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security, and other applications, a cyber-society domain; where integration of different societies, such as hospitals, police stations, and fire brigade stations are connected to web application server, performs and initiates actions based on the signals received from other domain, and finally, the cyber mobile domain; where web of vehicles are interconnected to each other as well to the GPS. The GPA service provides the facility of finding the current location of the vehicles (by home use users, police stations, fire brigade, and ambulance). The performance of the system architecture is tested on Hadoop using UBUNTU 14.04 LTS coreTM i5 machine with 3.2 GHz processor and 4 GB memory. The final evaluations show that the performance of the proposed network architecture fulfills the required desires of the users connected to it, whether the input data is a real-time as well as offline while taking actions at real time. Future challenges are in implementing M2M or device to device level integration along with various sensors in an IoT environment and complexities involved in analyzing such big data [29–31]. We would extend our capillary device integration towards IoT with big data analytics.

Acknowledgments

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shows the throughput results with respect to size. Since Hadoop divides the larger datasets into blocks of fixed size and performs parallel tasking on them, therefore, throughput is reduced. However for very smaller dataset, it cannot be divided into blocks, and moreover MapReduce implementation requires a lot of switchings, therefore the parallel tasking cannot be performed on smaller datasets and the switching remains the same. Resultantly the throughput is more for smaller datasets as compared to larger datasets.

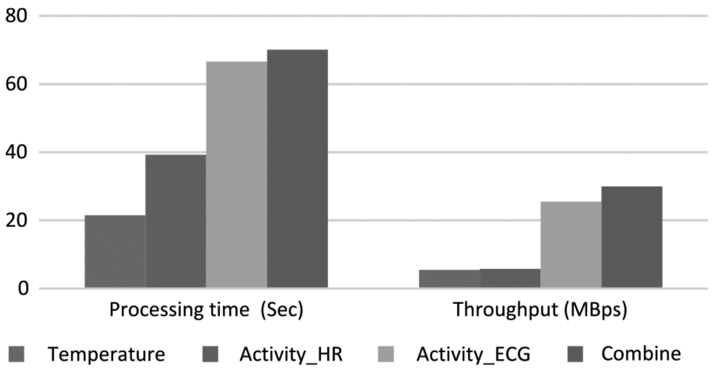

Fig. 11. Efficiency of proposed system.

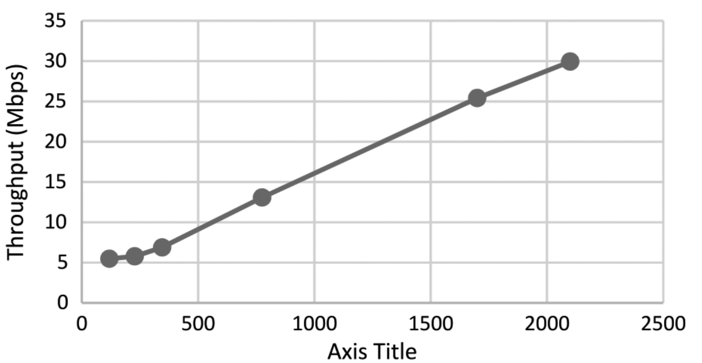

Fig. 12. Throughput of the proposed system with respect to size.

5. Conclusion

In this paper, we provide a new concept of smart cyber society that integrates the concept of the WoT based on CPS. Furthermore, we define a virtual communications platform for sharing data using the same medium. The proposed communication platform provides a common medium for the communication of all the heterogeneous capillary devices. Furthermore, system architecture is also proposed based on the web application. The web application concept is used to send or receive action message over the network.

The proposed architecture consists of three domains, i.e., cyber home domain; an advanced form of the smart home where integration of different capillary devices are used for monitoring the home in terms of healthcare,

Algorithm 1: Fire Detection and Patient Monitoring

1. For each (Temperature readings) do
   IF (Temp>δ_{STemp} && Flush_light>δ_{FL})
   Fire: Detected;
   Else IF: (Temp>δ_{NTemp})
   Fire = Analyze (x□$_{Temp}$, σ^2_{Temp}, Max_val$_{Temp}$)
   Else
   Next();
   Alert();

2. For each (Heart_Rate) Do
   //Define Thresholds
   Assign δ_{NR} and δ_{SR} by following table

Age	δ_{NR}	δ_{SR}	Age	δ_{NR}	δ_{SR}
<20)	170	200	<50	145	175
<30	162	190	<60	136	170
<40	153	185	>60	128	150

//Decision
IF: (Hear_Rate>δ_{SR})
Alert();
ELSE IF: (Hear_Rate>δ_{NR})
Analyze (Heart_Rate)
ELSE:
Next();

In such a way, one line of the sequence file contains one record of various sensors. Map function performs parameters calculations on incoming readings when required and finally sends the reading number as a key and list of parameters results as a value to the Reduce function. Reduce function uses parameter results as performing final decision making on them.
We test the proposed system with respect to the effectiveness and the time taken to process large datasets. Since Hadoop stored data in the various block using HDFS file system on the various data server to achieve parallel taking on same datasets. Therefore, the efficiency of the system is dramatically increased as compared to existing system implemented using other technologies. We considers temperature dataset [28] of size 118 MB, ECG dataset of size 227 MB [27], and heartbeat rate dataset of 1.7 GB [25,26] with various number of attributes including activity parameters and medical health parameters in a single datasets. We consider the processing time and throughput to evaluate the efficiency of the system. The processing time is calculated in seconds (s) while throughput is calculated in a millisecond (ms) by dividing processing time with the size of the dataset. Temperature dataset takes less processing time as the size of the dataset is smaller, but the throughput is more. Similarly, when we combine all the datasets of size 2.1 GB, the processing time to process the combined dataset is too large but the throughput is shorter to 33 ms. The processing time and throughput for various datasets are shown in Fig. 11. Moreover, we also tested our system on different datasets of different sizes from smaller to a larger size. We observed that when we increase the size of datasets the overall throughput is decreased. Fig. 12

Fig. 10. ECG of a patient while performing various activities.

Initially, when the temperature and flush_light readings are encountered, the system measures them for their specified thresholds. If the temperature exceeds the serious threshold, it is detected as fire, and the corresponding action is taken (fire brigade section in cyber society domain). However, if the temperature is in normal range, no action will be performed, and the system is transferred to the next reading. However, when the readings are neither exceeded from serious threshold nor below normal, the system analyzed the readings based on the previous history by taking the mean, standard deviation, and maximum value of readings. Finally, the action is taken based on the analysis of results. While monitoring a user-health by considering the heart measurements, the algorithm first assigns serious and normal threshold values of heartbeat rate based on the user age. Later, the heart readings are compared with the thresholds and actions are taking similar to the actions discussed above in the case of fire.

Pseudocode is given as Algorithm 1.

4.2. Implementation and evaluation

The implementation of the proposed system architecture is done at Hadoop architecture in Linux environment using MapReduce Java programming. In the Hadoop implementation, Map function takes the sequence file offset as a key, and the temperature or heart values are taken as a value parameter. Since Hadoop MapReduce cannot directly process network traffic in an efficient way, therefore, the whole traffic that contains sensors measurements are converted into sequence file that is to be processed using MapReduce.

Table 1
Notation used in algorithm.

Notation	Description	Notation	Description
Temp	Temperature in degree Celsius	δ_{NTemp}	Normal threshold of temperature for fire
δ_{STemp}	Serious threshold of temperature for fire	x_{Temp}	Mean value of previous x Temp readings
Flush_ light	Flush light intensity	σ^2_{Temp}	Standard deviation value of previous x Temp readings
δ_{FL}	Serious threshold of flush light for fire	Max_val_{Temp}	Maximum value of previous x Temp readings
Next();	Function to go next reading	Alert();	Function to generate alert or actio
δ_{NR}	Normal threshold of heartbeat rate	δ_{SR}	Serious threshold of heartbeat rate
Analyze ()	Function to analyze readings based on history		

ered as fifty Celsius. When the temperature of the room exceeds the serious threshold, the fire alarm is generated to alert the system, as shown by reading number 18, 56, 110 165, and 435. Afterward, the data is sent to the web server, where the signals are sent to the corresponding domain for further action. However, when the data exceeds the normal range, the data is sent to the analysis server, which takes statistical measures to analyze the current temperature based on previous history. It might use variation and an average (mean) mechanism to analyze the temperature for fire detection. Finally, based on the analysis results the action will be taken if fire event is detected. Furthermore, if the temperature is normal, then no action will be taken. The normal and serious threshold varies from season to season depending upon the location of the sensor.

In the next level, heart-related data is analyzed. The heartbeat rate dataset contains the heartbeat rate readings of three patients while performing various activities like computer work, cleaning, driving, and playing soccer. Moreover, ICU patient's heartbeat rate is also considered, which contains some serious readings that require emergency actions (ICU patient's heartbeat rate is a serious patient at home). Since the computer work and cleaning are not a hard work, therefore, the heartbeat rate is quite lower while performing these activities. On the other hand, driving and playing soccer are bit complex and require more efforts. Therefore, at the time of these activities, the user's heartbeat rate is more than the heartbeat rate while performing normal activities, such as cleaning and computer work. Furthermore, while playing soccer, the user is tired of the time and has more stress of the game, so the heartbeat rate gradually increases. The system measures the heartbeat rate while performing various activities and generate an alarm when heartbeat rate exceeds normal range to alert the user. The emergency action will be taken when the heartbeat rate exceeds the serious threshold. Heartbeat rate thresholds are considered based on the age of the users and the corresponding activities they performed. One small baby's heartbeat rate data is also considered, in which few times the heartbeat rate exceeds from serious range, as shown in the readings, i.e., 529, 617, and 620. In these readings, emergency actions are taken by the doctor as the patient is in critical state. The heartbeat rate at readings 203, 195, and 389 might be considered for elder patients but not for a small baby. The heartbeat rate graph is depicted in Fig. 9.

With the heartbeat rate, the ECG is also considered as one of the medical parameters to monitor user's heart. ECG measures are analyzed for different activities, such as standing, sitting, walking, cycling, jogging, etc. Fig. 10 shows the ECG real-time measurement of one of the monitored users while performing these activities. For physical exercises, such as jogging and cycling, ECG readings have more jumps as compared to other normal activities. Additionally, the ECG reading are also considered as more for these activities as compared to other normal activities. ECG and heartbeat rate are analyzed for more than ten activities. For simplicity, we just depicted the measures of five important activities as shown in Fig. 10.

4.1. Algorithm: fire detection and patient monitoring

To test and evaluate the working of the proposed system architecture, a sample algorithm is designed, which detects fire in the house or another area. Moreover, it also monitors a user for his health by extracting and analyzing the heartbeat rate of the user. Table 1 shows the notation used in an Algorithm 1.

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Overall, more than 2 GB data is analyzed. Also, the temperature dataset file consists of four attributes, heartbeat rate dataset have fifty-four attributes, whereas ECG dataset have twenty-four attributes for each record. The data is simulated and analyzed in Linux environment using Apache Hadoop with MapReduce programming on a single-node Hadoop setup.

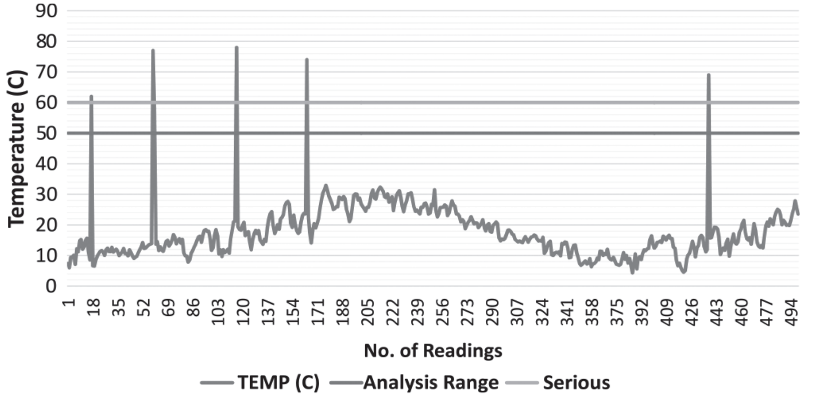

Fig. 8. Temperature of fire data.

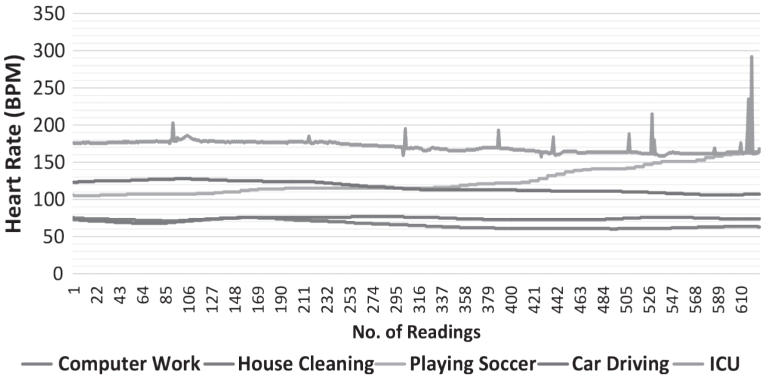

Fig. 9. Heartbeat rate of various patient.

To detect fire in a given scenario based on temperature, we observed that at the time of fire event occurrence, the temperature is dramatically deviated from normal temperature range. Moreover, the light is also flushed with high intensity. We also observed that the room temperature sometimes exceeds the normal range due to a various reason other than fire, such as during cooking time. Therefore, two thresholds are considered, i.e., one is the serious threshold, and other is the normal threshold to detect any fire in a room. For illustration purpose, the temperature data from Fresno city of California, USA is taken and illustrated in Fig. 8.

The serious threshold is considered as sixty Celsius, and normal is consid-

• Fast Response (FR): various services, such as web, roadside unit and vehicle to vehicle communication (V2V), vehicle to infrastructure communication (V2I), and infrastructure to infrastructure communication (I2I) are integrated to facilitate the flexible and quickly respond to the event.

3.2.3. Cyber society domain

The core attribute of the smart cyber society is the cyber society domain, which is composed of various societies, such as hospital (for healthcare system), police and fire brigade station (for security and fire). This domain is capable of receiving service calls from both home and mobile domain by being connected to the gateway (i.e., web server), and reports them to proper authorities, through a reliable communication channel, such as mobile telephone base station (3G/LTE). All the societies in this domain are connected to their actuator and web servers, and thus able to provide valueadded services for a variety of society applications, such as security, healthcare, fire brigade, and ambulance. Hence, the society domain is shared by multiple of other domains for their ease and comfort as illustrated in Fig. 7.

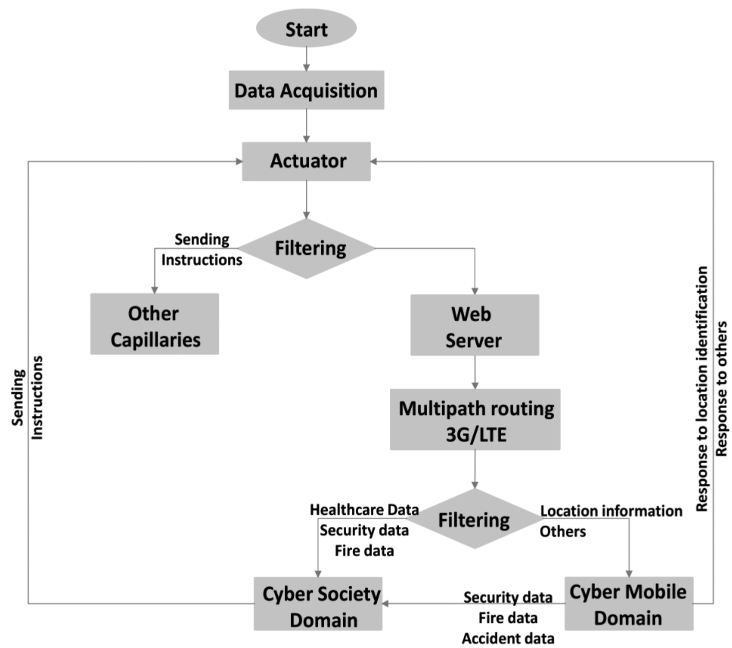

Fig. 7. Flowchart of the smart cyber society communication.

4. Analysis and discussion

Analyses are performed on various sample datasets, which are collected from different locations to design algorithms and evaluate the proposed system architecture. The heart-related medical datasets, such as heartbeat rate corresponding to various activities generated by Reiss et al. [25,26] and ECG corresponding to different activities generated by Banos [27] are taken for analysis purposes. Moreover, to consider the fire detection scenarios, the temperature data is taking covering readings of California State of The USA from National Climatic Data Center [28].

Nowadays, for elderly age citizens with chronic disease, it is crucial to follow or visit the doctors for a routine checkup. However, it is important to make a contact with a physician to discuss various health issues. As mentioned, this is not as easy as it sounds. Moreover, the misuse of prescriptions also causes a severe reaction. Therefore, keeping in view such factors, a system is designed that carefully tackles the factors mentioned above and helps elderly age people. To do so, various sensors are attached to the elderly age people that continuously measure the blood pressure, ECG, and others. Second, an algorithm is designed for the healthcare system (discussed in later sections) at the actuator's end, which handles generating the alert message. If the condition of the user becomes worse (e.g. increase in blood pressure or temperature),a threshold is defined for the said purpose at the actuator's end. If it crosses the specified threshold, the actuator generated an alert message and transmitted the signals to the web server. The web server is connected to cyber society domain web server (Hospital). Upon receiving an alert, the concerned department in the hospital immediately reacts and may send an ambulance or doctor depending on the patient condition. The web server plays a role of cluster head where it can inform other web servers for particular actions.
3.2.2. Cyber mobile domain Before talking about a cyber-mobile domain, we need to pay attention to what cyber mobile is. Cyber mobile is, under the perfect infrastructure (including vehicles, ambulance, GPS, roadside units and the web station), the effective integration of information technology, control technology, sensor technology, and GPS system technology. Moreover, it can applied to roads infrastructure to achieve the real-time monitoring system accurately and with the highly effective transportation system. The cyber mobile domain is based on the cyber transport network (CTS), in which all the vehicles are connected to the roadside units. The roadside units are connected to the GPS system and web station. Such technique helps the vehicle to broadcast its physical location. Hence, cyber home domain and cyber society can easily get various information about the vehicle, such as arrival time, current location, accident, and other. The basic idea of the cyber home domain is illustrated with the assistance of an example. Let us consider one vehicle. A user in a home wants to know its current location. So, the user can easily access it with the help of web server. Moreover, the user in a vehicle can control various capillary devices in a home since the vehicle is connected to the roadside unit, and roadside unit is connected to the web station, where the user can have access to control over its home appliances, such as checking the medical status of the elderly age people, the security system, and control over various electronic appliances. Furthermore, if there is an accident on the road, the desired information is passed on to cyber society domain where the police station, fire brigade and ambulance react accordingly.
The CTS has the following characteristics.

- Application Advancements (AA): the resource facility technique of web computing leads the application service, to facilitate the integration of various services of the mobility resource.
- Interoperation (IO): it supports the interoperation of the cyber mobile domain with the cyber home and society domain.
- Dynamic Resource Distribution (DRD): through resource distribution, calculating the speed of the vehicle, current location with the help of GPS, updating record of vehicle in the web station, sharing the information with the domains.

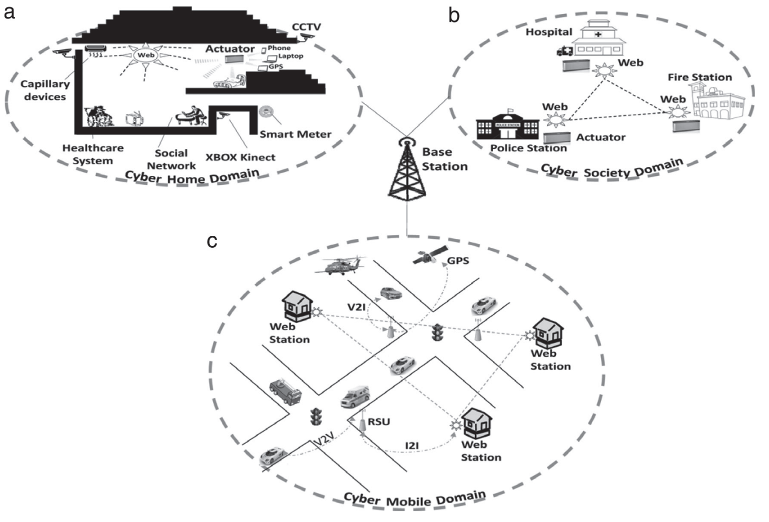

Fig. 5. The smart cyber society architecture: (a) Cyber home domain; (b) Cyber society domain; (c) Cyber mobile domain.

care system for elderly age people, wearable devices, social network, KINECT XBOX for a security system, and all electronic appliances. Such devices monitor realtime monitoring of residents in the home environment. According to the architecture, these devices are connected to the actuator with the help of Bluetooth/Wi-Fi or ZigBee where they can send signals to the web server for further actions. The actuator is a smart, and intelligent device responsible for sending instructions to other devices. For instance, various electronic appliances, such as refrigerator, air conditioning system, television, lights, etc. are connected to the actuator. These capillary devices perform accordingly when the user is at home or not. Furthermore, the KINECT XBOX system is fixed at the door entrance to the security system and is attached to the actuator. The web server has the database of all the users in a home. In case, if a non-user is entering into a home, it compares the characteristics of a new user with the saved one. If it does not match with the database, it sends instructions to the actuator. The actuator is then responsible to inform the appropriate user in a home and displays its result in the smart home, as delineated in Fig. 6.

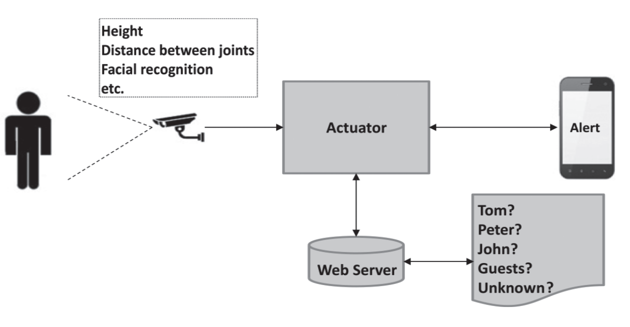

Fig. 6. Typical scenario for identifying objects.

standing in terms of devices and WoT that provide generalized set of functions to capture the knowledge and provide the advanced control logic support. Examples include data and information model and representation of knowledge to establish a successful end-toend connection in WoT.

iii. Accessibility Layer: This layer is a core layer in WoT, which gives access to the Internet as it ensures that things have an accessible web APIs, transforming things into programming APIs. This layer depends on two major patterns i.e. (i) the devices used in the WoT should expose their services through the RESTful APIs at root level connectivity, (ii) if the devices offers RESTful APIs over HTTP, they can acquire an URL and can be integrated to WWW.

iv. Findability Layer: The focus of this layer is to find a way to locate devices in WoT and hence strongly influence the semantic web.

v. Sharing Layer: This layer helps the device sharing instructions (sensors, Kinect, wearable devices, car, GPS, etc.) on the web in WoT. The sharing layer ensures the data generated by various devices in WoT and can share in an efficient and secure manner.

vi. Composition Layer: This layer helps in WoT to integrate the data produced by the devices into high-level web tools (analytical software). This results in creating applications involving things and virtual web services. Tools participating in this layer include (Java SDKs).

3.2. Architecture of the smart cyber society

A smart cyber society is a virtual environment composed of network to various societies and transportation system located in a large geographic area. These different societies include smart homes, police stations, hospitals, fire brigade centers, web stations, GPS, and roadside units. These societies are powered by web application server that is used for integration of various capillary devices (wearable devices, healthcare system, electronic appliances, social networking, and so on so forth) and provide a same communication medium. Architecturally, a smart cyber society is composed of three large domains, such as cyber home domain, cyber society domain, and cyber mobile domain, as delineated in Fig. 5.

3.2.1. Cyber home domain

In this domain, a home network is formed by the interconnected capillary devices with the help of the web server. These capillary devices include a health

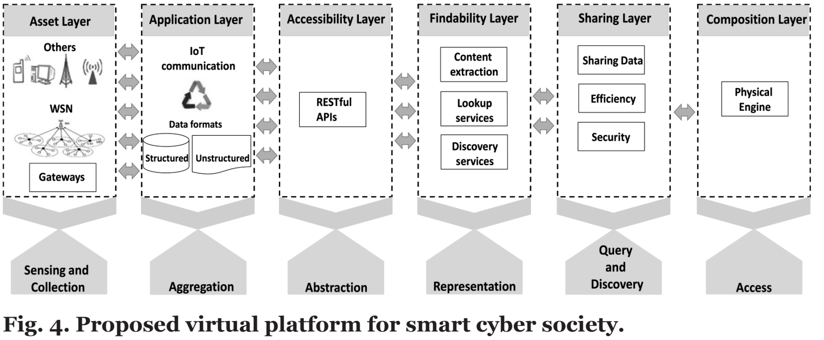

Fig. 4. Proposed virtual platform for smart cyber society.

has only 72.5% successful rate of one step forward detection because of HOG implementation as a vertical range of a person's body fluctuates a lot. So still in this system there is a need to add more sensors to the robot car to avoid obstacles. Second, the robot body should lack most of the critical behaviors of a human, such as to move upstairs and downstairs. Han and Lim's proposed system [21] could not provide support for location services, so there is a need for IEEE 802.15 standard implementation.

Framework for Cloud-based Smart Home proposed in [22] is just an imaginary framework, not practically implemented. Therefore to cater these problems, a stronger emphasis needs to be set on device adaptation, usability and scalability, which can seamlessly accommodate new smart home services. Moreover, we need a system that resolves the issues of interoperability problems of different hardware and software components, the complexity of configuration, lack of universal service consideration, and weak smart home security.

3. Smart cyber society

In this section, we discuss the breakdown of the proposed system into two parts, i.e., virtual platform and the architecture for smart cyber society. Before propelling towards the architecture for smart cyber society, it is worth presenting the proposed virtual platform for smart cyber society. In this way, it will be easy enough for the capillary devices to be interconnected and share useful information using the shared medium.

3.1. Virtual communication platform enables smart cyber society The virtual communications platform for smart cyber society is delineated in Fig. 4. It consists of six communication layers, namely: (1) Asset layer, (2) Application Layer, (3) Accessibility Layer, (4) Findability Layer, (5) Sharing Layer, and (6) Composition Layer.

The above-mentioned communication platform layers integrate the CPS and WoT under the same domain, i.e., Web, which supports the research community to provide the generalized framework and architecture that can help the domestic users in case of security, health, elderly age people and kids, and transportation system. The proposed virtual communication platform is described as below.

i. Asset Layer: Starting from the bottom layer i.e. Asset Layer is composed of the real world entities that are subject to monitoring or controlling with the help of sensors or some other means (i.e. Kinect camera) e.g., people. Virtual characters also come under the umbrella of assets i.e. the subjective representative of various parts of the real world that are of interest of any human being of any organization. Also, assets provide a role of a bridge between the digital world and the physical world. Identification of various assets can be provided by different tags i.e. quick response codes, sensors, and radio identification (RFID), etc.

ii. Application Layer: Applications layer take advantage of the simplification of services that perform common and routine tasks. These services include the various format of data to be converted to a single format that could be easily processed by different machines involved in the WoT network. The various format of data is receiving a device from sensors, Kinect camera and other devices (smartphone, car GPS, etc.). Having a view to establishing a same understanding model between various devices in any WoT is achieved by the application layer. Under such circumstances, where the resources, the asset layer, and the application layer have tangible under-networks more intelligent and automatic. They design smart home device descriptions and standard practices for demand response and load management "Smart Energy" applications needed for intelligent energy based residential or light commercial environment. The control application domains included in this initial version are sensing device control, pricing and demand response and load control applications.

This paper introduces smart home interfaces and device definitions to allow interoperability among ZigBee devices produced by various manufacturers of electrical equipment, meters, and smart energy enabling products. They have proposed a home energy control systems design that provide intelligent services for users. This work is implementation using a real test bed environment. Their work was supported by Priority Research Centers Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology.

Xiaojing Ye and Junwei Huang [22] present a theoretical framework for a Cloud-based Smart home for enabling home automation, household mobility, and interconnection. They claimed that the system was easily extensible and fit for future demands. They only focus on the overall Smart Home Framework, the features and architecture of the components of Smart Home, the interaction and cooperation between them in detail. They did not provide the real implementation of the system. They suggested the use of Cloud computing, and Web services for six smart home application, such as Home Entertainment, Security, Environmental, Health, Information and Communication, Domestic appliances.

Yang Song et al. [23] proposed an IoT based model and simulation scenario. They discussed the family networking technology and proposed several typical smart home system solutions.

Basic networking mode and primary communications technology of smart home are also introduced. Also, a related modeling and simulation study is carried out for Wi-Fi and LTE coexistence scenario.

Their work was supported by "the Fundamental Research Funds for the Central Universities".

2.4. Problems in previous research

Smart home automation technologies have been commercially available already over ten years without becoming such a mass product as expected. The expectations of potential users of mentioned solutions have not yet fulfilled due to missing globally accepted standards causing interoperability problems of different hardware and software components, complexity of configuration and use, lack of universal service consideration, Weak security and insufficient ROI for private residence owners. The main reason

is that, smart environment networks consists of a large variety of content sources (e.g., sensors), multiple information carriers (wired and wireless media) and communication standards which lead to problems of interoperability, administration and reducing the ease of use. Moreover, to provide more humanized services and make household life more comfortable, safer and energy-efficient, smart home applies to smart space environment built at digital home. However, existing smart homes cannot provide more home services with sustained growing digital home appliances.

The current research works presented in Framework for Cloudbased Smart Home "Current trend of domestic and foreign

research" still have some limitations. Haidong Wang et al.'s technique [24] work, the researchers could get an intuition into real-time structural analysis, i.e., easiness towards the timing constraints as well as effects of the integration of the cyber and physical systems upon the system features.

The designed approach could also be extended towards the nondestructive testing power systems before actual use. Similarly, another hierarchical approach has been developed for designing the CPS, which combines the estimation methods with the data mining methods to apprehend the composite behavior of the system at various levels of abstraction [18]. In this technique, the usage of green transportation has been employed, which focuses on the fuel consumption and carbon footprint of the vehicles. In this method, vehicles are moving on the roads under diverse traffic conditions. Whereas, the routing optimization software has been used for cars, streets, and traffic conditions to empower green transportation. The results show that the designed system deliver significant improvements in the fuel consumptions predictions.

Apart from that, very less work is presented in the literature related to smart cities and others, which requires more attention, i.e., incorporation of WoT in the said scenarios.

2.3. Smart home

Many researchers are still working on Smart Home as individually and also with the coordination of some organization. Haidong Wang et al. [19] describe a new concept of interface in a home environment.

They use a smart robot with a smartphone as the brain and a robot car like the body. With this system, a person will be allowed to carry the robot's brain when she is out of their home.

Thus, the brain monitors different parameters such as the temperature at home. On the other hand, when the person is at home, she will be allowed to put their phones on the robot car. By invoking the system, she will have an assist-robot. This assist-robot will act as a new interface in the smart home by following the person and recognizing the individual's voice commands for taking notes, reading notes and controlling smart home devices. They provide a high-level design and use Google voice recognition for user voice recognition. To invoke the Google Voice search itself, they developed

a method by implementing Haarcascade from the OpenCV on Android phone and face recognition web service is developed by implementing the Eigenfaces algorithm.

Nektarios Papadopoulos et al. [20] present a Connected Home Platform and Development Framework for easy design, development and deployment of smart home services by offering a wealth of new exciting smart home experience on top of existing broadband service bundles. The Home Controller is used to integrate connectivity with home devices of various home control technologies. The Service Platform embeds the use of OSGi

technology in the Home Controller that enables the OSG illiterate engineer to develop quickly and deploy home services utilizing the widely adopted automation technologies. The different home network subsystems are interfaced in a joint way through the Network Adaptation Layer, a set of OSGi components known as ROCob. Following the ROCob API Specification, a developer may build various applications, such as presentation layer applications (e.g., a webbased UI), monitoring applications that collect data and send them to a backbone server, and other home control and pervasive applications.

Their work is partially supported by ATRACO. Han and Lim [21] address a new smart home control system based on sensor networks to make home

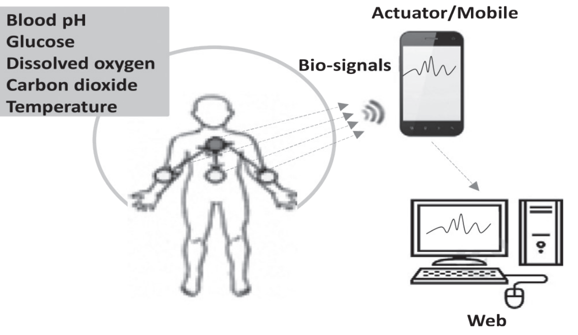

Fig. 3. Remote patient monitoring using CPS and WoT.

A similar scheme is developed of a central air-conditioning system that adaptively adjusts the PID gain using cascade controller [9].
Also, a scheme called CMAC–PID control system for HVAC system is proposed that combines CMAC, neural network, and general PID control. Whereas, to regulate the indoor temperature, a model based on the design of embedded controllers for the integration of building system is presented in [10].
A very less contribution is found in the field of CPS approach for integrating various devices with the help of WoT technology in the home environment. For this reason, related work for room temperature is available in [11], in which two actuators are used for air conditioning and window. However, the extension of the said work is to use another actuator for curtains. Interested reader are referred to [12–14] for more details.
Integration of different devices with the assistance of the Web can be achieved with the help of unique IDs, which interact with other devices, infrastructure, and the physical environment [15].
Various applications are also mentioned related to the machine-tomachine communication (M2M), machine-to-infrastructure (M2I) could be involved. Also, various data mining technique for different people could also be incorporated in the same technology, which generate valuable information for supplementary information. The major advantage of communicating with other devices is that they can go far local computing processing, and take the benefit of the supercomputing machines without human intervention [16].
One of the fascinating areas of the research is context-aware automation and decision optimization, which refers to monitoring unknown factors, such as physical environment, M2M, M2I, etc.
Such approach penetrates the capabilities of 'human-like' to machines [16].
To present such approach in a better way, we are considering a remote patient monitoring system as shown in Fig. 3.
In this figure, sensor nodes sense the human object and transmit the biosignals to the remote station with the help of CPS and WoT.
Various research challenges have been presented in the design of CPS that handles the real-time hybrid structural testing [17].
In such environment, the real-life testing could not be tested and verified prior to on-site deployment, deprived of using caustic testing. Such problem is tried to solve by the authors who proposed a middleware architecture that welcomes cyber as well as physical components. In order to use this frame-

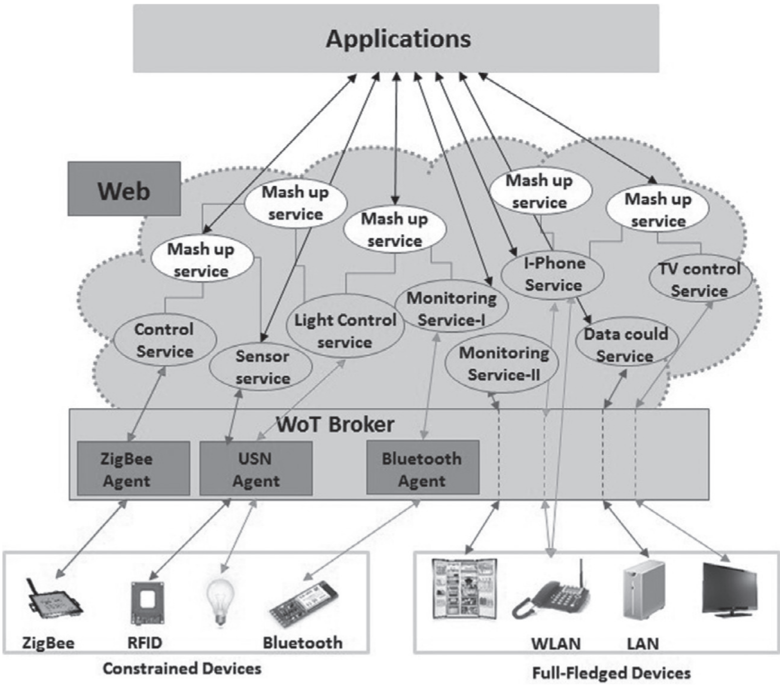

Fig. 2. WoT architecture.

Fig. 2. WoT architecture.

[6] that helps in supporting interoperability of machine-to-machine/Internet of Things communication over the Internet. The purpose of the speech and audio taxonomy is used for partition and label the audio (as an input) into a speech, music, and commercials. Similarly, the integration of real-world objects with the Web by converting real objects into RESTful resources, which could be used over HTTP [7]. Here, first step is to describe a Web server that could be implemented on tiny embedded devices and to convert them into RESTful resources, whereas, second step is to use gateways when there are limitations or devices do not offer a RESTful interface. In such case, the intermediate gateways provide a unified REST API to access devices by walloping actual communication protocols.

2.2. Cyber–Physical System/Internet of Things

The following section reviews some of the major advancement made in the field of CPS and discusses the manner in which these advancements can be useful in the home environment and related areas.

Recently, various research work have been conducted in the home automation and smart home, in which the focus is on how to control the temperature of the house, room with HVAC system.

The various intelligent control system for HVAC system can be found in the literature [8–10]. For instance, a technique based on a feedback control strategy for indoor temperature is proposed in which the building is equipped with underfloor air distribution [8].

can share information using a same communication medium, i.e., the Web. The shared medium is supported by the Web Server and virtual communication platform where a variety of devices is interconnected with each other to form a smart cyber society. The nature of these devices is heterogeneous, which requires a unique platform to exchange useful information. Such facility is provided by the proposed virtual communication platform. Moreover, a smart cyber community architecture is also proposed that consists of three domains, i.e., cyber home domain, cyber society domain, and cyber mobile domain. It can be viewed that these devices (such as, smart watch, healthcare, KINECT XBOX 360, Internet of Vehicles, GPS, and so on so forth), are continuously monitoring the physical entities, and when required, automatic or controlled physical system gives alert to the specific event to improve healthcare, security, accidents, fire brigade system, and so on so forth. The major contribution of the proposed smart cyber society is as follows:

- Various electronic appliances are interconnected to each other with the help of the web-based application.
- The web-based application provides a common application that welcomes all kind of electronic devices.
- The web server is connected to other servers in different societies, which helps in sharing instructions throughout the smart society.
- Finally, virtual communication platform is introduced, which provides a background for the devices to communicate with each other following the same rules.

This system is connected to theWebwith the help of Wi-Fi (IEEE 802.11) and the third generation (3G) of a mobile telephone, as delineated in Fig. 2.

The remaining part of this paper is organized as follows. In Section 2, we give a detailed description of the background and related studies. In Section 3, we propose a virtual communication platform and system architecture for smart cyber society. In Section 4, a detailed analytical analysis and discussion are provided. Finally, Section 5 offers the conclusion of the paper.

2. Background and related studies

In this section, we provide the background of WoT that could be integrated with the CPS along with the related studies in the field of CPS/IoT, and smart home.

2.1. Background

In recent years, we can find the WoT/CPS, and under the anticipation that 1 trillion devices could be connected to each other with the help of Internet by 2020 [2]. Hence, we can assume that the market of WoT would grow quickly than that of the Smartphone.

The concept of WoT is extending the usage of Web into real-world scenarios other than connecting a computer, where Web standards could be used for information sharing, as well as device interoperability.

Such concept could be extended towards penetrating all the embedded devices including smart objects into the Web, as the traditional web services are supplemented with physical world services. Thus, WoT vision enables a new and modern way of constructing the blockade between virtual and physical world [2].

The conceptual architectural overview of WoT is delegated in Fig. 2, in which various smart devices having various capabilities are integrated into the Web. Web standards/services are defined by World Wide Web Consortium (W3C)

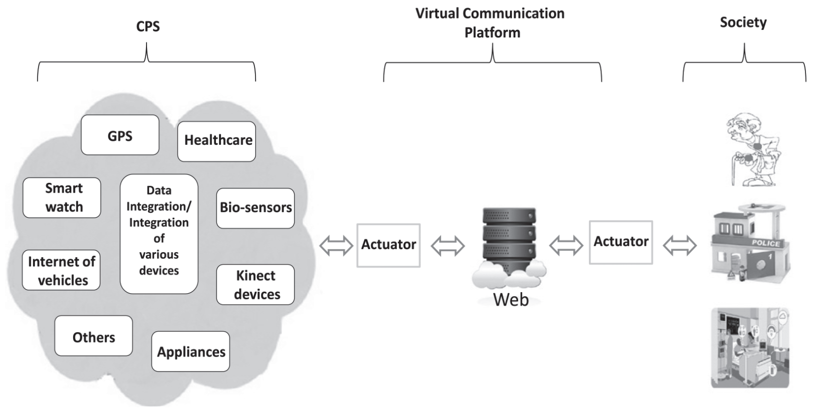

Fig. 1. Skeleton of the designed system.

Other than that, to make the CPS more appealing, a traditional application can be considered i.e., the Smart Home where embedded devices, such as sensors and actuators are self-configurable and can be controlled remotely with the help of the Web Technology. Such kind of technology is used to enable a large variety of security, as well as monitoring application. The involved devices senses user's activities and transmit these data to the remote station (any community services) where it can be processed, analyzed, and predict or give response to the user for his/her convenience
based on the received data. In the literature, extensive research work performed on the Smart Home technology [4] have been observed. Such research work have been focused on individual homes. Similarly, the idea of the Smart Home is also extended towards the Smart Community where Home Domain, Community Domain, and Service Domain are integrated to provide benefits to the human kind. However, such technology is lacking of various factors, such as how to connect vehicles, roadside units, GPS, and other to the same infrastructure, i.e., the central Web.

The concept of Smart Home is further extended towards the Smart Community where a multihop network of smart homes are interconnected with the help of radio frequency [5]. Furthermore, it can also be noticed that the designed smart home (under the domain of CPS) worked under multifunctional sensors, continuously monitoring physical environment (such as security, safety, healthcare, and emergency) for its improvement. However, given the variety of the smart home and smart community contributions,
several challenges need to be tackled in developing such systems.

First is how to integrate various embedded system under a single umbrella, i.e., requires a virtual or physical platform for the exploitation of the smart community. The second challenge is how to integrate various systems since each specific system has its assumptions and strategies to control physical world variables without much knowledge of the other system, which leads to conflicts when these systems are integrated without careful consideration. Having understood the feasibility and potential of the CPS and WoT, in this paper, we drive the concept of smart home along with the smart community to a further extent and introduce a notion of smart cyber community. The smart cyber community is comprised of CPS and the society where they

1. Introduction

Over the last several decades, the usage of Internet has evolved extraordinary around our lives. This technical appraisal underway from the premature research on packet switching and the ARPANET [1]. Such evaluation molded the way each computer shares its information with another using a specified protocol. In this context, the Internet today is one of the advents that becomes a strong medium to connect various people around the globe rather computers. It can be seen that approximately 1.7 billion users

are connected to each other with the help of Internet, whereas, National Science Foundation gives the estimation of 5 billion users to be interconnected by 2020 [2]. Furthermore, the communication aspect of such technology is supported by recent development in the field of Internet, i.e., the Internet is now more possibly become frequently accessible by smart devices, motivating the impression of Cyber–Physical System (CPS).

Traditionally, CPS is considered as the next big prospect and challenge to the world of Internet. The Internet will be no longer considered as the network of computers. However, it will be involved with the billions of smart devices along with the embedded systems. As a result, Internet of Things (IoT) will greatly increase its size and scope, providing a new way of opportunities, as well as challenges [3]. Generally, the Internet with the smart devices can be viewed as constrained IP network, which is having limited packet size, packet loss, and characterized by minimum throughput, power availability, and mainly the complication can be achieved [3]. A variety of research work has been done that address those challenges, ranging from technological aspect towards the social aspect. In particular, a major focus on how to create a full interoperability of interconnected devices, to provide them a higher degree of smartness by considering their autonomous nature, whereas, guaranteeing their security and privacy aspect.

The fact is that the Web is one of the important medium of communication in today's Internet. Contrariwise, web servers have been researched for past decades, resultantly provide a broad range of small web servers. More precisely, today's web services have proven to be essential in producing interoperable applications [3]. Smart devices with embedded web servers can be distant as web servers and flawlessly assimilated into existing web. It is likely to reuse the existing web technologies as well as standards to integrate the cyber and physical world. Therefore, such form of integration can lead us towards Web of Things (WoT) where existing web technologies can be reused to develop new applications. This technique yields more customized and scalable.

In particular, unlike the nature of CPS that provides connectivity among various devices on the Internet with the specific IP, the WoT allows them to speak the same language, so as to communicate and interoperate freely on the web. Such trend of recent advancement is leading us to the latest technology where heterogeneous devices are interconnected with each other and share a common medium, i.e., Web, known as Web of things. Traditionally, as large number of devices are connected to the Internet, the important step is to use the World Wide Web (WWW) as a platform for connecting smart devices, such as sensors, embedded devices, actuators, and electronic appliances, etc. [2]. Hence, smart devices become easier to build on such platforms. Based on such platform, popular various technologies, such as Java, HTML, and Ajax, and so on so forth can be used to develop such application scenarios incorporating smart devices (see Fig. 1).

Smart cyber society:
Integration of capillary devices with high usability based on Cyber–Physical System

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abstract

The recent development in the field of embedded devices, such as sensors, actuators, and smartphones, etc. is providing a great business potential towards the new era of web of things (WoT); in which all the capillary devices (electronic devices) are capable of interconnecting and communicating with each other over the Internet. Therefore, web technologies provide a way towards integrating and sharing a common communication medium. However, for integrating Cyber–Physical System (CPS) and WoT, a comprehensive architecture and platform is still missing. Therefore, this paper proposes the concept of Smart Cyber Society; propelling the concept of smart home. We then propose the virtual communication platform that is composed of six functional communication layers, which provides a common medium for communication, i.e., same communication language. In addition, a system architecture for smart cyber society is also proposed, which consists of three networked domains, such as cyber home domain (networked-home), cyber society domain (networked of various societies, i.e., hospitals, police station, and fire brigade), and cyber mobile domain (networked of vehicles). Furthermore, the feasibility and efficiency of the proposed system are implemented on Hadoop single node setup on UBUNTU 14.04 LTS coreTMi5 machine with 3.2 GHz processor and 4 GB memory. Sample medical, sensory datasets and fire detection datasets are tested on the proposed system. Finally, the results show that the proposed system architecture efficiently processes, analyzes, and integrates different datasets efficiently and triggers actions to provide safety measurements for elderly age people, vehicles and others.

Keywords

cyber–Physical Systems, Cyber society, Virtual communication platform, Web of things (WoT)