International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8, Issue-7S, May 2019

Location Based Secure Energy Efficient Cross Layer Routing Protocols for IoT Enabling Technologies

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Abstract: ***Internet is getting integrated into almost every aspect of our lives. Almost all new technology is now becoming a part of Internet of Things (IoT) networks. Due to the addition of numerous devices, the network of IoT is getting larger and larger. All these devices use internet to communicate with each other for transmitting and obtaining data. It is used in various fields from cellular technology, transportation, medical devices and even home appliances. This paper has surveyed the different layers of IoT framework and suggested cross layered routing protocols for better communication within the layers. Since, location based protocols are more important and is used for determining the position of destination nodes before sending the packets, they are surveyed in this paper. The traditional signalling architecture are discussed along with the applications of each layer and it has been concluded that node location data can be used by utilizing restricted flooding approach for obtaining a lower network overhead.***

Index Terms: ***Cross layer, Internet of Things, Energy efficiency, Routing protocol, location based***

I. INTRODUCTION

IoT is defined as the technology that strives to interconnect and join all the devices within the same network. This is made possible by using Wireless Sensor Networks (WSN) which plays a major role in implementing this technique [1]. It is a technique which is normally utilized for identifying the system containing unique objects that can be identified which are naturally independent and hence will have the ability to get connected to the internet for presenting and exchanging real time data in a digital format. IoT has lots of similarities to Networked control System on the basis of Industrial WSN. This persists the WSN technology to be implemented in industries [2]. These devices usually contain sensors, processors, transceivers, energy sources, etc. for monitoring their environment and transferring the necessary data. It is used in a various fields like home automation, transportation, surveillance, healthcare, etc. [3]. The design of the devices depends upon its usage in the available equipment for Wireless Sensor Network.

Conventional protocols follow strict rules for the communication between the layers. This is done for ensuring faster deployment and efficient implementation.

Revised Manuscript Received on May 05, 2019.

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However, there is no coordination between the different layers and this hinders the performance of the architectures due to the problems in transmission. In order to overcome this limitation, cross layered design is proposed as an alternative. This will keep the functionalities of the original layers, but allows to coordinate and interact the functionalities linked with the available layers and joint optimisation of protocols using different layers.

II. LAYERS OF IOTFRAMEWORK

There are five layers in the IoT frameworks. These are built on already available TCP and IP structures. The layers are Perception Layer, Data Processing Layer, Transport layer, Network layer and Application Layer as shown in Figure1.

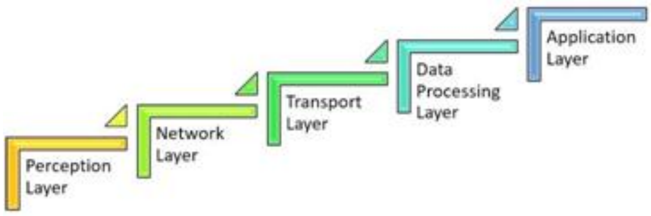

Fig. 1 Layers of the IoT Architecture

A. Perception Layer

The bottom most layer in the model is the perception layer that is also called as the physical layer, which assigns various features like electrical, optical and radio of the channel. This layer selects the required modulation technique and the bandwidth. Its quality is calculated using Peak Error Rate (PER). At the same time, the data link layer controls the flow of data. It creates frames from packets and contains two sub layers, each for controlling the media access and the logical link. The logical link control contains common interfacing, flow control and reliability, whereas the media access control has the physical addresses for framing them. Hence, these two layers may be used for cross layered applications and give techniques like Adaptive modulation and Coding, scheduling, etc. The information from the physical objects is present in different networks like RFID, GPS and sensor networks. The interaction between these nodes have physical objects that collect the data periodically, coordinates the nodes that transmit the raw data through the network, frame the control instructions sent to the actuations in the network, execute these instructions in these actuation nodes [4].

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B. Network layer

The next layer is the architecture is the Network layer. Connections are established through common network devices and then IP addresses are assigned individually. The network layer uses Internet Protocol security for providing the confidentiality, integrity and authentication of data. The functionalities like Data addressing, data routing, and translation of logical addresses to physical addresses are provided.

C. Transport Layer

The next upper layer is the transportation layer and its main work is to ensure that there is a good amount of communication. It is known that the transmitting and receiving the data consumes more energy when compared to the energy consumed while processing the data, hence is necessary for the sensor objects to show the different phases while transmitting the data packets. It utilizes UDP and TCP protocols to perform appropriate communication. It also allows compressing the header, fragmenting the packet, reassembling and routing the edges. The major function of the transportation layer is to address the objects in the IoT which is mapped to only one address, integrating the network using different heterogeneous terminals, managing the resources by efficiently by utilizing the resources efficiently.

D. Data Processing layer

This layer focuses on formatting the data and giving a schematic understanding of the data that is gathered. The functions of this layer involve analysing, storing, querying and mining the data. The layer utilises a combination of computing strategies, database storage and intelligent processing for handling large volume of data.

E. Application Layer

This layer wants to converge between the social needs of the IoT and the industrial technology. It is structured at the upper part of the framework and provides different IoT applications like status monitoring, operational control, public enquiry and other value added services for using in collaboration services and interconnections between the things. When this data is analysed and processed, the data is used by this layer for providing the users. The business strategies of the IoT applications like management and charges are defined. The services based on the data obtained through security protocols, analytics, processing models and management devices are also rendered.

III. TYPES OF CROSS ROUTING PROTOCOLS

The cross layered routing techniques for IoT applications is different from traditional single layered routing technique since it allows the communication of different layers between themselves without any dependency on the intermediate layers. Open System Interconnection (OSI) models are used to decide routing decisions that involves as shown in Figure2.

Different parameters that are available in the above layers help in improving the robustness of the protocols along with the parameters which reduce the quality of the links like congestion and interference [5].

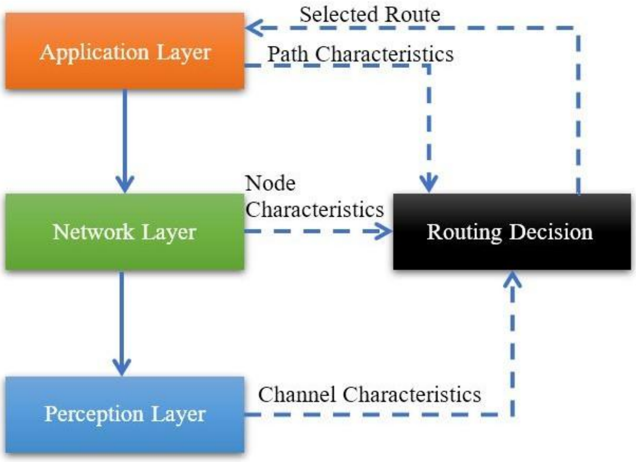

Fig. 2 Decision Making for Cross-layer Routing

One type of these parameters are the Signal to interference and noise ratio (SINR) that is present at the physical layers of wireless networks for determining the interference. Some other parameters that are present are the buffer spaces that makes sure that the congestion is avoided in the network. Other parameters that can be considered are the round trip and hop-count. The classification of the cross layer routing protocols is discussed below along with the limitations and perspective solutions for overcoming the selimitations.

A. Location Based Protocols

Location-based services are utilized for determining the positioning of a targeted node before sending the packets. The location of the neighbours are typically obtained by sending positioning services to all the layers. These systems are sent at regular intervals by each of the nodes. The nodes must ensure that the location of particular nodes is maintained in the network. There are three major kinds of techniques for forwarding that have been utilised, which are greed forwarding, restricted-directional forwarding and hierarchical-forwarding. In the first technique, the transmitting nodes utilize the estimated positional data of the target node for sending the packets through the location services. The route establishment and maintenance phase of the routes are not involved in this type of forwarding. When the nearby nodes get the packets from a transmitting node, they are forwarded again to the neighbouring nodes towards the targeted node. This continues till it reaches the destination nodes. The decision is made according to the requirement of the algorithm. Another type is the hierarchical forwarding which is utilized for hierarchical network structure. Here, the nodes that contain the highest energy may be used for processing and forwarding the data whereas the lower energy nodes may be utilized for sending the data.

Therefore, energy efficiency in the routers is achieved and also the lifetime in the network is increased. In the flooding technique, the packets that come in are sent to all the neighboring nodes at the same time. This is done till all the nodes are covered and the data reaches the targeted node[6].

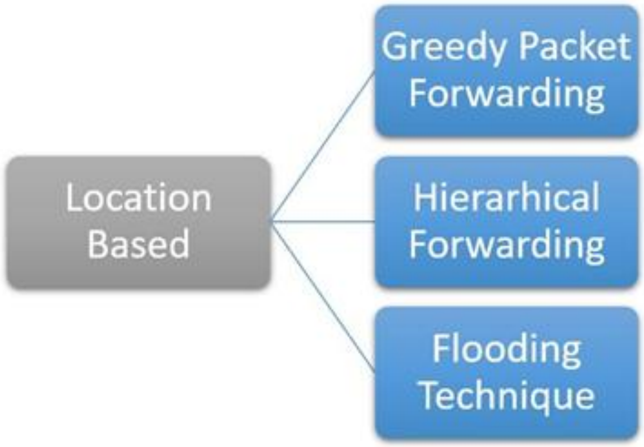

Fig. 3 Types of Location Based Routing Protocols

Location-Aided Routing (LAR) have been proposed in [7] for mobile ad-hoc networks where the positional data is utilized for routing the restricted LAR. This is done for reducing the routing overhead and energy usage in the network. Two different LAR schemes are performed. In the first one, the zone is rectangular and includes both the transmitting node and the targeted node. When the request zones is small, then the range of the routing searches will also be small. A location based protocol known as "Energy-Efficient Location-Aided Routing" (EELAR) was proposed in [8] for utilizing the location data of the nodes with the aim to decrease the routing overheads in MANET. It contains a BS that keeps a position table storing the location of the all the MANETs. From the results, it has been seen that the proposed framework has superior methods in reducing the usage of energy of the network nodes by reducing the region of discovery for the new route.

An efficient Greedy Location-based Routing protocol has been proposed in [9], where the efficiency of the location aided routing protocol has been improved. A baseline has been used that partitions the line between the transmitting node and the target node. This is utilized for broadcasting the requested packets in the zones for discovering the routes. The nodes with the smallest distance is chosen as the next node. The results have shown that the basic LAR and the proposed GLR can reduce the overheads in the network and improve the overall lifetime. A Location based Energy Efficiency routing known as Location Aided Energy Efficient Routing (LEER) has been proposed in [10] for wireless sensor networks. Here, both location and the residual energy have been considered. Only the nodes that are nearby take part during the forwarding whereas the other nodes are converted to idl estate. The results of the proposed technique is compared to the available technique AODV on the basis of mean end-to-end delay , PDR and mean power consumption in the network.

Another routing protocol known as "Anonymous Location- Aided Routing in Suspicious MANETs" (ALARM) has been proposed by [11] for providing both secure and private features for the node authentication, data integrity intractability and anonymity in MANET. It has been seen to be efficient. In the same year, [12] has proposed an algorithm that used location. It used a WSN for automation at home and was known as WSNHA-LBAR. The proposed routing protocol used cylindrical request zones thereby reducing the routing control overhead and broadcasting storms. It has been seen that the self-adaptive technique was used for adjusting the size of the request zones. The proposed technique utilizes the location data of the sensor-nodes for restricting the flooding routes that search space to a small predicted request-zone that denotes the zone of route searching. It has improved the reliability in the network and also diminished the routing-overheads in the networks.

A hybrid protocol called Im-proved Hybrid Location-based Adhoc Routing protocol (IH- LAR) has been proposed in [13]. This technique combines both AODV routing with the geographic routing in order to overcome the problems and improving the performance. From the results, it has been seen that the proposed routing protocol works better than the pure reactive routing on the basis of delivering the packets and average delay, when compared to other protocols. A Location based Opportunistic Routing protocol (LOR) has been proposed by [14] to reduce the problem of data delivery for higher dynamic networks. In order to track the targeted nodes, more work is required. The results have been compared with GPSR and AOMDV routing algorithms to show better PDR and reduced end-to-end delay.

Another location based cross layered routing protocol (CLMHR) has been proposed in [15] on the basis of LAR routing protocol. Here, the cross layering is applied with the physical layers for more effective routing. The proposed routing protocol increases the life of the network and maintains the network equilibrium. Another framework called "Anonymous Location-Based Efficient Routing Protocol" [ALERT] has been proposed in [16]. The proposed system splits the region in the network into different regions and chooses the nodes in the relay. It is compared to GPSR routing protocol for significantly achieving routing efficiency.

IV. CROSS-LAYER SIGNALLING ARCHITECTURE

The exchange of data between the different layers of the nodes is not direct and must be able to jump between the layers without visiting the layer. Hence, protocols must be put into place to identify the method of data transfer between the layers. Several researchers have developed cross layered signaling architecture for this purpose.

A. Inter layered signalling g pipe

In this type, the signals are transmitted using a signal pipe between the inter layers along with the packet data propagation within the protocol.

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Table. 1 Comparison of Cross-Layered Routing Protocols

Protocol	Overhead	Scalability
LAR[7]	Low	Good
EELAR[8]	Low	Good
GLR[9]	Low	Good
LEER[10]	Low	Good
ALARM[11]	High	Bad
WSNHA	–	
LBAR [12]	Low	Good
IHLAR[13]	High	Good
LOR[14]	Low	Good
CLMHR[15]	Low	Good
ALERT[16]	High	Bad

It can either work in a top to bottom approach or the bottom to top approach. This is one of the earlier techniques of cross layer signaling [17]. The messages in the signal are sent layer to layer along the flow of packet. The main thing in this technique is that the signalling data may be linked with specific incoming packets or the outgoing packet from the stack. This may be implemented by en-capsuling the signal data into packet headers. This can be seen in IPv6 headers [18]. It can also be done by formatting the packet structures allocated by the protocol stack internally. In general, the signalling method that utilizes the packet structures is more favourable since its processing overhead is low, better flexibility and simplicity at the protocol layers. The general representation is given in Figure 4.

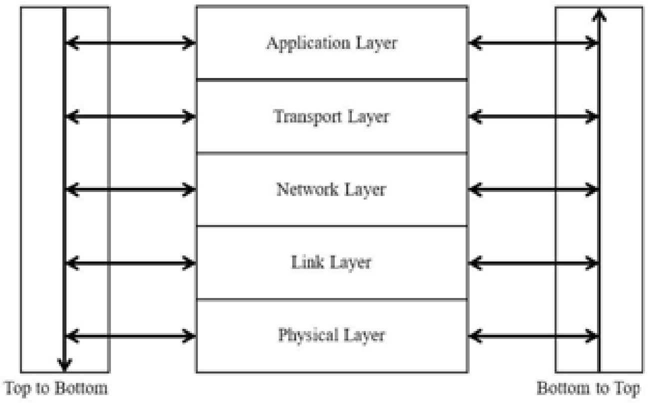

Fig. 4 Inter layered signalling pipe

B. Data Exchange using direct interlayer

This technique is better for inter layer signalling pipes by using signal shortcuts. The layers that are not nearby can communicate with each other without the intervention of the existing layers. The variables may be visible one layer at a time during the run. In an orderly architecture, each of the layers manages their own variables, which are hidden from other layers. Figure 5 gives the representation of the direct interlayer.

C. Plane of middle cross-layer

This is one of the most widely used structures since a single parallel structure is able to transfer data between the layers directly. It is also known as Cross layer Server and use the clients average protocols at different layers. The main challenge in this type is the interactions between the different layers and the shared database. The representation of the cross layer server is shown in Figure 6.

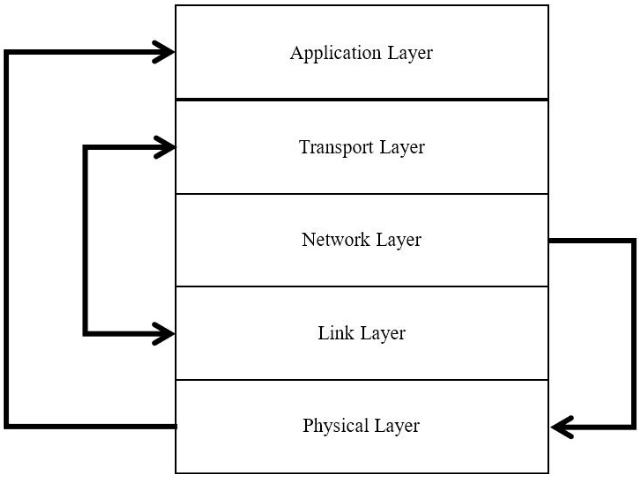

Fig. 5 Direct Inter Layer

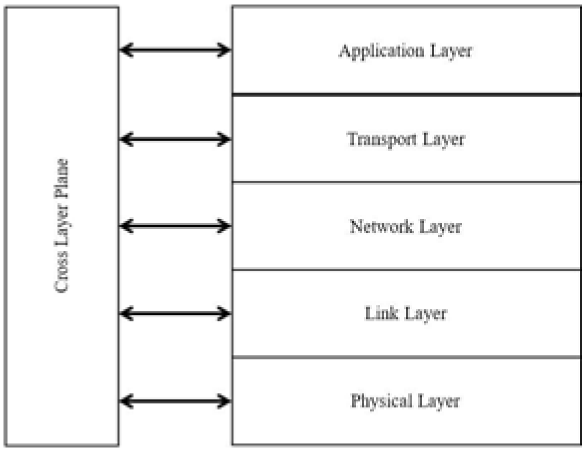

Fig. 6 Middle cross-layer

V. LAYERS AND ITSAPPLICATIONS

The conventional Transmission Control Protocol (TCP) / Internet Protocol (IP) performs data encapsulation in terms of standardized network connections and gives ideas for implementing the design of the network. Also, the Open System Interconnection (OSI) model is used for the same encapsulation and affects the service quality and the time of response. It also brings problems in the overhead.

In order to solve these issues, different studies have proposed many cross layered designs that are able to exchange data with the other layers thereby improving the quality of service with respect to security, performance and mobility. It also aids in creating communications between different networks and different devices.

The networks in the IoT enables end to end communications by using multiple layers present in the model [19]. The different layers available are transport layer, application layer, data link layer, network layer and physical layer. However, the communication is possible only between the neighbouring layers and it is not possible to

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communicate between other layers. With this kind of design, it provides only restricted interaction between only two of the neighbouring layers, and cannot provide any communication between any other layers. This design provides features known as data hiding for which the intended data sharing cannot be performed between different layers resulting in multiple problems. When there is failure in connection, the feature hides the actual reason for the failure, hence it is not considered as a solution for repairing the connection [20]. When there is a disturbance in the connection due to noises in the network, then there would be lots of failure in these networks with the same amount of connection attempts in the network and this will cause lots of problems. When there are disturbances in the connection again due to noises in the network, there may be lots of connection failures and hence the network tries to reconnect multiple times. This re- connection is costly since the connections have to pass through all the layers [21]. These problems can be solved using cross layered designs. There are many applications of cross layer design.

The physical layer defines the various attributes like optical channel, electrical channel and radio channel. This layer is responsible for identifying the necessary modulation technique and the necessary bandwidth. Packet Error Rate is used to measure the Quality of Service. Whereas, the data-link is used for controlling the flow of data. It creates frames from packets and consists of two sub layers which are MAC and logical-link control. The MAC uses the physical addresses to frame, while the logical link control brings in common interfacing, reliability and flow control. These layers may be utilized for cross layered design and provides various methods like Hybrid ARQ/FEC, Adaptive Modulation and Coding, opportunistic rescheduling, etc. When the Adaptive Modulation and Coding are considered, the modulation of the link quality is based on the controller. When the quality of the link is high, then there is an increase in the modulation. On the other hand the modulation is reduced when the channel gets degraded. This aids to achieve the optimum usage of link capacity. In cross layered design for data link and physical layers, the Automatic-Repeat Request (ARQ) and Fault error-correction (FEC) are combined together for creating a hybrid layer. The ARQ and FEC are both data link layered protocol. There are two types of HARQ methods which are combined chase method and the incremental redundancy method [22].

These methods may be utilized for obtaining the results from other coding techniques like based interleaved or bit interleaved. When the initial coding rate is increased, then the coding gains are increased in both these methods. These layers may also be used for opportunistic scheduling. For opportunistic scheduling, the base stations are used to divide the channel into small-time slots. Transmission Time Interval (TTI) is the smallest time interval that is required for the links to adapt and make scheduling decisions. By utilizing this scheme, a large download speed may be obtained. In the Open Source Interconnection model, the third layer is the network layer and this can be based either with connection or without connections. In the case of TCP, the network layer is not based on connections, but without connections. This layer is mainly responsible for using routers to forward the packets using the IP addresses. The cross layered design can be applied on this layer also. One of the cross layered technique for this layer is the Radio Resource Management and Mobility Management. The mobility information that takes place within the session and the information that takes place outside the session can be grouped together for predicting a common scheme. The mobility information within the session is obtained during the call, whereas the information obtained outside the session is the information between two calls [23].

By using this mobility management along with the provisioning of QoS in the RRC module can be done. In addition to physical and application layers, the radio resource module in the networking layer may be utilized for designing a cross layered architecture in CDMA network increasing the network utilization and resolve the different constraints. They are Signal to Interference Ratio constraints available in the physical layers and blocking probability constraint for the networking layer [24]. Another application in the above layers is the cross layer relay control. The measuring relay is placed between the Media access control and the Radio resource control. Also, the physical layer is one that estimates the Markov channel[25].

Transport layer is the fourth layer in the open source interconnection model that is responsible for the management of the transportation from the sending node to the target node. It is also utilized for identifying the data loss, defining the sequences, re-sending the data and rechecking the data. The layer is responsible for adding only the headers. In addition, it also provides flow control, reliability and multiplexing. It is also responsible for transporting the data between the hosts. The performance obtained by secondary users is one of the determining factors of the QoS for the cognitive radios. Cross layered designs in the transportation layer uses spectrum-sensing and takes access decisions. It also considers the coding schemes and modulation when the physical layer is taken into consideration. Whereas for data-link layers, the throughput of the TCP is reduced by utilising the frame sizes [26].

VI. PROBLEMS FACED IN CROSS LAYERED ROUTING

There are few problems faced in applying cross layered routing, and they are listed out below.

A. Hard to Redesign

The different layers are interleaved tightly with each other and most of the protocols follow the traditional architectural design. These conventional designs are well suited for wired connections, but for wireless IoTs, it does not work well. Hence, novel cross layered designs are necessary for better performance of data transfer between the layers and uncovering the dynamics. But, it is difficult to review and redesign the cross layered routers since an alteration in one subsystem may lead to changes in the other parts[27].

B. Lack of Standardization

Since the conventional systems were not suitable for wireless techniques, there was a rapid implementation of novel systems for wireless networks. Due to this, different types of protocols started to pop up without any uniform standard. The multiple frameworks that came into existence did not gain any acceptance since there is no standard for the routing protocols. This has led to multiple problems and resulted in an overall reduced performance in the network. It is also not clear how the different frame works are implemented since each of them follow different standards.

C. Coexistence with Other Wireless Protocols

The increase in the number of cross routing protocols has resulted in the problems since it is difficult for multiple problems to coexist with each other. These problems will be able to alter the stability and reach of the network. A cross routing network has different algorithms located at multiple locations. Hence, it will not be able to cover a dynamic network wireless networking framework. Such existence of different incompatible protocols won't be appropriate for different application due to the presence of the available problems [28].

D. Security

One of the main features in IoT is heterogeneity which leads to security challenges in the protocols. This impacts lots of infrastructure protection. Zigbee can be considered as a case study, where it must be able to generate sage communication channels with stronger devices like smart phone communication with cellular networks. This requires multiple encryption algorithms for managing the secured protocols and keys for communicating with various different devices based on the Internet [29]. This may be obtained from privacy by design and transparency with respect to the management of the user data. The other is the identity management with which the devices in the setup can be uniquely identified. By utilizing these criteria, its accessibility may be managed. Since, the IoT is getting popular, its subscribe paradigm is also becoming interesting. Most IoT designs based on its service communication infrastructure are exploiting its loose coupled and scalable nature. Hence, there are producers that create the necessary information and also targeted nodes which can classify the messages based on the interest. The receiving nodes are the consumers or they are able to receive real time, flexible and indirect access by utilizing multicast methodology. But, in this method, its accessibility to a targeted event is controlled and managed by the IoT and can be used to solve cross layered solutions [30]. As per the proposed technique, the security policies of the producing nodes may be classified into events and the events are directed according to the policies and the guidelines. Hence, this can improve the security.

E. Energy Efficiency

The main challenge in most of the recent technologies is making energy efficient devices. The devices should consume very less power and those technologies that consume less power is considered to be more efficient. The rule is the same in IoT devices as well.

It is well known that IoT devices are a rising technology with multiple advantages. However, it consumes lots of power due to collection of multiple devices that is used. Energy efficient designs have been proposed in [31] in three different layers of IoT for sensing the devices, processing the data and presenting them. The systems will be able to predict the sleep timing of the sensors on the basis of power in batteries or on the basis of historical data. With this, the re-provisioning may be done when the devices are in sleep mode, thereby leading to a more energy efficient solution. It is necessary to bring in energy efficiency to cross layer design for IoT framework.

As previously known, most of the IoT devices used sensor devices that depend upon low powered battery. The base stations of the IoT devices are called Femtocells and are becoming common in IoT and cognitive radios. Even though most researchers have focused on sharing the spectrum or avoiding interference, making energy efficient devices were not the main objective of many. Hence, in order to make use of the IoT framework fully, energy efficient models must be created. A useful energy efficient resource allocating technique has been proposed in [32] for the networks. Hence, the energy efficiency of the devices are a major factor in IoT devices.

Various problems faced in cross layered protocols have been explained in this section. It is necessary to overcome these problems in order to make more energy efficient routing and devices.

VII. CONCLUSION AND FUTURESCOPE

Due to the presence of different cross layer protocols, it can be seen that there are lots of problems faced. However, when compared to conventional network layers, cross layered approaches have better efficiency. These protocols have a large impact on the lifetime of the network. Hence, the different cross layered protocols have been studied and more emphasis have been given in location based routing protocols.

It can be concluded from the studies that a significant lower network overhead can be achieved when compared to other routing protocols by using the information of node location and by utilizing restricted flooding technique. Also, it provides a higher packet delivery ratio. In the future, location based routing protocols may be used for exchanging the battery information between the physical layers and the MAC layers. This is necessary in order to improve the lifetime of the network and achieve energy efficiency.

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