A Survey on Recent Trends in Environment Monitoring Based on IoT Application

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Abstract— Environment monitoring is the newly emerging field in significant ways and it influenced many directions. IoT and its progress regarding this area are quite well, but being dynamic in nature environment monitoring required precision in data, therefore requirements of real-time data are increased. The problem of power consumption, communication and computation are still in the development phase in IoT. In this paper, we represent a literature survey about recent trends in the environmental monitoring. We mainly focused on the small scale application and its implementation. Furthermore, our objective is to investigate recent small-scale IoT applications and network layer protocols that are embedded in the small-scale landscape system.

Key words: Wireless Sensor Network, Sensor Network, IoT, Environment Monitoring

I. INTRODUCTION

The environment is a vital part of our living. The significance of the environment will never be ignored from our life. Yet, today, by fulfilling vicious thoughts of the humans, it influences environment severely. In this period of propelling expectation for everyday comforts of person, our environment is getting influenced, as it were, by the methods of air pollution, noise pollution, deforestation, water pollution, soil pollution, acid rain and different unsafe catastrophe made by the people through this technological progression.

Here, how we are dealing with the utilization of advancement in technological innovation plays a noteworthy part. By utilizing most recent invented technological innovations we can give our profitable push to the environment. IoT is rising as a most recent advance technological pattern in the world and demonstrated its advantages to human culture. Environmental pollution is one of the most concerning issues we are confronting at the present time. UN is additionally attempting to spread awareness message with respect to this, however, we haven't seen any recognizable improvement in it. Technological innovation is worth being thankful for yet in parallel we also need to watch our environmental conditions. We require a strong solution which adjusts everything and changes our standard living to better living.

If that we want to make a situation better utilizing most recent technological innovation then Wireless sensor network is most appropriate for observing condition. Major issues in wireless sensor network like energy utilization and communication cost viability make this thought useless. However, due to advancement in WSN sensors and protocols, the sensor turns out to be effective and vitality productive.

Since the concept of IoT appeared, it changed the world. Everything becomes smart today such as smart home, smart vehicle, smart shoes, smart fitness bands, smart toothbrush, smart management system etc. Idea of a smart city is likewise pull in numerous scientists and business visionaries. Governments are dealing with private association regarding this idea and making a decent attempt to influence city to keen. Imagine, people can discover air quality list of a specific region in one touch, if noise pollution brings up in your area then an automated system acknowledge to your Municipal corporation; if water quality of city degrades then a computerized system contact Municipal corporation about the issue. Everything winds up smart and that thing turns out to be a part of the smart city.

Generally, here need of spatio-temporal data raises. To settle on any errorless decision we have to manipulate, analyze and model spatio-temporal data. In the next segment, we have explored the world of sensors and explained miniaturization on the sensor in this field.

II. TECHNOLOGY DEVELOPMENT

A. Sensors

Basically, sensors are used for detecting or sensing surrounding and that could be temperature, humidity, moisture, light, motion, pressure or any number of great numbers of physical phenomenon. After the development of nanotechnology, advancement in sensor development increased in a rapid manner. Size of the sensor decreased after advancement appeared; Micro-Electro-Mechanical Systems or MEMS is the technology to build small size sensors.

These processes include deposition, photolithography, etching and wet etching, and others [1]. MEMS sensors are made up of components between 1 to 100 micrometers in size (i.e., 0.001 to 0.1 mm). They are made out of silicon, polymers or metals such as gold, titanium, or, platinum. The microsensors use standard interfaces to attach to MEMS computing devices.

Fig. 1: Computing devices [1]

Selection of sensors absolutely depends on the ecological conditions. Here in environment monitoring, we need to keep in mind the essential parameters such as humidity, temperature, air pressure etc. Therefore, we need sensors which are capable of doing all those mentioned

activities. To detect certain gases in the air, micro-chemosensors will be useful in this case. Furthermore, some bio-chemical microsensors are also available which can be useful in measuring biological and chemical activities in a small range. There is one sensor specially designed for tree monitoring which is PiCUS. This sensor used for measuring structural root zone movement in high wind area. It uses dynamic wind loading due to uncertainty in the environment.

B. Computing Platforms

Area of electrical and computer engineering has concentrated their vision in the development of tiny size computation platform, as well as the development of an operating system for tiny sized special sensors. Computation platform should be less in size, therefore, it consumes less energy. Another thing is we have to compile fewer lines of code to execute, in the long run, it requires less energy. One of the first software systems has been the development of an operating system, appropriately called TinyOS.

TinyOS is an open-source operating system [2] designed for low-power wireless devices, such a sensor networks, ubiquitous computing, personal area networks, smart buildings and smart meters. TinyOS is especially useful for microcontroller-based devices that have sensors and/or networking capabilities. It's been designed for very resource-constrained devices, such as microcontrollers with a few kB of RAM and a few tens of kB of code space. It's also been designed for devices that need to be very low power. It requires in-depth knowledge of programming our deployed sensor network, the event user interface is also needed for better understanding. Other operating systems and programming environments are Contiki [3] and Sentilla‘s Perk Java-compliant platform for embedded 8-bit and 16-bit microcontrollers [4].

Then again advancement of tiny sized sensors and computing platform, yet much research is required in low-power and robust routing protocol. In environmental condition sensor nodes are sending information in a multi-hop way; total energy utilization in the deployed network is extremely effective. Therefore, we require protocols which send information from one node to other node utilizing minimum energy and hops; also it should automatically be adjusted in case of communication link failure. In 2012 one protocol was standardized for low power and lossy network, which was RPL. Especially for energy issue many protocols based on clustering scheme have been proposed. Among all those clustering algorithms LEACH (Low Energy Adaptive Clustering Hierarchy Protocol for WSNs) gets huge attention as it works in a distributed manner [5], [6], [7]. Selection of cluster head in LEACH is very dynamic in nature and rotated periodically which counts for less power [8]. Yet, this works on single level clustering so it consumes more energy comparatively multi-level clustering. Detailed survey regarding protocols is in the next section.

III. RELATED WORK

A. IoT Applications

Linh et al. [9] address the problem of efficiently monitoring environmental fields in a smart building with the use of the wireless noisy sensor. Well, noisy sensor means a sensor which reads its reading in an inaccurate manner because of the noise present in the environment. The entire set-up took 10 Libelium temperature monitoring sensor and 10 Monnit temperature monitoring sensor which are utilizing ambient condition to monitor temperature. They have utilized a one-hop algorithm for routing the information to the server. Their approach is to prepare a reading model utilizing Gaussian procedures. After making an examination with a prepared model whatever the data they get, they make a decision to managed expected parameters. Still, after the usage of this calculation, mapping natural fields in the entire building is as yet faulty. They have made a perfect situation by keeping air channels and outlets off. You require continuous information with the accuracy of time and space which is precisely utilized as a part of the environmental monitoring system.

Antonnikov et al. [10] authors have proposed an algorithm for choosing an optimal channel for communication. They have utilized a repeater, radio-relay, a cellular network, satellite communication and WI-FI communication. Each hardware has few constraints that are why authors have proposed a system utilizing all of them. Alright, by considering all hardware, the disadvantage of this proposed arrangement is cost. This system isn‘t cost effective. Another flaw is energy utilization by the proposed system additionally not regulated. The flow of the proposed system is as described; when the PC is turned on, correspondence with the estimating system is built up. The information from the sensor is started gathering; the information shaped into records and sent it to the server by means of a selected correspondence channel. For checking the nature of the correspondence station, controller of equipment broadcast communications is turned exchange a pilot signal via the satellite communication system, mobile communication, and radio-relay communication system. While getting response signal, controller equipment breaks down the nature of correspondence by the weight coefficient of the signal level at the input receiver and selects the optimal channel. For fast information exchange, it chooses a channel which had a minimum delay.

Baharudin et al. [11] authors have proposed an approach for tracking a mobile object, an object which is in motion. They have expressed that in conventional wireless technology innovations, for example, ZigBee and Bluetooth distance is noticeably restricted. They have assessed long-range wireless technology utilizing application scenario. As the object is moving, authors have utilized some user parameters, for example, speed, the direction of movement, latitude, longitude, time and date. However, this proposed system is confronting multipath fading impact because of high rise buildings and hills. It influences the signal quality. Multiple sensor obstructions are also likewise present. One advantage of this system is the utilization of or long-range wireless technology which is a reliable interface for long-range wireless information transmission.

Rusli et al. [12] authors have proposed an algorithm for the indoor environment. They have utilized trilateration technique with RSSI. Here RSSI is used for distance estimation and trilateration is used for position estimation. Authors chose Wi-Fi in their approach on account of it is cost-effective and effortlessly deployable. Wi-Fi doesn't require any extra equipment for localization. Wi-Fi is generally, utilizing radio waves of 2.4GHz, yet

today 5GHz is broadly used. In their approach, they have utilized Wi-Fi switches as Access Point in which they have stored all the MAC addresses. As the location is stored in the database, they calculated co-ordinates offline. Wi-Fi analyzer sends stored information to the server. The server performs the trilateration technique. In the outcome, he found that trilateration procedure is inclined to blunder because of signal interference.

Chen et al. [13] authors have proposed higher accuracy localization scheme for the indoor and outdoor environment. Entire set up didn't require any exceptional equipment; accordingly, the system is economically less cost-effective.

As the localization is the significant issue in the wireless sensor system and IoT, they have proposed an algorithm which is light weighted. Their proposed algorithm performed better in the created condition. All things considered, they have talked about future improvement like a scenario in which the hub is moving with high speed. In this situation localization precession will degrade. Second is the manner by which to maintain a similar execution when the distance between two reference hubs is enlarged.

Tree census, Pune, India [14]*:* According to Maharashtra (Urban Areas) Protection & Preservation Of Trees Act 1975 chapter four section 7 (b) once before December 1996 and thereafter once in every five years, carrying out a census of the existing trees in all land within its jurisdiction is mandatory. Thus, Pune Municipal Corporation chose to take a geo-enabled tree evaluation. This evaluation is taken care of by SAAR IT Company. The result of this gigantic task is expected as; *first*, Geo labeling of all trees under PMC purview. *Second*, Search for trees by species, area, or advanced filters for example, diameter, and date planted, or tree characteristics, and so forth. *Third*, photographs of the trees and monitor every last geotagged tree on ongoing premise. For this evaluation, they require few information at a pilot stage, for example, geographic information, tree-specific information, and programming specific information are required. Geographic information will be gathered through GIS base map and for the simplicity of work and verifiability they discretize map in the cluster. As per Pune Municipal record, there are around 500 of the trees are accessible. Each tree has a local name including synonym word and botanical names. Accordingly, it ought to be gathered in the pilot stage. They have anticipated the application; subsequently, they need to transfer all the gathered information on the mobile application. For the evaluation of the tree, they need to take in some particular botanical skills for recognizable proof of tree likewise they have to remember that they need to give constant information of tree [15].

Agriculture and the 'Internet of Things', Australia [16]*:* Australia is working on battery farming with the help of IoT devices. Agriculture, more than almost any other pursuit involves daily interaction between humans and very complex physical environments – the land and its soil, water and vegetation, farm equipment and machinery, animals, seeds, chemicals and other inputs, fuel, vehicles, buildings, tanks, and fences – the list goes on. Australia already designed LoRaWan (a Low Powered Wide Area Network) and Bluetooth network specifically for IoT connectivity. The core infrastructure was like; sensor measures change in the environment and send data to a central computer for analysis, as this is real-time data so it is huge in size and not in human-readable format. To make sense of this huge gathered data, big data analysis is required.

Yang et al. [17] have developed system which is based on wireless sensor network to measures industry CO (Carbon Monoxide) all the time. Because of energy utilization issue, this system didn't demonstrate the level of CO persistently. They planned three distinct modules: rest, wake up and execution. Dozing time for every hub is for 5 minutes, after this time one router sends a signal to each station for beginning up. Sensor hub restores a reaction signal, and the position in the coordinate arrangement of PC or cell phone is situated by doing this they can decide the nature of the sensor and the recently included sensor hub. Following a moment of information obtaining, the CO concentration of every hub can be shown.

Werner-Allen et al. [18] research groups from Harvard, the University of New Hampshire and North Carolina have collaborated for several sensor network deployments in the remote, inaccessible area at the active volcano Reventador in Ecuador in 2005–2008. They need to test the capacity of the sensor to measure the tremor occasions of the liquid magma. They set up sensor coordinate with TMotes sky utilizing the thesis-acoustic sensor. If we monitor reading consistently then it would deplete the battery quick. So they discovered one solution for this, they utilized short-term average and long-term average based on locally stored examples. If the difference is greater than a threshold, at that point the hub would make an impression on the station. If adequate hub reported for an occasion at that point base station triggers a demand for information gathering. Prior to the information accumulation ask for set off, the hub utilized local storage for finding the short-term average and long-term average.

Nittel et al. [19], Yang et al. [20] and Jiang et al. [21] discussed *oceanographic monitoring* via sensor network is called *mobile sensor network*, the design, implementation, and deployment of a WSN for oceanographic applications poses new challenges different to the ones that arise on land, as the impact of the marine environment on the sensor network limits and affects their development. After the drawbacks in a marine monitoring system with WSN has been done, for the solution purpose they have in common that is they are largely designed and implemented ad-hoc (buoys, electronics, and software), and oceanographic sensors and some other components are normally the only element aquatic acquire from third parties.

If we are talking about mobile sensor network, New Zealand, UK and even India are using this approach for *habitat monitoring*. In New Zealand, under FLAGS [22] projects done by Australia, they measure the sheep flock by attaching sensors on sheep. With the help of this, they monitored and control sheep flock. The same way in the UK, they attach the sensor to monitor the activity of badger [23]. This project was done with the collaboration of Oxford and Cambridge University. They collected 400,000 observations per week, for routing of the data they used is based on routing protocol. Power utilization was the problem though, 18Ah 12V batteries didn_t last long. Even in Gujarat, Gujarat government started census of Asiatic lion in Gir sanctuary using RFID tags. The government started

monitoring and observation of lions and in 2015, the lion census pegged the population at the national park at 523 [24].

B. Network Layer Routing Protocols for IoT

Gaddour et al. [25] have presented brief literature survey about low power and lossy network protocol, RPL. RPL is a routing protocol for low power and lossy network. To support large-scale network IETF has defined this routing protocol. RPL is distance vector routing protocol, it does not contain pre define topology but it will generate through the construction of DODAG (Distance Oriented Directed Acyclic Graph). It is a tree-like structure in which one node allows to have multiple parent nodes. The DODAG topology maintains with control messages such as DODAG Information Object (DIO), DODAG Information Solicitation (DIS) and Destination Advertisement Object (DAO) messages these all messages belongs to Internet Control Message Protocol (ICMP).

Collection tree protocol [26] is distance vector routing protocol. It is predecessor to RPL and was considered the de-facto routing standards for TinyOS. It makes tree based topology with root node at sink of the network. It also uses adaptive broadcast routing beaconing mechanism to broadcast routing control message. Collection tree protocol knows for efficient energy utilization and high packet Reception Ratio.

Lightweight on-demand ad hoc distance-vector routing protocol-next generation *LOADng* [27] is a lightweight variation of AODV for Low power Lossy Network. It is made on the suspicion that most of the time LLN is ideal. LOADng is utilizing reactive routing approach, in which routes are built up just when there are some data to send where adoptive routing approach increases superfluous overhead. LOADng doesn‘t have root like node which performs uncommon functions. As LOADng is light weighted protocol its data format is compact and adaptable, along these lines there is no plausibility stay exhibit for information fragmentation. Adaptable data format impose to adaptability in routing rules. The real drawback is of this protocol is higher delay in route revelation stage.

Sno	Protocol Type	Server Technologies	Security	Storage Management	Data Management
1	RPL	Yes	No	Yes	Yes
2	CTP	Yes	No	No	No
3	LOADng	Yes	No	Yes	Yes
4	LOAD	Yes	No	Yes	Yes
5	CORPL	Yes	No	No	Yes
6	CARP	No	No	Yes	Yes

Table 1: comparison of Various IoT network layer protocols [32]

CORPL Routing Protocol [28] is fairly adjusted variety of RPL. It retains Directed Acyclic Graph (DAG) from RPL and presented new approach for permitting its use in subjective radio conditions. There are significant two key steps in this approach; *one* is choice of forwarder that implies every node chooses various next hop neighbor nodes to forward information and *two*, coordination scheme that guarantees that lone the best collector of every packets of best recipient forwards it, i.e. one of a unique forward selectors. This protocol keeps up forwarder set and from kept up set best sending recipient will be deftly chosen. For DAG development, CORPL takes after an indistinguishable methodology from RPL. After recognizing void channel, gateway node send DIO (Destination Information Object) message. The forwarder set is built in such way that each forwarding nodes are in the transmission scope of each other. Each node constantly refreshes their neighborhood information and progressively prioritizes its neighbors with a specific end goal to make the forwarder list.

Channel-aware Routing protocol *CARP* [29] is multi-hop data delivery to sink for Wireless Sensor Network. CARP is made for underwater communication. It guarantees short information packets conveyance however may not concern about longer information packets. Execution of CARP is demonstrated superior to FBR (Focused beam routing protocol for underwater acoustic networks) [30]. Before sending information packets, interface nature of relay node ought to be considered as imperative parameter. Applicability of CARP is tested in progressively sea condition. However, there may have superfluous control packets sent amid choice of relay node yet it can be maintained a strategic distance from in certain circumstance. CARP is utilizing exceptionally basic topology information such as hop counts for routing, consideration of residual energy and buffer spaces, and exploiting power control, if accessible, for choosing transmission controls with the goal that short packets encounter comparable Packet Error Rate (PER) of longer packets.

E-CARP Routing Protocol [30] is upgraded variation of CARP which is created for sending packets from sensor nodes to sink node in energy efficient way. CARP doesn‘t consider sensory information collected at sink node which might be helpful for certain domain applications. E-CARP permits caching sensory information at sink node. CARP reply a PONG control packet whenever receives PING control packet, when selecting most proper relay node for packet forwarding. At the point when the system is moderately enduring, by then this PING-PONG procedure may not be required. Therefore, this observation leads us to improve relay node determination technique in CARP. This change has been done in E-CARP and in simulation it diminishes communication cost and increase the system capacity to vast degree, particularly when the proportion of packets measure between control packets and sensory information packets is generally huge.

IV. RESEARCH CHALLENGES

Here we have talked about small-scale sensor network application and their type, yet it raises new challenges. Their goal is to make a small-scale network which tests geographic events occur in the environment but battery supply turns into the primary research issue. And at the product level or computing platform level additionally a few issues are raised.

In this section, we will go to investigate research challenges in the current embedded system. The *principal challenge* that we experienced is power utilization. Some way or another we need to lessen power utilization so we

can extend sensor network lifetime. The other method to decrease power utilization is to assemble context-aware systems which just wake up when a particular geographic occasion happens. In any case, the disadvantage is that we can't get ongoing information. *Second*, Most of the present systems are dealing with GIS that is incorporated geographic data framework utilized for capturing, managing, analyzing, and displaying all types of topographically referenced data, yet it is costly software [1] and it takes various measure of contribution to be reasonable for a few errands. Even the earth is round and if we have to measure large scale area the error would be increased.

Third, information administration is kind of problem here, we deploy sensor network, as well as traditional sensor network and both, are collecting information in real-time so the processing would be tough there. *Forth*, the programming interface is extremely perplexing today e.g., TinyOS. TinyOS is an open-source operating system [2] designed for low-power wireless devices, such a sensor networks, ubiquitous computing, personal area networks, smart buildings and smart meters. TinyOS is particularly helpful for microcontroller-based devices that have sensors and/or networking capabilities. It's been intended for exceptionally asset, for example, microcontrollers with a couple of kB of RAM and a couple of several kB of code space. It's additionally been intended for gadgets that should be low power. It requires in-depth information of programming our deployed sensor network, the event user interface is also needed for better understanding.

Fifth, with continuously wider spread utilization of sensor platforms, sensor information coordination is of key significance to empower an alleged ―Sensor Web making. It is simple to share one's sensor information streams and use the ongoing sensor information from different organizations for one's applications [1]. The other challenge is to know about specific domain before deploying sensor network there. We need to get information about particular geographic marvels so we can investigate the last outcome which is given by sensor.

V. Conclusion

Previous, wireless sensor network was not so mature field of interest, but after inventing intelligent sensor, this filed spreads new wave in the world. Especially in environment monitoring, this field requires precise and context-aware data to reach some certain conclusion. After growth of IoT, the world has seen the capacity of sensors, that we can combine with our traditional sensor and can produce some quality output. We can overcome some of the challenges using IoT with traditional sensor platforms such as power utilization and information analysis.

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