International Journal of Research in Advent Technology, Special Issue, August 2018
E-ISSN: 2321-9637
International Conference on "Topical Transcends in Science, Technology and Management" (ICTTSTM-2018)
Available online at www.ijrat.org

A Cost-Effective Framework of Wireless Network to Monitor the Transmission Line in Smart Grid

1.P.Muruga Priya,Ph.D scholar,
Dept of CS,Vellalar College for Women,
Erode,Tamil Nadu,India
murugapriyaphd@gmail.com

2.Dr.E.S.Samundeeswari.
Associate Professor,Dept of CS,
Vellalar College for Women

ABSTRACT

Smart Grid is a power-enabled grid which is highly concentrated in academics and Research. The monitoring of transmission line for Smart Grid is very essential. A cost –effective framework of Wireless Sensor Networks is used.WSN is a booming area used in various applications. The sensors are deployed on the transmission towers which sense the data and report the data for transmission. WSN are low in cost, show reliability and have self healing characteristics. The system deals with designing of the framework of different technologies used to monitor the intangible vigor of the transmission towers. The clear assessment of this brings out a solution for the usage of a better technology which is cost efficient, fault tolerant provides link reliability and transfer data with high data rates without any transmission delay. Hybrid multi-layered network architecture is framed for this purpose. A cost efficient mathematical model is derived for providing low transmission delay and network cost. Bandwidth and latency constraints are also satisfied.

Keywords— Cost Efficient, WSN, Transmission line, fault tolerant, high data rate, link reliability.

I. INTRODUCTION

Smart Grid is a power-enabled grid which is highly concentrated in Academics and Research. The power grid system is composed of electric power infrastructure which has nature and malicious attacks[1].These are to be monitored on the real-time basis. Human monitoring is difficult for large distance and terrain region which is a time consuming and inefficiency [2].The monitoring through cables installation costs very high [3]. The monitoring through wireless technologies with low cost and efficiency is to be done[4]. A network has to be framed with WSN which is a promising one. A network is an interconnection of one or more systems. The systems are interconnected for data collection, processing, monitoring, alarming and producing the output depending upon the application.

The WSN is deployed on towers to monitor the transmission line of the smart grid.Hybrid multi-layered network architecture is framed for this monitoring. The wired (optical fiber), wireless (Zigbee) and LTE are used as the hybrid network technology. The first layer consists of the tower and sensors which are deployed on them. These sensors will sense the data, collect the data and report the data to the relay node. The second layer communicates between the relay node and the control center. The third layer consists of the control center and two substations. A super node is selected for the optimal placement of the LTE. This wireless technology consists of high data rate and low cost. The LTE plays a vital role in the cost optimization.[13].The two substations communicate to the control center through wired network. The communication between sensors, towers and relay nodes is wireless (Zigbee and LTE).These systems are used in applications like smart grid, health monitoring, environment monitoring habitat monitoring etc.The electric current is transmitted through transmission lines from one substation to another.

In between these substations the transmission towers carry the transmission lines. The whole system will be disturbed by various hazards like wind, over temperature, rain, birds and ice etc. These disturbances will affect the data sensed by sensors which is measured as data rate from one substation to another substation. These are monitored by using sensors which are placed on transmission towers. The sensors are designed based on temperature, humidity, ultrasonic, tilt, wind and infrared sensors which measure different parameters of this transmission tower [12]. Hybrid multi-layered network architecture provides optimized transmission delay, bandwidth and latency. It also addresses issues like placement of sensors and the operation of it. The deployment of sensor is near the relay node so easy sensing can be done.

The paper extend in Section II which consists of the related work, then Section III describes about the proposed network model. Section IV discusses about the cost efficient mathematical model. The Section V presents performance evaluation. Finally we conclude our work with some future directions in Section VI.

II. RELATED WORK

There are many research activities on the area of Smart Grid, Wireless sensor Network particularly in transmission line monitoring. The method of using wireless sensor network was discussed [9]. A power line sensor and its prototype proved its feasibility [10] but the communication held between the sensors was failed to be highlighted .A linear network model was proposed for the monitoring of overhead transmission lines, the model was unable to deliver the data in time. The delay was addressed along with the imbalance in load. This model is not suitable for extensive and fast communication. The wireless link can be used directly to deliver data to control center from relay node. For long distance of the delivery of data a network model with reconfigurable system was proposed [13] to the placement of the cellular tower.

This model is not suitable for actual conditions of symmetry which is highly dependent. In paper[13] a hybrid hierarchical network structure was designed which minimized the network cost and met the bandwidth and latency constraints and it resolved the asymmetric bandwidth requirements of dataflow and cellular coverage is irregular. The transmission line monitoring is done with the cognitive radio where it is unidirectional [12-CR] if the device moves from the alignment then the data transmission is failed. The robot delay-tolerant Sensor network based monitoring is performed [14]. According to this paper a study on monitoring issue of the installation and operation cost of LTE is discussed with the WSN deployed. Along with it a cost efficient mathematical model is framed which addresses the delay in transmission, network cost and placement of the LTE. The simulation proves that this system is a cost efficient and improves the performance of the network.

III. PROPOSED NETWORK MODEL

The proposed model consists of the hybrid multi-layered network architecture of wired(optical fiber),wireless(Zigbee) and the LTE for monitoring the transmission tower .Initial stage consists of the sensors deployed on towers report data to the relay node. The sensors are designed based on temperature, humidity, ultrasonic, tilt, wind and infrared sensors which measure different parameters of this transmission tower [12].

In the second stage the relay node nearest the substation report data through the wireless technology Zigbee. The relay node far from substation is considered to be super node deployed by LTE directly reports data to the control center. Third stage, the substations with wired technology communicate to control center. Then these data are sent to the control center in a timely manner. As much of the data is sent there will be minimum delay. So the delivery of data in time economically to the control center is a challenging issue. The energy consumption is not considered in this system, it is provided by magnetic field. It enhances the network life time and reliability.[14].

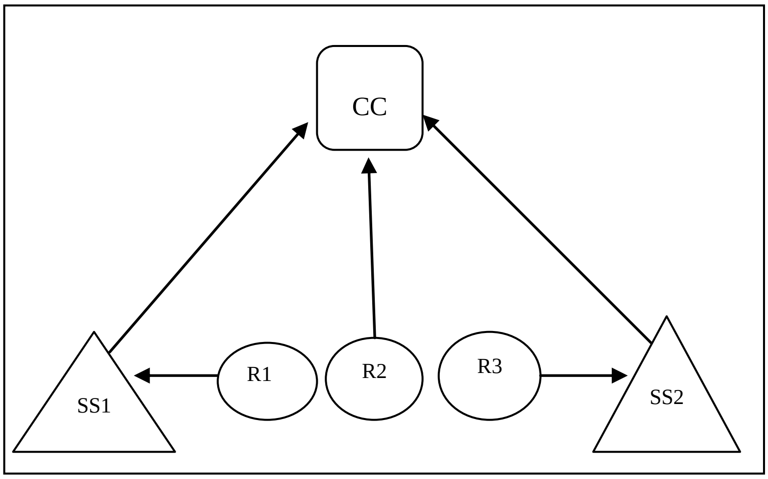


Fig 1. Proposed Network Model

IV. COST EFFICIENT MATHEMATICAL MODEL

The proposed network model is converted to a directed graph (A, B). A stands for the vertices and B stands for Edges. The vertices are the Control center CC, two substations (SS1, SS 2) and Ri relay nodes deployed on poles. The vertex is connected through different edge. The substations are connected to the control center by optical fiber. The transmission poles are connected with substations through wireless Zigbee. In order to transmit the data fast the some relay nodes as are considered as super nodes and they are incorporated with LTE. Since the data are collected same from all the sensors that are nearby [13] they are symmetry in the network. This complexity is for the actual situation. This lead to the formulation of quadratic equation which solves the determination of cellular locations. As the roots are rounded off in the quadratic equation which gives the incorrect output. The system describes the improving of the placing cellular enabled. The transmission delay and channel access delay problem was addressed [13]. Only the network cost was very high for the cellular modules to be implemented. As the node increases the transmission delay is reduced but it is not cost efficient. The proposed system discusses about the usage of the LTE transceiver instead of cellular module which is speed in transmission covers up to 15km and transmits a high data rate.LTE transmits high data rate hence there are possibilities of collision of data. The mechanism of the channel sense medium access/collision Avoidance (CSMA/CA) is used. The average access time for a sensor network is 41ms [6]. During the transmission of the data, there are two delays existing: a) transmission delay b) Channel Access Delay.

Table 1 : Symbols of mathematical model

S	End to end deadline
tijk	Latency incurred by the kth flow on link(*i,j*)
Tijk	Binary variable. Is 1 if node k selects edge(*i,j*) as a link
ZB	Per ZigBee link cost
Bd	Total bandwidth of the link(*i,j*)
Eij	Binary variable. Is 1 if link(*i,j*)used by any flow. Indicates presence of a flow on link(*i,j*)
LKCij	Total link(*i,j*) cost
C	Installation cost per LTE transceiver
LTi	Binary variable. Is 1 if tower is enabled LTE. Indicates presence of a LTE transceiver on tower *i*

Minimize :

$$F(E_{ij}, X_j) = \sum_{(i,j)} € P \; LKC_{i,j} E_{ij} + \sum^{N}_{i=1} C .Xi \qquad (1)$$

Subject to :

$$LKC_{ij} (n,k) = \sum_{v=1}^{k} ZB .l_v + \sum_{u=k+1}^{n} LTE. L_u$$

$$(i,j) € P, (u,v) € N \qquad (2)$$

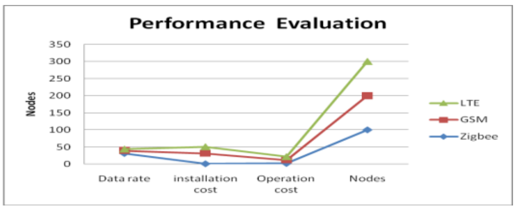
$$f (E_{ij}, X_i) = \sum_{(i,j)} € P \; T_{ijk} . t_{ijk} <= S¥ K€N \qquad (3)$$

$$\sum_{(i,j)} € P \; E_{ij} = 1 , ¥ € N \qquad (4)$$

$$E_{ij}, X_I, T_{ijk} € \{0,1\} \qquad (5)$$

V. PERFORMANCE EVALUATION

The simulations results are taken based on the number of nodes, data rate and cost the different wireless technologies can communicate



VI.CONCLUSION

In this paper we discussed about the cost efficient framework of wireless network to monitor the transmission line in smart grid. The study was done from the need of secure electric energy infrastructure, usage of wireless links for monitoring,the important parameters like temperature and sag was also discussed. The opportunities and challenges of smart grid was also discussed. The monitoring was initially done using Wireless Sensor networks, then Zigbee were also used for no telecommunication area.The 802.22 was used for effective monitoring. Even though the all these technologies are used there are issues which has to be worked out for future. High bandwidth, link reliability. In order to address this a hybrid multi-layered network architecture was framed with an effective mathematical model.This provided a less transmission delay,low network cost transmission of data.In future, the this system can be extended to find the fault tolerant network design.

REFERENCES

[1] Ramon A. Leon, Vijay Vital and G.Manimaran, "Application of Sensor Network for Secure Electric Energy Infrastructure,
IEEE Transactions on Power Delivery, April 2007
[2] Vehbi C. Gungor, Bin Lu, and Gerhard P. Hancke, " Opportunities And Challenges Of Wireless Sensor Networks In SmartGrid", IEEE Transactions on Industrial Electronics, Vol. 57, No. 10, October 2010.
[3] K.S. Hung, W.K. Lee, V.O.K. Li, K.S. Lui, P.W.T. Pong, K.K.Y. Wong, G.H. Yang, And J. Zhong, " On Wireless Sensors Communication For Overhead Transmission Line Monitoring In Power Delivery Systems" ,Ieee,2010.
[4] Yang Yang, Guang zhong Xie, Xiang dong Xu, Yadong Jiang ," A Monitoring System Design In Transmission Lines Based On Wireless Sensor Networks, September 2011
[5] Wu, Yc Cheung, Lf Wong Lui, Ks Pong, Pwt, " Efficient Communication Of Sensors Monitoring Overhead Transmission Lines", IEEE Transactions on Smart Grid, 2012
[6] Sauvik Das Gupta, Souvik Kundu, Abhishek Mallik," Monitoring Of Sag & Temperature In The Electrical Power Transmission Lines", October 2012
[7] Benazir Fateh, Manimaran Govindarasu and Venkataramana Ajjarapu, " Wireless Network Design For Transmission LineMonitoring In Smart Grid", IEEE Transactions On Smart Grid, Vol. 4, No. 2, June 2013
[8] Athanasios G. Lazaropoulos," Wireless Sensor Network Design For Transmission Line Monitoring, Metering, And Controlling: Introducing Broadband Over Power Lines-Enhanced Network Model (Bplenm),2014
[9] Katarzyna Mazur,Michal Wydra And Bogdan Ksiezopolski," Secure And Time-Aware Communication of Wireless Sensors Monitoring Overhead Transmission Lines",2017
[10] Saeed Ahmed, Young Doo Lee, Seung Ho Hyun, And Insoo Koo," A Cognitive Radio-Based Energy-Efficient System For PowerTransmission Line Monitoring In Smart Grids",2017
[11] Fei Fan, Gongping Wu, Man Wang, Qi Cao And Song Yang" Robot Delay-Tolerant Sensor Network For Overhead Transmission Line Monitoring",2018
[12] Guo-Ming Maya-Bo Li, Nai-Qiang Mao, Cheng Shi, Bo Zhang And Cheng-Rong Li,A Fiber Bragg Grating-Based Dynamic Tension Detection System For Overhead Transmission Line Galloping,2018
[13] Miao Li, Xiao-Bo Chi, Xin-Chun Jia, Jun-Li Zhang, "WSN-Based Efficient Monitoring for Overhead Transmission Line In Smart Grid",Proceedings of Chinese control conference,July 2016.