Runway Control using Smart Sensor Networks

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Project Information

On August 27th 2006, Comair flight 5191 departing from Lexington, Kentucky, crashed killing all the passengers aboard and the crew members excepting one. The basic human error leading to the crash was the shorter runway that the Comair flight took off. The present technology to deal with runway air traffic control is the manual monitoring done by the air traffic controllers. For the Comair flight, the air traffic controller cleared taking off from runway 22 and then proceeded for further duties without checking which runway the flight was actually taking off from. The flight by mistake taxied on runway 26; an error that got undetected leading to the unfortunate event. As an aftermath of the incident the pilot reporting policy has been changed to verify the runway clearance information but the real time errors/faults remains undetected. Severe weather conditions or negligence or shortage of workers can still lead to delayed or undetected diagnosis of an error which leads to unfortunate loss of life.

Runway mishaps occur due to the lack of real time monitoring and time gap in alerting on diagnosing a severe condition. The event response time gap can be reduced by deploying automated technology to handle constant 24/7 monitoring, and alerting on severe condition detection by transmitting a warning signal. One such technology we propose is the deployment of wireless sensor network to detect errors/faults on the runway and transmit warning messages to the pilot and air traffic controller in real time. With wireless sensor network deployment, crashes like that of Comair 5191 could be avoided as the pilot would be instantly notified of the length of the runways based on the signals received from the sensors deployed on different runways in an airport. The wireless sensor network could also detect severe weather conditions which can go undetected by human beings thus preventing further loss of lives.

Stages of development of the technology

The network will be developed in four stages. In the first stage the scalability of the network will be analyzed so that the following required parameters can be determined: battery power, computational energy, communication energy, re-chargeability, sleep patterns, transmission range, memory, tamper protection, and unattended operations. In the second stage the following networking constraints will be analyzed: data rate, channel error rate, latency, limited pre-configuration, unreliable communication, frequent route changes, unknown recipients and population density. In the third stage we will simulate the network to observe the network parameters in the proposed architecture. We will use TinyOS and TOSSIM for simulation with 2000 sensor nodes distributed uniformly in a region of $7 \times 8 miles$. The communication range of the nodes is $100m$. The nodes will be divided into groups (clusters) of 10 to 50 nodes. The nodes will communicate with each other using multi hop paths and existing routing algorithms (AODV, DSDV). We will simulate the organization of the network using general sensors, relay nodes and cluster head. This will also help us to measure the communication time and energy consumption before deployment of the sensor hardware. In the fourth stage we will do the hardware implementation. We will create a self-configurable structure of the group hierarchy as shown in Figure 1. Thus, each node has a flag indicating whether it is a cluster head; this flag influences the behavior of the node (i.e., which messages it responds to). Additionally, each group will has its own broadcast address, that is, where TinyOS normally recognizes one broadcast address, in our implementation there could be several of the messages. The upshot of this is that a node can broadcast a message to everyone in its group (including the cluster head), but a cluster head can also broadcast messages to its neighboring cluster heads.

Potential customers to be targeted

According to the publications of National Transportation Safety Board aviation accidents in the recent past indicate a number of crashes due to runway errors. The probability of the number of runway related crashes can be reduced by using smart wireless sensor networks. So our technology would be a reasonable, cost effective indicator of risk prone situation for a disaster. Wireless sensor network of different capability can be considered for deployment at airports of different sizes. These wireless sensor networks can be used to diagnose severe weather conditions and risk prone damages on the runway which otherwise goes undetected by humans. On demand maintenance of runways can be performed based on sensor data received. The diagnosis could be sent as a warning signal to the air traffic controller or concerned person to prevent hazardous landing or take off. Wireless sensor network can also be used to get real time information about the traffic on a runway. This would prevent flights landing and taking off from colliding with each other.

We require reliable and safer runways for take-of and landing of airplanes. Different applications of wireless sensor network will enable the reliability and safety of runways. As a result, we would target the airport authorities as our potential customers in order to implement smart runway control.

Market Assessment

The latest Government Accountability Office report shows that the risk for catastrophic crashes on runways has increased. This has occurred due to malfunctioning technology and overworked air traffic controllers. The reports prove the need to update the technology; Wireless Sensor Network (WSN) is a promising technology to replace the earlier technologies to get better response.

Present technology according to the reports of Raytheon is to use radar surveillance for Precision Runway Monitor (PRM) (deployed at MSP, New York and Philadelphia), Integrated Terminal Weather System (ITWS), Low-cost Advanced Surface Movement

Radar (ASMR). It captures the environmental parameter from a distance and transmits back to display panel. Event classification is done by human

Commercial Assessment

Small to mid size airports carry out the monitoring manually. Thus there is a need to have an automated technology to handle discrepancies. WSN are commercially viable technology that is cheap and easy to install.