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Monitoring Concentration of Alcohol Gas in Alcohol Generation Plant of Sugar Industry Using Wireless Sensor Network

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Abstract: **Wireless sensor network provides new paradigm for sensing and disseminating information from various environments with a great potential to serve many and diverse applications. To monitor environmental parameters, the wireless sensor network is established, wherein the sensor nodes play a commendable role. On the inspection of the sugar industry, it is found that, for monitoring of physico-chemical parameters, the traditional methods are employed. Moreover, these parameters are monitored at local level only. Presently, no any system is available, wherein centralized monitoring and control is emphasized. Therefore, the sugar industries depict wide scope for deployment of modern technologies such as Wireless Sensor Network. Along with indoor parameters, environmental as well as process parameters, the monitoring of outdoor parameters is also of great importance. The industries are releasing effluents either in the form of gases or liquids. These effluents adversely affect on the quality of the air and soil at large. Spreading of the gases such as alcohol, ammonia etc in to the air surrounded by the industry reveals site specific variability. To monitor unevenly distributed parameters the WSN is most suitable. With the greater reliability and flexibility the wireless sensors nodes are designed, wherein ARM processor, 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 concentration of the alcohol gas in indoor as well as outdoor environment of the sugar industry. The smart sensor based on MQ-135 family FC-22-I alcohol sensor is employed for measurement of concentration of alcohol gas. The results of implementation of WSN for monitoring of environmental concentration of alcohol gas in the alcohol generation plant of sugar industry are interpreted in present paper.**

Keywords- Wireless Sensor Node, Wireless Sensor Networks, Xbee-chip, ARM Processor, Base Station.

1.Introduction:

Recent advances in the electronics technologies results into revolutionary developments in fields of science and technology. Due to relentless efforts of scientists and technologists the fields such as Embedded Technology, Integration technology, communication technology, smart sensor design technology etc are pervasively growing and evolving innovative fields for research and developments [1-2]. During early days, the wired networks have been deployed for monitoring of such parameters. However, 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. The sensor nodes are intelligent and have capabilities such as sensing of physical environment, signal processing and wireless communication. Recently, an embedded technology, wherein smart devices such as microcontrollers of promising features are deployed as computing unit, helps to enhance the intelligence of the sensor nodes. Deployment of advanced microcontrollers helps to design the sensor nodes of high preciseness and great reliability in assimilating and disseminating the data of spatio-temporal variance [10]. The ARM microcontrollers have promising on chip resources and it work with 32 bit processing capacity. Significant research work is going on to

facilitate the middleware of the WSN. Now, instead of data communication in single hop, the routing protocols are also suggested, wherein clustered hierarchical architecture is employed to realize the power conservation and hence increase in the life of WSN as well [11]. The different data security majors have been suggested by the researchers to avoid foreign attack [12]. To ensure wireless communication different communication topologies such as Bluetooth, Zigbee, Wi-Fi etc are available. However, it is found that, the Zigbee technology is most suitable for WSN of indoor as well as outdoor applications [13]. On extensive study of the literature and survey of the industries, such as Sugar industry, Alcohol industry, Textile industry, milk processing, food processing industry, paper and pulp making industries etc, it is found that, the sophisticated industries are demanding an electronic system of a great preciseness and reliability to monitor and control the various parameters. Therefore, wireless sensor network is designed and implemented in alcohol generation plant of sugar industry for monitoring the concentration of alcolhol gas. Emphasizing an implementation at sugar 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. In Section 3 on-site implementation of the wireless sensor network is discussed and conclusion is given in section 4.

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 [10-13]. The general architecture of wireless sensor network is shown in figure 1. 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 [14]. As depicted in figure 1, 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 [15,16]. The relative humidity of an environment should be controlled at 55%RH [17,18,19]. 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.

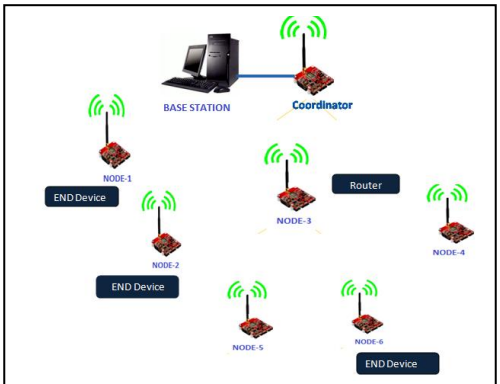

Figure 1: General Architecture of Wireless Sensor Network

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. The photograph of the Sensor Node is shown in the figure 2.

Figure 2: The photograph of Wireless Sensor Node

Moreover, figure 3 depicts the base Station. This coordinator is interfaced to the computer and the Base Station is designed and presented in figure 3. On inspection figures 2, 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

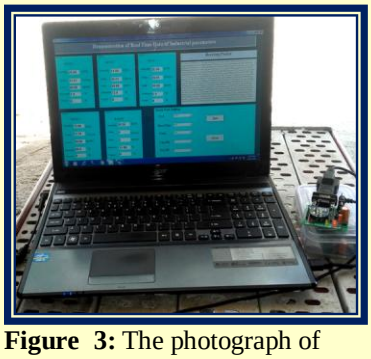

Figure 3: The photograph of Base Station with Coordinator

serial port of the microcontroller. The sensor nodes are encapsulated in box.

The coordinator, as shown in figure 3, is also separately designed. Figure 3, depict the organization of the Base Station [20]. 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. Implementation of Wireless Sensor Network in Alcohol Generation plant of Sugar Industry.

On-site implementation of the WSN is the major objective of present research work. Emphasizing this fact, the

Figure 4: The Photograph of the Sahakar Maharshi Shankarrao Mohite- Patil Sahakari Sakhar Karkhana Ltd, Yashwantnagar, Akluj.

WSN of five nodes has been established in different industries. It is known that, indoor as well as outdoor environment of the industry depends on Nature of the Product, chemical processes, raw materials availed, waste released either in the form of gas or liquid. Many times releasing of gases effluents seriously affects the indoor as well as outdoor environment. Moreover, due to leakage of the gases during processing as well as transportation environmental pollution may takes place. The typical chemical plants are contributing significantly in the process of air pollution. Environmental parameters depict Site Specific Variability. For management of such widely distributed data, the WSN is most suitable technology. During recent days, the sugar industries are associated with the industries such as Electricity Co-generation plant, Alcohol plant, Paper and Pulp making units etc. These plants are also releasing gases in the environment. Out various gases, air

pollution due to alcohol gas, near industrial atmosphere, is serious matter. Generally, Sugar industries are associated with the alcohol manufacturing unit. Due to trace amount of leakage of the alcohol the environment may be polluted. Moreover, due to effluents of the sugar industry the air pollution is observed. To monitor the concentration of typical gases into the air, the WSN can be deployed.

As discussed earlier, WSN under investigation is implemented for monitoring of indoor environment of renowned industries. To ensure outdoor deployment, the WSN under investigation is established in the environment of alcohol manufacturing unit of S.M.S.M.P.S.S. Karkhana Ltd. Akluj and results of implementation are interpreted in this section.

3.a) Deployment of WSN at Alcohol Generation Plant

Alcohol generation plant of the sugar industry, 'Sahakar Maharshi Shankarrao Mohite- Patil Sahakari Sakhar Karkhana Ltd, Yashwantnagar, Akluj', is one of renowned industry manufacturing about 99% pure alcohol. This plant is having its own alcohol detection unit. But it is installed at typical place in this plant. Therefore, it could not monitor the concentration of alcohol gas spread into the air. Moreover, the

Figure 5: The Photograph of Internal View of the Alcohol Generation Plant

unit is not having facility of data storage in real time. Therefore, the WSN under investigation is established in the area of this plant. The figure 5 depicts the internal view of the alcohol generation plant.

(i) Experimental Setup:

The Wireless Sensor Network under investigation, comprising five sensor nodes and the Base Station is established within an environment of alcohol generation plant

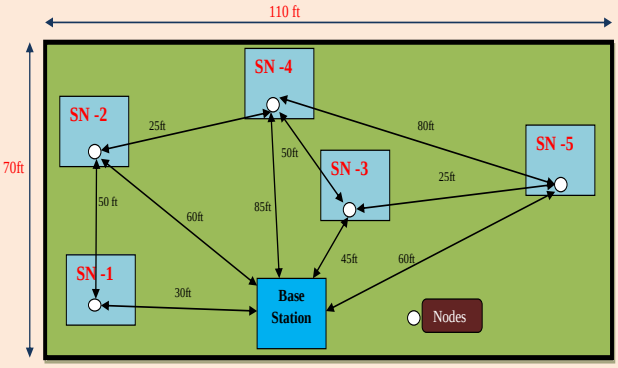

Figure.6 The Schematic of distribution of sensor nodes at Alcohol Generation plant

Figure 7: The Base Station Installation at the Alcohol Generation Plant

of above cited industry. The schematic of deployment of the sensor nodes to realize the establishment of WSN is presented in figure 6. As shown in the figure 6, the distance between sensor nodes, placed at the alcohol generation plant, varies from 60 ft to 80 ft. The total area covered by the WSN is about 110ft x 70ft. The Sensor Nodes under investigation are placed at different places of the alcohol generation plant so that WSN can cover the whole area of the plant. The Sensor Nodes under investigation are placed at different sites of the alcohol generation plants. The Figures 8 (a-e) reveals the deployment of the sensor nodes. Moreover, the figure 7 depicts the photograph of the Base Station. The sensor nodes are facilitated with an array of the sensors. However, for present implementation only concentration of alcohol gas spread into he air is monitored. The instantaneous values of the concentration of alcohol gas are recorded at the base station and used for further interpretation.

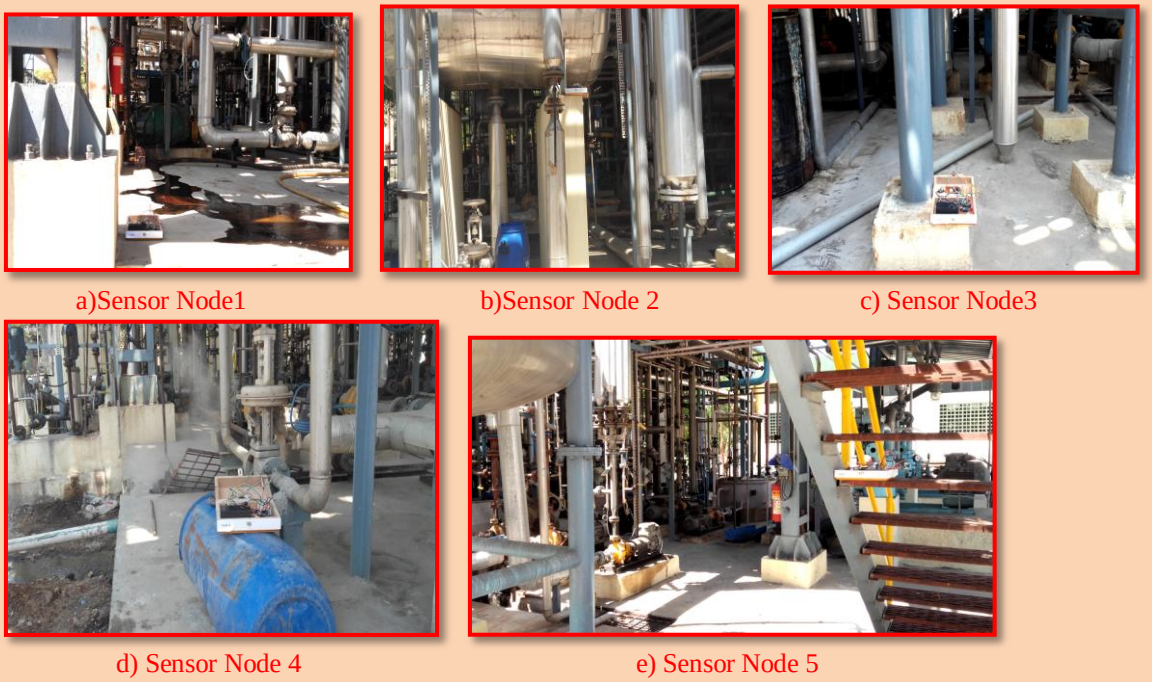

Figure 8 (a-e) The Placement of sensor Nodes at the Alcohol Generation Plant for the Measurement of Concentration of the Alcohol Gas.

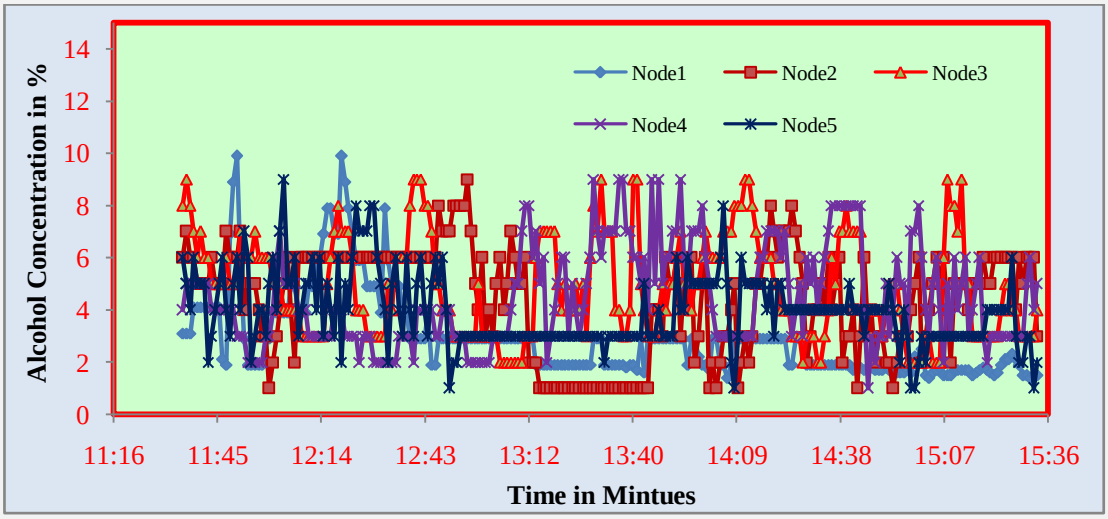

Figure 9 The graph of instantaneous values of Concentration of Alcohol gas (%) in environment of Alcohol Generation plant.

ii) Results and Discussion

Wireless Sensor Network (WSN) under investigation is implemented to monitor the concentration of the alcohol gas in the environment of the alcohol plant of the sugar industry. Five sensor nodes have been systematically placed and instantaneous values of the alcohol gas sensed and transmitted by the sensor nodes are collected at the base station. The values are demonstrated on the GUI of the base station and stored in to the data base. The recorded values are plotted against the time in minutes and presented in figure 9. In fact, the experiment is carried out for 10 days and for different period of the day. The data of typical period is depicted in figure 9. From figure 9, it is found that, the concentration of alcohol gas is different at different sites. This realizes Site Specific Variability of the environmental parameters. On inspection of figure 9, it is found that, concentration of alcohol gas in the outdoor environment of

the alcohol generation plant is varies from 1% to 12%. The graph also shows temporal variance.

Thus, the WSN under investigation is successfully deployed in the outdoor environment of alcohol manufacturing plants and environmental data is monitored in real time.

4. Conclusion

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 as well as body temperature, concentration of ammonia gas spread into the air, concentration of alcohol gas in the environment nearby alcohol manufacturing plant etc. Moreover, present WSN is also deployed for monitoring weight of milk packet in real time. For realization of on-site implementation, the industries such as fabtech industry (Textile Division), milk processing industry and alcohol manufacturing plant of sugar industry are 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. The WSN parameters such as RSSI, LQI etc have been investigated. Values of these parameters are in the limit of zigbee communication. On investigation of instantaneous values of various parameters, it can be concluded that the environmental parameters depict site specific variability with spatio-temporal variations. The multihopping techniques also successfully implemented to ensure monitoring of wide area of typical industry. 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.

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