RFID and Sensors

IoT and M2M applications need a large magnitude of data which is generated from a large number of devices, ATMs, sensors at parking slots, health devices in ICUs, machines in industrial plants, embedded components in automobiles, RFIDs, or wireless sensor networks. Data is generated using sensors, embedded devices and systems at the physical layer in the IoT architecture. Thereafter, the data communicates through the data-link, data adaptation, network, application-support and application layers to the applications of IoT.

Data is used for analytics, visualization, intelligence and knowledge discovery or Controls and monitoring. Control systems use the sensors for monitoring and the actuators for actions.

Prototyping and designing of IoT need embedded device platforms, which provide connectivity to the internet and can communicate with applications using the internet. The applications in IoT monitor and control devices, systems and machines using the actuators.

Sensor technology

Sensor technology is a technology used for designing sensors and associated electronic readers, circuits and devices. A sensor can sense a change in physical parameters, such as temperature, pressure, light, metal, smoke and proximity to an object. Sensors can also sense acceleration, orientation, location, vibrations or smell, organic vapors or gases. A microphone senses the voice and changes in the sound, and is used to record voice or music. A sensor converts physical energy like heat, sound, strain, pressure, vibrations and motion into electrical energy. An electronic circuit connects to the input at a sensor. The circuit receives the output of the sensor. The output is according to the variation in physical condition.

A smart sensor includes the electronic circuit within itself, and includes computing and communication capabilities. The circuit receives energy in form of variations through currents, voltages, phase angles or frequencies. Analog sensors measure the variations in the parameters with respect to a reference or normal condition and provide the value of sensed parameter after appropriate calculations. The change of states with respect to a reference or normal condition senses the states in the form of 0s and 1s in digital sensors.

Electronic components can function as sensors. Sensor is an electronic device in a circuit that senses a physical environment or condition. The sensor sends signals to an electronic circuit, which interconnects to a serial port interface at a microcontroller or controller or computing device.

A sensor senses a specific physical condition when it exhibits a measurable change in a characteristic circuit parameter on the change in the specific physical condition or environment. A characteristic parameter of a circuit changes with the physical conditions. Technology that facilitates such changes due to sensing is also used in mobile phone. A mobile phone can sense surrounding conditions. The touch screen of a mobile phone cans senses a finger touch and gestures. Smart phones have

resistive and capacitive sensors, photodiode current-based sensors, and acceleration, gyroscope, temperature and pressure sensors. The sensors enable the functioning of applications and games.

A microcontroller is an associate computing device with a sensor circuit which calculates the touched position and maps it to a user command when a resistive-based touch screen is used. Then the mobile phone takes further actions as per the command.

Analog sensors

Analog sensors use a sensor and an associated electronic analog circuit. Analog sensors generate analog outputs as per the physical environmental parameters, such as temperature, strain, pressure, force, flex, vapors, magnetic field, or proximity.

Resistance of the sensing component may show measurable changes with surrounding pressure or strain or magnetic field or humidity. Resistance of a pressure sensor increases on pressure which creates a strain on the sensor. A flex sensor, for example, of 2.2 inch or 4.5 inch length, shows that its resistance across the sensor strip increases on flexing due to a changed path and deflection of the sensing resistor.

The measurement of analog output from a sensor circuit is performed as follows—

The sensor output is given to the input of a signal conditioning-cum-amplifying circuit (sc). The sc output is the input to an analog-to-digital converter (adc). The adc gives a digital output; for example, 8 or 12 bits. This output is read using a microcontroller.

Microcontroller reading and computation gives the value of the sensed parameter value and shows the physical condition around the sensor.

Digital sensors

A specific electronic component or circuit gives digital output 1 or 0 (on-off state) or output of 1s and 0s as a binary number (corresponding to a set of on-off states). A digital sensor uses the sensor and has an associated electronic circuit which gives Digital output. The output 1 or 0 (1s and 0s) is read through a port in a microcontroller. This circuit can be used for sensing a sudden change in specific physical state or condition or can be used for sensing a sudden change in specific set of physical states or conditions.

Sensing of an on-off state

A number of conditions need detection using the concept of digital output of on-off state. Output for reading by a circuit or microcontroler. A number of other applications exist for digital on-off sensing. For example, sensing of presence of traffic on a street, sensing the filling of a waste container up to a certain preset level that sends an alert on the internet to the city waste management service, sensing the presence of organic vapours which generates an alert when sensed, sensing gas leakage or fire and generating an emergency alert.

Sensing a set of on-off states

A number of conditions together need detection in many applications. A circuit generates digital output for a set of on/off states. A specific electronic component or circuit gives digital output, such as, a set of 4 or 8 or 16 states consisting of 1s and 0s for sensing a set of discrete changes in a specific set of physical states or conditions.

The output connects to a port input of a microcontroller, which reads the input at a given instance.

Participatory sensing (PS)

Information collected from sensors of multiple heterogeneous sources can lead to knowledge discovery after analytics and data visualization. A web source defines participatory sensing (ps) as "sensing by the individuals and groups of people contributing sensory information to form a body of knowledge". Another definition defines participatory sensing as, "participatory sensing is the process whereby individuals and communities use evermore-capable mobile phones and cloud services to collect and analyze systematic data for use in discovery."

A participant of a participatory sensing process can be sensors used in mobile phones. Mobile phones have camera, temperature and humidity sensors, an accelerometer, a gyroscope, a compass, infrared sensors, NFC sensors, bar or QR code readers, microphone and GPS. Mobiles communicate on the internet the sensed information with time, date and location stamps.

Applications of participatory sensing include retrieving information about weather, environment information, pollution, waste management, road faults, health of individuals and group of people, traffic congestion, urban mobility, or disaster management, such as flood, fire etc. Participatory sensing has many challenges such as—security, privacy, reputation and ineffective incentives to participating entities.

ACTUATOR

An actuator is a device that takes actions as per the input command, pulse or state (1 or 0), or set of 1s and 0s, or a control signal. An attached motor, speaker, LED or an output device converts electrical energy into physical action. Examples of applications of actuators are:

- Light sources
- LEDs
- Piezoelectric vibrators and sounders
- Speakers
- Solenoids
- Servomotor
- Relay switch
- Switching on a set of streetlights
- Application of brakes in a moving vehicle
- Ringing of alarm bell

- Switching off or on a heater or air-conditioner or boiler current in a steam boiler in a thermal plant.

RFID IoT Systems

A tag enables identification of an object at different locations and times. A product, parcel, postal article, person, bird, animal, vehicle or object can have a tag or label in order to make the identification feasible. The reader circuit of an ID can use UART or NFC protocol to identify the tag, when the RFID tag is at a distance less than 20 cm.

An active NFC device/mobile generates an RF field which induces the currents in RFID and generates enough power for RFID. Using that power, the RFID transmits the identification of tag contents. Passive device drives power from the electrical current induced in its antenna by the incoming RF signals from a reader or hotspot, and then transmits the tag information back.

The active device has an in-built power source (battery) and transmits the information on its own. A hotspot consists of a wireless transceiver or Wi-Fi transceiver for Internet connectivity. It receives signals from a number of RFID tags in an organization and transmits the data to the web server over the Internet. The hotspot connects to the Internet for IoT services, applications and business processes. A mobile or wireless nearby the device can also function as a hotspot.

RFIDs form an IoT network

RFIDs form an IoT network. They connect to the Internet and then to an IoT server. An IoT server consists of RFID identity manager, device manager, data router, analyser, storage and database server and services.

Principle of RFID

A tag is an electronic circuit which transmits its ID using RF signals. The ID transmits to a reader, then that transmits along with the additional information to a remote server or cloud connected through the Internet. The additional information is as per the application. For example, for a tracking application, it is location and time-stamped data along with the ID.

An RFID tag has an advantage over a barcode or QR code in terms of simpler processing of the RFID data. It can also be made invisible to a person. This is because it uses short range RF transceivers instead of light or laser. The tag transmits back a short string of data to reader. The RFID reader picks the RF and communicates to the Internet or remote web server or cloud server. An active system can transmit to the reader at longer range compared to a passive system. An active system can receive commands, process and then send information compared to no actions except sending the ID in the passive system.

RFID IoT Network Architecture

A four layered ITU-T reference model for the Internet of RFIDs, individual capabilities of the layers and data interchange. Fourth layer capabilities are for IoT/M2M services and applications. RFID technology has many applications.

RFID IoT Applications

Examples are tracking and inventory control of goods, supply chain systems, business processes such as for payment, leasing, insurance, and quality management, access to buildings and road tolls or secured store centre entries, and devices such as RFID based temperature or any other parameter sensor. New applications of RFID network have been found in designing a factory, protecting a brand and anti-counterfeiting measures.

Components of an RFID System

The components of an RFID system are:

RFID is a tiny chip which functions as a tag or label onto an object. The chip is one of three types—passive, active and battery powered passive (battery switches when reader is nearby).

A transceiver is in-built at the chip. It communicates in a range 10 cm to 200 m according to the chip. The chip does UART communication to the reader either using RF link or does NFC.

A nearby RFID reader for receiving ID uses the transceiver within it. It receives the header which consists of 1 start byte, then 10 byte ID and then one end byte when using the UART protocol. Hotspot, mobile or computer with wireless transceiver or Wi-Fi transceiver transmits and receives signals from the RFID tag.

Data processing subsystem: A reader associates a data processing subsystem which consists of a computing device and a middleware and provides connectivity to the Internet, directly or through a gateway which includes a data adaptation sublayer.

The subsystem is a backend system. A reader circuit may send data directly or through a computer, mobile or tablet to the Internet. The computations for transmission (of the contents information of tagged device) are usually little. Example of a reader is SparkFun SEN-08419 for prototype developments.

Middleware: Middleware are software components used at the reader, read manager, data store for the transaction data store and APIs of the applications. Applications and services and other associated applications software use the data store at the cloud or web server.