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Implementation of Sensor Network to Monitor Environmental Parameters of Preparatory Unit of Textile Industry

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***Abstract*- To maintain the quality of the cotton yarn, the environmental temperature and humidity is maintained at the précised level in textile industry. In textile industry, monitoring of the environmental parameters such as temperature and relative humidity is essential. In fact, these parameters depict site specific variability (SSV). To play with such site specific data, deployment of the Wireless Sensor Network is most suitable solution. To monitor such parameters the wireless sensor network is established, wherein the wireless sensor nodes play a vital role. With the greater reliability and flexibility the wireless sensors nodes are designed, wherein ARM microcontroller, ARM LM4F120H5QR, is used as a core for computational task and RF transceiver module Xbee series-2, from DIGI International Inc, is used for Wireless Networking. Deploying embedded technology the sensor nodes have been designed for on-line monitoring of the two parameters such as, environmental temperature (^{0}C) and environmental humidity of the preparatory unit of textile industry. The smart sensors, SY-HS-220 for humidity measurement and LM35 for temperature measurement are deployed. By employing of embedded system, both hardware as well as software is co-designed. Deploying such nodes and the coordinator, the wireless sensor network is established by employing Zigbee technology and implemented for monitoring of the dedicated parameters of the preparatory unit of textiles industry. The results of implementation of WSN for monitoring of environmental parameters of preparatory unit of textile industry are interpreted in present paper.**

***Keywords*-- Sensor Node, Wireless Sensor Networks, RF Module, Microcontroller, Base Station.**

1. Introduction

Wireless sensor network provides new paradigm for sensing and disseminating information from various environments with a great potential to serve many and diverse applications [1]. The monitoring of various physical parameters such as temperature, fluid level, relative humidity, intensity of light, concentration of gasses dissolved in the atmosphere, vibrations, strain, soil moisture, industrial process parameters, pH and salinity of water etc plays commendable role in various sectors such as environmental pollution monitoring, high-tech agriculture, structural engineering, chemical and physical industries, transportation, military and defense, healthcare, forestry etc [2-6]. The Wireless Sensor Network (WSN) may be described as the collection of nodes organized into co-operative network. Due its salient features, the WSN is becoming significant area of research of global relevance. Due to their several popular applications, efficient design and implementation, wireless sensor networks [7-8] have become an area of current research. Sensing, processing and communication are key elements, whose combination in one tiny device gives rise to a vast number of remote sensing applications [9-10]. The Sensor Nodes in a WSN operate with small and limited battery power and usually non-renewable resource. Since communication among nodes consumes most of the energy [11], it is important to design the network with less communication among the nodes to estimate the required parameter vector. The important factor in designing of the sensor network is the reduction of the cost of the node without compromise in the performance. Due to low cost of the nodes the denser deployment can be ensured. Recently, to establish a wireless sensor network, the use of Zigbee technology is suggested [12]. Moreover, IEEE has also laid down the standards, IEEE802.15.4 standards for WSN [13] and allowed to works at 2.4 GHz of ISM frequency band [14].

The wired networks are not only infeasible for typical environment but also shows high cost, hardware complexity, hard to debug and upgrade. The wireless sensor network provides suitable solution to overcome the limitations of the wired system. The WSN is the application specific establishment of smart sensor nodes. The sensor nodes are systematically distributed over a geographical area of interest. Therefore, it becomes possible to design the intelligent, autonomous and energy efficient sensor nodes to facilitate the desired WSN. Emphasizing an implementation at textile industry, the WSN is designed and results of investigation are reported in this paper. Section 1 is of introduction. Section 2 is devoted for design and establishment of the WSN. Results of on-site implementation are interpreted in section 3 and 4 and conclusion is given in section 5.

2. Wireless Sensor Network (WSN)

Wireless sensor network (WSN) is the distributed network of large number of wirelessly connected autonomous devices, called Wireless Sensor Nodes, which collaboratively collects the information about physical world and disseminates the same towards the monitoring stations

called Base Station (BS) for the deterministic analysis and presentation [15-18]. The WSN is an infrastructure comprised of sensing, computing and communication elements, which provides the information about area and process of interest to the administrator, to ensure the sustainable management [19]. The WSN comprises following four components.

1. An assembly of distributed Wireless Sensor Nodes.
2. An interconnecting wireless network in suitable protocol.
3. A smart base station.
4. A set of computing devices required for data computation, co-relation, event, trending, status querying and actuations etc.

2.1 Development of Wireless Sensor Network for Industrial Applications

The processes of the textile industries were studied and it is observed that, to maintain the quality of the cotton yarn, the parameter such as temperature and humidity etc of the environment, should be precisely controlled. To optimize the quality of the yarn, essentially, the temperature is maintained precisely at 32^0C [20]. The relative humidity of an environment should be controlled at 55%RH [21]. At present, for monitoring of temperature and humidity, electronic, monitoring units, are installed, wherein usually only local values of these parameters are displayed. This unit of textile industry is spread over wide area and the said parameters are depicting Site Specific Variability. To monitor the parameter values very few numbers of such devices have been deployed. Therefore, these rarely spaced monitoring units could not cover the area of textile industry. Moreover, normally these monitoring units are not networked. Therefore, it is essential to collect the data manually. This hardly provides the data in real time. Therefore, precision controlling of the temperature as well as relative humidity of the environment is not ensured. This may adversely affect the quality of the yarn. Therefore, textile industry is demanding electronic system to cater this need.

The Wireless Sensor Network can be suitably designed and implemented to monitor the various parameters, indoor as well as outdoor, of the textile industry, at control cabin. For establishment of the WSN to collect the site specific data, the five sensor nodes of promising capabilities have been successfully designed. In addition to this, to facilitate the Base Station, the inherent part of the WSN, a coordinator is also deployed. The Senor Nodes are identified with the name as Node1, Node2, Node3, Node4 and Node5. it is found the sensor nodes are associated with the transducer interface modules, which comprises of an array of the sensors. To ensure autonomous operation, the nodes are facilitated with the chargeable battery. The Zigbee device is interfaced to the serial port of the microcontroller. The sensor nodes are encapsulated in box.

The Node ID and Parameter ID are allocated to each of the nodes and process of assembling and disassembling of the packets is carried out. Thus, the WSN of five sensor nodes and the Base Station is developed and deployed for monitoring of the environmental parameters at the site of manufacturing of cotton yarn in the textile industry.

3. On-Site Implementation of WSN under Investigation

The major objective of the present research work is to design and deployment of the Wireless Sensor Network (WSN) for monitoring of indoor industrial environment. Emphasizing the features of the WSN, it is found that, the WSN is most suitable technology, which can be used for monitoring Site Specific and spatio-temporal data and management of the same. It is found that, in many industries monitoring and controlling of indoor environment is vital job. The quality as well as quantity of the products depends upon the environmental conditions. Unfavorable environment adversely effect on the Quality of Product (QoP). Therefore, indoor environment of the industry must be precisely monitored and controlled as well. As discussed earlier, the WSN is dedicatedly developed for monitoring of industrial environment and it is made ready for deployment. To ensure on site deployment various industries have been studied. Fabtech Group of Industries is performing pioneering job in establishment of renowned industries such as textile industries. This group of Engineers has established the textile industry at Ekatpaure near Sangola with title as “Fabtech Projects and Engineers Ltd (Textile Division), Ekhatpur, Tal Sangola Dist Solapur”. The indoor area of the Phase –I is 250m x 40 m (=10,000 sq.m.) wide. Therefore, monitoring the parameters of the indoor environment is very tedious task. Due to this wide area, it is found that, the environmental parameters are depicting Site Specific Variability (SSV). It is found that, the environmental parameters such as temperature and relative humidity are playing significant role on the process of manufacturing of the yarn. Therefore, it is attempted to monitor these two parameters by using WSN under investigation.

The WSN under investigation is arranged in such a way that, it will cover entire area of the phase-I. According to the architecture of WSN, to realize the site specific variability, an area under consideration should be divided into the cells of typical area. It is supposed that, a Sensor Node is collecting the information of the respective cell. In fact, the phase-I is fragmented into four sections such as blower section, prefatory section, spinning section and ring conner section etc. While deploying the WSN into phase-I, prefatory section is separately considered and WSN is established and the parameters such as temperature and relative humidity are monitored in real time. Thus Wireless Sensor Network under investigation is implemented in Fabtech (Textile division) Sangola and results of investigation are interpreted.

4. Implementation of Wireless Sensor Network at Preparatory Section of Fabtech (Textile Division) Industries Sangola

The Preparatory section of the textile division is spread over wide area, approximately double of that of Blower section. Therefore, parameters under investigation widely show the Site Specific Variability (SSV). To realize the collection of such widely distributed data, the WSN plays commendable role. Therefore, the WSN under investigation is established in the Preparatory section of the above cited textile industry. To have view of this Preparatory section, the photograph of the same is presented in the figure 1. The widely distributed parameter values are accumulated at the base station and results of the investigation are discussed in this section. An experimental arrangement of five nodes of the wireless sensor network within the preparatory section is shown in figure 2. The distance between the distributed sensor nodes to the base station given in table 1. As shown in figure 2, the nodes have been distributed in the preparatory section of the textile industry. The values of the parameters under consideration are sensed by the nodes and data is disseminated towards the Base Station in Star topology. The results of the investigation are interpreted in this section. In fact, the data is recorded in real time for different days and for different periods. However, the typical data is presented.

Figure 1 : Photograph of Preparatory Section of the Fabtech industry (Textile division)

4.1 Monitoring of Relative Humidity (RH%) of the Preparatory section

As discussed earlier, relative humidity values of different sites of the Preparatory section are collected from five nodes and presented in the figure 3. Figure 3 depicts the instantaneous values of the relative humidity in RH% recorded for typical period. On the inspection of the figure 3, it is observed that, the sensor node-1 shows the humidity in the range of 55%RH to 58%RH, sensor node-2 shows the humidity in the range of 50%RH to 54%RH, the sensor node-3 shows the humidity in range of 55%RH to 58%RH, the sensor node-4 shows the humidity values in the range of 59%RH to 61%RH and sensor node-5 shows the humidity values in the range of 60%RH to 63%RH. From figure 3, it is also found that, the humidity of the region of node 2, varies with the limit of 4 %RH. Moreover, other regions have less variation. This realizes the site specific variability in the relative humidity data. The Preparatory section is very wide. Therefore, humidity is not remaining constant throughout but depicts spatio- temporal variations. The average value of the humidity shown by the WSN under investigation found close match with that of demonstrated by the humidity meter of the industry. This supports the accuracy in the design of hardware and software for present WSN.

Table 1: Distance of Nodes placed in the preparatory section from Base station.

Sr. No.	Sensor Node	Distance from Base Station (m)
1	Node 1	25
2	Node 2	35
3	Node 3	48
4	Node 4	22
5	Node 5	30

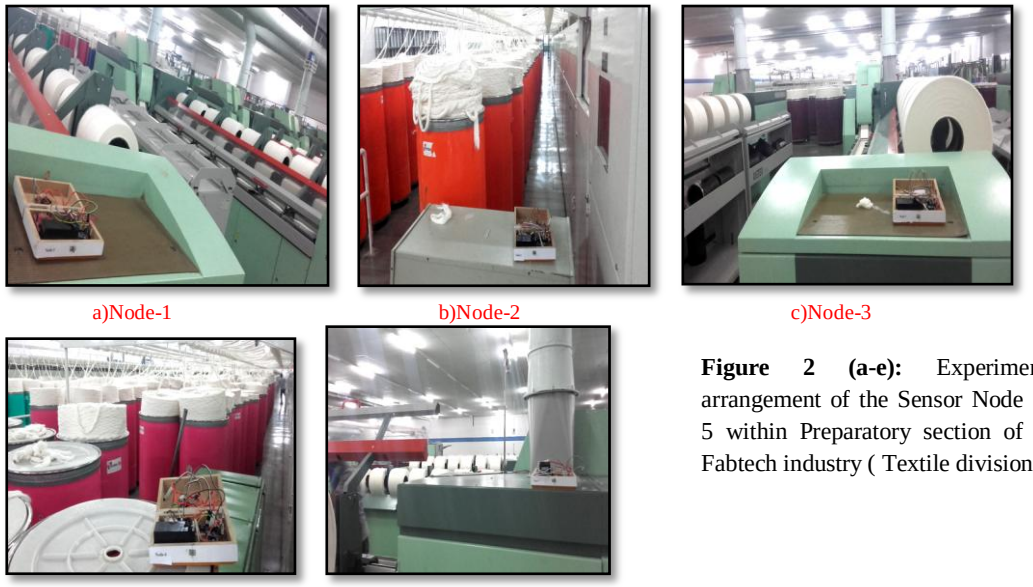

Figure 2 (a-e): Experimental arrangement of the Sensor Node 1 – 5 within Preparatory section of the Fabtech industry (Textile division)

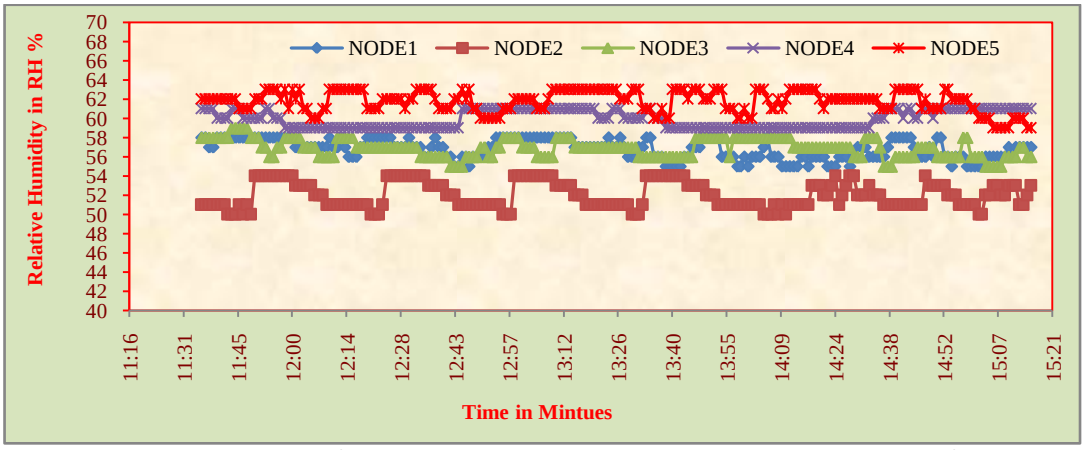

Figure 3: Instantaneous values of relative humidity in (RH%) measured in an environment of the Preparatory section of the textile division of the Fabtech industry.

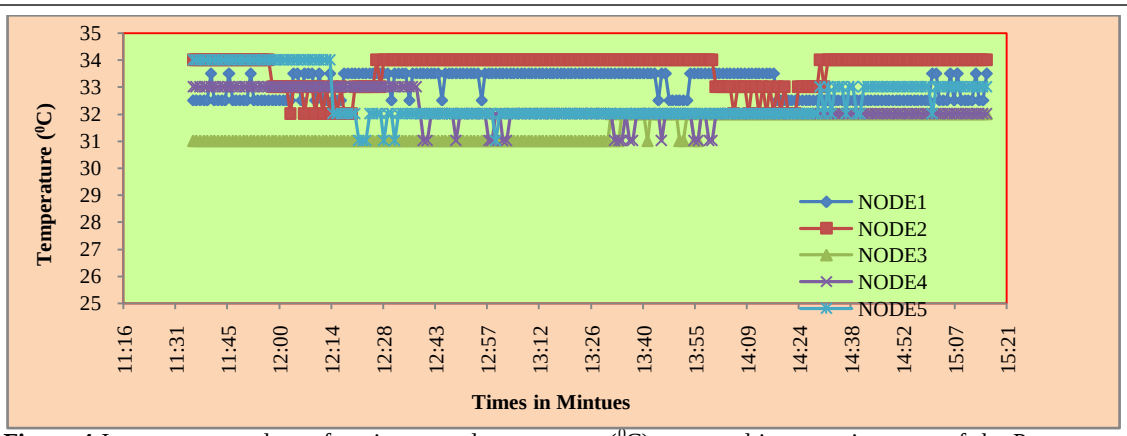

Figure 4 Instantaneous values of environmental temperature (^{0}C) measured in an environment of the Preparatory section of the textile division of the Fabtech industry.

4.2 Monitoring of Environmental Temperature (^{0}C) of the Preparatory section

The five nodes of the WSN are collecting thermal status of the environment of preparatory section. The instantaneous values of temperature values are recorded and plotted against time and presented in figure 4. The figure 4 depicts the temperature values of the preparatory section, recorded at the base station. On the inspection of the figure 4, it is observed that, the sensor node-1 shows the temperature in range of 32^{0}C to 33^{0}C, the sensor node-2 shows the temperature in range of 32^{0}C to 34^{0}C, the sensor node-3 shows the temperature in range of 31^{0}C to 32^{0}C, the sensor node-4 shows the temperature in range of 31^{0}C to 33^{0}C and the sensor node-5 shows the temperature in range of 32^{0}C to 34^{0}C. From these results, it is found that, average temperature value of the indoor environment about 32 ^{0}C. Moreover, the temperature by the standard digital thermometer middle site is about 32 ^{0}C. This close match in the data reveals the preciseness in the design.

5. Conclusions

The wireless sensor network of five sensor nodes and the coordinator node is successfully established and deployed for monitoring of industrial environmental parameters such as indoor relative humidity, indoor environmental temperature of the preparatory unit of textile industry. For realization of on-site implementation, the industries such as fabtech industry (Textile Division), industry is selected. The WSN under investigation is deployed for monitoring of above parameters. Under the frame of IEEE 802.15.4, the WSN is successfully implemented in star topology. On investigation of instantaneous values of various parameters, it can be concluded that the environmental parameters depict site specific variability with spatio-temporal variations. On investigation of the results of on-site deployment of WSN under investigation, it can be concluded that, the WSN under investigation is operating with great reliability and preciseness.

References:

1. K. Maraiya, K. Kant and N. Gupta, “Application Based Study on Wireless Sensor Network”, Int. J. of Comp. App., 218, (2011) 9-15.
2. K. Khedo, R. Perseedoss and A. Mungur, “A Wireless Sensor Network Air Pollution Monitoring System”, Int. J. of Wire. And Mobi. Netw., 22 (2010) 31-45.
3. S. Mishra, D. Tijare and G. Asuthar, “Design of Energy Aware Air Pollution Monitoring System Using WSN”, Int. J of Adv. In Engg. and Tech., 1 2 107-116.
4. S. El-Kader and B. El-Basioni, “Precision Forming Solution in Egypt Using the Wireless Sensor Network Technology”, Egyptian Informatics Journal, 14, (2013) 221-233.
5. N. Kurata, M. Suzuki, S. Saruwatri and H. Morikawa, “Actual Application of Ubiquitous Structural Monitoring System using Wireless Sensor Networks”, 14th World Conf. on Earth. Engg., (2008), Beijing, China.
6. J. Ko, C. Lu, M. Srivastava, J. Stankovic, A. Terzis and M. Welsh, “Wireless Sensor Networks for Healthcare”, Proc. Of the IEEE, 98 11 (2010) 1947-1960.

7. A. Hac, "Wireless Sensor Network Designs" John Wiley and Sons, 2003.
8. C. Raghavendra, K. M. Sivalingam, and T. Znati, "Wireless Sensor Networks", Springer, (2006).
9. I. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on Sensor Networks," IEEE Communications Magazine, 408 (Aug. 2002) 102–114.
10. D. Puccinelli and M. Haenggi, "Wireless Sensor Networks: Applications And Challenges Of Ubiquitous Sensing," IEEE Circuits and Systems Magazine, 53 (2005) 19 – 31.
11. D. Estrin and M. Srivastav, "Instrumenting the World with Wireless Sensor Networks," in IEEE International conference on Acoustics, Speech, Signal Processing (ICASSP'01), May 2001, 2033–2036.
12. P. Rajamohan, W. Kong and H. Yee, "Review and Special Issues of Zigbee Technology in LR-WPAN and Voice Communication Over Zigbee Networks", Int. J. of Latest Trends in Engg. Sci. and Techno., 1 5 (2014) 1-12.
13. I. Howitt and J. Gutierrez, "IEEE 802.15.4 low rate-wireless personal area network coexistence issues", IEEE Wireless Comm. and Networking Conf. (WCNC'03), 16-20 Mar. 3 (2003) 1481- 1486.
14. Zigbee Alliance www.zigbee.org.
15. K. Ramesh and K. Somasundaram, "Improved Fair-Zone Technique Using Mobility Prediction in WSN", International Journal of Advanced Smart Sensor Network System, 2 2 (2012) 23-32.
16. H. Wu, Y. Wang, H. Dang and F. Lin, "Analytic, Simulation and Empirical Evaluation of Delay/ Fault Tolerent Mobile Sensor Network", IEEE Trans. on Wireless Communication, 69 (2007) 3287-3296.
17. A. Hamzi, M. Koudil, J. Jamont and M. Occell, "Multi-Agent Architecture for the Design of WSN Applications", Wireless Sensor Network, 5 (2013) 14-25.
18. E. Yoneki and J. Bacon, "A Survey of Wireless Sensor Network Topologies: Research Trends and Middle Ware's Role", Technical Report, UCAM-CL-TR-646 University of Cambridge, Cambridge (2005).
19. K. Sohraby, D. Minoli and T. Znati, "Wireless Sensor Network: Technology, Protocol and Applications", John Willey and Son. Inc, (2007).
20. I. Mansoor, S. Munazza, A. Aleem, A. Kamran, M.Arsheen and A. Khalil, " Textile Environmental Conditioing : Effect of Relative Humidity Variation on the Tensile Properties of Different Fabrics", J. of Analytical Sciences, Methods and Instrumentation, 2 (2012),92-97.
21. K. Brown, J. Mann, "The Influence of Humidity on the Elastic Properties of Cotton Part-V- The Tensile Behaviour", The Journal of Textile Institute, 21(4) 1930, 186-204.

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