Mitigating and Monitoring Smart City Using Internet of Things

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Abstract: The present trends in smart world reflects the extensive use of limited resources through information and communication technology. The limited resources like space, mobility, energy, etc., have been consumed rigorously towards creating optimized but smart instances. Thus, a new concept of IoT integrated smart city vision is yet to be proposed which includes a combination of systems like noise and air loss monitoring, web monitoring and fire detection systems, smart waste bin systems, etc., that have not been clearly addressed in the previous researches. This paper focuses on developing an effective system for possible monitoring of losses, traffic management, thus innovating smart city at large with digitalized and integrated systems and software for fast and effective implementations. In our proposed system, a real time data analysis is performed. These data are collected by various sensors to analyze different factors that are responsible for such losses. The proposed work is validated on a real case study.

Keywords: Internet of Things, smart city, environmental impairments, pollution, temperature.

1 Introduction

A smart city refers to effective use of limited resources like energy, mobility, space, etc., [Shin (2017)]. Municipalities use smart technologies for monitoring environment parameters [Shin (2017)] to provide quality services to citizens. Information is infused with the physical infrastructure to improve the quality in all aspects of the environment by troubleshooting the problems and solving them quickly [Kaba (2018)]. The smart city is supposed to rapidly recover from natural disasters, preserve data for future predictions and decisions. These data collaborate with domains and entities [Chen and Chiu (2018)]. However, infusing just intelligence is not feasible before Internet of Things (IoT) comes into action [Jin, Gubbi, Marusic et al. (2014)]. Jayakumar et al. [Jayakumar, Raha, Stevens et al. (2017)] defines Internet of Things (IoT) as a system in which physical objects like sensors nodes are interconnected and collects real time or live data (through

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the Internet). Each object possesses an IP address and are capable to receive and transfer throughout the network [Pawar (2013)]. The embedded technology in the objects helps to interact with external environments. With the advent of time in around 2013, IoT evolved into a system that used multiple technologies ranged from wireless communication, micro-electromechanical systems to embedded systems [Khajenasiri, Estebsari, Verhelst et al. (2017)]. Other fields of development include automation of buildings and homes, wireless sensor networks, global positioning satellites, and control systems [Perera, Zaslavsky, Christen et al. (2014)]. Nowadays, in simple terminology, IoT includes a number of digital equipment such as cell phones, building maintenance services, jet engine of an airplane [Shelby and Bormann (2011)]. It also aids in the field of medicines like a heart monitor implant or a biochip transponder in farm animals. These IoT-connected devices transfer data over a network and are the component members of IoT [Zanella, Bui, Castellani et al. (2014)].

The recent developments on IoT utilization for smart city applications have been conducted [Andreev, Galinina, Pyattaev et al. (2015); Badii, Bellini, Cenni et al. (2017); Bellavista, Cardone, Corradi et al. (2013); Ding, Zhang and Zhao (2017); Lützenberger, Masuch, Küster et al. (2015); Pramanik, Lau, Demirkan et al. (2017); Jha and Pandey (2016); Kieu, Vo, Le et al. (2017); Long, Son and Ha (2014); Raipure and Mehetre (2015); Sanchez, Muñoz, Galache et al. (2014); Erra and Capece (2017); Thong and Son (2016); Tuan, Ngan and Son (2016); Uppoor, Trullols-Cruces, Fiore et al. (2014); Vakali, Angelis and Giatsoglou (2013); Vijai and Sivakumar (2016); Vo, Le, Nguyen et al. (2017); Wan, Li, Zou et al. (2012); Chen, Liu and Xu (2015)].

For implementation of such systems, it is necessary to exploit a new concept of IoT integrated smart city vision which includes a combination of systems like noise and air impairments monitoring, web monitoring and fire detection systems, and smart waste bin systems. Various sensors are programmed for detection of abnormalities by calculating the crossed levels of climatic elements, and raising alarm during danger. This speedy information transportation aids in speedy implementation of curative measures and control preventives. Efficient parking management for city dwellers for traffic control, pollution control (such as air, and noise, safety of children, aged people, etc.) is also rectified and taken care of. Thus, the aim of this paper is to develop a smart city system, which is equipped with a multitude of mobile terminals and embedded devices along with connected sensors. The proposed work can accomplish the following things: A centrally managed IoT-based smart city model, a solar system which provides the power supply to the smart city, monitoring the weather and prediction of weather condition, a smart waste management system, a fire detection system and a speed monitoring system.

In this paper, we have used Internet of Things framework. Further, we have identified some key areas of application of the proposed work such as "Automatic parking management system", and "Structural health monitoring system". The technique used in this model is to fetch the data from various interconnected devices and then analyzing those data to get more prevised value to make a system smart enough. The key technique used in this paper is data analysis to find the reason which causes the alert in various domains like weather, pollution, etc. We have also used different prediction-based algorithm to design and predict the effect of the data.

The rest of this article is organized as follows. Section 2 discussed the related works. Section 3 describes the proposed work including the architecture framework and designs of sensors. Section 4 deals with the results and discussions. Finally, Section 5 concludes the paper.

2 Related work

Buyya et al. [Buyya, Yeo, Venugopal et al. (2009)] addressed the requirements and outlined the parts of a reference Machine-to-Machine (M2M) correspondence stage. [Nam and Pardo (2011)] discussed how a particular city can be a smart one, thereby drawing into account the recent practices involved for making the city smart and intelligent on a digital environment. They offered strategic working definitions and principles aligning to three major dimensions of human-digital world namely technology, people and institutions that explore the basic fundamental properties of a smart city concept (integration of infrastructures technologically. Naphade et al. [Naphade, Banavar, Harrison et al. (2011)] provided a connection between key difficulties and developing innovation measures regarding the privacy and security of smart cities. Shelby et al. [Shelby and Bormann (2011)] presented a method of information assembling and alert plan for medicinal services administrations. Elmangoush et al. [Elmangoush, Coskun, Wahle et al. (2013)] introduced City Bench, a complete benchmarking suite for assessing motors inside brilliant city applications along with smart city information. Zygiaris [Zygiaris (2013)] emphasized on a smart system that illuminated the cumulation of all green, interconnected, open-integrated and digitally-instrumented notions with intelligent and innovative layers to create a planned framework known as the Smart City Reference Model. Kyriazis et al. [Kyriazis, Varvarigou, White et al. (2013)] presented the second application boasts of cruise control for public transport for exploring various resources like environmental and traffic sensors in order to ensure provisions for driving recommendations aiming at eco-efficiency.

Theodoridis et al. [Theodoridis, Mylonas and Chatzigiannakis (2013)] developed an IoT smart city framework resolving technological challenges. This paper focused on socio-economic opportunities in Smart City as a key finding. Karadağ [Karadağ (2013)] proposed the method of reasoning for joining of IoT ideal models and asset biological systems with a Cloud-situated condition on Smart City. Pawar [Pawar (2013)] proposed a uniquely arranged system to coordinate and craftily exploit overlays, offhand, and cooperatively framed over a network. Zanella et al. [Zanella, Bui, Castellani et al. (2014)] proposed the idea of focusing specifically on an urban IoT system that is designed to support the smart city vision. A comprehensive study of newest technologies, protocols, and digital architecture for conceptualizing an Urban IoT was discussed therein. Jin et al. [Jin, Gubbi, Marusic et al. (2014)] proposed building blocks of IoT based smart city focusing different domains of IoT for communications, management and computational requirements.

Perera et al. [Perera, Zaslavsky, Christen et al. (2014)] discussed about IoT favorable advantages over the set-up standards as far as proficiency, viability, and engineering aspects are concerned, specifically for the commonplace Smart Cities applications. Anthopoulos [Anthopoulos (2015)] presented the Smart Santander exploratory office. Kelaidonis et al. [Kelaidonis, Vlacheas, Stavroulaki et al. (2017)] portrayed few of the after-effects of the non-specified execution in the light of the Ubiquitous Sensor Network demonstrating body. Initially, the deployment of 2000 sensors has been borne by the urban communities. However, this happens to be inadequate for collection, storage and detection of the data for the larger urban areas. Other works regarding smart city development using IoT and can be retrieved from Andreev et al. [Andreev, Galinina, Pyattaev et al. (2015); Badii, Bellini, Cenni et al. (2017); Bellavista, Cardone, Corradi et al. (2013); Ding, Zhang and Zhao (2017); Lützenberger, Masuch, Küster et al. (2015); Pramanik, Lau, Demirkan et al. (2017); Jha and Pandey (2016); Raipure and Mehetre (2015); Sanchez, Muñoz, Galache et al. (2014); Erra and Capece (2017); Uppoor Trullols-Cruces, Fiore et al. (2014); Vakali, Angelis and Giatsoglou (2013); Vijai and Sivakumar (2016); Wan, Li, Zou et al. (2012); Chen, Liu and Xu (2015)].

3 Proposed methodology

3.1 Framework

Our proposed model is a combination of systems which constitute monitoring and controlling the impediments rising from air, noise, temperature, weather, fire, etc. It also incorporates smart waste bin and GIS system. Solar power system is used as a renewal source to minimize the requirements of any kind of external power supply as a backup [Zeng, Guo and Cheng (2011)]. Fig. 1 illustrates the architecture of the proposed framework. The following describes the aim and tasks of the main components in Smart city:

a) Air & Noise impairments monitoring & controlling system (A&NIMCS): Monitors the air and noise impairments present in the environments. Different sensors are implemented to collect data from environments. The A&NIMCS system makes analysis of collected data to find the variation in air and noise impairments in environments [Chen, Liu and Xu (2015)]. A web monitoring system (WMS) is implemented along with the noise impairments monitoring system, which capture the video of a particular region where noise impairments increase.

b) Speed and Web monitoring system: The radar system is installed at different locations in a city, which detects and measures the speed of vehicles. Different roads and regions have different predefined speed limits in their databases. If any vehicle crosses the speed limit or broken traffic rules of a particular region/road, the webcam monitor will be automatically activated and subsequently captures pictures of the vehicles responsible for it [Zeng, Duo and Cheng (2014)].

c) Temperature & Weather monitoring system (T&WMS): Measures the temperature of environment and parameters of weather like wind, UV index, pressure, etc. and display them for public information [Pawar (2013)].

d) Fire detecting system (FDS): Detects fire accidents in a particular region and informs the region office as well as central control room [Ding, Zhang and Zhao (2017)]. It also captures videos of accident to find the reason of fire accident and losses.

e) Smart waste bin management system (SWMS): Monitors the wastes matter from different places of the city. Smart waste bins are used in SWMS system which detects the types of waste material inside waste bins, whether waste bins are full or not, and sends locations of the waste bins [Jin, Gubbi, Marusic et al. (2014)].

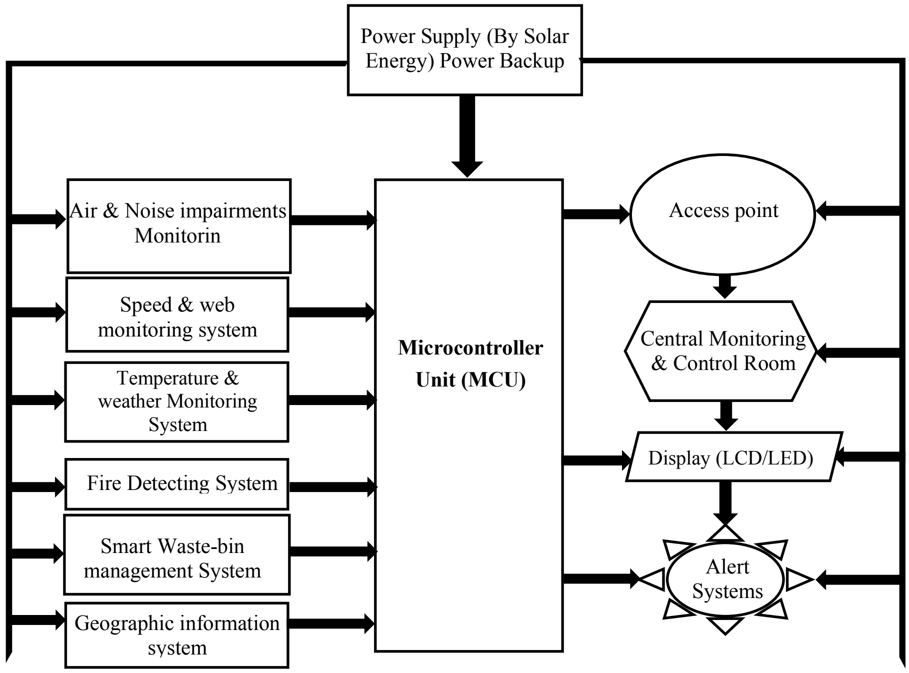

Figure 1: Block diagram of proposed framework

f) Power Supply (By Solar Energy) Power Backup: It is used for power supply to the system with clean energy and power backup. Proposed framework does not mean that the entire system will be backed up by the solar energy, but the sensors which play the most important role throughout out proposed model, need lesser amount of power back up which can be easily covered by solar systems, And it is also not necessary that all the sensors get failed in working [Karadağ (2013)].

g) LCD/LED screens: It display the calculated data of monitored locations throughout the city with corresponding guidelines and precautions throughout the city using LCDs and LED screens [Karadağ (2013)].

h) Central Monitoring & Control Room: The collected data are sent to the central control room where the analysis of the collected information is conducted [Karadağ (2013)].

i) Alert System: As soon as there is any alteration of impediments, the alarm installed in the system generates an alert signal or message [Karadağ (2013)].

3.2 Speed and web monitoring system

The Speed and Web monitoring system (SWMS) [Zeng, Guo and Cheng (2011); Uppoor, Trullols-Cruces, Fiore et al. (2014)] ensures safety of road passengers. It monitors speed through radar systems along with a camera in order to captures images of the vehicle. The following describes main components of SWMS as shown in Fig. 2:

1. Vehicle speed sensors (Radar system): Microwave signal is used to the vehicle and then the signal yielded out from those vehicles is used to determine various parameters

including speed, vehicle length, lanes etc. These parameters are based on the wavelength sent by the radar.

2. Web camera: The web camera, once a vehicle is traced, starts snapping the images which is further shared with the control room.

3.3 Fire detecting system

Fire Detecting System (FDM) aims to detect fire in a particular region through fire detector sensors implemented in different regions of a city. The fire detecting system comprises of a series of instructions to be followed for monitoring and preventing outbreak of fire and controlling its consequences. A camera is implemented with the FDS [Ding, Zhang and Zhao (2017)] system to capture video/imagery when fire is detected. A region fire control room is installed at different regions of the city. The prediction, whether fire can be controlled by substations or not are done by the video/imagery data collected by cameras as shown in Fig. 3.

3.4 Temperature and weather monitoring system (TWMS)

This system monitors the temperature and correspondingly the weather [Pawar (2013)] by the following sensors:

1. Temperature sensor: measures temperature through an electrical signal.

2. Atmospheric pressure sensor: a device that measures the atmospheric pressure. When air pressure increases, it indicates raise in barometer and decrease in air pressure indicates fall in barometer.

As shown in Fig. 4, sensors fetch and check the data from different locations for synchronization and then shared in the centralized control room. Later on, the collected information is displayed in a LCD and other handheld output devices for the concerned department and public services.

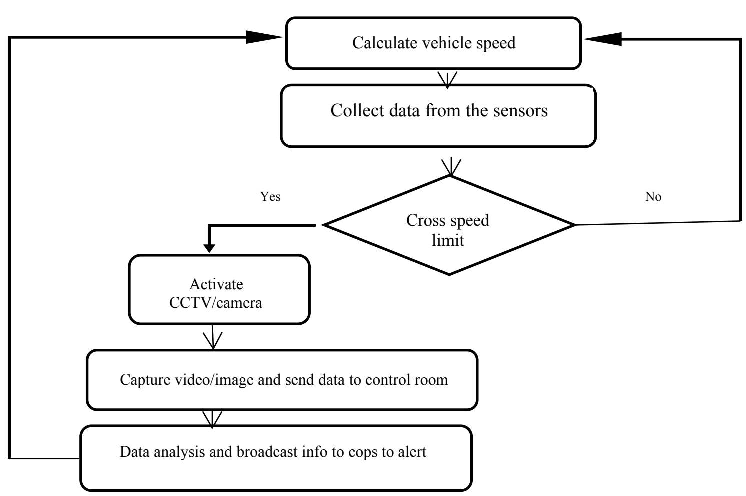

Figure 2: Data flow diagram of the Speed & Web Monitoring System (SWMS)

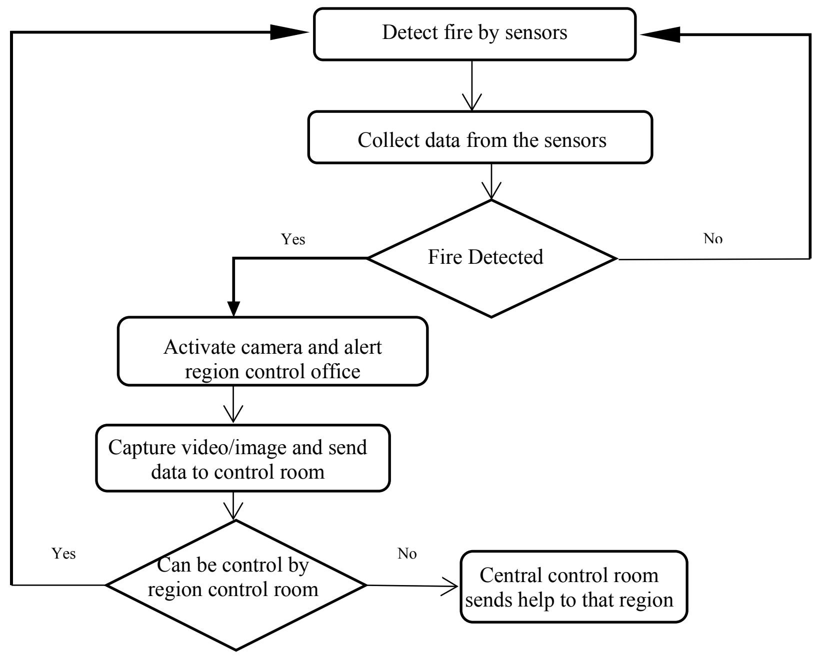

Figure 3: Data flow diagram of Fire detecting system (FDS)

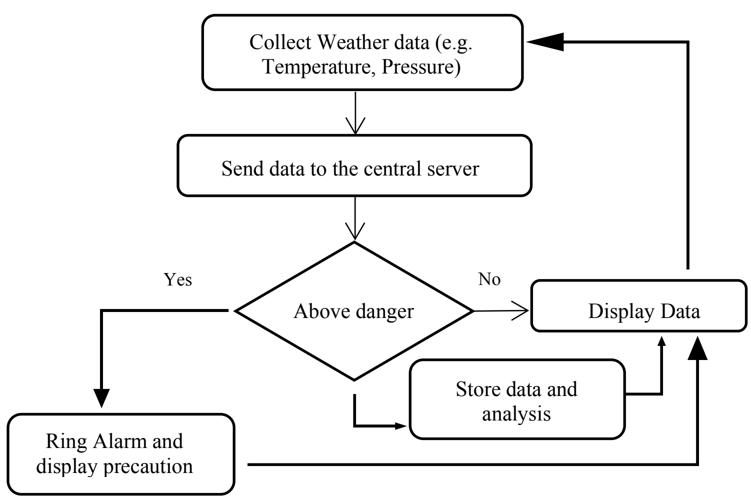

Figure 4: Data flow diagram to measure Weather data

Algorithm 1: *Measuring temperature and weather data and data analysis/Smart Waste Management System/Air & Noise impairments monitoring and control system (A&NIMCS)*	
Input: *Dataset (Temperature, pressure, weather data, Air, Noise, Waste Data)* ***Initialize:*** *All types of sensor data initially = 0.* ***Output:*** *Send the collected data to the central server using access point and display on the LED/LCD.*	
1.	*For (i=0; i<=n; i++) Where, n = number of sensor nodes.* *For (i=j; j<n; j++)* $\sum_{i,j=0}^{n}$(Sij) *//Sensors collect data (Sij)*
2.	T_{cal} ← *(Cr ← Sij&& Hierarchical Clustering (*Han *et al.*, 2011)) *//Store data in the central repository (Cr) and analysis of data by the experts (or by AI bots).* *Data analysis.* Which is done with the following measurements and generated data sets: *i.* *s= M – E (for the residual "s" is the difference between values paired time wise).* *ii.* $\overline{s}$ *=1/N ∑s (for Average difference denoted by s).* *iii.* $S^2 = \sum \frac{(s-\bar{s})^2}{N} = \frac{\sum s^2}{N} - \left(\frac{\sum s}{N}\right)^2$ *(for the measurement of the variability of the difference is the variance* S^2*).* *iv.* MAE = $\sum \frac{\lvert s \rvert}{N}$ *(for mean absolute error (MAE)).* *v.* $MSE = \frac{\sum s^2}{N}$ *(For mean square error (MSE)).* *vi.* FE = (M - E) / 0.5(M + E). *vii.* FE = (M - E) / 0.5(M + E) *(For the fractional error (FE)).* *viii.* MFE = $\frac{\sum FE}{N}$ *(For the mean fractional error (MFE)).* *Continue from Step-1.*
3.	***If*** *(T ≤ Tcal) // If the any of the collected is below danger level* *i.* *Alert=0;* *ii.* *Display "All are in control stage" and continue measuring.* *iii.* *Data analysis based on prediction*

4.	*Else // if any of collected data is above danger level*
	i. *Alert=1; //Activate alert system. (Ring the alarm and alert the entire city and Display precautions to be taken by the citizens.)*
	ii. *Display the safe places and services provided by government (like, nearer rest room location in extreme summer days, Masks in case of pollution, etc.)*
	iii. *Identify type of data which is above the danger level*
	• *Data analysis to find the reason*
	• *Prediction-based data analysis to control/minimize it.*
	• *Action to be performed by concern to control/minimize it.*

5.	***End If***
6.	***End of Process***

Algorithm 1 clearly shows that sensors nodes are installed in different locations/areas of the city/town which collect the data from different parameters like temperature, air, noise, wastes etc. from the environment. These data are stored in central repository where different techniques are used to check the data if data is above danger level or not. If in danger level, then it alerts the citizens by alarm installed throughout the city to follow precautions and take safe places and also alerts the control room. Analysis is done on the data to find the reason which causes the alert. Different prediction-based algorithms were designed to predict the effect of the data. Proper action needs to be performed by the concern authority to control and minimize it. If all goes well then it continues to collect data and stores in central repository.

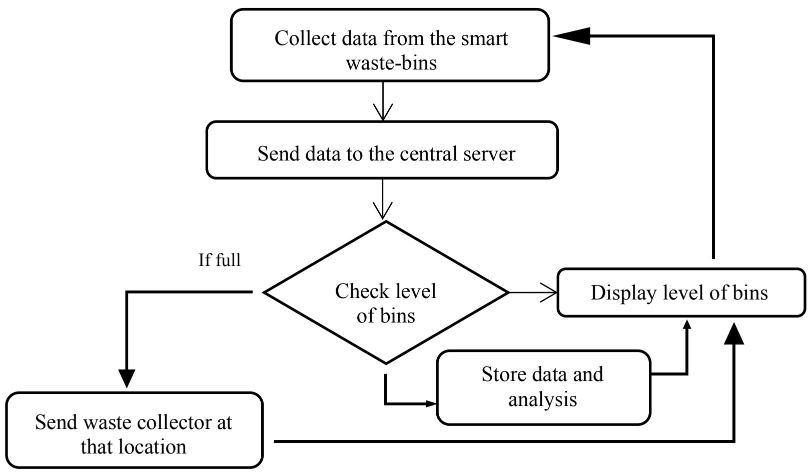

Figure 5: Block diagram of smart waste management system

3.5 Smart waste management system (SWMS)

This system is implemented throughout the city. This is a centrally controlled system which finds locations of several waste bins. These sensors constitute a smart waste bin system to send information like level of smart waste bin and locations of the smart waste-bins. In Fig. 5, the flow of collected data is shown.

3.6 Air and noise impairments monitoring/control system

1. *Smoke sensor*: a device that measures smoke present in the environment.

2. *Humidity Sensor*: a device that measures the humidity present in the environment.

3. *Sound Sensor*: a device which detects the sound in DB from the environment

The proper precaution is displayed on the information guide LCD/LED to follow.

As shown in Fig. 6, firstly the data collected by the sensors located at various locations are fetched and checked for synchronization. Then, the data are delivered to the centralized control room and are also displayed in the LCD and other handheld output devices for the concerned department and public services. The collected data are stored in central repository for analysis. The danger level of the polluted data is checked. If it is found to be above than a prescribed danger level, an alert system is generated and the subsequent message is circulated and broadcasted to all the concerned cities.

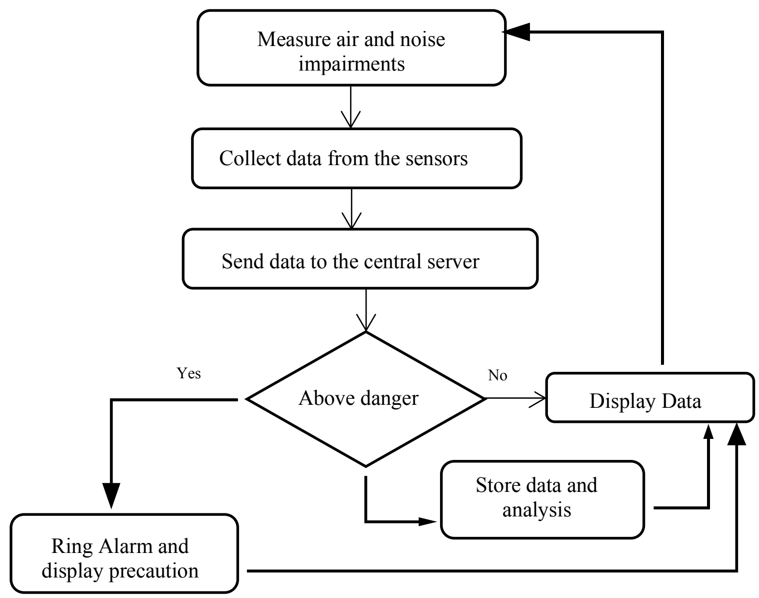

Figure 6: Block diagram of Noise and Air impairment monitoring/control system

3.6 System implementation

Fig. 7 shows the implementation of the model consisting of sensors for temperature sensor, humidity sensor, smoke sensor, piezo alarm, sound sensor, motion sensor, fire monitor, alarm/siren, webcam, smart wate bin, GIS and solar system. These sensors are connected with microcontroller unit (MCU) to form a Smart City model. In our model, data collected by different sensors are processed centrally. The data flow diagram of the proposed model is given in Fig. 8.

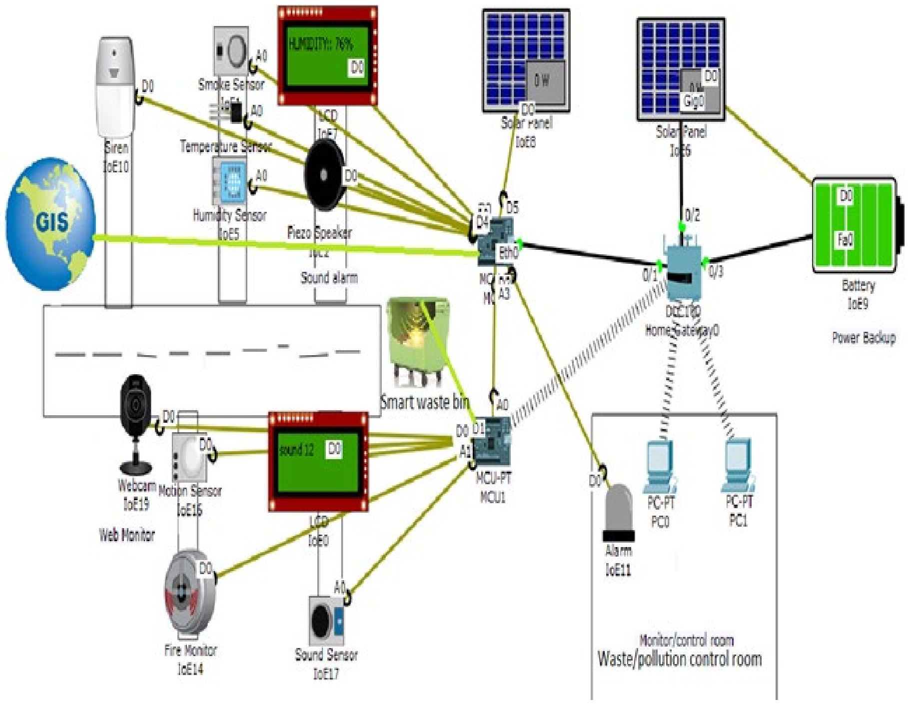

Figure 7: Implementation of the new model

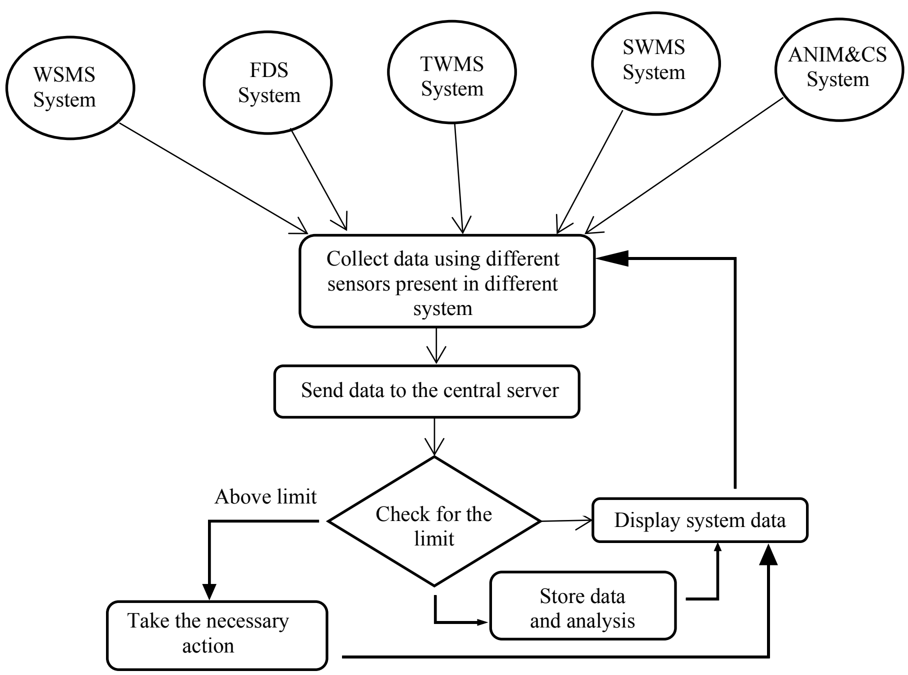

Figure 8: Data flow diagram of our model

4 Experiments

4.1 Testing with real case study

The proposed system is firstly validated on a real time case study from different regions of the Bhubaneswar City (http://www.smartcitybhubaneswar.gov.in/), India as shown in Fig. 9. With potential of transformation, we take the city Bhubaneswar, Odisha, India which hinges on the principle of bringing together people, jobs, and services in a smarter way. The data are collected by sensors installed in different regions of the city such as: Neelachal Hospital (Region 1), Railway Coach Depot (Region 2), Government Textbook Press (Region 3), Ram Mandir (Region 4), City Bus Stand (Region 5), Proposed Lake Zone (Region 6), State Drug Managements (Region 7), Neelanchal Institute of Medical Sciences (Region 8), New Marion Hotel (Region 9), Kalinga Institute of Management and Technology (Region 10), Odisha School of Business Management (Region 11), Chandra Complex (Region 12), Ashoka Market (Region 13) and UCO Bank Regional Office (Region 14). For example, Region 7 has high population density, which causes the slighter raise in temperature, pressure, noise and waste productivity. The data collected from this region are directly sent to the central repository, and some relatively prevention techniques are required to control after analysis.

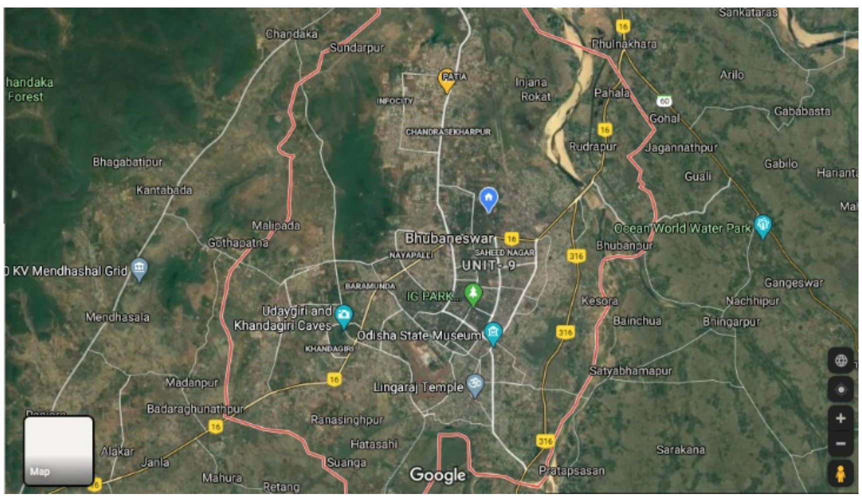

Figure 9: Bhubaneswar city

Fig. 10 depicts the data fetched from various sensors nodes and articulated into the centralized node. The control room senses all the data and delivers the next state of act depending upon the state of data and necessary analysis. In this figure, we have considered 14 various regions for a particular city in India with reference to a particular environment. Considering the Region 1, we see that at a particular point of time, various parameters like level/quantity can be checked and cross evaluated, and verified accordingly. For example, let us consider the wastage level of Region 1 at a particular time, the respective level of waste bin is being shown. The proposed model can be used to monitor various levels throughout the day.

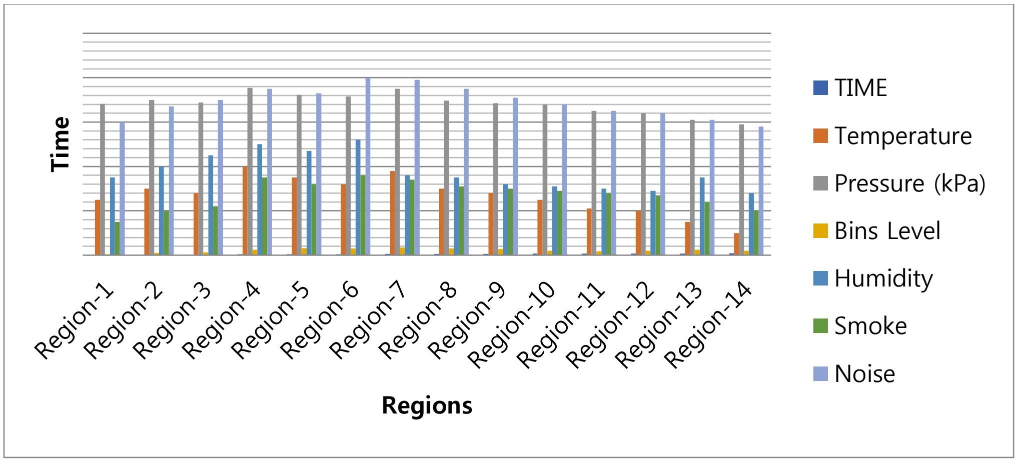

Figure 10: IoT data collected in 14 regions of the case study

Fig. 11 shows the graphical representation of weather data collected by different sensors at different location/region in the city. The graph clearly depicts that there is variation in temperature and atmospheric pressure in different locations/regions. Real-time realization of collected temperature data by the temperature sensors and atmospheric pressure data by barometric pressure sensor are described in Tab. 1.

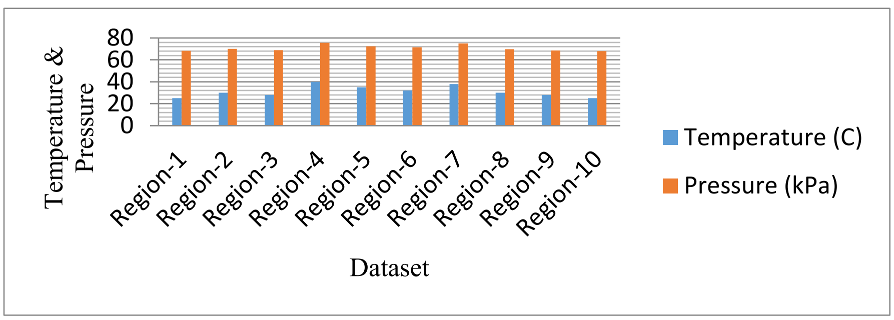

Figure 11: Real-time collected weather data

Table 1: Weather data

Region	Temperature (°C)	Pressure (kPa)
Region-1	25	68.2
Region-2	30	70
Region-3	28	68.8
Region-4	40	75.5
Region-5	35	72.3
Region-6	32	71.6
Region-7	38	75
Region-8	30	69.7
Region-9	28	68.5
Region-10	25	68

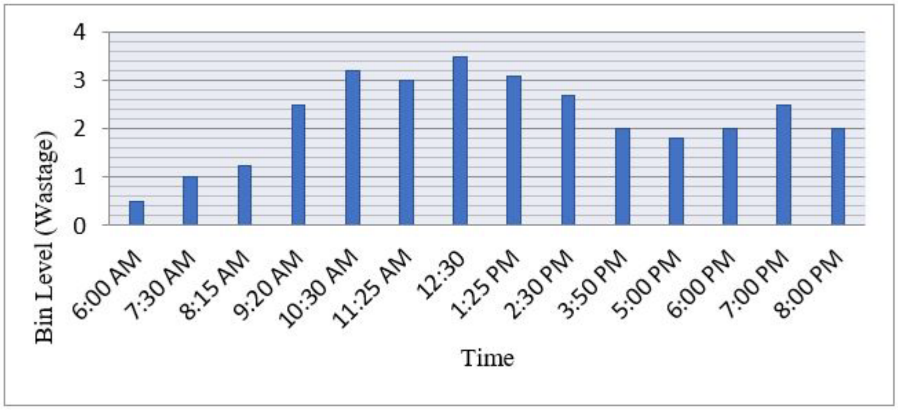

Figure 12: Data collected by smart waste-bins

Fig. 12 shows the graphical representation of level of data collected by smart waste bin sensors with respect to time. At morning time (i.e., 6:00 AM) the level of waste in waste bin is about 0.5 feet. With increasing in time, the level of wastes in waste bin increase as people start using smart waste bin. The variation in graph clearly depicts that the level of waste material in waste bin varies with time. The information data like location bins, level of bins, types of wastes are collected using the sensors installed in smart waste bins (See Tab. 2).

Table 2: Data set for smart waste bins

Time	Level (Meter)
6:00	0.5
7:30	1
8:15	1.25
9:20	2.5
10:30	3.2
11:25	3
12:30	3.5
1:25	3.1
2:30	2.7
3:50	2
5:00	1.8
6:00	2
7:00	2.5
8:00	2

Fig. 13 depicts the graphical representation by the simulator. The datasets are generated by the various sensors like Noise sensor, smoke sensor and humidity sensor. The data are fetched by the sensor controller and sent to the central control room. A tool embedded within the central controller analyses these data and are represented in various ways as shown in Tab. 2 and Fig. 13. Regions 1, 2, 3 and 4 depict different simulated environment and subsequently the data from respective impairment sensor detects these data which is been analyzed by the central controller. The graph shows clearly that there is a significant difference in humidity at Region 1 and that at Region 4. The obvious reason is the environment. Likewise, the smoke too differs highly at Region 1 and that at Region 4 (Tab. 3 and Fig. 13).

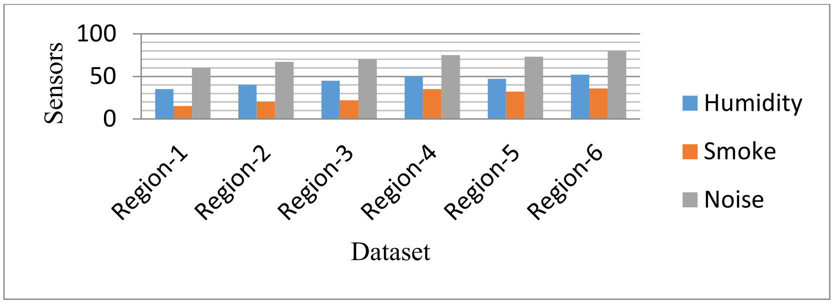

Figure 13: Data collected by smart waste-bins

Table 3: Data set for smart waste bins

	Humidity	Smoke	Noise
Region-1	35	15	60
Region-2	40	20	67
Region-3	45	22	70
Region-4	50	35	75
Region-5	47	32	73
Region-6	52	36	80

4 Comparative analysis

This section discussed the detailed comparative analysis of our work against the existing works with concurrent justification and findings. As illustrated in Tab. 4, one can easily observe that the proposed work has advantages over the existing works. On the other hand, we can clearly see that the new model aims to build a smart city by making the compilation of most of significant features that help in building a city IoT based Smart City with all these components interconnected, open-integrated and digitally-instrumented in conceptualized way.

Table 4: Comparative analysis

Authors	Findings	Proposed Work
Zanella, Bui, Castellani et al. (2014)	Provided enabling of newest and conceptualized IoT	It used the latest technologies, protocols, and unique digital architecture and worked in stimulated environment for an urban IoT
Zygiaris (2013)	Proposed a smart innovation ecosystem	Proposed work used the solar energy as a source of clean energy, interconnected with each other and digitally-instrumented with smart and innovation layers in stimulated environment
	Conceptualizes a green, interconnected, open-integrated and digitally-instrumented intelligent system.	
Nam and Pardo (2011)		It worked and satisfied the maximum requirements for a smart city

Kyriazis, Varvarigou, White et al. (2013)	Gave a brief survey on a smart city innovation project for sustainable development and presented the two innovative smart cities IoT application	It used more than two innovative smart cities IoT application for sustainable development
Theodoridis, Mylonas and Chatzigiannakis (2013)	Developed an IoT smart city framework in Smart City area. But most of the idea was conceptualized	It analyzed and concluded the results based on the various datasets in stimulated environment
Hartung, Han, Seielstad et al. (2006)	Presented wireless system for checking climatic conditions and fire detection techniques, prevention and control methods	It developed a tree-tiered portable WSN system for monitoring environmental impairments, weather reporting and fire detection techniques along with web monitoring system
Jin, Gubbi, Marusic et al. (2014)	Proposed the building blocks of smart city IoT infrastructure	It analyzed and realized the different infrastructure of IoT smart city
Vo, Le, Nguyen et al. (2017)	Provided enabling of newest and conceptualized IoT	It used the latest technologies, protocols, and unique digital architecture and worked in stimulated environment for an urban IoT
Shin (2017)	Proposed a smart innovation ecosystem characteristic that makes the compilation of all smart city nations into green, interconnected, open-integrated and digitally-instrumented with intelligent and innovations layers in conceptualize way.	Proposed work used the solar energy as a source of clean energy, interconnected with each other and digitally-instrumented with smart and innovation layers in stimulated environment
Kaba (2018)	Discussed how a particular city can be a smart one, thereby drawing into account the recent practices involved for making the city smart and intelligent that can run on a digital environment	It worked and satisfied the maximum requirements for a smart city
Chen and Chiu (2018)	Developed an IoT smart city framework in Smart City area. But most of the idea was conceptualized	It analyzed and concluded the results based on the various datasets in stimulated environment

Figs. 14-17 demonstrate various empirical studies of recent research domains. We can clearly see that the proposed, algorithms and suggestions from our findings are far enhanced than them. Given a particular impairment, for example noise- the previous study has given an empirical value of 58 against our empirical value is 60. Likewise, all the others evaluations can be observed.

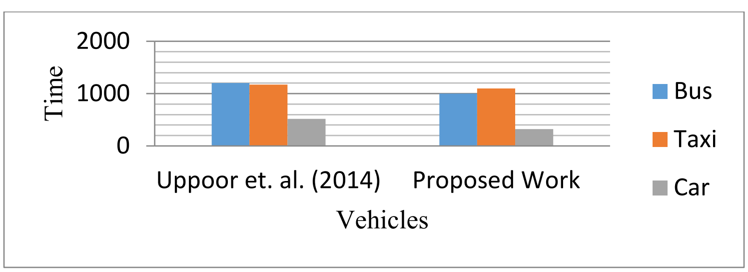

Figure 14: A comparative diagram reference to the noise in decibel of Bus, car and taxi in the particular environment at the given time

In Fig. 14, it is clear that the work of Uppoor et al. [Uppoor, Trullols-Cruces, Fiore et al. (2014)] showed that the pollution level for bus, taxi and car have crossed 1150 level of units. Since the IoT components in this work keeps track of each of these components' pollution parameters, the control server immediately reacts with various modes for e.g. setting and throwing alert to the concerned authority / department, the pollution level has significantly decreased down to 1100 unit level. This is a reduction of 30% at large to the whole pollution level.

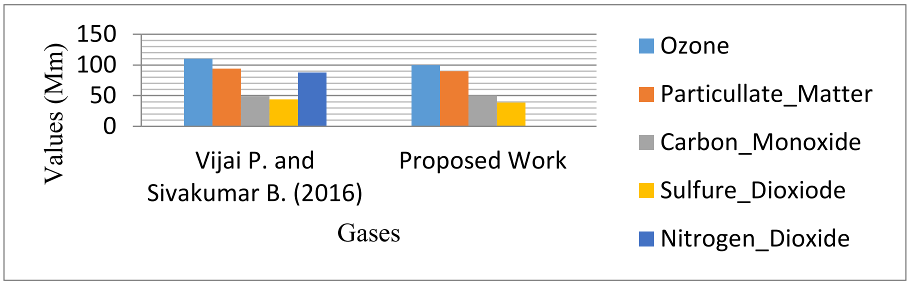

Figure 15: A comparison between in terms of thickness Gases

From Fig. 15, Vijai et al. [Vijai and Sivakumar (2016)] has shown the Ozone with 110, Particulate matter with 90. Our results show 100 for Ozone and 85 for particulate matter. There is variation of approximately 20 to 25% at large to all the environmental impairments. This work has significant decrement of the values of these variables and finally approaches the main target of developing smart cities with decreased noises, environmental impairments, and moreover going the city to green. Fig. 16 clearly indicates the variations of factors humidity, smoke and noise. Ding et al. [Ding, Zhang and Zhao (2017)] proposed the model which had humidity level of 40 units, smoke with 19 level units and noise with 52 units. However, they did not consider the IT enabled services where these parameters could have been reduced by invoking the IoT and IT based awareness system. Here in our work, we have clearly projected an integrated component in which once any of these variables, i.e., Humidity, Smoke or Noise is increased, the sensor immediately reacts and sends and acknowledging message to the control room via various access points. For example, if a person is traveling from destination X to destination Y, and if he gets an alert of high humidity, smoke or noise, he can deviate the path and chose another one. Subsequently, if a good number of travelers follow our alert message, then the congestion at destination Y gets decreased and hence the variable values substantially get decreased which as an example is shown in the Fig. 16, with a humidity level of 32 units against 40, smoke 12 units against 19 and noise 51 against 52.

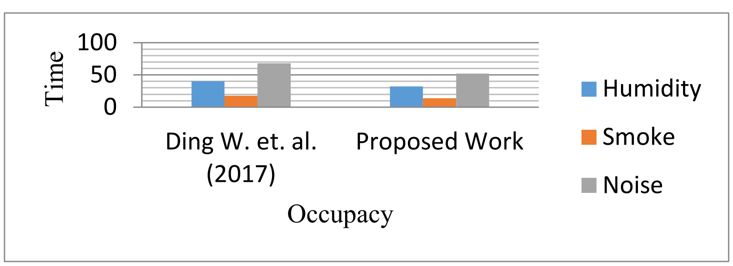

Figure 16: A comparative diagram with reference to the percentage of occupancy

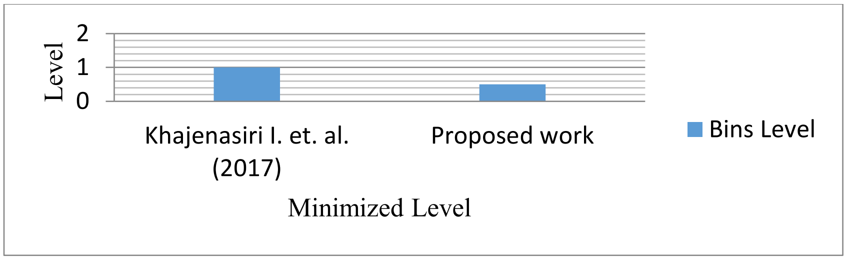

Figure 17: Depicting the wastage level minimization

We have yielded out with significant result in terms of wastage bin level calculation where [Khajenasiri, Estebsari, Verhelst et al. (2017)] showed a result of 1 against ours which is very close to 3, i.e., the leveling is more enhanced and almost accurate.

5 Conclusions

This paper proposes a conceptual model of smart city. We have used environmental impairments, humidity, temperature, noise, etc. as variable to mitigate, monitor and manage various aspects in building the smart city. The organic connection among technological, human, and environmental components were also investigated and analyzed. The experiments on a real case study from different regions of the Bhubaneswar city, India showed the efficiency of the proposed framework. Whilst the recent trending of extensive use of limited sources towards building smarter world, our proposed approach has been successful by using renewal resources; thus making it highly economic and easy to be availed any time as desired. The real case study presented in our work justifies that a smart city can be smarter by using renewal energy/resources

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