Chapter

Smart Buildings: A Model Approach for Institutional Buildings

Kumar Avinash Chandra

Abstract

Smart Buildings should be seen from a multi-industrial standpoint, involving the right combination of architecture, structure, information technology, automation, environment and energy, services and facility management such as to minimize life-cycle costs, maximize comfort and adapt properly to cultural stimuli. Intelligent architecture concerns with intelligent design to meet cultural and contextual requirements, with proper use of IT and smart technology, as well as with optimal building exploitation and cost-effective maintenance over its life-time. This might also include intelligent and responsive facades. Facility management looks for the best financial management for maintenance, rebuild and renovation, for the best space utilization, for the best daily operational services and for maximizing user satisfaction.

Keywords: internet of things, sensors, smart city, smart buildings, smart governance, testbed, urban development, sensor networks

1. Introduction

Today, like the pattern in developing nations across the globe there is major shift of the population for rural to urban areas. As per a survey, our nation India, also perceives brisk for population shifting in urban areas by huge figures. The accumulating trend of swerving populace to civic living been discerned. The group of researchers stated that approximately 55% percent of population across the globe resides in the urban area, and is believed the percentage to hike up to 70% by the year 2050 [1]. The facts states that 31.2% (approximately 377 millions) of increase in urban population in 2011, the result also predict the numbers to rise to 40% by the year 2030 and up to 60% of the country's total population would move to the urban living in the nation.

The nimble relocation of populace in civic is usually confronted by service delivery and infrastructure management, are most asserted among all others challenges offered due to population explosion. The local management responsible for urban management should always have the smarter means for the cop-up with any confrontations and any related affairs due to emerging population relocation as in health care management, congestion in traffic management, infrastructure development, waste management, energy demand, pollution, etc. The concept for smart city engages for sophisticated civic modus, which within self has various sophisticated system fir daily requirements and challenges faced by the habitat of a area. The concept of Smart City coined being a blueprint for tackling with all these

challenges mentioned. An intelligent and smart game plan for, manages components as in for all the challenges is provided in within Smart City.

With the growth and expansion in the city , new agile, shrewd and ingenious approach is required for the advancement in operational competence, enhancing productivity and as well as diminishing the managerial expenses [2]. Gradually, there has been increase in the IoT appliances such as smart boxes, TV sets, etc. by the dwellers. Even in the sectors of chattels real the appositeness of akin gadgets has upturned as in for Smart locks, thermostats, smart alarms, intelligent voice assistant and many more such gadgets. The neoteric augmentation in the field of digital automation has made the smart cities slicker than antecedent version of self. A smart or intelligent metropolis is rigged with the sensors as in for commutation, state-of-the-art cameras on the streets for influx management on the streets and for the purpose of cognizance as well, sensors at parking for monitoring the vacant slots (if any), etc.The eloquent amelioration in the permissive appliances tech, as in NFC, ingrained actuators, RFID tags, etc. Alongside materialization pertinent utility and appliances the IoT been lauded as abut dominating development to the contemporary hooked and ambulatory hobnob infrastructure. The recent prognosis as envisages that IoT would be imperative chunk of FI, as its akin appliances might surmount the total numbers of mobile and computer devices been accessed by the individuals. For such sequential events unfurls in the impending time frame, deduction of the schema and architecture delineation of FI be dependent on the staunchly be swayed by stipulation of IoT.

A framework of connectivity is catered by the recent turmoil in FI by which plebeians, society can annex with each other and as well as the devices as well. A study conducted which states, the total number of gadgets which are annexed with each other is much greater in number than total of humans on the planet [3]. The technical advancements and elucidations for scientific know-how for conceiving Smart Cities are sprouting and are surfacing up. **Figure 1** shows the inter-linkage of individual commodity as in terms of IoT. Multifarious facets of an entity can be stirred by IoT as in healthiness, commutation salvation etc. As in for governance it could play vital job as in to provide better efficiency, policy making, close and obscure monitoring, energy policy, pollution measurements, etc.

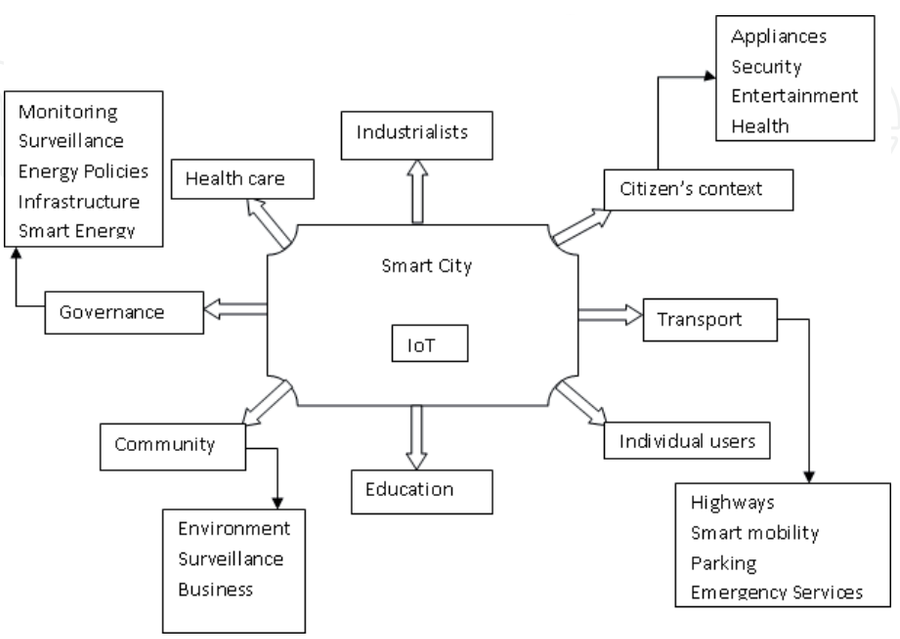

Figure 1.
Main aspects of smart city and inter-linkages based on IoT.

2. Indian perspective of smart cities

Government of India (GoI), in its' election manifesto for 2014 proposed development of 100 smart cities, which in later stage transformed to brown city from green city. In other words, GoI which earlier planning for developing 100 new cities as Smart Cities later planned to develop the existing cities into smart cities. And for this purpose, SCM and AMRUT a completely different wing under Ministry of Urban Development (MoUD) was setup, which was considered a compelling stride for encyclopedic enactment for Smart Cities (**Figures 2** and **3**). The implementation

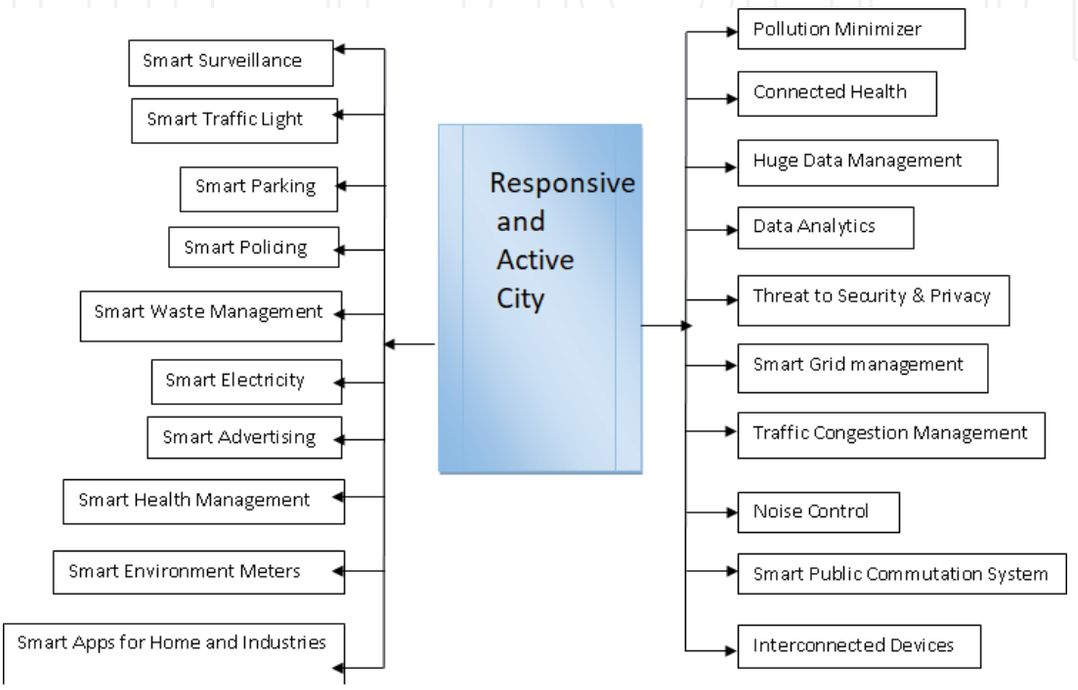

Figure 2.
Smart cities: Available technologies (right) and challenges (left).

Figure 3.
Example of prevailing smart building technologies (Image source: https://thegibraltarmagazine.com).

of SCM be annexed as the contingency plan to knuckle down to defiance of securing the intent of urbanization as per nationwide domestic development plan. Sectors where SCM needs to cynosure are:

i. Development of competent infrastructure for Civic Establishments and provincial governments.

ii. Development of competent Civic Administrative Organization.

iii. Enacting upon decentralization policy.

iv. Curtailing disagreement in civic domain.

v. Developing permissive plight for decent and broad urbanization.

The clamant materialization for gestating of Smart Cities along Indian lexicon be enunciated as adhere to:

i. A civic is obligated to be viable and imperishable.

ii. Fundamentals for the reliable administration be cherished.

iii. Abiding foresight, technology, strength of the governance and supportive administration and schema.

iv. Adequacy of the Civic administration to enact the above.

v. The nation is required to erect its own allusion for ontogenesis of Smart Cities.

Smart City be defined as in Indian lexicon as "A Smart City would be the one which plans judiciously to meet its aspirations and challenges in a sustainable manner while fostering principles of good governance. These are achieved in a Smart City by utilizing the enhanced power of technology, engaging with a more aware and informed citizenry and creating a more competent and capacitated set of people working within an accountable framework."

The schema for regional area augmentation has been designed by SCM and MoUD with intent to revamping fiscal development and aspect of living. The schema has basically trilateral factors [4]: a) Area – Based Development (ABD) responsible for uplifting of the regional extant inclusive of the blighted areas into advanced and planned ones; b) Green – field Projects which would develop new provinces into state-of-the-art centre so as to facilitate the exploding populace; c) Pan –city Development (PAN) which shall anticipate the appositeness of the elicited smart and intelligent elucidation to prolonging city framework.

3. Technologies for Smart Cities

The hefty fortification of IoT is playing pivotal guise in the administering of Smart City ventures. The constant advancements in the technology are enabling facilitating Smart Cities across the globe. The commodity by individuals be in service on routine basis are rigged with digital and computerized gears, mechanism and covenants so as to make them pertinent and associated with other linked and connected devices with Internet Protocol. The competence of surveillance and supervise of obscure and secluded area as well is ease with help of IoT. Apart from that one could administer remotely. The important physiognomy of the Smart City

is the enormous heterogeneous data from the various sensors and devices deployed within for administrative purposes. The super meteoric accretion of smart cities and the IoT coaxed various challenges for all researchers and industries as well for designing of a conducive and impeccable smart city.

With the use of Standard Web Protocols for communication [5, 6], IoT enact as Broadband Network having Internet at its concenter. For the employment of IoT demand for the communication standards that operates placidly amidst the numerous commodity whichever be computed, implicated and can hatch variance in purlieus. Among all the technologies pertinent to IoT are confabulated in brief as follows:

3.1 RFID

The arrangement comprises of a chip or a tag along a chip to read the tag. This advancement in technology can be used for registering any individual or an object for the intent to self recognized by the system. Each of the interlinked objects or gadgets accredited with diacritic identity [7].

3.2 Addressing

The prevailing fad in the fields of IoT could facilitate kinship of the individual associated gadgets and equipments so as to entrench smart and intelligent purlieus. The individual identity of the associated gadgets and equipments is must for in IoT.

3.3 Wireless sensor networks (WSNs)

With the help of WSNs data from different sources be collected easily and then be used in for various sectors as in Traffic Management, wellness program, pollution control, etc. It could also be tagged with some other sensors as in RFID to infer much accurate details about the individual object (**Table 1**).

Network type	**NFC**	**WPAN**	**WPAN**	**WPAN**	**WLAN**	**WLAN**
Year	2011	2002/2005	2003	2007	2012	2009
Network Size	—	7	245	65,535		30
Bit Rate	424 Kbps	3Mbps	55Mbps	250Kbps	> 7Gbps	248Mbps
Frequency	13.56 MHz	2.4 GHz	2.4 GHz	868–915 MHz/2.4GHz	2.4/5/60 GHz	2.4/5 GHz
Range	0.2 m	100 m	100 m	75 m	5 m	50 m

Table 1.
Important communication standards within IoT.

4. Smart buildings

About 30–40% of total power usage and discharge of CO2 is occurring at edifice [8]. The government is trying to clinch to reduce the energy consumption in new and as well as extant infrastructure as well so as to secure sustainability of the environment. Government through its stake holders, real-estate developers, land owner, proprietors, tenants and customers is trying to reforms in the sector to reducing the

carbon emission in the buildings. The further energy effectualness can be abated to achieve the objective set by IPCC [9]. Many researchers and industries are working in this regard making the building smart so as to minimize the consumption of energy within the infra-structure.

Over last few decades, there has been rigorous research and advancement in the over Smart Intelligent buildings. Though theoretically, in disquisitions and also in technical communiqué the phrase 'Smart' is being cited more often in last few years. With the advancement in new and boost in the technologies, the smart buildings have secured much enthusiasm from researchers and industries as well [10]. Computerization and automation has been so much part of modern days living standard required to chasten our living. Nowadays, everyone is longing to manage and administer the gadgets and devices installed remotely and effortlessly.

The buildings are elementary and fundamental fragment of the society. The buildings in-houses the inhabitancy, plaza, emporiums, office area, deli, residentiary and market complexes, etc. Designing the smart city is intrinsic stride for the ontogenesis towards the Smart City. The Smart Buildings or Intelligent buildings, in defiance of diversified interpretation of the IB from the various Industrials, researchers be observed from the perspective of industrial and technical crux, implicating amalgam construction design, framework, power, utility, technological advancements, environment and amenity administration in a manner so as to aggrandize the assuages and also to curtail the circuition price [11, 12], by means of aid from advanced state-of-the-art technology and information technology advancements. The Smart Intelligent Buildings are also well efficient of curtailing the intramural energy dilapidation.

The ambit of automation and modern IT industry, the modern Smart Intelligent Buildings be confabulated based on technical elegance and assimilation in assorted multitudinous folds [13]. Facilities like control over aegis, avenue, luminosity, elevators, data, Infobahn etc. falls as in basal or crux of the folds of the Smart Buildings. The assimilation of various functionality of the basal fold forms the next in hierarchy of the layers. Assimilated communication system forms the next in line. The comprehensive grid structure of all the Smart buildings forms the apogee for the folds or layers of assimilation. The advancement in IT sector administers the crucial and omphalic aspect here in Smart Buildings, explicitly in cognizance of the subsequent:

- Imposing for energy and policies codes and protocols, Building bylaws.
- Assimilating with the nearby power/smart grids
- Self guided and intelligent uninterrupted building responds.
- Visualization of diminishing carbon emission and energy savings.

5. System architecture

The new modern advancement in wireless system and sensor grid network can provide provides convenience in structuring for the Smart Buildings as in to administer the smart and complaisant abutment for the occupants. The continuous and unceasing monitoring and administering of the various factors in and out of a building is the necessity to diminish the energy consumption of a building. Sensors and actuators installed at the proper locations and also be attainable at any moment over the grid, is very important for the same purpose of conducive management and automation. As there been development in IoT technology and Smart

buildings in recent years, the dominion protocols, building acts and standards for industrial regulations is also been changes accordingly with due course of time, as in Consumer Electronic Bus (CEBus), Local Control Network (LCN). Suite of Internet Protocol (IP) turned to be new and paramount inclination for amalgamation of various services. Smart modern gateways are deployed at the network edge which then equipped with the access to protocols based on IP. The technology based on IEEE 802.154.4 helps in sending IPv6 packets efficiently through 6LoWPAN technique for header compression [14]. The following figure (**Figure 4**) depicts the rough architecture for the system.

The various sensors and actuators installed in a building combine to be the elementary or fundamental cause for data or information procreation. The initial level or Level one for the system be the raw data acquired from the sensor nodule, which then by communication service act upon farther processing of the data acquired. The architecture for the Smart Building is described with as mentioned principles of design.

- Information Assemblage. At the primary stage at this level, the raw data from the various sensors and actuators implanted at the building is collected and is stored for processing at later stage.

- Dossier Processing. Here at this level, all the data or information compiled in the previous stage is put together and processed so as all the data is stored in common format as in Resource Description Framework (RDF). Resource Description Framework (RDF) is most trivial approach for data castling over the web. Pre-refined data at this level will then be used for morphological knowledge and ambivalent inference at the preceding level.

- Dossier Assimilation and Inference. The exploitation of domain dependent distinct data is allowed through morphological web technology. Here all the information from the previous level is assorted and classified in as classes. Later the data collected is categorized into two base Data or Object Property and association of all the data is to defined with the either of two property based on Web Ontology Language (OWL).

  SPARQL is a query language subsidiary of RDF which is adopted to salvage and beguile the records hoarded in the RDF form. This stage galvanize towards amalgamation of low-level database.

- Gadget Control and Admonition. All the data processed in the previous stage of the architectural hierarchy is now ready to be used by various applications installed for smart activity and administration to ease of human.

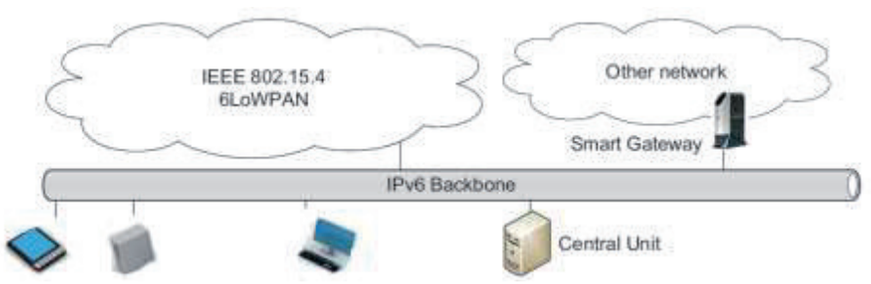

Figure 4.
Architecture for administrating and controlling over the system.

6. System application in buildings

To many individuals in the field of building automation continuance praxis, IoT plugging might look alike a jargon for gray wont. Might be that be total untrue. The coronation of sensors and imbrute praxis, angling to comprehend benediction associated with it as in crouched obligation to continuance of the building and viable competence with ameliorated superintendency and crouched corps outlay. The appositeness of IoT overture aggrandized prospects as in worth, viable efficacy, affinity through enhanced valise and liquidity management [15].

6.1 Architectonics

Apprehending the statistics on real time basis and cloud dependent dossier capacitate the enterprises in optimization of potency and curb operational squeezes as well. Annexation of the machinery and heirloom appurtenances could large amount of extra debts. Monitoring of those appurtenances installed do provides inestimable insights for the management for lapse, delinquency and to reckon regime bent as well [16–19].

6.2 Surveillance

Modern art-of-the-state designed IoT dossier with agitation apprehension sensors are the next generation system which could be wireless and also be quite setup for temporary setup as well, easily manageable remotely. These monitoring systems are battery operated and unlike conventional CCTV setup compared to are cost effective as well [20].

The present-day advanced system can also be used for securing the electric panels, which could trigger an effective alarm which when detects any unplanned apprehension in the proximity. If GPS be attached for advanced feature can also be triggered to activate with the alarm so as to manage theft if in case it occurs.

IoT based hazard control alarm system could prove very effective in the case of emergency. Fire or smoke alarm which when connected with the cloud dossier can automatically contact nearby fire station and police in case of any emergency. This could curtail ample amount of man hour for maintenance of the alarm and time-honored gratuitous auditing of the system.

6.3 Automation management

The system equipped modern sensors could be instated easily and effectively to manage the equipment as in light power, HVAC, fire, security, etc. and cloud-based dossier helps in supervise and oversight easily and efficiently [21–23]. Parameters as in temperature, automated door operation, humidity, air quality and pressure, etc. Apart from managing machinery as lift, escalators they also be prognosticate in case of disruption and be prompted for abrupt alleviative alacrity.

The system equipped with sensors once triggered could easily transfer statistics to cloud for further processing and record. It helps in control and optimization and also eliminate the long man-hour for data collection as well also increase the effectiveness with cost diminishing.

7. Conclusion

In years to come the art-of-the-state real estate development can be visualized globally. The trend of IoT, be then conceptualized in practical manner by next

few years. The assemblage of IoT and updated sensors certainly do aggrandize the efficacy, performance, wherewithal, unlimitedness and also curb the outlay over the building. Buildings are the one large power consumer, fact to the government across the globe have their focus now on them, regulations and mandates are updated regarding buildings are updated regularly for carbon footprint mandate.

Apart from management of power the IoT controlled system helps in diminishing carbon emission. With technicality point of view the development of such buildings with proper architecture and standardized codes would not only interoperability be salubrious but cost amiable as well. The bottom-line discussion of this paper is modern sensor based IoT equipped buildings be a necessity in coming years for a healthy and future-secured environment and be cost effective at the same time when making our life a lot simpler and easier.

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Conflict of interest

The authors declare no conflict of interest.

Abbreviations

IoT	internet of things
RFID	radio frequency identification
NFC	near field communication
FI	future internet
SCM	smart city mission
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
IB	intelligent buildings

Author details

Kumar Avinash Chandra
Department of Electrical Engineering, Dr. A.P.J.A.K. Women's Institute of Technology, Darbhanga, Bihar, India

*Address all correspondence to: energy.avinash@gmail.com

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