Performance Enhancement of Wireless Sensor Networks based on a Novel Data Quality Framework-An approach

B. Prathiba[1], Dr. K. Jaya Sankar[2], Dr. V. Sumalatha[3]
[1]Jawaharlal Nehru Technological University Anantapur
[2]Vasavi College of Engineering, Hyderabad
[3] Jawaharlal Nehru Technological University Anantapur
(E-mail: balireddyprathibha@gmail.com)

***Abstract*—** Wireless sensor networks are key to the formation of internet of things and internet of things and wireless sensor networks are very important components for building smart cities which have become very popular since the last few years.. Although WSN is featured with various advantageous characteristics, but still WSN share many similarities with other distributed systems, but at the same time the challenges are also huge which impact the design of a WSN. Various significant problems that are being addressed in the literatures are energy issues, security issues, bandwidth issues, deployment issues, networking etc. This paper briefs about the issues of data quality from the data aggregation or fusion process in wireless sensor network. This paper has presented a technique to enhance energy efficiency and data consistency.

Keywords— *Data Quality, Energy Efficiency, Data Consistency, WSN*

I. Introduction

The usage and commercial adoption of Wireless Sensor Network (WSN) is more than two decades old, where it is found increasingly used in habitat monitoring system, forest fire detection, industrial monitoring system and healthcare etc., Fahmy et al. (2016) & Emary et al. (2013). With the presence of infrastructure, the sensor nodes capture environmental information and forward this information to the base station. This process is called as data aggregation Lu et al. (2017). At present, various studies give a quick overview of different data aggregation procedures Ranjan et al. (2015) & Pantazis et al. (2013). The research work carried out till date essentially focuses on solving energy problems Pantazis et al. (2013), traffic management issues Ploumis et al. (2012), scheduling and provisioning Nithya et al. (2015) and security Modirkhazeni et al. (2010), etc. In addition to this, there have been various studies in WSN that has only emphasized on incorporating optimization techniques to improve communication performance among the sensor nodes Fei et al. (2017).

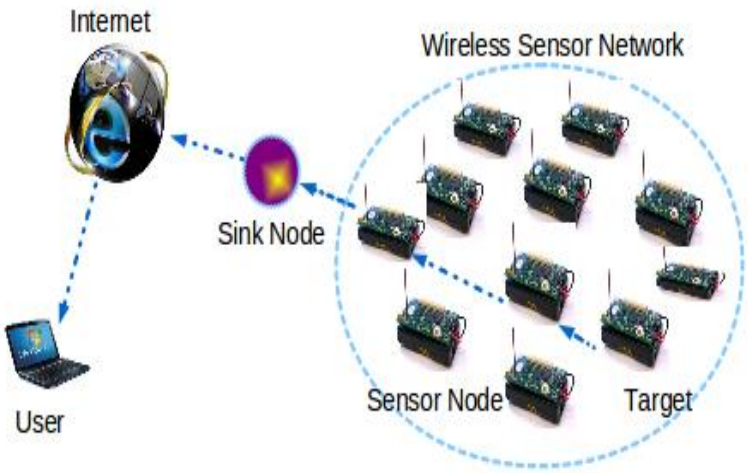

Fig.1 Architecture of WSN

The pace of such research work is quite good even today, as there are many problems in WSN that are quite unsolved even with the presence of a series of dedicated research contributions. A closer look in all the 99% methodologies adopted in research contribution is only limited to communication from member node to cluster head that completes at base station Wang et al. (2018, Sivagami et al. (2016), Rajeswari et al. (2017), Sasirekha et al. (2017), Nayak et al. (2017), Liu et al. (2017) and Zhou et al. (2017). Little information is reported in the research work about what happens to the aggregated data when it finally arrives in the base station. Existing studies of analytical base operation used in Internet-of-Things (IoT) explains, that there is a massive generation of voluminous sensory data that is subjected to mining process to extract specific knowledge Kaiwartya et al. (2018), Sheng et al. (2015), Abidoye et al. (2017), Zhu et al. (2016) and Bijarbooneh et al. (2016). Interestingly, such sensory data suffers from various problems of heterogeneity, veracity, and velocity if a heterogeneous sensor application is considered.

Another significant problem is that the data quality is highly unstructured. As a result it is quite hard to subject it to any specific storage model. Although there are various causes and reasons of such advance problems, one simple cause of all of the issues is the presence of redundant data in the base station.

The initiation of this problem begins right from the clustering process. In existing system of clustering Firdaus et al. (2016), Subha et al. (2013), Kumari et al. (2013), Tiwari et al. (2015) and Krishnakumar et al. (2016), the algorithms are more inclined on grouping the nodes on the basis of distance from the base station to generate clusters followed by selection of cluster head. The existing research work towards such problems is successful in solving the problem of cluster head selection but is unable to solve the ongoing issues of data redundancy. It is a computational challenge if the assumed network is multi-hop in WSN which calls for a vicious loop of internal communication among the nodes. Hence, at present, we do not find much work where clustering operation is developed to address the issue of data quality. An absence of data quality has various adverse effects on communication.

The first harmful effect is non-reliable data that generates false positive. Such data is non-tolerable for some applications, e.g., healthcare, weather broadcasting, etc., where precision is the sole important factor in data captured from the sensory application. There can be a definition of data quality, where it is mainly related to how unique it could be. Data quality will also mean that each sensor node should be able to forward unique information during the process of data aggregation as well as data fusion process. However, it is very likely that same event could happen in multiple places and information about the same event is captured by multiple sensors. Although such information may be unique for local cluster, it may pose a higher degree of redundancy in the more significant number of clusters. As an aggregated data are time-stamped, so even same data could be time-stamped in a different way, and they successfully bypass the redundancy check within a base station. This phenomenon also adversely affect when the analysis is carried out in this aggregated data. Hence, data redundancy directly affects data quality and is worth investigating this problem to ensure that data aggregation smoothly takes place and also saves some energy while forwarding the data.

Although our work is limited only till base station, knowing what happens to the data in the base station may give a better realization of some potential protocol to offer better quality of data. Therefore, we introduce *a new design approach to enhance data quality with an aid of new mathematical model for ensuring energy efficiency and data consistency*.

II. LITERATURE REVIEW

This section briefs various existing research techniques towards data quality problems associated with WSN. Our prior study (Prathiba et al., 2016) has briefed certain approaches while this section further updates more. Xenekis et al. (2015) have presented a weighted clustering approach by introducing a cost-based factor on the selection of cluster head in WSN as an enhancement from LEACH. Study towards uneven clustering technique was proven to be solving the energy problem associated with the sensor nodes especially in the case of heterogeneous networks (Zhang et al., 2016). Omari and Fateh et al. (2015) have implemented ant colony optimization for enhancing the performance of a hierarchical clustering technique in sensory application. Energy-efficient clustering approaches are also proven to be effective towards multi-hop network formation (Liu et al., 2013). Katiyar et al. (2011) have presented a clustering technique especially focusing on heterogeneous WSN. The work was focused entirely on incorporating energy efficiency in WSN using multilevel clustering approach. There are also literatures reported to use weighted clustering mechanism for solving energy efficiency issues.The works carried out by Zhang et al. (2016) have jointly used hierarchical approach integrated with weighted method to carry out clustering operation. The work carried out by Ambekari and Sirsikar (2016) have presented a study where different forms of the clustering techniques have been evaluated to address the energy efficiency problems in WSN.

The mechanism of selection of cluster head was advocated to be one of the most effective approaches for clustering as studied by Belabed et al. (2017) and Bouallegue et al. (2016). This approach integrates the clustering methodology with the fountain code. Adoption of similar form of weighted methodology towards enhancing clustering operation was discussed by Kumrawat and Dhawan (2015). The work has discussed a unique optimization mechanism for improving the battery of node. The research work carried out by Ebadi et al. (2012) had presented such mechanism where the selection of cluster-head is encouraged for enhancing network lifetime using degree of node and remnant energy. Li et al. (2017) have recently implemented the concept of compressive sensing to perform routing operation during clustering in WSN. The complete work has focused on energy dissipation problems and uses sparse sensing in modeling purpose. The analysis of the clustering mechanism for designing a specific performance metric was carried out by Zeb et al. (2016).

Inclusion of network concept over clustering method was also found to be an effective part of energy efficiency techniques (Chidean et al., 2016). Literature has also contributed increasing number of work towards using weighted clustering mechanism. Discussion of varied clustering schemes was carried out by Tripathy and Chinara et al. (2012). Similar direction of problem addressing was carried out by Hong et al. (2016) where the energy modeling is carried out by tree-based topologies. Usage of received signal strength indicator was reported to contribute for energy efficient clustering (Wang et al., 2014). There are also existing research works focusing on energy-problems, e.g., Aldawsari et al. (2015), Baker et al. (2017), Baker et al. (2013), Baker et al. (2015), and Baker et al. (2010).Irrespective of varied clustering schemes, majority of the existing mechanisms of clustering is only focused on solving energy dissipation issue among the sensor nodes in WSN. Few research works have emphasized on solving the

data redundancy issues that may exist large-scale network. Consideration of dense network and its adverse effect on data packet is also few to find. More importantly, there is no reported standard clustering model to claim robust data quality in any form of the environmental condition that the node may encounter. This is a significant research gap, which calls for immediate attention of researchers. The proposed study considers completely mathematical modeling approach as the standard of the research methodology. The prime reason behind this is majority of the existing system was found to propose a scheme which solves one problem factor responsible for degrading data quality in wireless sensor network, which makes the solution very much narrowed. Such solutions will not be applicable to solve other set of problems. Therefore, mathematical modeling is the better way to represents the problems and solve it, which can be tested based on its anticipated outcomes and actual outcomes in mathematical convergence testing. A technique with better convergence rate will only show better outcomes. In a nutshell, a highly validated outcomes can be generated by adopting mathematical modeling approach as well as it will also keep an open scope to fine-tune the model in future.

III. PROBLEM IDENTIFICATION

At present, various research works are being carried out towards improving the energy efficiency approaches in WSN that also focus on data consistency. However various problems are found unaddressed. *Data consistency*, which is one of the most overlooked phenomenon in associated with data quality investigations. Every sensor nodes have a hardware clock and its operation depends on the residual energy (or rather battery life). The moment the residual energy depletes, the oscillation frequency too becomes slower and irregular. This process is very important to understand as it leads to wrong time stamping the sensed data that significant degrades the quality of the sensed data by the wireless sensor nodes. It is quite difficult to mathematically model the energy-efficient clock synchronization algorithm to ensure data quality by reducing the levels of synchronization errors.

A. Challenges to enhance data quality

- Conventional energy modeling techniques cannot ensure clock synchronization.
- Occurrence of clock drift is quite difficult to compensate considering large scale wireless sensor network.

IV. PROPOSED METHODOLOGY

This work is an extended version of our prior work prathiba et al. (2017), prathiba et al. (2018).the core goal of the proposed study is to introduce an analytical model approach for enhancing the data quality of a sensor node using a technique to enhance energy efficiency and data consistency.

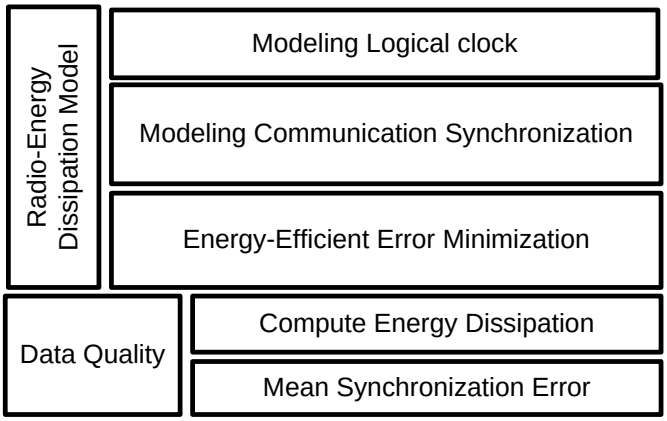

Fig.2 Architecture of proposed study

The design of the proposed system starts with a simple modeling of a logical clock in sensor nodes to develop a relationship among clock, oscillator frequency, and time. The study will consider uncertain amount of error in clock modeling in order to mimic the real-time scenario where hardware clock is error-prone. The proposed system will perform synchronization of clock by the means of exchanging the control messages among the sensor nodes.

Finally, the system will also formulate various test-condition that generates error in clock synchronization and then the proposed study will present a solution which will perform compensation of drift and thereby it will ensure that time stamping of the data packets are as fresh as possible. Moreover, an enhancement of the prior energy model is to be implemented to further ensure that maximum amount of energy is conserved. The system will also formulate strategy for minimizing the number of clock synchronization request for ensuring better data quality and also energy dissipation.

V. Conclusion

Conventional clustering technique in WSN has some good number of research contributions to ensure energy efficiency among the sensor nodes that tend to increase the network lifetime. The proposed system will be checked for its effectiveness using processing time, memory consumption of the algorithm, data quality, and synchronization error. The anticipated outcome of the proposed system will be quality of data which will be gauges with respective to minimization of synchronization error and maximization of energy efficiency. The proposed system is mainly meant to be applicable in the cases that demands higher precision/accuracy of the aggregated data in wireless sensor network e.g., healthcare

applications, nuclear plant surveillance system, climate monitoring system etc. The expected outcomes of the proposed study is to enhance quality of aggregated data, energy efficiency, minimization of synchronization errors and cost effective algorithm that can perform multiple operations in adherence to memory limitations of sensor nodes.

REFERENCES

[1] H.M.A. Fahmy, Wireless Sensor Networks: Concepts, Applications, Experimentation and Analysis, Springer, 2016

[2] M. M. E. E. Emary, S. Ramakrishnan, Wireless Sensor Networks: From Theory to Applications.CRC Press, 799 (2013)

[3] Y. Lu, P. Kuonen, B. Hirsbrunner, & M. Lin, M. Benefits of data aggregation on energy consumption in wireless sensor networks, IET Communications, 11, 8, (2017) 1216-1223

[4] R.K. Ranjan, & S.P. Karmore, Survey on secured data aggregation in wireless sensor network.International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), Coimbatore, (2015), 1-4

[5] N.A. Pantazis, S.A. Nikolidakis, & D.D. Vergados, Energy-Efficient Routing Protocols in Wireless Sensor Networks: A Survey. IEEE Communications Surveys & Tutorials, 15, 2 (2013) 551-591

[6] R. Nithya, & N. Mahendran, A Survey: Duty cycle based routing and scheduling in wireless sensor networks, 2nd International Conference on Electronics and Communication Systems (ICECS), Coimbatore, (2015), 813-817

[7] A. Modirkhazeni, N. Ithnin, & O. Ibrahim, Secure Multipath Routing Protocols in Wireless Sensor Networks: A Security Survey Analysis. Second International Conference on Network Applications, Protocols and Services, Kedah, (2010), 228-233

[8] Z. Fei, B. Li, S. Yang, C. Xing, H. Chen, & L. Hanzo, A Survey of Multi-Objective Optimization in Wireless Sensor Networks: Metrics, Algorithms, and Open Problems. IEEE Communications Surveys Tutorials, 19, 1, (2017) 550-586

[9] H. Wang, D. Xiong, L. Chen, & P. Wang, A Consensus-Based Time Synchronization Scheme with Low Overhead for Clustered Wireless Sensor Networks. IEEE Signal Processing Letters (2018)

[10] L. Sivagami, & J. M. L. Manickam, Cluster-Based MAC Protocol for Collision Avoidance and TDMA Scheduling in Underwater Wireless Sensor Networks. The Computer Journal, 59(10), (2016) 1527-1535

[11] K. Rajeswari, & S. Neduncheliyan, Genetic algorithm based fault tolerant clustering in wireless sensor network. IET Communications, 11(12), (2017) 1927-1932.

[12] S. Sasirekha, & S. Swamynathan, S,Cluster-chain mobile agent routing algorithm for efficient data aggregation in wireless sensor network. Journal of Communications and Networks, 19(4), (2017) 392-401

[13] P. Nayak, & B. Vathasavai, Energy efficient clustering algorithm for multi-hop wireless sensor network using type-2 fuzzy logic. IEEE Sensors Journal, 17(14), (2017) 4492-4499

[14] X. Liu, J. Li, Z. Dong & F. Xiong, Joint design of energy-efficient clustering and data recovery for wireless sensor networks, IEEE Access, 5, (2017) 3646-3656.

[15] Y. Zhou, N. Wang & W. Xiang, Clustering hierarchy protocol in wireless sensor networks using an improved PSO algorithm, IEEE Access, 5, (2017) 2241-2253

[16] O. Kaiwartya, A.H. Abdullah, Y. Cao, J. Lloret, S. Kumar, R.R. Shah, & S. Prakash, Virtualization in wireless sensor networks: fault tolerant embedding for internet of things. IEEE Internet of Things Journal, 5(2), (2018) 571-580.

[17] Z. Sheng, H. Wang, C. Yin, X. Hu, S. Yang, & V.C. Leung, Lightweight management of resource-constrained sensor devices in internet of things IEEE internet of things journal, 2(5), (2015) 402-411.

[18] A.P. Abidoye, & I.C. Obagbuwa, Models for integrating wireless sensor networks into the Internet of Things, IET Wireless Sensor Systems, 7(3), (2017) 65-72.

[19] J. Zhu, Y. Song, D. Jiang, & H. Song Multi-armed bandit channel access scheme with cognitive radio technology in wireless sensor networks for the internet of things. IEEE access, 4, (2016) 4609-4617

[20] F.H. Bijarbooneh, W. Du, E.C. Ngai, X. Fu & J. Liu, Cloud-assisted data fusion and sensor selection for internet of things. IEEE Internet of Things Journal, 3(3), (2016) 257-268

[21] T. Firdaus & M. Hasan, A survey on clustering algorithms for energy efficiency in wireless sensor network. In Computing for Sustainable Global Development (INDIACom), 3rd International Conference, (2016, March) 759-763

[22] C.P. Subha, S. Malarkan, & K. Vaithinathan, A survey on energy efficient neural network based clustering models in wireless sensor networks. In Emerging Trends in VLSI, Embedded System, Nano Electronics and Telecommunication System (ICEVENT), International Conference, (2013, January) 1-6

[23] P. Kumari, M.P. Singh, & P. Kumar, Survey of clustering algorithms using fuzzy logic in wireless sensor network. In Energy Efficient Technologies for Sustainability (ICEETS), International Conference, (2013, April) 924-928

[24] T. Tiwari, & N.R. Roy, Heirarchical clustering in heterogeneous wireless sensor networks: A survey. In Computing, Communication & Automation (ICCCA), International Conference (2015) 1385-1390

[25] A. Krishnakumar, & V. Anuratha, Survey on energy efficient load-balanced clustering algorithm based on variable convergence time for wireless sensor networks. In Advanced Computing and Communication Systems (ICACCS), 3rd International Conference, 1, (2016, January)1-5

[26] B. Prathiba, K.J. Sankar, & V. Sumalatha, Enhancing the data quality in wireless sensor networks—A review. In Automatic Control and Dynamic Optimization Techniques (ICACDOT), International Conference, (2016, September) 448-454

[27] A. Xenakis, F. Foukalas, & G. Stamoulis, Minimum weighted clustering algorithm for wireless sensor networks, In Proceedings of the 19th Panhellenic Conference on Informatics, (2015, October) 255-260

[28] Y. Zhang, W. Xiong, D. Han, W. Chen, & J. Wang, Routing algorithm with uneven clustering for energy heterogeneous wireless sensor networks. Journal of Sensors, (2016)

[29] M. Omari & W.H. Fateh, Hybrid Hierarchical Clustering Protocol in Wireless Sensor Networks based on Ant Colony Algorithm and MR-LEACH. In Proceedings of the International Conference on Intelligent Information Processing, Security and Advanced Communication, 72, (2015, November)

[30] Z. Liu, W. Xing, Y. Wang & D. Lu, Hierarchical spatial clustering in multihop wireless sensor networks. International Journal of Distributed Sensor Networks, 9, 11, (2013)

[31] V. Katiyar, N. Chand, & S. Soni, Efficient multilevel clustering for large-scale heterogeneous wireless sensor networks. In Proceedings of the International Conference on Communication, Computing & Security, (2011, February) 1-6

[32] J. Zhang, J. Chen, Z. Xu, & Y. Liu, LEACH-WM: Weighted and intra-cluster multi-hop energy-efficient algorithm for wireless sensor networks. In Control Conference (CCC), 35th Chinese, (2016, July) 8325-8329

[33] J.S. Ambekari & S. Sirsikar, Comparative Study of Optimal Clustering Techniques in Wireless Sensor Network: A Survey, In Proceedings of the ACM Symposium on Women in Research, (2016, March) 38-44
[34] F. Belabed & R. Bouallegue, Performance evaluation of the optimized weighted clustering algorithm in wireless sensor networks. In Advanced Information Networking and Applications Workshops (WAINA), 31st International Conference, (2017, March) 222-225
[35] R. Bouallegue & Belabed, An optimized weight-based clustering algorithm in wireless sensor networks. In Wireless Communications and Mobile Computing Conference (IWCMC), International, (2016, September) 757-762
[36] M. Kumrawat & M. Dhawan, Optimizing energy consumption in wireless sensor network through distributed weighted clustering algorithm, In Computer, Communication and Control (IC4), International Conference, (2015, September) 1-5
[37] S. Ebadi, A Multihop Clustering Algorithm for Energy Saving in Wireless Sensor Networks, International Scholarly Research Network ISRN Sensor Networks (2012)
[38] X. Li, X. Tao & G. Mao, Unbalanced expander based compressive data gathering in clustered wireless sensor networks. IEEE Access, 5, (2017) 7553-7566
[39] A. Zeb, A.M. Islam, M. Zareei, I-A. Mamoon, N. Mansoor, S. Baharun, & S. Komaki, Clustering analysis in wireless sensor networks: the ambit of performance metrics and schemes taxonomy. International Journal of Distributed Sensor Networks, 12(7), (2016) 4979142
[40] M.I. Chidean, E. Morgado, M. S-Junquera, J. R-Bargueño, J. Ramos, & A.J. Caamaño, Energy efficiency and quality of data reconstruction through data-coupled clustering for self-organized large-scale WSNs. IEEE sensors journal, 16(12), (2016) 5010-5020
[41] A.K. Tripathy & S. Chinara, Comparison of residual energy-based clustering algorithms for wireless sensor network, ISRN Sensor Networks, (2012)
[42] Z. Hong, R. Wang, & X. Li, A clustering-tree topology control based on the energy forecast for heterogeneous wireless sensor networks. IEEE/CAA Journal of Automatica Sinica, 3(1), (2016) 68-77
[43] Y. Wang, I.G. Guardiola, & X. Wu, RSSI and LQI data clustering techniques to determine the number of nodes in wireless sensor networks, International Journal of distributed sensor networks, 10(5), (2014) 380-526
[44] B. Aldawsari, T. Baker & D. England, Trusted energy efficient cloud-based services brokerage platform. Int. J. Intell. Comput. Res, 6, (2015) 630-639.
[45] T. Baker, M. Asim, H. Tawfik, B. Aldawsari & R. Buyya, An energy-aware service composition algorithm for multiple cloud-based IoT applications. Journal of Network and Computer Applications, 89, (2017) 96-108
[46] T. Baker, Y. Ngoko, R. T-Calasanz, O.F. Rana, & M. Randles, Energy efficient cloud computing environment via autonomic meta-director framework. In Developments in e-Systems Engineering (DeSE), Sixth International Conference, (2013) 198-203
[47] T. Baker, B. A-Dawsari, H. Tawfik, D. Reid & Y. Ngoko, GreeDi: An energy efficient routing algorithm for big data on cloud, Ad Hoc Networks, 35, (2015) 83-96.
[48] T. Baker, D. Lamb, A. T-Bendiab, & D. A-Jumeily, Facilitating Semantic Adaptation of Web Services at Runtime Using a Meta-Data Layer. In Developments in E-systems Engineering (DESE), (2010) 231-236
[49] B. Prathiba, K.J. Sankar & V. Sumalatha, A Novel Clustering Algorithm for Leveraging Data Quality in Wireless Sensor Network. In International Conference on Next Generation Computing Technologies Springer, Singapore (2017, October). 687-694
[50] Prathiba B., Jaya Sankar K., Sumalatha V. (2019) SDQE: Sensor Data Quality Enhancement in Reconfigurable Network for Optimal Reliability. In: Silhavy R. (eds) Cybernetics and Algorithms in Intelligent Systems. CSOC2018 2018. Advances in Intelligent Systems and Computing, vol 765. Springer, Cham

Prathiba B is a research scholar of Jawaharlal Nehru Technological University, Anantapur. She received the B.Tech degree in Electronics and Communication Engineering from JNTU, Hyderabad in the year 2005, and the M.Tech degree in Digital Electronics and Communication System from JNTU, Hyderabad in the year 2007.Presently she is working as an Asst. Professor in the department of Electronics and Telecommunication Engineering in G.H.Raisoni Institute of Engineering and Technology, Pune affiliated to SPPuneUniversity. Her current research interests include Wireless Communication, Wireless Sensor Networks, Embedded systems, Digital Electronics. Prathiba is a Fellow of the Institution of Electronics and Telecommunication Engineers (IETE). She is a Life Member of the Indian Society for Technical Education (ISTE).She has attended many International/National Conferences and Workshops in the area of Communication and Networking.

Dr.K. Jaya Sankar is a Professor and Head of the department in the same college since 2005 in the Department of Electronics and Communication Engineering at Vasavi College of Engineering which is a premier educational institute in Hyderabad, India. He actively campaigns to collect funds for SACH (Save a Child's Heart) programme and initiated 'SAHAAY' scheme to help poor students by organizing funds from students, colleagues and corporate. He is a member of Board of Studies in ECE, Osmania University, Hyderabad since the year 2005. He is a subject expert on the selection committee of OU, Hyderabad for recruitment of Assistant Professors, Associate Professors and Professors. He is thesis examiner of M.E./M.Tech program and Ph.D. program of O.U. Hyderabad, JNTU, Hyderabad and Anantapur. On appointment he has set question papers for professional exams conducted by various universities. He was session chair at many conferences and delivered many invited talks. He is an expert committee member on Departmental Promotion Committee in the areas of 'Electronics / Avionics & Airborne Instrument Operation' – National Remote Sensing Center, Balanagar, Hyderabad. He has guided more than 50 UG projects covering approx. 200 B.E / B.Tech students and 12 PG projects covering 12 M.E / M.Tech students. One candidate received Ph.D. degree under his supervision and another seven candidates are actively pursuing research under his guidance. He got elected as member of the executive committee of IETE Hyderabad center for two terms, i.e., 2008-2010

Dr. V. Sumalatha is a Professor of Electronics & Communication Engineering in JNTUA College of Engineering, Ananthapuramu. Presently, she is the Director, Industrial Relations & Placements of JNT University Anantapur. She started her career as Assistant Professor in the year 2000 and subsequently promoted as

Associate Professor in 2011 & as Professor in 2014. She is actively engaged in teaching & research for more than 18 years. She has implemented an AICTE – RPS research project. She has organized several conferences/technical symposia, seminars & workshops in the emerging areas for the benefit of student & faculty members. She has guided more than 20 UG projects, 25 PG theses and published 28 research papers in reputed journals. She has presented 12 research papers in several international conferences. She is an active member of IEEE, IEI & ISTE professional societies. She also has taken active role in administration. She worked as Training & Placement Officer of JNTUA CEA during 2008-12, Coordinator, Academic & Planning of JNTUA during 2012 -15 and Head of ECE, JNTUACEA during 2015-18.

□□□□□□□□□□□□□ □□□ □□□