Case Based Recommendations on Network Topologies for Internet of Things System Deployment in Retail Sector

Hariharan Ramalingam
Research scholar – PhD.[1]
Department of Banking Technology (BT),
School of Management (SOM), Pondicherry University,
Puducherry, India.

Dr. V. Prasanna Venkatesan[2]
Associate Prof. & Head.
Department of Banking Technology (BT),
School of Management (SOM), Pondicherry University,
Puducherry, India.

***Abstract* - The current boom in Retail industry demands improvement in many functions related to retail business. With evolution of Internet of things, as a technology to capture data from physical objects interacting with user, automation for backend infrastructure supporting the business, retail business can be open up opportunities that could engage IoT. Some of the application areas are analytics, inventory and material management, logistics management, security and maintenance. In this paper, recommendations for IoT system network topology deployments using above application areas for retail sector are discussed.**

Keywords— Internet of things (IoT), Retail, Point to Point (P2P), Star, Mesh, Network topology

I. INTRODUCTION

The process of retail allows selling goods or services to customers using multiple distribution channels with the objective of making profit. There are multiple ways of retailing engaging B2B, B2C or Point of Sale (POS). Technology today has penetrated into all these ways and improves efficiency and effectiveness of the retail business. Engaging technology such as IoT could open up further improvements and opportunities for application level integration. The challenges are in deployment of IoT where consistent practices are not followed and in this paper recommendations will be made for IoT deployment in different environments for best case implementations. IoT basics and applications are mentioned below for understanding the potential opportunities.

Brief summary on IoT

Internet of things (IoT) is the combination of variety of sensing devices such as RFID devices, infrared sensors, Global positioning systems and Internet. IoT in the form of devices enable physical devices to connect to Internet for variety of application and services. Low cost connected devices allows data for servicing customers, easing out the operational functions, scoping for software analytics over the traditional manual analysis, minimizing the threats by engaging security protocols, monitoring and tracking for logistics related services, support for connected objects maintenance. All these have a purpose and applications in the retail business.

Typical IoT application architecture can be divided in 3 layers [2]. With reference to figure.1, the level architecture of IOT are detailed as below

1) Perception layer - It's the core layer of IoT whose purpose is to accommodate the origin of information. All kinds of physical world information used in IoT are perceived and collected in this layer. Key components are sensors and wireless sensor network which are used to execute the collection of data.
2) Network layer - It's the transport layer of IoT which includes the access network, core network, provides transparent data transmission capability using the existing mobile communication network, WSN, Radio access network and other communication equipments.
3) Service layer - It's the application layer where critical function such as data management and application support/execution is done.

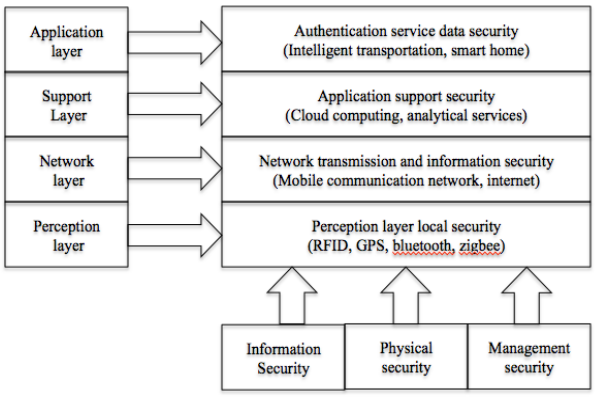

Fig. 1: Level architecture of Internet of things (IOT)

IoT gateway can provide the functionalities of protocol conversion and device management.

II.Retail model and technology practices

Current trends in retail model emphasis customer-centricity, digital fluency and tremendous agility [5]. From traditional style of push mentality of the consumer goods industry to pull based on customer interests and priorities, technology is expected to over haul of retail systems to accommodate the above purpose.

Technology has been the primary focus for retail industries and acts as a medium to accomplish goals, feedback & improvements. Improvements identified are in the areas of Supply chain management, inventory management, customer experience and security. Technology that involves wireless domain has created potential opportunities for dramatic transformation in the retail industry.

Retailers benefit from IoT in the following functions [1] as per the table below (Table I)

TABLE 1: Functions of Internet of things (IoT) devices for Retail

S.No.	Functions	Details
1	Inventory Management	Tracking: Real time tracking is enabled on products by using sensors such as RFID in places such as storage area, ware house, shelves.
		Inventory levels can be monitored and alerts can be raised for placing orders.
2	Fleet management	Trucks can be monitored using IoT by allowing rules such as delivery route, speed, storage temperature while transporting perishable items. Again alerts can be set for unplanned or extended stopages or notify maintenance issues before break down.
		Customers can track their shippment in real time versus getting updates from origin point.
3	Maintenance and warranty	Products under warranty can be tracked using IoT. Real time data will be notified to retailer for product malfunction or warranty issues.
		Theft monitoring can be done using embedded sensors.
4	Real-time promotions	Mobile phones/ Smart phone are integral part of IoT. This can be used by the retailers for promotions based on customer shipping history.
		Location based tracking can be done for customer support.

II. CASE BASED RECOMMENDATIONS IN RETAIL SECTOR

With currently available articles of similar domain application areas there is no consolidation & application specific examples covered. In this paper a consolidated view of various design parameters such as network topology types, characteristics, deployment cases in retail sector are detailed. The primary parameters such as network topology types and their related characteristics are mentioned initially to understand the deployment model illustrated further below.

Network Topology

Topology recommendations for networking IoT devices are primarily classified into 3 types. They are briefed in the table below (Table II) and show in Fig.2.

TABLE II: Types of Network Topologies

No.	Types of Topologies	Description
1	Point to Point (P2P)	Communication can only happen between 2 nodes. One side is usually the gateway to internet and the other could be end point device. Ex: Bluetooth link that is established between an ear piece and a mobile phone.
2	Star	Has a central hub to which all other nodes are connected. This central hub could be the gateway device to internet and all others are end point devices. Ex: Wifi network in a typical house hold.
3	Mesh	Has 3 types of nodes, a gateway node similar to the star topology, simple sensor based edge devices, sensor/router based devices, which are sensor based devices with routing capability or repeating functions. Ex: applications such as Building automation, asset management. Zigbee wireless communication protocol serves in Mesh network based on its low data rate, low power characteristics.

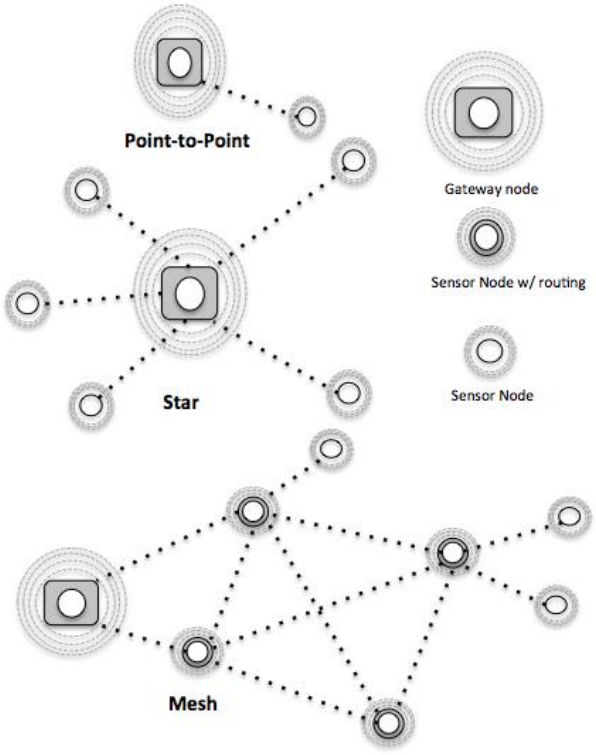

Fig.2: Types of Network topologies for Internet of things (IoT)

Characteristics

Primary characteristics driving the design of these networks [4] are mentioned in the table below (Table III)

TABLE III: Characteristics for Internet of things (IoT) design

Characteristics	Description
Latency	Here latency refers to the speed of the data packet that travel from sensor devices to gateway device/server into internet or vice versa. Based on application this parameter needs to be evaluated.
Throughput	Amount of data that pass thru the network per second. Ex: Audio, video data requires high throughput.
Fault resiliency	Its about recovery or reconfigure when a network failure occurs. Mesh network has the ability to resume and its flexible.
Scalability	Possibility of accomodating more nodes in a single network.
Hops	A data packet transmission from one device/node to another. The number of hops refers to the number of devices/node through which a data packet travels.
Range	Range refers to the maximum distance of one hop i.e., from one node to the other. A network range refers to the overal distance a complete network can span.
Power consumption	Sensor nodes operate on battery power mostly, so power consumption is a significant parameter. Engaging wireless communication protocols such as Zigbee which is designed for low power consumption creates a sustainable business model.
Bandwidth	Bandwidth for different applications can vary. Video/ audio may require a power consuming protocol such as Wifi or bluetooh whereas Zigbee serves low data rate applications.
Security	A Bare minimum security standard must be supported in a wireless network environment such as dynamic WEP 802.1x authentication and rapid key rotation. Retailer are served with WPA (Wifi-protected Access) or WPA-2(IEEE 802.11i standard).

Cases for IoT system deployment

IoT deployment in retail could be subjective to the business engagement model. Following briefs will summarize those network topology models recommendations used in IoT deployment for various environments.

- *A Pet store – Star deployment model*
  A pet service store may need a RFID tag deployed in all the pets collar or object in contact with pet to identify the related details. IoT here can act as a point to point device in a star topology network just transmitting the pet information such as location, identity to the gateway node. For example, [7] Walmart uses Sensor tags/RFID/IoT at item level and data generated are in Terabytes every day.
  - The system can operate in WIFI environment with a star topology deployment for nodes.
  - The sensors fall in the perception layer, network layer operates with the wireless protocol (includes security), Application to manage information related to identity, tags fall in to the service layer.
- *Maintenance for critical parts – Mesh deployment model*
  The heavy machinary in the industry which needs constant monitoring for fault, wear and tear of parts can use mesh topology for fault tolerant communication. Here IoT deployed as sensor devices in the manufacturing equipment [10] sends periodic data to the gateway node for warranty and maintenance purpose of the parts. Also it helps the product owners to understand the field data of the machines for any design improvements in the future.
  - The system can operate in Zigbee environment with a mesh topology deployment for nodes.
  - The sensors fall in the perception layer, network layer operates with the Zigbee protocol (includes security), Application to manage information related to parts fall in to the service layer.
- *Energy efficiency – Star deployment model*
  For larger infrastructure such as public enclosures, schools power management to meet efficiency is a constant challenge. In those areas we can deploy IOT in a star topology to monitor power at selected places which has the potential opportunity for conservation or optimization of power consumption. For example, [8] to promote green mind-set, large sensor network was deployed in 12 schools by Govt. of Greece to monitor the temperature inside the class room and switch the air-conditioning as required or send alerts if the temperature is dropping very low. Multiple sensors report to the node and later into the gate way for centralized monitoring and analysis.
  - The system can operate in Wifi environment with a star topology for nodes.
  - The sensors fall in the perception layer, network layer operates with the wireless protocol (includes security), Application to manage information related to temperature of class rooms and alert mechanics is in service layer.
- *Surveillance/ security – Mesh deployment model*
  Surveillance [11] is a critical security function in retail to prevent loss of property or mishandling. IoT enabled cameras can remotely capture video/audio data on the secured premises and serve monitoring function by sending the data over internet using gateway device/server. Alerts can be set based on intrusion or theft detected. Here again star network topology is recommended considering the high data rate and power consumption of the end device.
  - The system can operate in Wifi or network based with a star topology for nodes.
  - The sensors fall in the perception layer, network layer operates with the wireless protocol (includes security), Application to manage information related to video/audio and alert mechanics is in service layer.
- *Customer Kiosk – P2P deployment model*
  Customer interaction is a critical requirement in any retail environment. Kiosk displays [9] when enabled with IoT can interact with customer based on his requirements and send the data to central server for context aware analysis and requirements. This is a point to point network topology like customer mobile with bluetooth which can transmit or receive from the Kiosk.
  - The system can operate in Bluetooth link with a P2P topology for node.
  - The sensors fall in the perception layer, network layer operates with the bluetooth (includes security), Application to manage information related to display in Kiosk is in service layer.

III.CONCLUSION

IoT technology in retail business has the potential to create technotonic shift in various functions. Low cost, low power opportunities with internet & user connectivity seamlessly enables micro services like applications to dominate the future with underlying IoT part of the infrastructure. More business will adopt these changes and as a result data will directly contribute adding values to customer engagement and business intelligence. The above illustrations can open up future opportunities in IT infrastructure design & deployment for Small and medium business establishments.

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