authorities having jurisdiction in parts or whole of the city.

In Smart Cities, data is the fuel that drives intelligent transportation systems and it will be gather from everywhere

– Sensors on signals, GPS trackers, social media posts, mobile phones and cameras. Cities can use predictive analytics from the data gathered to understand how congestion can be reduce. Drivers use social media to detect and avoid gridlock. City planners analyze data to pinpoint where new bus routes are most needed.

Overall the Big Data in the transportation sector, is still in its early stages to play a significant role in improving its public services and the quality of people's lives.

Big Data Analytics - Role in Congestion Management

Figure 5: Congestion Management - Data Analytics

Monitoring traffic performance - By monitoring traffic performance and patterns over time, cities can make significant progress in cutting congestion, emissions and noise; determine where to place buses and build mass transit stations to ensure they operate at full capacity; and improve emergency vehicle response times.

Reduce accidents – With Big Data analytics – Traffic department have beforehand knowledge on the traffic situation at particular location which they can share with commuters and advice them to take the detour or avoid congested area which can help in reducing accidents occur due to congestion.

Fuel cost and time - Big Data Analytics can help in analyzing the fuel cost incurred and precious time people lost due to congestion.

Future trends -Based on historical and current real-time traffic data, Big Data Analytics can help in understanding the future trends. Big data analytics can help in understanding the seasonality of the traffic patterns, motion of traffic during the day and night, location.

Predict speed of the traffic and volume - Data aggregates from multiple devices - cameras, detectors, bluetooth, mobile and social media can help in identify and measure traffic speed and volume on city roads using predictive analytics. Pattern of Traffic and behaviour - Big Data Analytics can help in analysis of the historical data to gain performance insights and understanding of patterns of behaviour of traffic and road incidents.

Road Maintenance: Through sensor on the roads, video camera, Analyst can analyse which road demands repairing.

Challenges in Implementing Big data

Smart cities are considered as dynamic and evolving environments. Following are the challenges organization, planner may face while designing and implementing the Smart City Solutions Using Big Data and Analytics.

Data sources and size

In Smart City Data will be generated from multiple sources and in multiple format – Structured, Unstructured, and Semi Structured. Storing and processing such data is not possible using traditional software. Also future anticipation about the data formats and sources needs to be considered and factored into the solution while designing the smart city applications. Due to evolving environment it is difficult to predict the growth of data – 3Vs.

Data sharing and information

The smart city vision holds out the promise of integrating data from multiple organizations, diverse environments, and a wide variety of intelligent devices. Data integration even within organizations is one of the hardest challenges in the IT world, Data integration from various department would be challenge. There are challenges in sharing of information and data across various departments. Every department have its own data warehouse

which works in silos, sharing information is difficult. Also there are legal mandatory privacy and security requirement like DPA (Data Protection Act) to ensure citizen rights of privacy. Smart City solution should be design keeping in mind how to prevent the privacy of the citizen.

Quality of Data

Since data in Smart city will be from various heterogeneous system and in different formats, maintaining data quality could be challenge. Transactional system may require data in one format but when it comes to Big Data warehouse where data from different sources are gathered may require specific format without compromising the meaning and quality. If data is coming from third party, it needs to be ensured that they have proper mechanism in place to fetch the quality data.

Security of Data

Big Data breaches will be big with potential of more serious damages to reputation and legal repercussion. Movement of data across various sources in a secure manner is a biggest challenge in Smart city application implementation. Security here means right information to a right person at right time and at right place. While designing smart city, it is important to look at how data can be masked and secured so that it cannot be reached to unwanted persons.

Technology Advancement

In Today's environment, keeping the pace with technology is very difficult and costly effort. The smart city solution should be design in a manner that with advancement of the technology, upgrades to the existing solution can be achieved easily or with less effort.

Skill Gaps

A lack of data skills may be the barrier to the effective use of big data for city management. Managing and analyzing large data sets and developing insights for effective policy making or operational improvement requires skills that are in short supply, particularly in the public sector.

Lack of Standards

With respect to Smart City Development, Standards will play important role in adhering to common platform. Currently there are lack of standards – Data integration, Policies, Procedures, formats which needs to be addressed.

5. Conclusion

The role Big Data is fundamental in building smart cities. Reliable technology and infrastructure which can tackle machine to machine, machine to human, human to equipment is required form managing public amenities and services in such cities. Big Data Analytics will help in analyzing and predicting information generated by smart devices connected through various channel in Smart Cities. Since data will come from various heterogeneous sources, this is challenging, as big data analytics and applications are not developed enough for real time processing of large data sets. Instead of targeting many sources, emphasis must be on a number of imperative sources of information, which are more crucial to public life and human wellbeing. Amenities that can be induced by IoT and Big Data are numerous in Smart Cities. However, the technology must be utilized with proper insight. Authorities must be open to implement innovative ideas and judge them with priority to public wellbeing. Only an accurate juxtaposition of physical and technological infrastructure can divulge a successful creation of such habitats. Technology

infrastructure in smart cities is all about IoT, Thus, leveraging and managing Big Data is crucial to transition of cities to smart cities.

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