Wireless Sensor Networks – Concepts

General Concepts

Wireless Sensor Networks (WSN) are built based on a combination of multiple sensors placed in diverse locations, wireless communication network infrastructure and software data processing to monitor and record multiple parameters. Commonly monitored parameters are temperature, atmospheric pressure, humidity, vibration, illuminance, sound level, power consumption, chemical concentration, body health signals and many others, dependant on the selected available sensors. The WSN are used in multiple fields, ranging from remote environment monitoring, medical health, to home surveillance and industrial machines monitoring. In some cases, WSN can also be additionally used for control functions, apart from monitoring functions.

Typically a WSN is made of sensor nodes that are wirelessly connected to a gateway that is then connected to a main computer (Fig. 1). In some WSN the sensor nodes can also be connected to each other, so that is possible to implement multi-hop wireless mesh networks. The gateway connects to the main computer through a cabled or wireless connection.

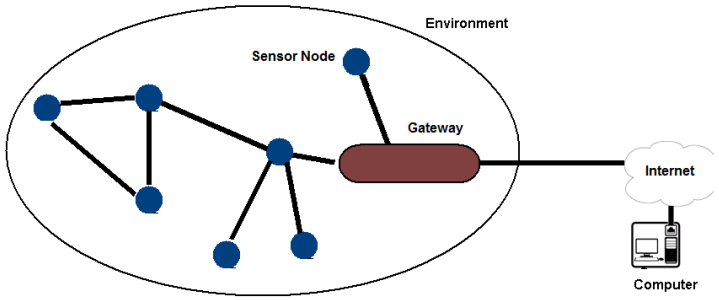
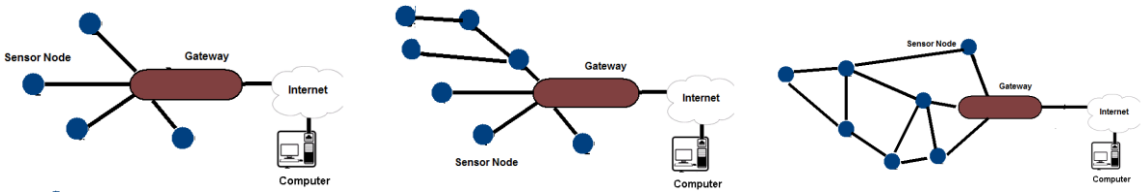


Figure 1 – Wireless sensor network

The wireless communications used in WSN depend on the application requirements, taking into consideration the needs in terms of transmission distance, sensor data bandwidth, energy source and power consumption. Common communications include standard protocols such as 2.4 GHz radio based on either IEEE802.15.4 (ZigBee, ISA 100, WirelessHart, MiWi) or IEEE802.11 (WiFi) standards. Each sensor node typically includes an embedded microcontroller system with adequate electronic interface with a sensor (or set of sensors), a radio transceiver with antenna (internal or external) and an energy source, usually a battery, or in some cases an energy harvesting circuit. The gateway, to which a given number of sensor nodes can be wirelessly connected, also uses an embedded microcontroller system, normally directly powered and with cabled or wireless connection with the main computer.

WSN topology

The sensor nodes of a WSN can be organized in a network of different topology, including star, cluster tree and mesh. In Figure 2 different topologies are presented.



Star Cluster tree Mesh

Figure 2 – Networks topologies

The complexity of these different network topologies need to be addressed both in terms of hardware and software. In tree and mesh networks, the sensors nodes have to be able to forward the data from other nodes. In mesh networks suitable paths need to be configured for transmitting the sensors data. In a WSN the power requirements for each sensor node is crucial. The use of batteries can limit the number of interconnected nodes and the transmission distance.

The NSensor WSN Configuration

The NSensor WSN adopts a star topology, where each gateway supports up to ten sensor nodes (Fig. 3). The communication between each sensor node and the gateway uses the MiWi protocol, based on a 2.4 GHz radio connection (IEEE802.15.4). Each sensor node is powered by batteries (4 x 1.5 V standard AAA batteries). Each sensor node can support multiple sensors, using analogue or digital (I^2C) interfaces. In the present implementation, the sensor node is configured to interface with five different sensors, allowing the measurement of air temperature, relative humidity, atmospheric pressure, illuminance and ultraviolet radiation intensity.

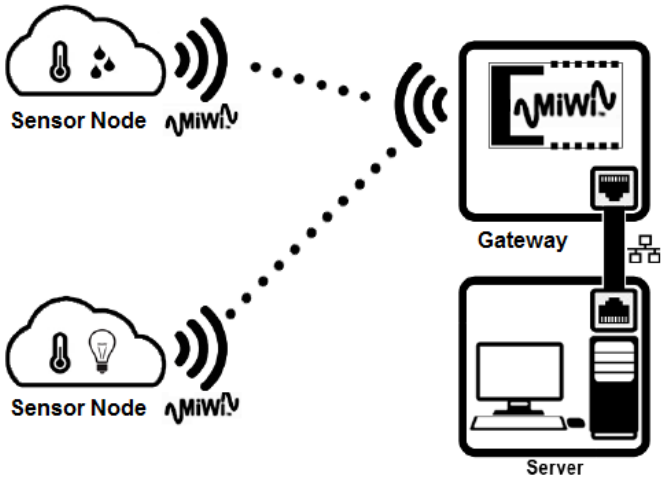


Figure 3 – The NSensor WSN configuration

The gateway supports the MiWi communication and connects to the internet through a cabled Ethernet port. The gateway is powered from the mains and provides a web server that can be accessed by a computer to reconfigure the module. The monitored data is stored in a database in a central server.

The software application provided allows two types of users, the administrator and registered users. The administrator can configure the sensor network, define the name and location of each sensor node, define the sampling interval and set the alarm parameters for each available sensor. The registered user can have access to the data of every sensor node, having the option to see and export the logged data for a chosen period.

The WSN was developed in-house, based on embedded microcontrollers from Microchip.

Node sensors' characteristics

Each sensor node is fitted with the following sensors. Further data about the sensors can be found in the datasheets available within the application.

Parameters	Characteristics	Reference Unit
Temperature (AM2320)	Range -40 to 80 Resolution 0.1 Accuracy ±0.5	°C
Temperature (BMP180)	Range -40 to 80 Resolution 0.1 Accuracy ±1	°C
Atmospheric Pressure (BMP180)	Range 300 to 1100 Resolution 0.01 Accuracy ±0.12	hPa
Relative Humidity (AM2320)	Range 0 to 99.9 Resolution 0.1 Accuracy ±3	%RH
Illuminance (VT935G)	Sensitivity (γ) = 0.9 R = 18.5kohm @10 lux R = 1Mohm @ Dark $L = 255.84 \times R^{-\frac{1}{\gamma}}$	lx
Ultraviolet Light Intensity (ML8511)	Sensitivity 0.124 $\frac{\mathrm{V}}{\mathrm{mW/cm^2}}$	mW/cm²
Battery voltage	Must be above 3.6V for proper operation	V