Status Monitoring and Control in Industrial Application Using Mobile Relay Node - LPC2148

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***ABSTRACT* - In the present industrial atmosphere, collecting reports from different units of the industries, sensor nodes are used. Continuous data monitoring, processing and transmitting affects the lifetime of nodes quickly. To overcome from this issue, a mobile relay node is developed and introduced in the industrial atmosphere. This mobile relay node tracks the location of sensor nodes placed at different locations and collects the data. This device reduces the power utilized for communication by a sensor node and extends its lifetime. It improves packet delivery by preventing loss of data and reduces the workload of sensor nodes. In this work, the mobile relay node is developed for the industrial application using LPC2148 processor, RFID reader, Infra Red sensor and XBee modules. The collected data are transmitted to the server room through the mobile relay node to monitor and control industrial devices. The algorithm for the mobile relay node and sensor node is developed and successfully implemented in simulation and also in real time environment. In this work, the number of routers and different configuration of routing devices are reduced. In result, the lifetime of a mobile device, nodes and packet delivery ratio are improved.**

Keywords: LPC2148, Sensor node, Mobile Relay Node, XBee, RFID

1. INTRODUCTION

Due to advancement in technology, industries are getting automated, so numbers of machines are placed in the shortest distance. This made monitoring and report collection process as a difficult task. So sensor nodes are introduced in the industries for status monitoring, controlling and report collection [1], [2], [3], [4]. These sensor nodes are deployed in a predefined location in industrial environment. A sensor node continuously monitors the status and uploads the data to server rooms via other sensor nodes is said to be as routed. This mode of communication overloads the function of other nodes; this may rise to loss of data and consumes more power which leads to node failure [5].

To overcome this issue, the mobile relay node is designed and implemented in the industrial application. This mobile relay node is also known as a mobile device. This device collects the data from different nodes placed in different locations by requesting. This mode of communication is point-point, which assures the improvement in packet delivery ratio. The power consumed by a node to transmit data is proportional to the fourth power of the distance between the node [6]. So a mobile device reduces the transmitting distance of a sensor node which indirectly increases the lifetime of the nodes.

In this proposed system, mobile device consists of LPC2148 processor which is assisted by an RFID reader and XBee. The mobile device performs different operation like to request, collecting, processing and transmitting. A sensor node in the industries used to count the product quantity and to collect status of the machines. These data's are uploaded to mobile device periodically. XBee is used in sensor node and mobile device for data sharing.

2. RELATED WORKS

In the work of Wen-Tsai Sung et al., [7] monitor the status of the industry by using different sensors and transmitted these data to the server room via Zigbee. In this work LabVIEW software is used in the server room for viewing the report. From this work its inferred that wireless communication improves the safety measurement and reduce human errors. But it fails to discuss about the difficulties in sensor network like traffic, node failure and data loss.

In the work of Berando Naticchia et al., [8] deployed sensor nodes in different units of the construction site for surveillance purpose. In this work routers are used to establish a link between sensor nodes and the server room. In this work all nodes follow routing method to communicate with the base station. So there is a chance of data loss in case of node failure.

In the work of Geoffrey Werner-Allen et al., [9] deployed sensor nodes randomly and monitor the status of the volcano continues. Here also the routing mode of communication is used. In those regions unpredicted things may happen at any time, this cause the node failure and loss of data. If the mobile node is introduced into the network, acquiring of data is possible in case of node failure.

In the work of Ruoshui Liu et al., [10] suggests an advantage of using relay node in the tunnel application. This work mainly contributes on relay node placement and establishing communication. It also describes usage of mobile device reduces the network traffic, protracting the lifetime of nodes and improving the packet delivery ratio. But it fails to discuss about the designing of mobile device. In our proposed work the relay node design, tracking new location, collecting data and transmitting the data's are discussed.

3. PROCESS DESCRIPTION

Mobile device moves throughout the unit to collect the data from sensor nodes. Relay board is developed and interfaced with LPC2148 processor to control the movement of mobile device. It is a 4 channel relay board, to which DC motor of mobile device is interfaced which made forward, reverse, left and right turns as possible. The RFID reader is connected to UART0 terminal and XBee is connected to the UART1 terminal of the LPC2148. The general arrangement is shown in figure 1. Whenever an RFID reader reads any tag mobile device stop moving and sends a request signal to sensor nodes. As a response mobile device receives the code of the machine, status of the machine and quantity of the product. This data will be stored in separate memory locations of the LPC2148 processor. If the received quantity is lesser than target then the control information like 'improve the response rate' will be generated for all other cases 'don't reduce the response rate' will be generated. Whenever the mobile device comes under the coverage area of server room, data will be transmitted else it transmitted to nearby mobile device. If any hurdle is detected on the track, then the mobile device alerts the operators nearby to remove the obstacle.

Sensor nodes are deployed nearer to each machine in the unit to acquire employee detail, status of the machine and quantity of the product. Keypad in sensor node used to collect employee detail and the IR sensor is used to count the product output from a machine. LCD used to display the output rate, status of the machine and control information locally. When a sensor node receives any request signal from a mobile device, it checks for authentication and transmit the report to the mobile device. This transmission and receiving operation is performed through XBee.

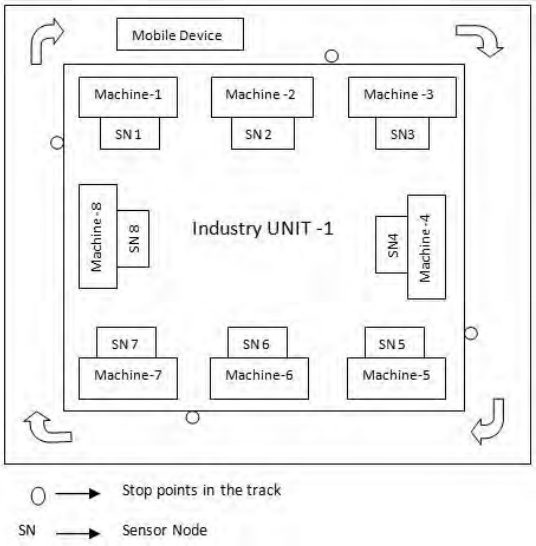

Fig. 1. Arrangement of sensor nodes in the industrial setup and mobile device movement

4. HARDWARE DESIGN

LPC2148 is said to be a low power consuming processor, which is suitable for power saving application. It's a 32 bit processor which is used in both mobile device and sensor nodes. Due to low cost and features in it like inbuilt ADC, DAC, PWM, Timer/counter, UART etc., it is chosen for this work [11]. This processor is implemented in various applications like key generation [12], node to node communication [13], home automation etc.

The 125KHz RFID reader is used in mobile device as a direction indicator and indication of stop point. It is connected to UART1 pin of the MAX232. The received tag value is acquired from a serial receiving buffer of the LPC2148 processor. Passive RFID tags are placed throughout the track for stop points and direction indicator.

IR sensor is connected with external interrupt (EINT) pin of the processor. Whenever a product comes out of the machine, its detected by IR sensor. This generates an interrupt signal on the processor and the counter value gets increased by 1. Similarly in a mobile device, IR sensor is connected with external interrupt pin of the controller. Whenever an obstacle is detected, interrupt signal is generated, it gives an alarm signal to the nearby operators to remove the obstacle.

XBee-s1 is used by both mobile device and sensor nodes, to establish communication between them. They connect to UART2 pin of the MAX232 IC. From which it is connected to LPC2148 [14].

5. PROCESS FLOW

The LP2148 processor triggers mobile device to find a sensor node in the unit. If the mobile device finds a new sensor node it transmits a request signal to the SN for acquiring data. Once the data is received from SN, the device starts to move. It checks whether communication between the server room and a mobile device is possible. If it is possible the acquired data will be transmitted to the server room via XBee. For finding new location RFID reader and tag is used. RFID tags are placed in a location such that request signals can be transmitted to more number of SN at a time. This reduces the power utilized for sending a request signal to each node individually which protract the lifetime of mobile device. In mobile device, the operations for movement, requesting, collecting and routing is described in the following algorithm.

Step 1: Wait for request signal

Step 2: If request signal =1, trigger mobile device

Step 3: If Tag value =1, stop mobile device and send request signal. Wait for report value, once received move it to a memory location. It compares the value with target and generates the control information which transmitted to SN. Move the device forward.

Step 4: Else If the tag value =2 repeat above step and make a right turn

Step 5: Else transmit report value to the server room

Interrupt routine in mobile device: An IR sensor is connected to the EINT1 pin of the processor. If the device reads any obstacle in the path interrupt signal is produced. This moves the mobile device in reverse direction and activates buzzer. Once it reaches the sink node coverage, it indicates the difficulty in the track to the sink node.

Step 1: If EINT1 =1, jump to service routine

Step 2: Move the mobile device in reverse direction with buzzer sound

Step 3: Move the device backward until tag value equal to ‘0’

Step 4: if tag value not equal to ‘1’ and ‘2’, then indicate server room about the hurdle on the track

Step 5: Return to the main function

IR sensor is interfaced in interrupt pin of the sensor node processor LPC2148. Whenever an IR sensor generates an interrupt signal, count value of the product quantity is increased by 1. When requesting signal is received from a mobile device, sensor node switches from counter mode to transceiver mode. Then sensor node checks whether the signal is received from a mobile device or from any other devices. If it is from mobile device then it sends the status report to the mobile device. By this method unnecessary data transmission and forwarding the data to other nodes are avoided which improves the lifetime of a node. In sensor node, the operation for counting product quantity, storing employee detail, displaying the status and transmitting data to mobile device is described in the following algorithm.

Step 1: When the machine powered up, SN assigns a value which indicates the status of the machine

Step 2: Store the detected value in memory location

Step 3: If IR sensor value = 1, then increase the register value by 1

Step 4: Display the employee code and quantity of product in LCD

In sensor node, XBee is interfaced in UART1 of the LPC2148 processor which is assigned as a serial interrupt. Whenever the request signal is received it checks for authentication and transmit the status to mobile device. This operation is described in the following algorithm.

Step 1: If the serial interrupt is received, jump to service routine address

Step 2: Transmit the machine code, status of the machine and quantity of the product to a mobile device

Step 3: Receive the control information and display it on the LCD

Step 4: Return to main function.

6. HARDWARE SETUP

Using LPC 2148 and Xbee series 1, the sensor node and rely node is developed. Figure 2 indicates the hardware arrangement of sensor node and mobile relay node. In this figure, the hardware arrangement of a sensor node at the each machine in the industrial application is shown. The sensor node displays, machine code and quantity of product output on the LCD at each machine and the report is transmitted to the control room through a mobile device. The experimental setup of the mobile device with RFID reader, XBee and IR sensor is also shown in figure 2. The various status monitoring of each machine in the industry and the control information between the industrial devices is observed. These information's are viewed using Win X Talk window and is shown in figure 3 and 4.

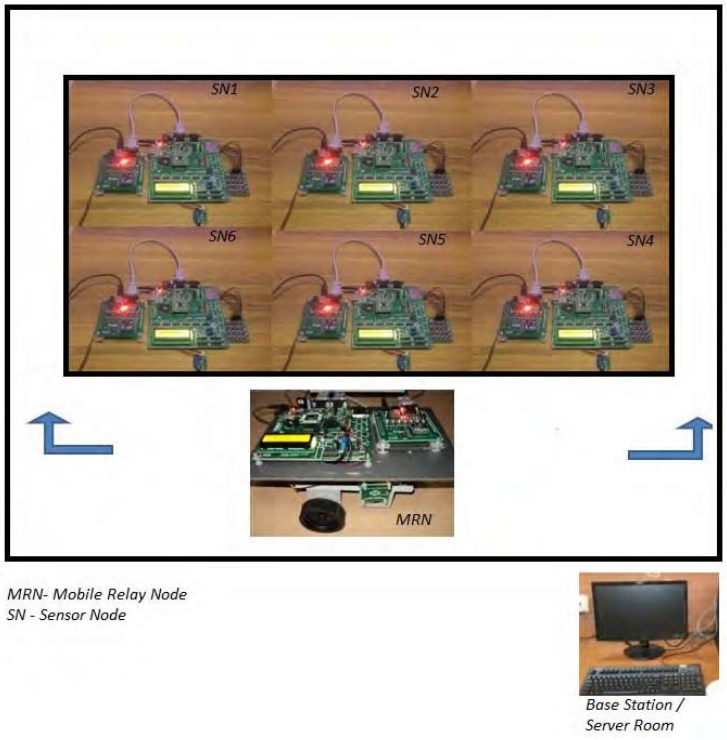

Fig. 2. Experimental setup of sensor node and relay node in industrial environment

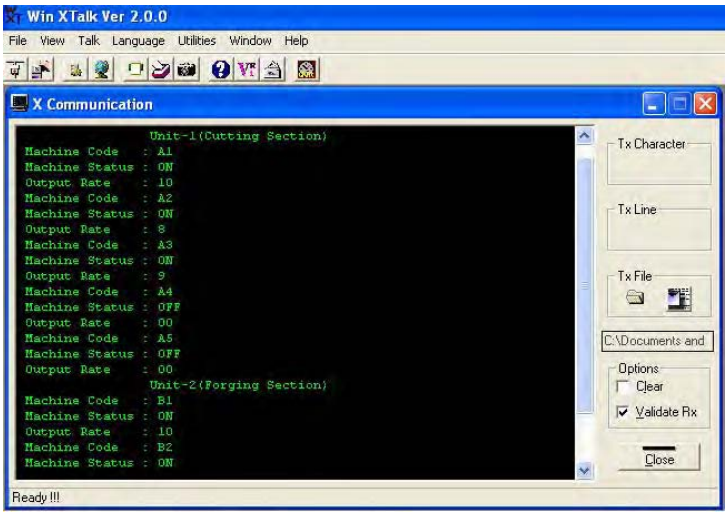

Fig. 3. Status information of sensor node output in the server room display

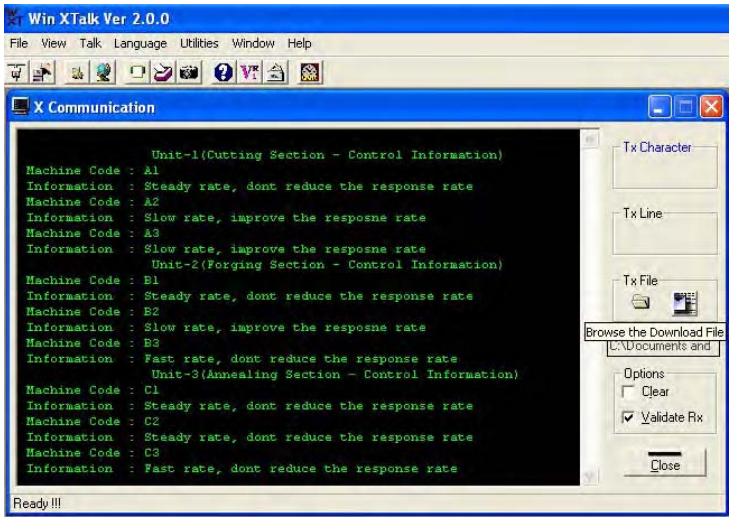

Fig. 4. Control information for sensor node in the server room display

7. CONCLUSION

In this paper a mobile device is developed and introduced in the industrial environment for collecting data. Using mobile relay node, the functions of the wireless sensor networks is enhanced in terms of energy, lifetime, reduction in data losses, and good in response time. The industrial processes are automated and status report is monitored using mobile relay node. In this experimental setup, the proposed relay node is tested in embedded test platform using different number of sensor nodes. This proposed system supports and provide long coverage area in minimum energy consumption and also improves the lifetime of sensor nodes in WSN. It also avoids the node failure problems and improves the system efficiency of the network. The low power 2148 processor is used throughout the network which reduces the overall system cost.

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