



EE3070 Design Project

Technical Specification Documentation (Semester A)

IoT Technical Specification for Retail Industry

1. Introduction

The retail industry is seeing a rapid transformation, with The Internet of Things (IoT) solutions taking the center stage in the sector. Having plenty of applications, IoT helps increase customer loyalty, boost sales, offer a personalized experience, and improve inventory management.

IoT will dramatically transform and innovate the retail industry in the coming years. The integration of IoT solutions will enable retail companies to create successful marketing campaigns based on customer behavior, deliver high-quality services, improve inventory management, and reduce operational costs.

2. How to make a IoT Mind Map for Retail Industry

Create a mind map to organize your thoughts, generate new ideas, and improve creativity. This guide will show you how to create an incredible mind map all your needs.

a) Begin with the main concept:

First determine the main purpose of your mind map and write it down. Since mind maps start from the inside and expand outward, your central idea will become the core topic of the diagram. Your main concept could be:

- A problem you're trying to work through
- The project you're brainstorming
- A difficult concept that you're trying to learn

b) Add branches to the main concept:

Now that you have determined the main purpose of your mind map, add branches that will outline the most basic subtopics. The branches should help you to begin organizing the information. Don't worry about including a lot of details, keywords and short phrases will be more than enough.

c) Explore topics by adding more branches:

Once you have identifying the main subjects within your topic, add more shapes until you run out of valuable information. Make sure that you continue to organize your information with the most important things closer to the main concept shape, and the more specific details further away.

d) Add images and colors:

Maintain organization within your mind map by using standard colors for the different levels of thoughts within your diagram. Furthermore, using images will help you to both visualize, and memorize the various parts of your mind map. Images can also be used to link shapes instead of the traditional box shape.

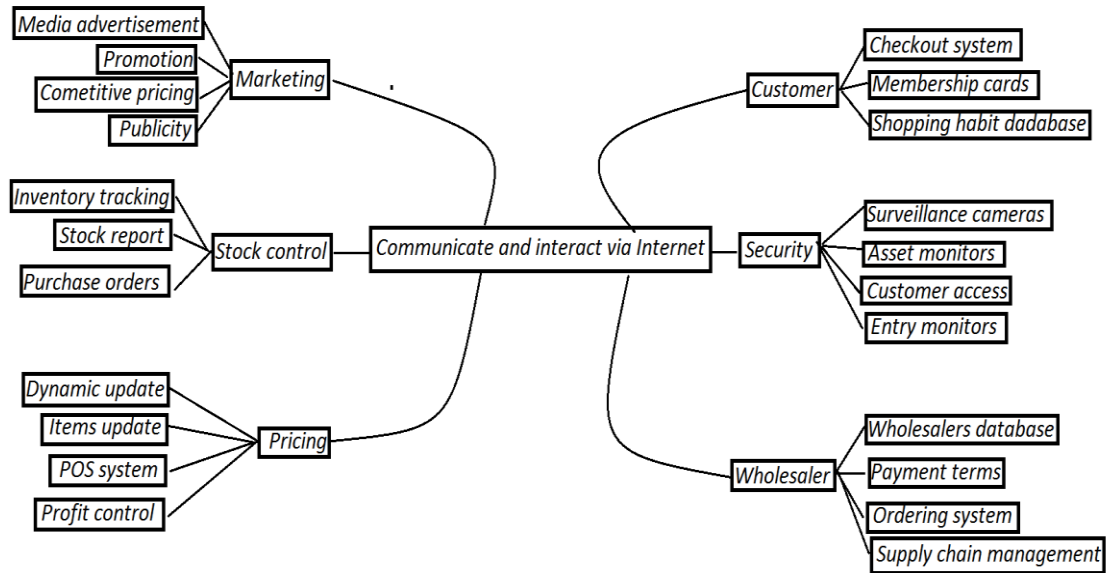


Figure 1: IoT Mind Map for Retail Industry

3. IoT Architecture

To achieve retail transformation, IoT solutions are an indispensable part and deploy smart things in building a complete end-to-end IoT architecture which can be simplified by three fundamental building blocks as shown in Figure 2.

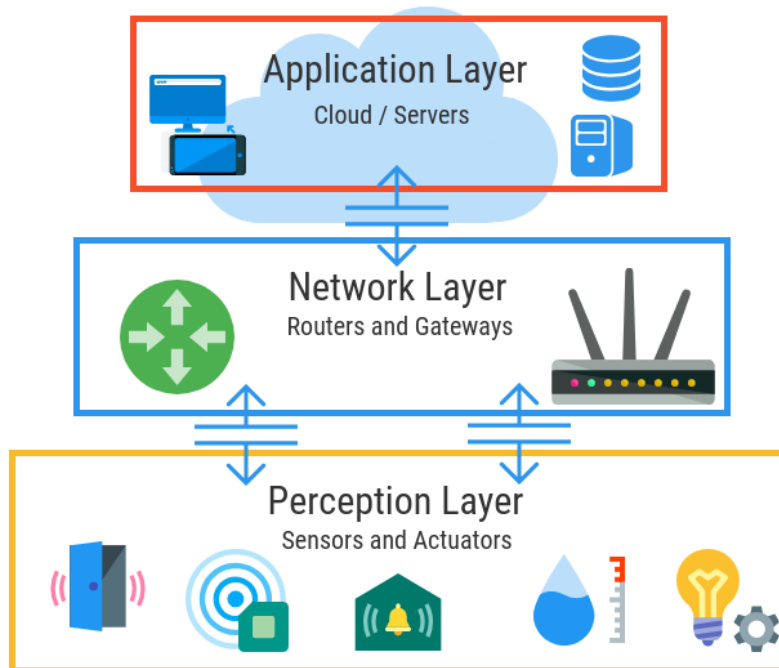


Figure 2: The fundamental Three Layer IoT Architecture

1. **Application Layer** – Data processing and storage with specialized services and functionality for users
2. **Network Layer** – Discovers, connects and translates devices over a network and in coordination with the application layer
3. **Perception layer** – Sensors, actuators and edge devices that interact with the environment

4. IoT Application Platforms (Layer)

An IoT platform is a multi-layer technology that enables straightforward provisioning, management, and automation of connected devices within the Internet of Things universe. It basically connects your hardware, however diverse, to the data network or internet by using flexible connectivity options, enterprise-grade security mechanisms, and broad data processing powers. For developers, an IoT platform provides a set of ready-to-use features that greatly speed up development of applications for connected devices as well as take care of scalability and cross-device compatibility. There are many IoT platforms available now that provide option to deploy internet of things applications on the go.

4.1 Amazon Web Services (AWS) IoT Platform

According to Amazon, their IoT platform will make it a lot easier for developers to connect sensors for multiple applications ranging from automobiles to turbines to smart home light bulbs.

Taking the scope of AWS IoT to the next level, the vendor has partnered with hardware manufacturers like Intel, Texas Instruments, Broadcom and Qualcomm to create starter kits compatible with their platform.

4.2 Microsoft Azure IoT

For processing the massive amount of information generated by sensors Azure IoT suite comes with Azure Stream Analytics to process massive amounts of information in real-time. This IoT platform is designed for different industry needs. It can be used from manufacturing to transportation to retail. It provides solutions for remote monitoring, predictive maintenance, smart spaces, and connected products.

4.3 Google Cloud Platform

With its end-to-end platform, Google cloud is among the best IoT platforms we have currently. With the ability to handle the vast amount of data using Cloud IoT Core, Google stands out from the rest. Google Cloud provides a multi-layered secure infrastructure. It helps in improving operational efficiency. It provides predictive maintenance for equipment, solutions for smart cities & buildings, and real-time asset tracking.

5. IoT Network Layer

The choice of communication technology directly affects your device's hardware requirements and costs. And IoT devices are deployed in so many different ways — in clothing, houses, buildings, campuses, factories, and even in your body — that no single networking technology can fit all bills.

Most IoT devices send and receive very little data. The vast majority of traffic is in the form of periodic transmissions of several lines of text containing sensor measurements, coordinates, toggle switch positions or simple commands, to name a few. This means that very low bandwidths are necessary at the access layer of the network. One of the major aspects that make network design challenging for IoT is the sheer number of connected devices.

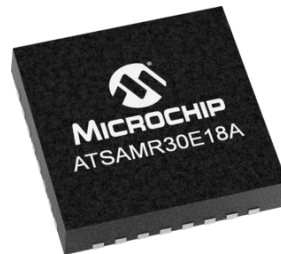
Wireless radio technologies			
Standard	IEEE 802.15.4	Bluetooth	Wi-Fi
Frequency	868/915 MHz, 2.4 GHz	2.4 GHz	2.4, 5.8 GHz
Data rate	250 Kpbs	723 Kpbs	11 to 105 Mbps
Range	10 to 300 m	10 m	10 to 100 m
Power	Very Low	Low	High
Battery Operation	Alkaline (months to years)	Rechargeable (days to weeks)	Rechargeable (hours)

5.1 IEEE 802.15.4

One of the major IoT enablers is the IEEE 802.15.4 radio standard, released in 2003. Commercial radios meeting this standard provide the basis for low-power systems. This IEEE standard was extended and improved in 2006 and 2011 with the 15.4e and 15.4g amendments. Power consumption of commercial RF devices is now cut in half compared to only a few years ago, and we are expecting another 50% reduction with the next generation of devices.

3.1.1 Microchip ATSAMR30E18A

Each ATSAMR30 device is an ultra low-power microcontroller equipped with an IEEE® 802.15.4 compliant radio for the sub-1GHz frequency bands 780 MHz (China), 868 MHz (Europe) and 915 MHz (North America). It uses the 32-bit ARM® Cortex®-M0+ processor and offers 256KB of Flash and 40KB of SRAM (8KB battery backed) in as small as a 5mm QFN32 package.

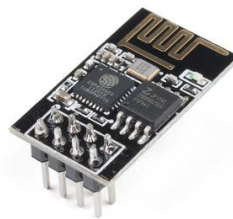


5.2 Wi-Fi

The first obvious networking technology candidate for an IoT device is Wi-Fi, because it is so ubiquitous. Certainly, Wi-Fi can be a good solution for many applications. Almost every house that has an Internet connection has a Wi-Fi router.

5.2.1 ESP8266 WiFi Module

The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning,



5.3 Bluetooth

To best meet the wireless connectivity needs of a diverse developer population, Bluetooth technology supports multiple topology options. From simple point-to-point connections for streaming audio between a smartphone and speaker, to broadcast connections that enable way-finding services in an airport, to mesh connections that support large-scale building automation, Bluetooth supports multiple topology options to best meet the unique wireless connectivity needs of a diverse, global developer population.

5.3.1 Bluetooth Low Energy NVC-MDCS71

NVC-MDCS71 is a highly integrated Bluetooth® Smart module targeted for low power Smart Devices and IoT applications. It integrates all features required for a Bluetooth Smart application, including Bluetooth radio, firmware stack and GATT-based profiles. The BLE Module NVC-MDCS71 can also host end-user applications to save external processor for the size or price constrained devices.



6. IoT Perception Layer

Perceptual IoT layer typically includes sensors, actuators and other smart devices. One might call these the “Things” in the Internet of Things. Devices, in turn, interface and communicate to the application layer via wire or localized wireless networks. Often times IoT devices are said to be at the “edge” of the IoT network and are referred to as “edge nodes”. When selecting a device, it is important to consider requirements for specific I/O protocols and potential latency, wired or RF interfaces, power, ruggedness and the device’s overall sensitivity. It is critical to determine how much device flexibility your architecture should have.

Many newer devices are IoT ready right out of the box. However, most sensors, actuators and legacy devices still interface via conventional “pre-IoT” methods such as analog or serial connections. It is common practice to connect one or more of these conventional devices to microcontrollers, systems on modules (SOMs) or single-board computers (SBCs) with the necessary peripherals (e.g. Arduino, NetBurner, or Raspberry Pi). At a minimum, such collectors provide network connectivity between the edge nodes and a master gateway. In some instances they may be capable of being configured as a gateway as well.

6.1 IoT devices: sensors

Among the environmental parameters, factors and events that sensors can ‘sense’ and communicate about are parameters such as sound, temperature, humidity, presence of specific chemical components or gases, light, occupancy (e.g. of a room) and much more. It is clear that sensors are essential IoT components and need to be very accurate because they are where the data gets captured to begin with.

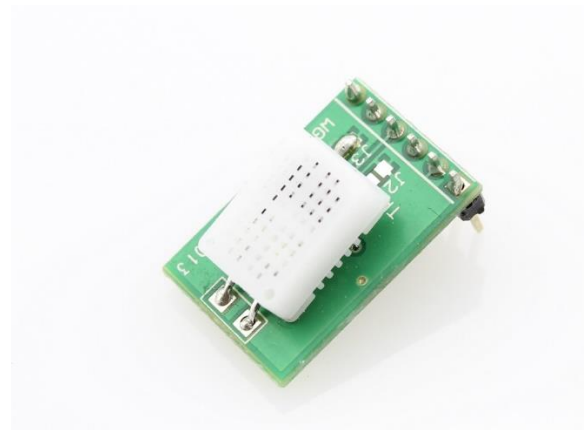
There are over 100 different types of sensors. They can be bought separately or on so-called sensor boards which have been designed to gather several sensors that are needed in the scope of an IoT use case or project. There are sensor boards for applications such as smart city air quality monitoring and smart traffic applications. There are also sensor boards which you can use to

customize to try out IoT applications or to build the precise boards you need for any given application, adding the sensors you want.

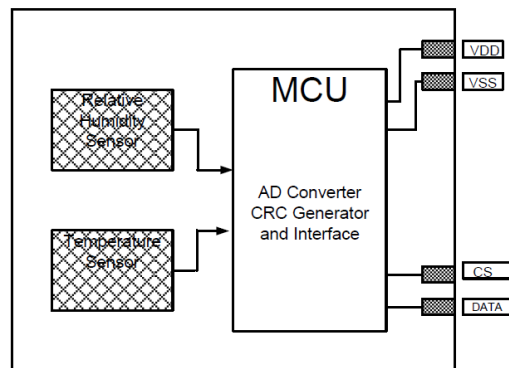
As said, sensors are anything but new and have been ubiquitous in many industries before someone even heard the term IoT. In today's smart buildings, smart factory projects of Industry 4.0, smart city projects and anything smart and IoT-related they are even more ubiquitous and both the offering and technologies have evolved.

6.1.1 Temperature & Humidity Sensor Specification: MTH02

The MTH02 is a MCU based temperature and relative humidity sensor module, comprising one wire interface for direct temperature and humidity read out. The digital output is pre-calculated and no extra calculation is required. The system applied two sensor elements: built in NTC type high precision temperature sensor and resistor type relative humidity sensor from Japan. With a very unique and patented relative humidity calculation algorithm, the system can assure accurate relative humidity output through fine tuned temperature compensation mechanism. Thus very high accurate reading of humidity in the full temperature range (0-50C) can be assured.



MTH02 Module



MTH02 Block Diagram

6.2 IoT devices: actuators

Whereas sensors sense and send, actuators act and activate. The actuator gets a signal and sets in motion what it needs to set in motion in order to act upon/within an environment. In a sense you could say that an actuator does the opposite of a sensor and it's at least as crucial, even if today what most companies do is acquiring and analyzing data, far less using data as triggers to make 'something' happen in the physical world where quite some value resides and not just in the scope of automation but also in consumer IoT applications.

An example goes like this: actuators sit on your radiator or control airflow in a smart room in a smart home or smart building; sensors detect there is no one in the room; actuators get triggered

to lower temperature (or stop HVAC or whatever); control system reports back decision to management system (with energy savings as a result) and everyone happy.

6.2.1 Linear actuator specification: LINAK Baselift

LINAK Baselift linear actuators are hi-tech electric devices able to convert rotational motion in low voltage DC motors into linear push/pull movement. Electric actuators are the perfect solution when you need simple, safe and clean movement with accurate and smooth motion control. LINAK linear actuators are ideal for all sorts of applications where tilting, lifting, pulling, or pushing with thrusts up to 15,000 N is required. Compact and innovative linear actuator concept for adjustable kitchens and shop counters. Ideal for creating optimal working height. Fits easily into the base of most kitchen designs.



LINAK Baselift - linear actuator

6.3 IoT devices: RFID

Radio frequency identification system (RFID) is an automatic technology and aids machines or computers to identify objects, record metadata or control individual target through radio waves. A typically RFID system is consisted of tags (transmitters/responders) and readers (transmitters/receivers). The tag is a microchip connected with an antenna, which can be attached to an object as the identifier of the object. The RFID reader communicates with the RFID tag using radio waves. The main advantage of RFID technology is the automated identification and data capture that promises wholesale changes across a broad spectrum of business activities and aims to reduce the cost of the already used systems such as bar codes.

RFID is one of the big opportunities in information technology, which will change the world broadly and deeply. When the RFID readers abided by appropriate communication protocols are connected to the terminal of Internet, the readers distributed throughout the world can identify, track and monitor the objects attached with tags globally, automatically, and in real time, if needed.

6.3.1 RFID specification: TI-RFid™

Texas Instruments Radio Frequency Identification Systems is one of the industry leader in RFID technology, and the world's largest integrated manufacturer of TI-RFid™ tags, TI-RFid smart labels, and TI-RFid reader systems. With more than 1 billion RFID tags manufactured, TI-RFid technology is used in a broad range of RFID applications worldwide.

The integration of TI-RFid™ products into proven application models, in conjunction with third party Developers Network partners gives customers the ability to adapt an end-to-end RFID asset tracking solutions for their business, without costly mistakes or development time. TI's RFID Application Solutions are state-of-the-art design and system models for unique vertical business needs that result in lower overall system cost and faster, more efficient roll-outs.

LF Reader Types

Part Number	TMS3705A1DRG4
Type	IC (SO 16)
Typical Read Range*	up to 20 cm
Interface	I/O
Operating Frequency	134.2 kHz
Operating Voltage	4.5Vdc...5.5Vdc

LF Antenna Types

Part Number	RI-ANT-S01C, RI-ANT-S02C
Type	Stick
Inductance	27µH
Dimensions	140 ± 2 × 21 ± 2 (dia.) mm
Operating Temperature	-30 to 70°C
Protection Class	IP66

LF Transponders

Part Number	RI-TRP-R9BK, RI-TRP-W9WK, RI-TRP-M9WK
Type	12 mm Wedge
Memory Types Available	R/O (64 bit), R/W (80 bit) Multi (32-bit UID, 208-bit R/W)
Typical Read Range*	up to 20 cm
Operating Frequency	134.2 kHz
Dimensions	12 × 6 × 3 mm
Protection Class	IP68
Case Material	Plastic Compound

TI-RFid™ RFID Systems Product Specifications

6.4 IoT Module

The IoT Module represents an open hardware and software standards for interfacing sensors, network adapters, and other IoT devices that can be "plugged" into host applications to provide new features. IoT Modules share a standardized footprint and pinout, with several interfaces to support various IoT devices.

6.4.1 IoT Module: USB

The IoT Module supports one high-speed USB2.0 Interface that conforms to Universal Serial Bus Specification, Revision 2.0. The interface may be used for application control and data transfer between the IoT Module and a host application.

Pin	Signal name	I/O	Function	If unused	Voltage
1	VCC_5V0	I	USB power supply/5V power supply	No connect	
2	USB_D+	I/O	Differential data interface positive	No connect	
3	USB_D-	I/O	Differential data interface negative	No connect	

USB2.0 Interface Pins

6.4.2 IoT Module: UART

The IoT Module supports a 4-wire UART interface. The interface may be used for data communication between the IoT device and a host application.

Flow control is managed using the RTS/CTS signals, or using software XON/XOFF.

Pin	Signal name	I/O	Function	If_unused	Voltage
12	UART_TXD	O	UART Transmit Data	No connect	1.8V ± 10%
13	UART_RXD	I	UART Receive Data	No connect	
14	UART_CTS	O	UART Clear to Send	No connect	
15	UART_RTS	I	UART Ready to Send	No connect	

UART Interface Pins

6.4.3 IoT Module: SPI Bus

The IoT Module supports a 3/4/5-wire serial peripheral interface (SPI) that may be used for data communication between the IoT device and a host application.

The following features are available on the SPI bus:

- Mode: Slave (Master mode is not supported)
- 3/4/5-wire interface

Pin	Signal name	I/O	Function	If unused	Voltage
16	SPI_CLK	I	SPI serial clock	No connect	1.8V ± 10%
17	SPI_MISO	O	SPI2 Master Input/ Slave Output (Data transfer from IoT Module to host application)	No connect	
18	SPI_MOSI	I	SPI Master Output/ Slave Input	No connect	

			(Data transfer from host application to IoT Module)		
19	SPI_SS/MRDY	I	SPI Slave Select	No connect	
26	SPI_SRDY (alternate function)	O	SPI Slave Ready	No connect	

SPI Interface Pins

Operation	Max Speed	SPI-Mode	Duplex	4-wire Type
Slave	Host application-dependent	0,1,2,3	Full	SCLK (SPI_CLK) MOSI (SPI_MOSI) MISO (SPI_MISO) SS (SPI1_SS/MRDY)

SPI Configuration

6.4.4 IoT Module: Digital Audio

The IoT Module supports a 4-wire digital audio interface that can be configured for either PCM (Pulse Code Modulation) or I²S (Inter-IC Sound) audio.

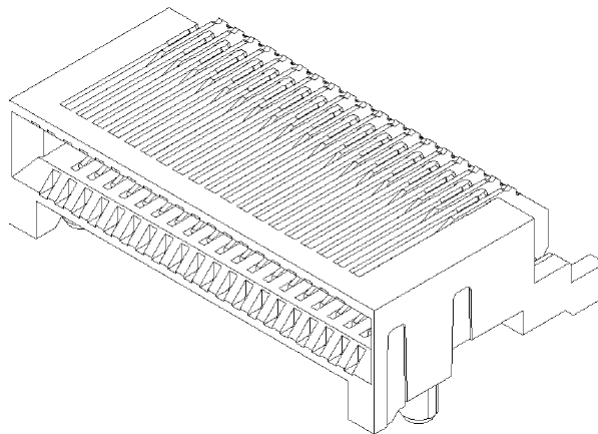
Pin	Signal name	I/O ²	Function	If Unused
33	PCM_DIN	Output	PCM Data In The frame “data in” relies on the selected configuration mode.	Leave open
	I2S_IN		I2S Data In The frame “data in” relies on the selected configuration mode.	
34	PCM_DOUT	Input	PCM Data Out The frame “data out” relies on the selected configuration mode.	Leave open
	I2S_OUT		I2S Data Out The frame “data out” relies on the selected configuration mode.	
35	PCM_SYNC	Input	PCM Sync The frame synchronization signal delivers an 8 kHz frequency pulse that synchronizes the frame data in and the frame data out	Leave open
	I2S_WS		I2S Word Select	

36			The word select clock indicates which channel is currently being transmitted (low cycle indicates left audio channel, high cycle indicates right audio channel).	Leave open
	PCM_CLK	Input	PCM Clock The frame bit clock signal controls data transfer with the audio peripheral.	
	I2S_CLK		I2S Clock The frame bit clock signal controls data transfer with the audio peripheral.	

PCM/ I²S interface signals

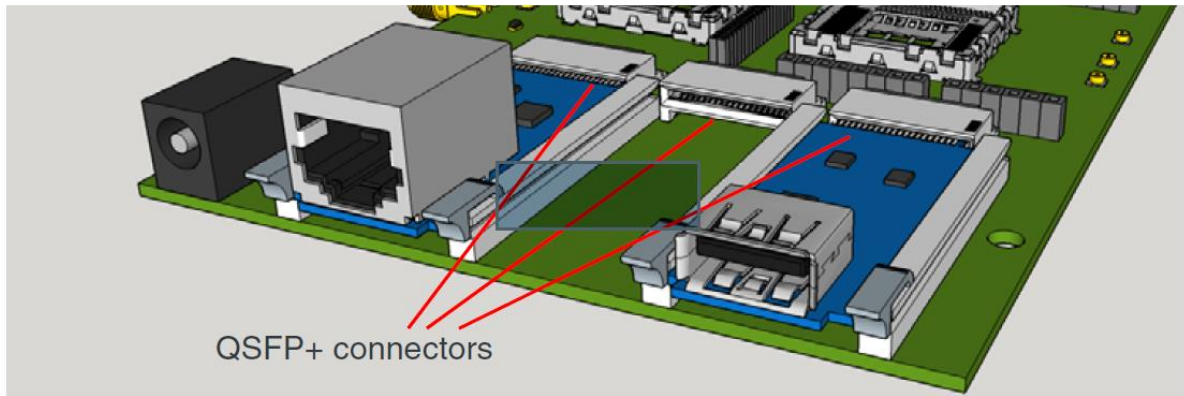
6.4.5 IoT Module: Connector

IoT Modules connect to host applications via a QSFP+ connector mounted on the host application. This connector style was selected for ease of use, and wide commercial availability from multiple vendors. The host application can be designed with as many connectors as desired there is no prescribed limitation on the number of IoT Modules that a host application may support at one time.



QSFP+ Connector

The QSFP+ connector standard is described in SFF-8436 Specification for QSFP+ 10Gbs 4X Pluggable Transceiver.



Installed QSFP+ Connectors

Smart shelf-management system for retail (example)

Introduction

One of the innovative technologies like the smart shelf-management system provides retailers with new revolutionary tools for observing customer behavior. It utilizes technologies like RFID, IoT and a variety of sensors to gather item-level visibility for almost any merchandise. Visibility is the key foundation to optimize overall performance and enhance the shopper experience in retail.

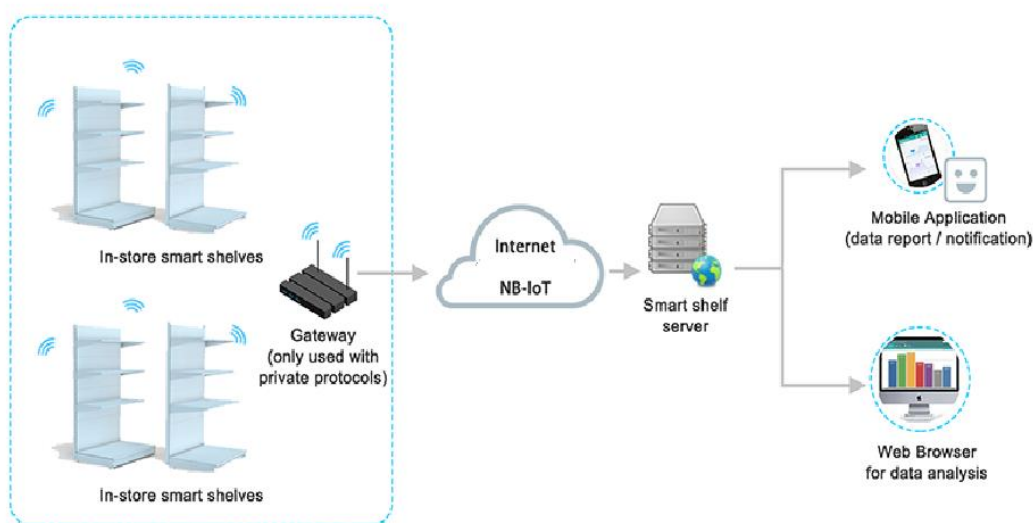
System Architecture

Smart shelves are wireless inventory control system that has been typically fitted with weight sensors and RFID tags:

- The weight sensors can be built-in the shelf itself or be installed under normal shelves.
These weight sensors consistently notify the back-end system about the existing quantity of

items on the shelves. Usually small-sized goods or soft flexible goods like clothes can be measured by weight sensors.

- The RFID tags and RFID reader (antenna) can be built-in the shelf itself or be installed behind/under/above normal shelves. By continuously scanning the RFID tagged items on the shelf, the RFID reader consistently notifies the back-end system about the existing items and their movements. Usually relatively big-sized goods like shoes can be measured by RFID method.
- Wireless data transmission via WiFi network, easy to install and free maintenance;
- Prevent Out-Of-Stock situations by alerting when stock level gets low or critical;
- Smart friendly cloud based program that provides both real time status information;
- Analyze data that has been collected from the shelves and produces business insights.



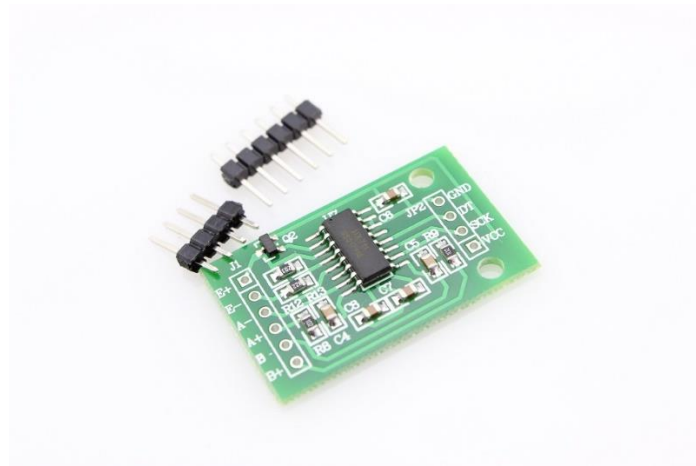
DFRobot: Arduino Weight Sensor

This Electronic Arduino Weight Sensor is able to detect 1kg weight. It based on HX711, a precision 24-bit analog-to-digital converter designed for weight scale and industrial control applications to interface directly with a bridge sensor.

Weight Sensor Module Specification:

- Range: 1kg
- Excitation voltage: 5-15 V
- Output sensitivity: $1.0 \pm 0.15 \text{ mV/V}$
- Synthetical error: 1 per thousand cent of full scale

- Zero shift: 0.05/0.03 (30min) %F.S
- Zero temperature shift: 0.05/0.03 %F.S/10°C
- Zero output: $\pm 0.1\text{mV/V}$
- Input impedance: $1055 \pm 15 \Omega$
- Output impedance: $1000 \pm 5 \Omega$
- Overload capability: 200 %F.S
- Output: Analog output
- Size: 33mm*38mm



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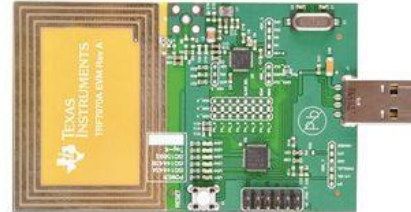
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TI-RFid™ RFID Systems Product Specifications



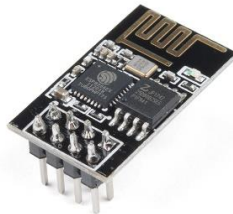
TI-RFid™ Reader



TI-RFid™ Transponder

ESP8266 WiFi Module

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SensorPush G1 WiFi Gateway specifications:

- Works with all existing SensorPush sensors (sensors sold separately)
- No set limit to the number of sensors you can connect
- Receive alerts on your mobile device anywhere that it has access to the internet
- No monthly fee. Internet cloud service and account included in the purchase price
- Use multiple mobile devices. All devices logged into the account stay up to date and receive alerts

