WHITE PAPER

Communication Modes in IoT for air quality monitoring

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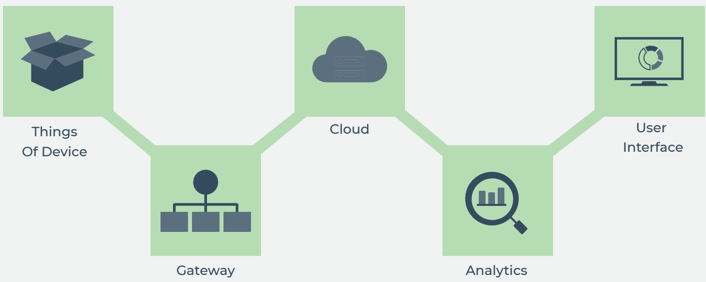
Introduction

IoT enables the collection of data with minimal human intervention. Machines and objects (i.e. the things of the device) with built-in sensors are connected to an IoT platform to which they transfer the data over the internet. This platform integrates data received from the different devices and applies analytics to share the required information with the user.

Over the past few years, IoT has become one of the most important technologies of the 21st century. Today more than 10 billion objects are connected to the Internet and this number is expected to surpass 25.4 billion in 2030.

Components Of IoT Architecture



The IoT platforms are powerful enough to pinpoint exactly what information is required by the user based on specific applications and needs. The data analysis performed can be used to detect patterns, make recommendations based on results, and detect possible problems before they occur. In a nutshell, a monitoring system using IoT acts as eyes, ears and a mouthpiece i.e. it watches, listens, and reports a vast range of information for the intended application, and sometimes even takes automated actions.

IoT in Air Quality Monitoring

The atmospheric pollution trends are complex and difficult to conceptualize. The use of conventional air quality monitoring technologies has many challenges, they are expensive, provide only a snapshot of data, require expertise, and take time in lab analysis. But many initiatives have been taken to tackle the problem with IoT-based technologies. The IoT sensors can detect and measure every type of environmental change making it easier to monitor the air quality in real-time. Monitoring using IoT devices reduces the need for human labor, allows for real-time monitoring, and increases the spatial range of monitoring. Using smart IoT air quality monitors to identify the exact source of harmful air pollutants, the policymakers and officials can pinpoint the numerous factors that contribute to it, and ultimately, take actions to reduce the air pollution.

The IoT-based for air quality monitoring system consists of continuous collection of air quality data from the environment using smart sensors and connected devices. These internet-connected devices, with embedded communication modules, then process the data collected using computing technologies and quickly send important information to the cloud or data center for further analysis.

These monitoring systems connected to IoT platforms are programmable to detect abnormalities or specific conditions and trigger alarms or alerts as well as automate processes.

Communication Modes

Connectivity is key to any Internet of Things (IoT) deployment. Communication between machines is integral in IoT as it enables pieces of hardware to gather and exchange data.

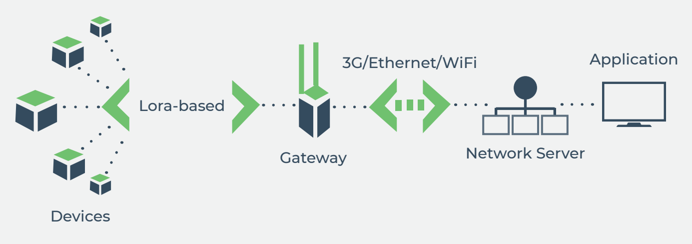
Many different communication protocols have been created over the years, allowing the IoT devices and platforms to send each other data in new, interconnected ways. The communication protocols for IoT-based real-time air quality monitoring systems are:

- LoRa
- GSM / GPRS
- LTE
- Wi-Fi
- LoRA
- NB-IoT
- MODBUS
- Ethernet
- Sigfox

Each type of communication technology has its own advantages and drawbacks in terms of coverage, range, scalability, cost, and network requirements.

LoRA

LoRA stands for "Long Range" and primarily finds its application in Machine-to-Machine (things-to-things) in the IoT. It was developed by a company called Semtech and enables public or multi-tenant networks to connect several applications running on the same network. This uses a proprietary spread spectrum modulation which is performed by representing each bit of payload information by multiple chirps of information.



A LoRa network uses LoRaWAN (i.e. a cloud-based media access control layer) protocol for sending and receiving data from LoRa sensors and managing the communication between LoRa gateways and LoRa devices (nodes). LoRaWAN is a low-power, wide-area networking protocol built on top of the LoRa radio modulation technique. The sensor nodes in a LoRa network are based on asynchronous communication, that transmits the data when its available to send. The data from the sensor nodes is transmitted at particular frequencies which are received by the LoRa gateway, which forwards the received data packets to a centralized network server (IoT server). Here, the LoRa gateway is connected to the internet and not the sensor nodes. The IoT server manages the complete network along with performing security checks and transmits the data to the application modules.

LoRa gateway can handle up to millions of nodes which are compiled and sent onwards. It provides for long-range communications i.e up to 5 km in urban areas and up to 15 or more in rural areas. This means that there is less infrastructure required, making constructing a network cost-effective and faster to implement. Only the gateway connects to the internet and not the whole networking and hence finds its application in connecting smart devices over the city.

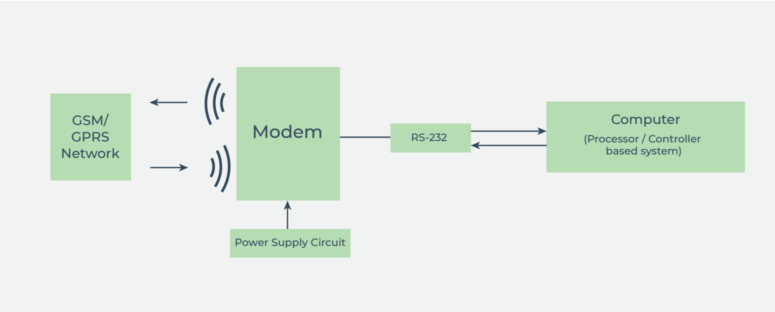
Furthermore, LoRA allows efficient monitoring of air quality by using the gateways with the advantage of prevailing low power consumption, an easy gathering of data from multiple nodes, high processing speed, reduced cost, and low latency time.[2] The delay in sending out the results of the LoRa Terminal to the cloud platforms is negligible.

The major drawback of using LoRa is its low bandwidth and inability to allow continuous data transfer. This is the reason why LoRa is most suitable for short and periodic communication applications.

GSM / GPRS

GSM or "Global System for Mobile communication" is a decades-old wireless communication. standard for cellular networks. This revolutionary technology was the first to support streaming data for mobile devices with built-in encryption and 50 kilobit-per-second speeds. The current 4G protocol speed runs between 200MB–1 gigabit per second, and 5G networks operate starting at 1 gigabit per second, running up to 1,000 times faster than 4G. GPRS i.e. General Packet Radio Service is an extension of the GPS network which provides an efficient way to transfer data with the same resources as the GSM Network

IoT architecture for this system has two methods of data transmission: (i) the gateway of the sensor node sends and receives data through a cloud server, and (ii) the data communication is done by using a fixed IP for the GPRS modem where the user can directly connect to the sensor node and sensor or receive the data.



GSM opens up Cellular IoT applications to more geographical locations offering global coverage. It can transfer large amounts of data and has the capability to continuously communicate within the network via the internet, unlike LoRa. However, this can also be a disadvantage at times. Sending large amounts of data continuously results in high power consumption and even higher data costs.

Cellular networks can match LoRa when it comes to range and coverage thanks to the existing infrastructure. However, the costs of maintaining a cellular network are much higher than maintaining a LoRa infrastructure. This is because through LoRa, the used bandwidth is much lower, and as a result, the demands on the underlying network will be much lower as well.

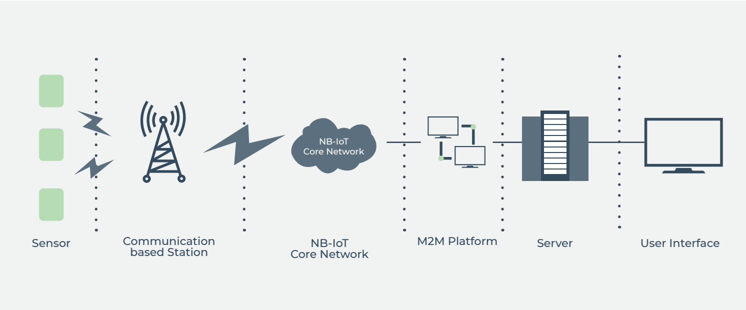
LTE

LTE (Long Term Evolution) is the fourth generation (4G) wireless standard with more speed and network capacity compared to the 3G technology counterparts. It provides reduced latency, scalable bandwidth capacity, and backward compatibility with the existing Global System for Mobile communication (GSM) and Universal Mobile Telecommunications Service (UMTS) technology. The carrier aggregation feature of LTE allows improved network capacity, adding bandwidth of up to 100 MHz across five component carriers (bands) with 20 MHz bandwidth each. LTE provides line-to-line encryption with password protection so that the transmission of data will take place after the line is secured.

NB-IoT

Narrowband Internet of things (NB-IoT) is a low-power wide-area network (LPWAN) radio technology standard developed by the 3rd generation partnership project (3GPP) for cellular devices and services. It is a wireless technology, an ideal communication mode for devices that need small amounts of data, low bandwidth, and long battery life.

NB-IoT is one of the most flexible networks and is built on cellular networks. It does not require any gateway to connect to the IoT devices within the network reducing the overall cost of development. It consumes only about 180KHz of bandwidth and can be deployed directly on GSM networks, UMTS networks, or LTE networks to support cellular data connectivity for Low Power Wide Area Networks (LPWA) nodes.



NB-IoT supports efficient connectivity for devices with long standby times and high network connectivity requirements. It is said that the battery life of NB-IoT devices can be increased to at least 10 years, while still providing very comprehensive coverage of indoor cellular data connections.

NB-IoT targets indoor coverage, low cost, long battery life, and high connection density. It is best suited for primarily static assets like meters and sensors e.g. smart dustbins, and parking sensors, in a fixed location, rather than roaming assets. It is similar to LoRa, however, It has a limited payload capacity (about <50bytes). The payload of multiple parameter sensors is usually high. To transmit such data through NB-IoT, the payload must be sent in parts causing a delay in total data transmission. Hence, is not an ideal solution for real-time air quality monitoring applications which require the transmission of the data of multiple parameters.

MODBUS

Modbus is a data communications protocol used for transmitting information over serial lines between electronic devices that works on DC power. It supports communication from multiple devices connected to the same cable or Ethernet network. Being the oldest automation protocol, it provides a common language for devices to communicate with one another. Modbus protocol is mainly used to convey signals from industrial devices primarily involving instrumentation control and data acquisition devices to a typical micro-controller unit (MCU) or to a data collection system

Modbus devices communicate using a Master-Slave technique, a slave is any peripheral device (measuring types of devices, I/O transducer, network drive, and others) that processes information and sends its response message to the master using Modbus. Masters can address individual slaves or initiate a broadcast message to all slaves. Slaves return a response to all message queries addressed to them individually, but do not respond to broadcast messages.

The main advantage that comes with this wired connection is the security of data as it is sent directly to the master and hence stays inside the organization or industry in a local network. It implements a very simple data representation and is very easy to understand. Its primary purpose is simply to move data between a Master device and a Slave device. There are no other pathways i.e. the data does not leave the industry and no one can access the data without having access to the Modbus master. However, for complex IoT devices such as multi-parameter ambient air quality monitoring systems, this can be a major setback. As the monitor cannot be accessed remotely due to the unavailability of the internet, the user cannot perform the required updates, calibration, or troubleshooting.

Ethernet

Ethernet comprises a physical connection between the devices via an ethernet cable (physical, encased wiring over which the data travels) in a local area network (LAN) or wide area network (WAN). It can offer a greater degree of network security and control than wireless technology due to the physical cabling of devices. The speed factor of ethernet is again a more reason to opt for the connection. It assigns a static IP address to itself and the receiver has to be connected to the same network for the communication. The data collected from the IoT devices remain in the said network and cannot be accessed elsewhere.

Although IoT is based on the wireless network, ethernet is still used in the IoT form of network. Many IoT applications need lower data rate connections. As the application becomes more bandwidth-intensive, wired Ethernet over DHCP can provide an internet connection for remote access and data transmission. This is the major advantage of ethernet over Modbus communication protocol. The Internet can be provided to the IoT device via ethernet allowing the user to remotely connect to the device for performing firmware updates, troubleshooting, etc.

Wi-Fi

WiFi stands for Wireless Fidelity/ frequencies. It is an industry term published by an organization called the Wireless Ethernet Compatibility Alliance. Based on the IEEE 802.11 family of standards, WiFi is primarily a local area networking (LAN) technology designed to provide in-building broadband coverage.

In a nutshell, WiFi is a collection of wireless network protocols used for local area networking, allowing nearby IoT devices to exchange data by radio waves. It is a short-range technology that can support radio signals for Internet access within a range of several hundred feet. It removes the data size limit (especially in the low range) and the delay in information is very low. IoT devices are connected to the internet via wifi and can send data payloads wherever required on a cloud-based platform.

When compared to other wireless technologies, WiFi has a few notable differences. For example, it transmits at much higher frequencies than the ones used for cellular transmission i.e. 2.4 GHz or 5 GHz. Higher frequency means that signals can carry more data. Also, it does not require cables, unlike wired communication protocols like Ethernet and Modbus, reducing the cost of deployment and expansion. WiFi can be reliant on measuring the air quality in urban areas, as it provides easier access to air quality monitoring data to a wider audience of citizens, scientists, and authorities. However, as you now know well, all forms of wireless communication represent a tradeoff between power consumption, range, and bandwidth. So in exchange for high data rates, WiFi consumes a lot of power and doesn't have a lot of range.

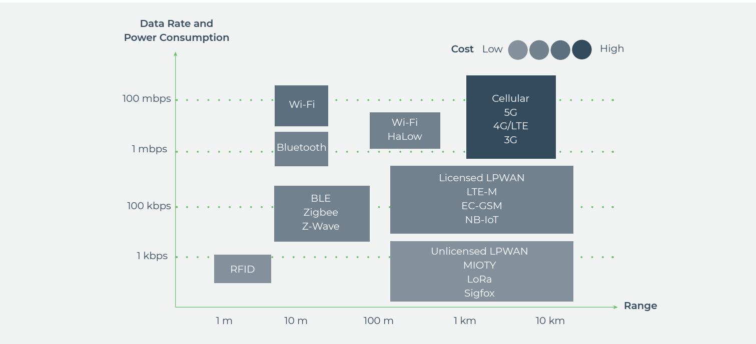
Sigfox

The SigFox is a long-range, low-power, low-data-rate form of communication that provides wireless connectivity to many machine-to-machine networks. IoT sensors send data through the Sigfox network to a gateway called a Sigfox base station, which posts the messages to the Sigfox cloud at least every 10 minutes. The Sigfox cloud then pushes the messages to client applications. Due to the cellular style approach, the remote Sigfox nodes are able to communicate with base stations that have Internet connectivity, thereby enabling remote control and data collection from anywhere with the Internet. However, Sigfox messages can carry a payload of only 12 bytes which is quite less for a multi-parameter monitoring instrument.

Choosing the Best Communication Modes:

There are numerous modes of communication in the IoT structure and the choice of the technology for communicating in air quality monitoring application depends on various factors like the site of installation, range of data transmission needed, rate of data transfer, overall data cost, availability of network infrastructure and its cost, the power consumption. There is not one communication mode that can fit into all the applications of air quality monitoring. Each and every technology has its pros and cons and it must be decided based on the application. The comparison of some features of the most common protocols are given below:

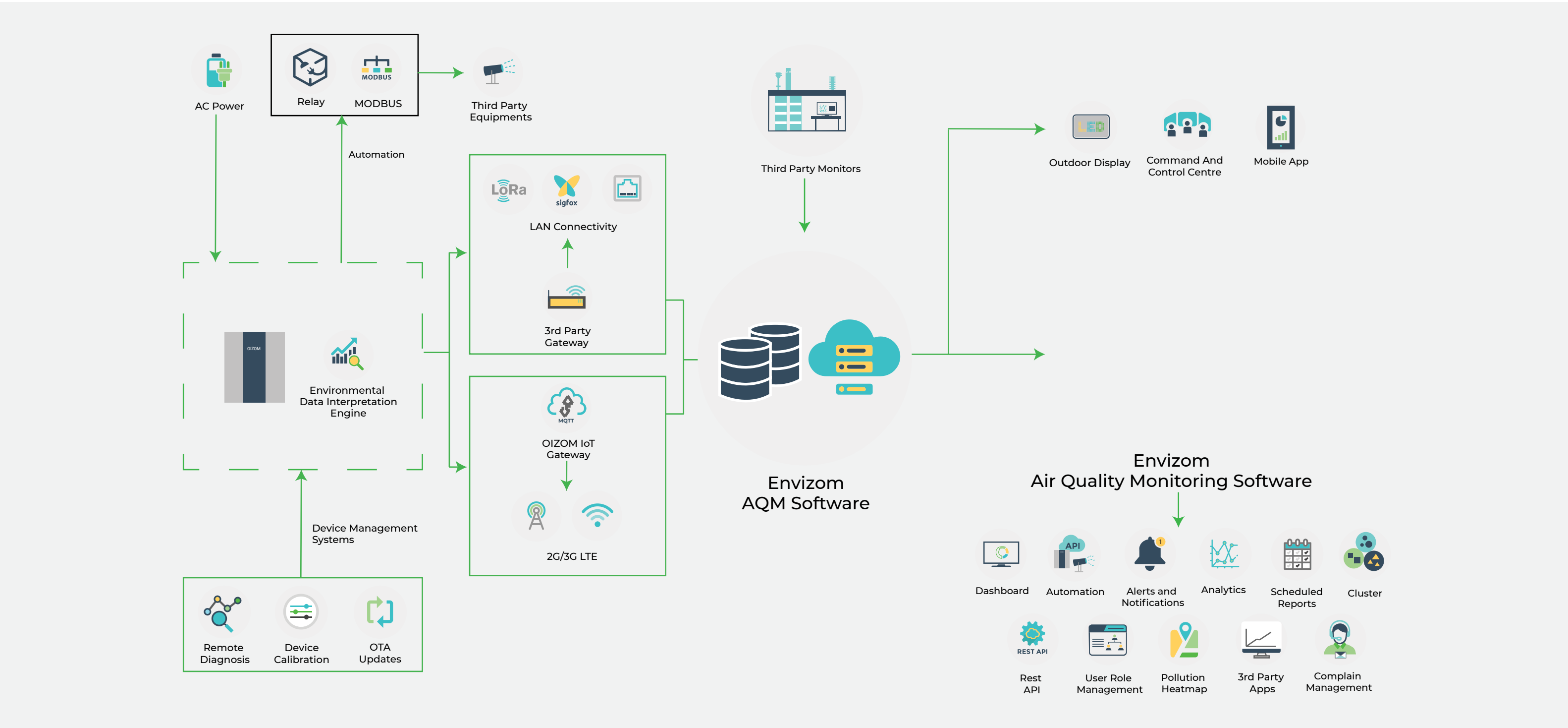
Technology	Frequency	Data Rate	Range	Power consumption	Cost
GSM (2G/3G)	Cellular bands	10 Mbps	Several miles	High	High
LoRa	subGhz	< 550 kbps	1-3 miles	Low	Medium
LTE Cat 0/1	Cellular Bands	1-10 Mbps	Several miles	Medium	High
NB-IoT	Cellular Bands	0.1-1 Mbps	Several Miles	Medium	High
SigFox	subGhz	< 1 kbps	Several miles	Low	Medium
WiFi	subGhz, 2.4Ghz, 5Ghz	0.1-54 Mbps	< 300 feet	Medium	Low



Oizom's offerings

Oizom offers end-to-end and scalable solutions for real-time air quality monitoring and advanced data analytics. All our products are compatible with a wide range of communication modes like 2G/3G/4G/LTE, LoRa, Sigfox, NBIoT, Wifi, MODBUS & Ethernet. All these communication protocols can be utilized in a number of use cases like Smart cities, Smart campuses, Dust suppression, Schools airport, Roadside traffic, Waste Water Treatment, Industrial emission & hygiene.

The following is the System Architecture of Oizom Solutions:



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About the Authors

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Bhumik Nayak manages global projects at Oizom, with experience as a Research & Development Engineer with Electronics & Communication background, he deals with the technical aspects of global deployments.

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