ENSURING OF SAFE TRANSPORT OF GOODS AND CARGOS AND MONİTORİNG OF VİBRATİON LEVELS USİNG WİRELESS SENSOR NETWORKS

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Abstract— Our country, in which the logistics services are rapidly increasing, is on its way to become a logistic hub with its unique location where the main trade routes intersect and with its increasing trade activities. Today, there are about 25.000 transport vehicles and 10.000 fixed cargo centres. During the transport operations, the cargos are exposed to vibrations and get damaged. And when the goods are delivered, the checks for damages are only conducted as per the appearance of the cargo, if the goods have been damaged or deformed due to the vibration; the transport companies accept no liabilities. These days, no transport companies record what vibration levels the cargos are exposed to during transport and the owners of the cargo can only track their cargo for their whereabouts. The only right the cargo owners have is whether or not the box is damaged. By including an Accelerometer and a Gyroscope to prevent this condition, the boxes will have been monitored during the journey and what kind vibration they have been exposed to will have been recorded.

Keywords— Wireless Sensor Networks, Zigbee, Sensor, Nodes, Accelerometers, Gyroscopes, Transport, Cargo

I. INTRODUCTION

The progresses in the architecture of low-cost detectors have made Wireless Sensor Networks a new and known research area[1]. These networks are generally formed with the haphazardly releasing of too many low-strength, low-cost transmitters with limited capacity and short range into an environment which is not reachable and most of the time not reliable. Each and every node has the ability of calculating, detecting and communicating. These nodes that can be distributed stochastically in to environment to be monitored can recognise themselves and can implement the measuring tasks in a broad range with a collective effort. Due to these characteristics, they can be used in many areas including pre-determination in medical applications to military zones and from ENSURING the safety of a building to preventing forest fires[2].

If data are wanted to be collected from many sensors in a specific area, performing of this task through Wireless Sensor Networks would be the cheapest, reliable and long-lasting solution. In these days, in the cargo services received by everyone the products are smitten and deformed due to vibration. The people using this service however, when their goods do get damaged due to the vibration and impacts, they have no right to claim for compensation, but they can only claim if the carrying box is damaged. For this reason many people cannot use cargo services for these devices which can get deformed as a result of vibration and they get aggrieved. In the study conducted, monitoring of impacts and vibration that are applied or exposed on the products from the receipt of the products by the carrier company until the delivery of them to the receiver in the cargo services that everyone uses was aimed. Thus, the users will be able to find out not only where their goods are but also what impacts and vibrations their goods have been exposed to, and instantly monitor these data.

In order to determine how much vibration the cargos have been exposed to, an ADXL345 accelerometer was used. The acceleration sensor measures forces it receives in three axes. The ADXL345 sensor can perform readings in ±2, ±4,±8, ±16g precision. Also in order to determine the angle of the goods on the carrying vehicle, an L3G4200D Gyroscope was used. The value that Gyroscope transmits is the angle formed by normal of the gravity vector and the Gyroscope Sensor. Thus, the vibration applied on the box (the force falling onto) will have been measured with the acceleration sensor and with the Gyroscope the angle of the cargo boxes will have been determined.

The data of the sensors located in the cargo vehicle are periodically by the central sensor node and sent to the central station. The central station ensures the saving of the data collected on the Server. The users can monitor the conditions of their cargo and in case of damage they can use these data as evidence.

II. ACCELEROMETER AND GYROSCOPE

Accelerometers and Gyroscopes are basic sensors for motion. With the progress of MEMS technology, the sensors which previously made calculations by means of mechanical systems and which were inefficient, were not easy to connect to the electronic systems and whose usages were not widespread have been left behind and sensors in small sizes (mm^2),

with low power consumption, programmable, and which can easily be integrated into electronic systems have come into the picture. The accuracy in readings and programmability of the MEMS sensors has ensured their usability in almost every application. The Accelerometer measures the G force (Static or Dynamic) that falls on it. The sensor will want to preserve its current location as per the law of inertia when it moves in a certain acceleration, for this reason a G-force in the opposite direction to which it is moved falls on it.

Nowadays, the MEMS (Microelectromechanical Systems) technology has progressed in a way that measurements of very tiny and rapid changes could be made. The accelerometer measures, when there is no motion, the gravitational acceleration that falls on it. This is called a static acceleration. And yet when there is a movement, it measures the G-force that falls on it in 3 axes. And this is called dynamic acceleration. Through the change in the G-force or the instantaneous value of it, it is determined whether the sensor is in vibration, accident or free fall. An accelerometer could be simply shown as in Figure 1.

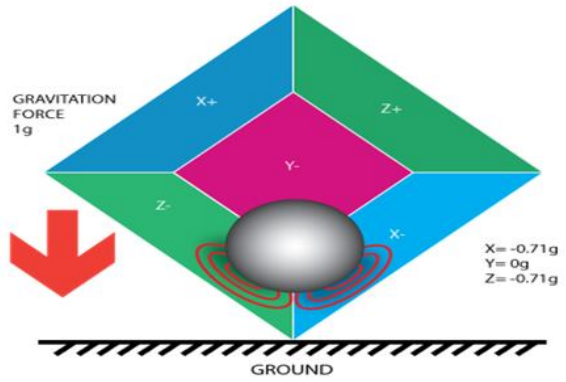


Figure 1. Accelerometer

As a result of the recording G-force applied on the sensors; the physical accelerations and sudden impacts they are exposed to can be determined. The output data of the accelerometers are defined as m/s^2 or gravity (G-Force). If the sensor is measuring G-force in continuously changing magnitudes or a vibration condition or a sudden high G-force value, an accident situation is then determined.

A gyroscope is formed with the swiftly spinning of a wheel in its axis. When two wheels are perpendicularly fixed, the centre of these wheels and the wheel on the gyroscope and the straight line crossing the centres of the other wheels would show the reference axis of the Gyroscope. As the Gyroscope would tend to stay always in the reference position, in the contrary case it produces a data of a force in the direction that would make it move closer to the reference value. MEMS gyroscopes always give the angle of the distance to this reference point. Thus, it is always possible to determine the angle needed to reach the normal or how much, in terms of angle, the object is far away from the normal. The output data of the Gyroscope is defined in degree/seconds. The sensor of the Gyroscope measures the angle created in between the normal of the gravitational acceleration and the sensor's. This way, the angle at which the sensor is fixed can be determined. A gyroscope sensor can be simply shown as in Figure 2. With a Gyroscope the tilts can be measured, how tilted the objects are can be determined.

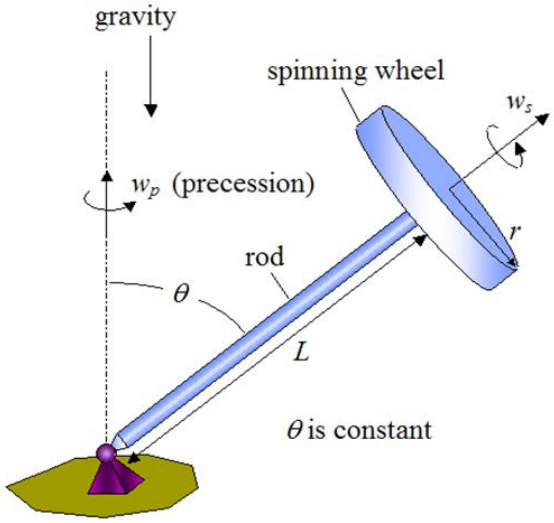


Figure 2. Gyroscope

III. DESIGN OF SENSOR NODES AND COORDINATOR NODE

Many of the problems we are facing nowadays will be solved with the increase of sensors collecting the data they measure in many different points. The concerns with the operations of collecting sensor data from multi points have opened the way for Wireless Sensor Network field. The communication sensors with low power consumption, low cost and small range used in this field work for the safely collection of data in a centralised server. The sensor nodes consist of microprocessors, sensors, communication units and memories.

The central station is responsible for collecting the data it has collected with the help of Zigbee Technology [3] from the sensor network on a server. The environment nodes however, send the measurements they make with the help their sensors to the central station.

As the processor, MSP430G2553 processor has been used. The MSP430 processors are microcontrollers produced by Texas Instruments Inc. in architecture of 16-Bit RISC and well known world-wide by its low power consumption. It pulls 0.1 µA current in sleeping mode and it can wake up from its sleeping mode in just under 1 µs. This way, it can give the same reaction, when interrupt or similar options are used, as most of the processors that are

not in sleep mode. It also has hardware I2C, SPI, UART. It can communicate with other sensors and computers by means of these communication interfaces.

In order to determine how much vibration the cargos have been exposed to, an ADXL345 accelerometer and a L3G4200D Gyroscope was used. The ADXL345 sensor can perform readings in ±2, ±4,±8, ±16g precision. Thus, different accuracy levels can be specified for each cargo type and more precise measurements can be made on fragile cargos. The sensor of the Gyroscope can perform readings in 250/500/2000 dps (Degrees per Second) in the same way.

The communication with the sensors is established over I2C protocol. On this protocol, the data on the sensors on the same line can be read. Also, when there is no data-reading on the sensors, the sensors are put in sleeping mode. The working temperature of the sensors is between -40°C and +85°C. Sensors in terms of Power Consumption:

- An accelerometer pulls 0.1µA current in sleeping mode and 140 µA in measuring mode with a 3200 Hz sample rate.
- A Gyroscope however, pulls 5 µA current in sleeping mode and approximately 6 mA in measuring mode.

The powers that the sensor nodes consume are important in the sense of not frequently changing batteries, not running flat of batteries when needed. By virtue of low power consumption longer recording of data can be achieved. In Figure 3, microcontroller circuit and the sensor circuits for the sensor node implemented are given.

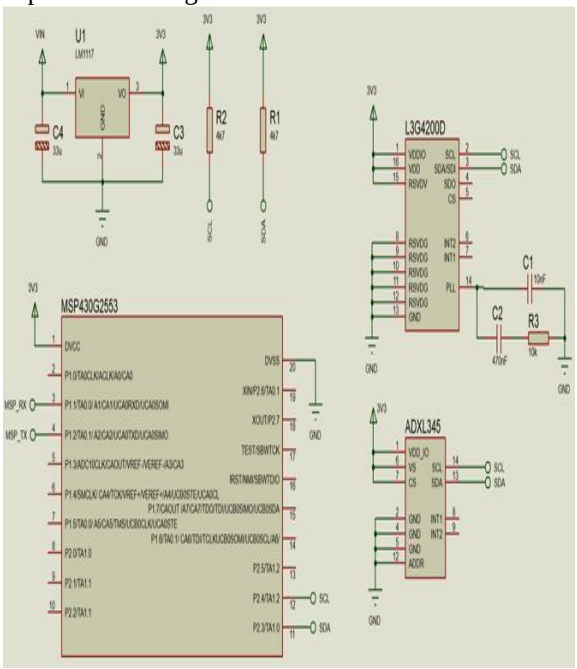


Figure 3. The circuit for Microcontroller and the Sensor

In addition to this, in coordinator node however, SIM900 GSM/GPRS module has been used. This way communication with the server or a mobile phone can be established. In Figure 4, given is the circuit drawing for SIM900 GSM/GPRS Module.

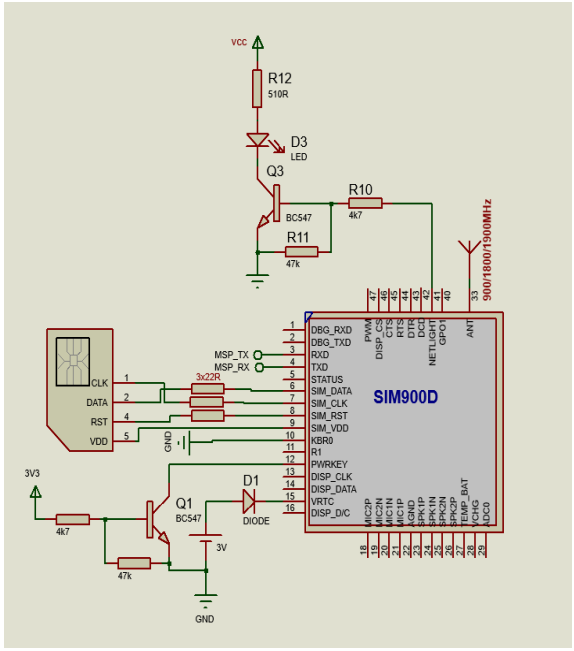


Figure 4. Circuit drawing for SIM900 GSM/GPRS Module

IV. MONITORING OF ENVIRONMENT DATA

A general architecture of collecting data from nodes is shown in Figure 5.

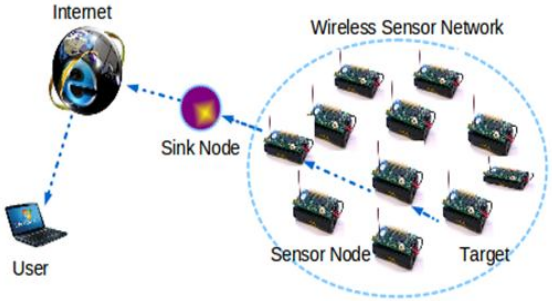


Figure 5. Architecture of Collecting Data

As seen here, many sensor nodes send their data to the central node and the central node uploads these data to the Server. The end users are able to display the sensor data. The threshold values of the data being monitored can be determined by the users. This information comes from the environment node instantly. If the value that arrives is higher than the threshold value, then it is understood that there is problem in the environment and the user is notified with an SMS/call. This way, sudden changes that might occur in the environment can be instantly identified and taking precautions will be lot easier. The values that the nodes in the environment detect are received by the coordinating device. As shown in

Figure 6, the sensor nodes are placed inside the boxes on the transport vehicle.



Figure 6. Placement of the Nodes

The coordinating device transiently sends the data to the Server by means of the Module SIM900. By virtue of the software that can be implemented on the computers, concluding of graphical statistics and triggering of instant warning systems can be performed. The instant behaviours of the systems can be remotely monitored by virtue of the web-based coded software and remote monitoring features; also the control of the devices can be accomplished.

CONCLUSIONS

In general, only the information on the whereabouts of the goods is given in tracking of the cargos. During the transport operations, the cargos are exposed to external impacts and get damaged. And when the goods are delivered, the checks for damages are only conducted as per the appearance of the cargo, if the goods have been damaged the transport companies accept no liabilities. In the study conducted, sensor nodes and coordinator nodes have been developed and accelerometers and gyroscopes were used in the sensor nodes developed. This way, accelerometers and gyroscopes were placed inside the cargo boxes and tracked during the period elapsed between the sender and the receiver and how much vibration they had been exposed to was recorded. In the system designed, lower and upper alarm thresholds can be determined, thus it becomes a product that can be utilised for each variable environment.

ACKNOWLEDGEMENTS

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