**Tentative deliverables\*\*:**

This project aims to develop a Wireless Sensor Network in the industry which would monitor the key stress points in the plant. The network of sensor nodes would measure various parameters of plant and the readings of these individual sensor nodes will be communicated to a centralized sink node. Only the sink node will have the ability to process or analyse the data, hence, all the intelligence would be residing in the sink. Different type of sensors can be used to monitor many parameters. Smoke or fire sensors will be used to sense any type of fire in the industry, so alarm can be generated automatically, hence making the life of the workers safe. Besides being used for monitoring purposes, the network may also control certain parameters based on the measured readings. We aim to build the sensor nodes indigenously in order to control the design parameters and tailor them for optimizations suitable for our environment. It may also allow us to make it cost effective and thus feasible monitoring and safety assurance solution for the local industries.

**Problem Introduction\*\*:**

Wireless sensor network has been proposed and implemented in the industry for the process monitoring and control. A survey of various issues related to the implementation of a WSN based monitoring and control in an industrial environment has been discussed in [4]. A platform based design of a WSN in industrial application has been proposed in [5] whereas a WSN for air pollution monitoring has been proposed in [6]. Gutiérrez et. al proposed the use of WSN in the energy evaluation of industrial plan ts [7] and a WSN based architecture has been proposed in [8-10] for preventing fire and environmental and/or industrial hazards.

In our regional context, one of the simplest applications of a wireless sensor network is in fire safety which is one of the main concerns in any industrial sector [1]. During the month of September Rescue 1122 reported a total of 172 fire incidents in Lahore only; most of them in factories and high rise commercial buildings. The main cause of such incidents is unmonitored working environment. If temperature is rising in a certain area of the factory it will not be noticed by some human until it catches fire. A key hindrance is the physical and civil infrastructural changes required to accommodate these sensors. With this automated, wireless sensing, our system will be able to detect and report fire incident to the central server system and also emergency response services can be notified automatically. This concept can be extended to other process parameters such as temperature, pressure, humidity, speed, activity etc. to gain insight into details fundamentally lacking in our current industrial setup. If the functionality for bidirectional information is enabled, the same network can also be used to control process parameters automatically. Successful implementation will result in safe and efficient working environments along with a higher industrial yield per capita. Automated control of many parameters will result in efficient utilization of resources and considerably higher product quality.

Development of wireless sensor networks is a cost effective and innovative way on monitoring and controlling a certain area. This solution will focus on the industrial sector but the same solution can be deployed in other areas such as traffic flow monitoring and control, street light monitoring and control, smart grids, energy efficiency initiatives in government facilities, etc. to centrally monitor and control the working parameters. Our solution will address many problems being faced in the industrial sector. This solution can be scaled to other area of the province also like Automated Street light control, Automated Traffic light monitoring and control and in medical industry for example wireless patient monitoring in case of non-availability of doctor. It addresses all of the following objectives of the Innovation Development Fund:

**System Implementation**

(Hardware and firm design)

-Sensor interface hardware design board.

-Motes Hardware design.

-Firmware for Monitoring and control.

-PCB fabrication.

**System Implementation (Networking)**

-Network layer Simulation and Implementation

System Design Specifications

Distributed initial prototypes

**System Implementation (Software End)**

-Implementation of the Graphical User Interface

**Sensor Data Analysis**

- Implementation of software data analysis Algorithm

- Implementation of Control Actions

**Design of the software & communication architecture**

1. Top level system architecture
2. Technical specifications
3. Technology decisions
4. Selection of communication methodology

**Requirement Elicitation and analysis**

1. Technical assessment and planning
2. Thorough literature review of the existing solutions
3. Identifying constraints in collaborations with the industrial partners
4. Hardware and software procurement
5. Requirement documentation & validation

Project Requirement specifications

**Integration and Testing**

**Performance evaluation**

1. Analysis of the battery life.

System reaction time and detection rate.

**Final Release**

1. Final software product
2. Software User Manual
3. Training of users

Initial prototype

Final Prototype

**Research and Development**

1. Requirements analysis
2. Architectural design
3. System implementation
4. Performance Analysis

**Contingency plan**

Design Issues

* It is an enabling technology that has the potential to address multiple areas of energy efficiency and conservation, societal wellbeing, efficient governance, enhanced industrial efficiency, etc.
* The development of the solution will use indigenous innovative and creative capabilities with a potential of disseminating information to both industrial and academic communities for sustainable progression beyond the project timelines.
* It is inherently a flexible, configurable and scalable project with minimal mandatory infrastructure requirements.

We have consulted with TetraPak, Pakistan, Pvt. Ltd at Sundar Industrial Estate and also visited their production facility. They have agreed to assist us in this project. We will be consulting them for key issues being faced by them. A prototype system will be completed and tested at their production facility. Once the project is initiated we may also collaborate with other public and private sector industries to confirm compatibility of our solution with their needs.

**Design\*\*:**

In order to design the solution tailored to our local needs and make our solution cost effective, we would be developing our own hardware. The sensor mote consists of the following main parts

* A controller (usually a micro controller)
* Memory
* Sensor Actuators
* Communication Device (An RF transceiver also called radio device)
* A battery or power supply

The need for a scalable solution that can easily be deployed and interfaced for a wide variety of applications in an industrial setup with large coverage area requires a solution that can reliably communicate over small to moderate distances and a network, preferably mesh, to allow these nodes to collectively provide connectivity over the entire area of coverage. Each node can thus act as a sensor node and/or a gateway node that ensures redundant connectivity in the entire network with a supporting protocol to eliminate unnecessary communication and interference. The overall solution may be plug-and-play with self-managing, node aware network that can eliminate management tasks entirely or reduce them to optimization tasks only. Off the shelf sensor motes are available that provide many of these features but are usually costly and may become unfeasible for large number of sensor motes thus reducing the useful footprint of WSN to a few choice applications.

The following figure dives a brief description of the components that comprise a typical sensor mote.

CONTROLLER

POWER SUPPLY

SENSORS/ ACTUATORS

COMMUNICATION DEVICE

MEMORY

Figure 2: Block Diagram of Hardware Sensor Mote

### Controller

The controller in the mote will be the main decision making device responsible for generating signals to the sensors, interacting with the memory, and initiating and responding to communication device. The design constraints of a sensor mote controller are similar to those in embedded systems. The most popular controllers include the Intel Strong ARM, the Texas Instruments MSP 430, and the Atmel ATmega [2]. As the nodes in our solution will not be analyzing the measurements, we will not be requiring a controller with large processing power.

### Memory

A non-volatile Read Only Memory (ROM) and Random Access Memory (RAM) are inherent requirements of all embedded systems; same is the case with sensor motes. Hence, we need to introduce some small memory chip into the hardware design, and integrate it for operation with the controller.

### Sensors/Actuators

A sensor is basically any device that measures a physical quantity and converts it into a signal that can be processed by the controller. Sensors that can measure temperature, humidity, speed, sound, optical characteristics and chemical composition can be employed in different industries for monitoring of process control variables. Popular vendors include Texas Instruments, Sensor Tran and Microchip. The basic requirement for sensors is their accuracy and low latency operation so that the measurements are precise in time. Depending on the requirement of the industry, sensors and actuators can be added on to the sensor motes. A further study can be done to include a generic interface development for sensors that are IEEE-1451 or other industry standard compliant. The architecture of these standards can be found in [11]. Another important consideration for typical sensors is their energy efficiency. Some sensors are not energy efficient because of the requirement of a large amount of current. As the proposed solution is supposed to be deployed in an industrial plant with devices accessible to the human resource, energy considerations for sensors will not be a prime focus of this project.

### Communication Device

A sensor network needs to communicate with the central station, so an RF device is needed for each mote. The choices include an IEEE 802.15.4 interface [12], IEEE 1451 [11], ISA100 [13], DASH 7 [14] and ZigBee [15]. The energy required for transmitting the signal increases with the frequency of the signal. This puts an important constraint on the design of RF device required for our application, i.e. to operate it at as low frequencies in the Electromagnetic Spectrum as possible. Much research has been carried out in designing energy efficient RF end architectures. Several standard transceivers are available off-the-shelf and further to the comparison listed in subsequent sections, a study of available technologies will be conducted to choose an appropriate device that meets the project requirements of scalability, reliability, data throughput, area of coverage, frequency of operation and security.

As the objective of the project is to record the readings of the sensors located at the key points in the plant, this would be a combination of types 1, 2 and 3 (described in section 2) WSN i.e. data gathering, periodic reporting, event detection/alerting and on-demand querying with the provision of sink initiated control commands based on event detection and/or data analysis. Readings of the individual sensor nodes will be communicated to the sink. All the processing and intelligence would reside in the sink. Suppose there are N nodes located at the key stress points in the industrial plant. Each node would be connected to the sink either directly or via multiple hops. The sink would be the brain of the network and would be gathering the information doing the analysis and ordering for process control at specific location. There would be three main components of our solution:

* The hardware (sensor mote)
* Implementation of the communication/networking protocol.
* Analysis at the sink node

Some advantages of our system over existing wired systems.

* No high cost of copper wire as these devices communicates wirelessly (No long running cables).
* Lower cost and energy efficient.
* Plug and play devices.
* Easy troubleshooting and repair.