LGT5215 – Practice of Global Supply Chain Management

Topic: Insight study on Artificial Intelligence of Things (AIOT) with real cases

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Table of Contents

INTRODUCTION

More and more enterprises regard Artificial Intelligence of Things (AIoT) as their main development direction. Since 2017, the word “AIoT” has become a buzz in the IoT industry. AIoT is the implementation and integration of AI and IoT in real life applications. It is not a new technology but a new application form of IoT. If Iot connects all common things that function independently through networks, AIoT is to provide more intelligent features to connect all things in a real sense. AIoT is not simply combining AI and IoT. AI and IoT technologies are used to integrate data, knowledge and intelligence through 5G network based on big data and cloud computing. With semi-conductors as algorithm carriers and cyber security as implementation assurance, more application scenarios can be implemented and more possibilities can be realized when AI is applied at application layer. AI can maximize the value of IoT and IoT can provide data flows required by AI. Only by combining them can the advantages of IoT and AI be maximized.

OBJECTIVE

This paper is literature-based research which explores and integrates the core knowledge of Artificial Intelligence and Internet of Things. From this paper, you will understand more about AI and IoT in depth. In addition, you will know how big enterprise is making use of AIoT to improve human life, in particular how the traditional e-commerce has been transformed to the new retail in Alibaba case. You will know how AIoT change new lifestyle of smart home from Xiaomi case. Besides, you will learn how AIoT can help enterprise to do e-commerce CTR prediction in particular case of JD.com. Other than above, you will also read a case study about Pizza Hut's success in Super Bowl.

By reading this paper, it is hoped that readers can understand more about how AIoT will impact human lifestyle and get well prepared for the new upcoming era change.

CHAPTER 1 – Artificial Intelligence (AI)

[1] Artificial Intelligence (AI) is the science technology to assign machines or devices to have ability to learn and interact with humans. The basic conditions for achieving AI include data algorithms and computer power. In terms of algorithms, the emergence of deep learning breaks through the limitation of shallow learning algorithms used in the past and disrupts the algorithm design ideas in basic application fields such as voice recognition, semantic understanding and computer vision. For computing power, the emergence of GPU NPU and FPGA dedicated chips make the data processing speed no longer a bottleneck of AI development.

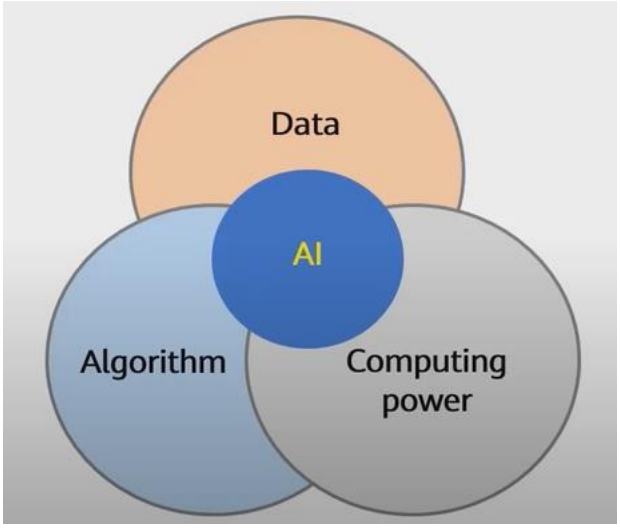


Figure 1a

Machine learning algorithm

There are numerous machine learning algorithms. The most general known algorithms are Regression Algorithm, K Nearest Neighbour Algorithm (KNN), Naïve Bayes Algorithm, Greedy Algorithm, K-means Algorithm, Ant Colony Optimization Algorithm, Neural Network Algorithm and Markov Algorithm.

Deep learning algorithm

The most general known algorithms are Generative Adversarial Network, Convolutional Neural Network, and Recurrent Neural Network

Reinforcement learning algorithm

The most general known algorithms are Q-learning, Monte Carlo Algorithm, etc.

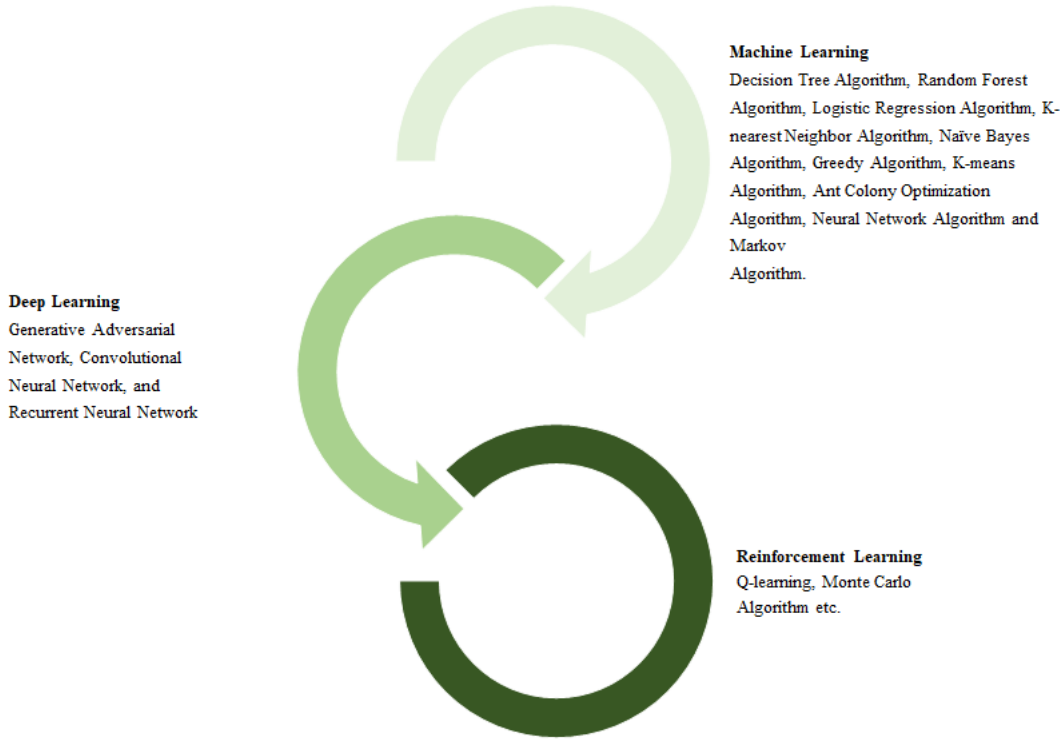


Figure 1b

Nowadays artificial intelligence is widely used in our life. Examples are Machine Vision / Prediction, Speech Recognition, Character Recognition, Natural Language Processing (NLP), Man-machine interaction such as chatbot, Expert system, statistical learning, data mining, pattern recognition, etc.

1.1 Deep Learning

Deep learning is a subset of machine learning.

Neural network is a network composed of artificial neurons. Neural network can be either biological or artificial neural network. The latter is widely used in artificial- intelligence as the simple neural network structure below.

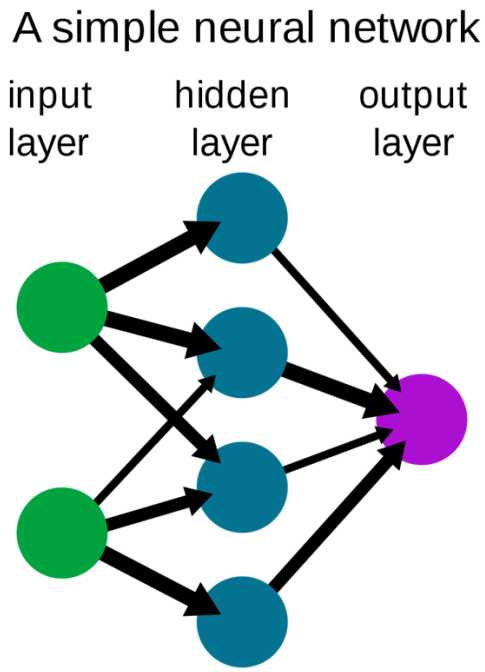


Figure 1.1a diagram for simple neural network

Convolutional Neural Network (CNN)

Convolutional neural network is deep neural network. It is widely used in image recognition or visual image analysis. It is an artificial neural network with shared-weight input that scan the hidden layers and translation constant characteristics. They are widely used in applications such as image/video recognition, image classification and analysis, natural language processing.

[2] There are mainly four steps in the process of convolutional neural network. Firstly, the sensor receives the initial digit image and distributes to input layer. The **weighted** sum of inputs is calculated. Secondly, the **bias** [21] is added. Thirdly, the result is fed to an **activation function** (step function/sigmoid function). Fourthly, the specific neuron is activated [18].

Mankind can recognize hand-written digit “9”. What about computer?

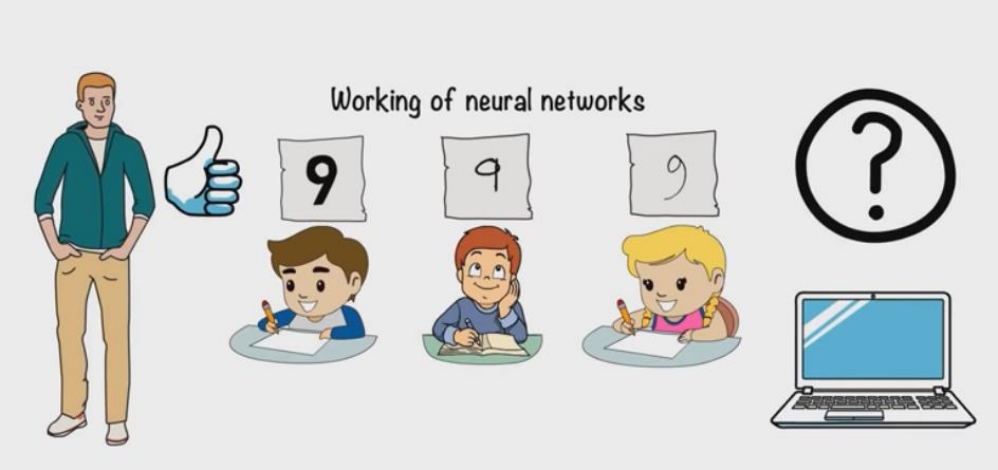


Figure 1.1b

The following diagram (Figure 1.1c and 1.1d) explains how the convolutional neural network works for recognizing digits “9”, “1” and “6”.

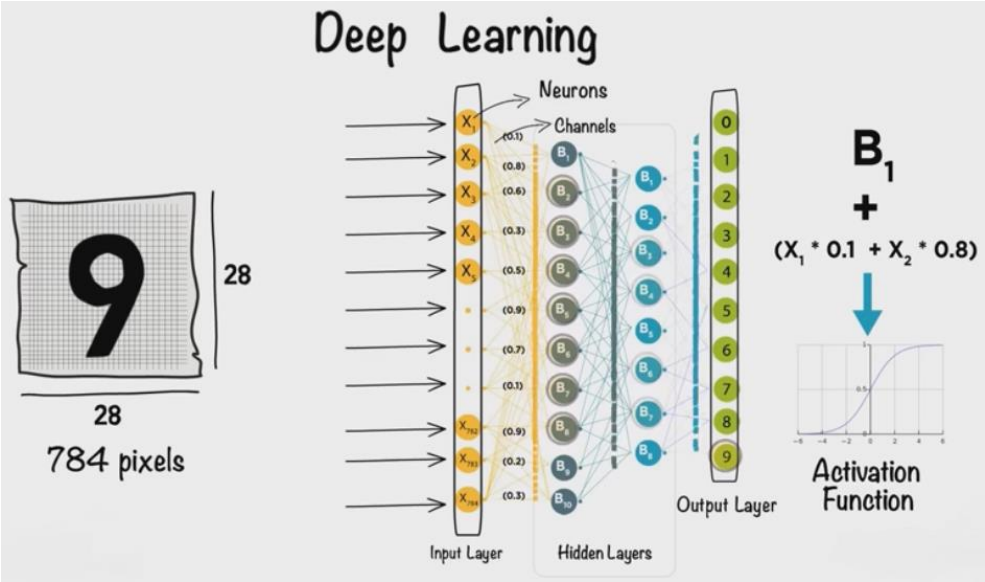
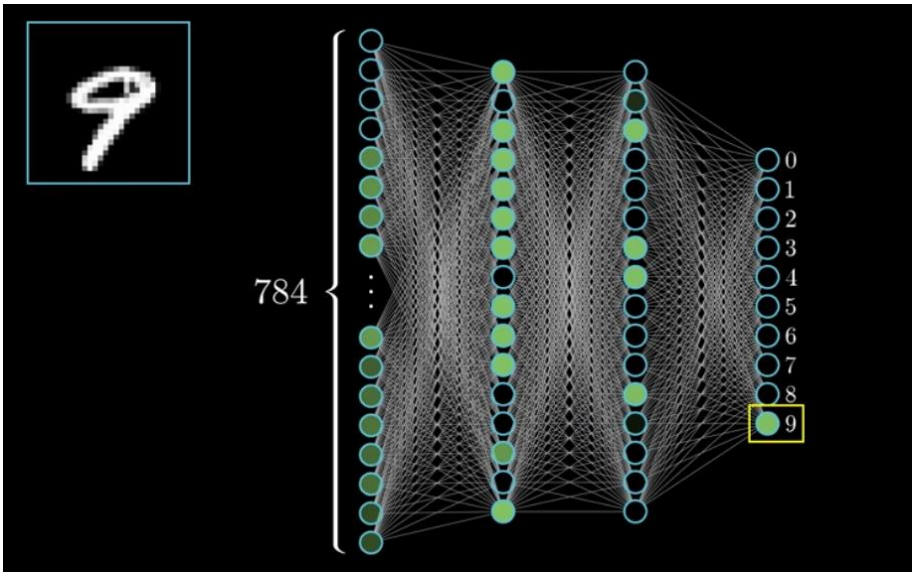
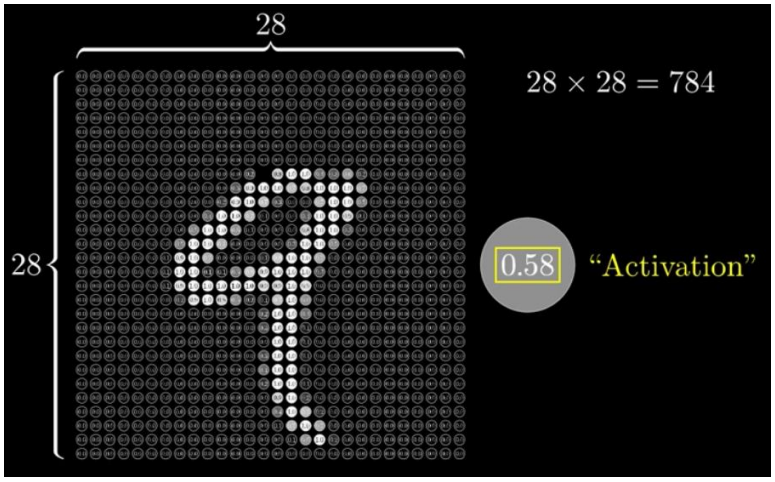
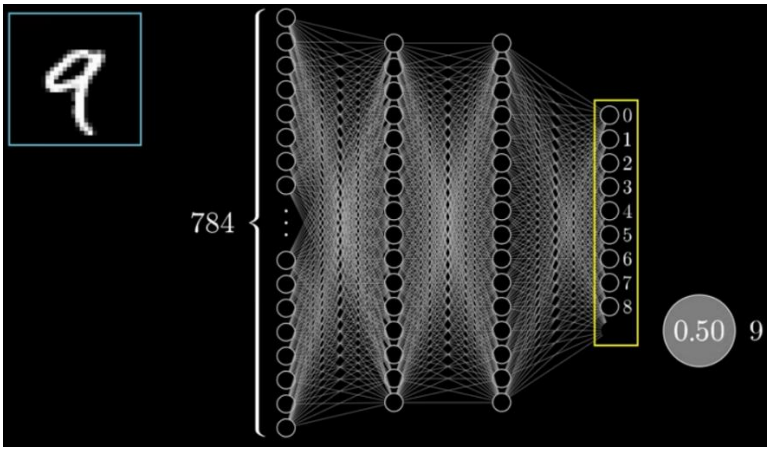


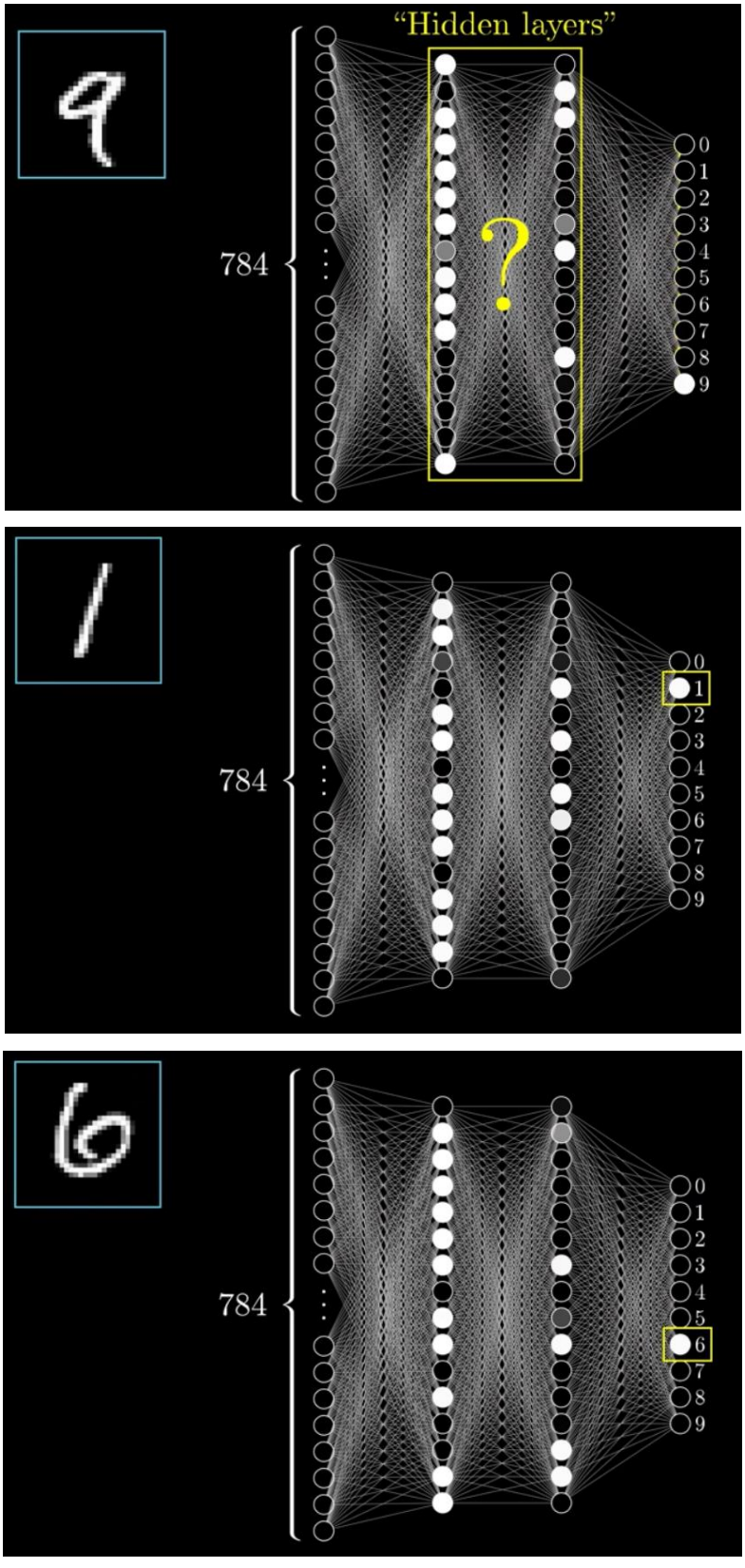
Figure 1.1c


784
0
1
2
3
4
5
6
7
8
9


28
28
28 × 28 = 784
0.58
"Activation"


0.4
Neuron → Thing that holds a number


784
0
1
2
3
4
5
6
7
8
0.50
9


"Hidden layers"
784
?
0
1
2
3
4
5
6
7
8
9
784
0
1
2
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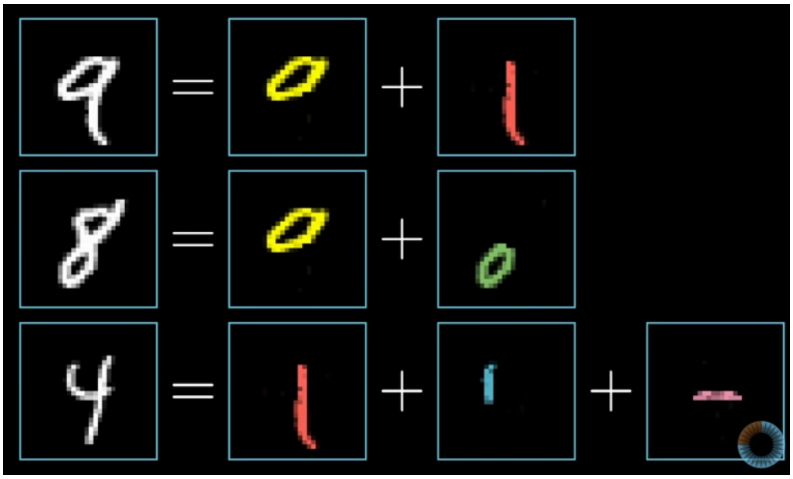


Figure 1.1d

1.2 Machine Learning

[4] Machine learning is a subset of artificial intelligence (AI) which provides machines the ability to learn automatically and improve from experience without being explicitly programmed.

[3] Analogy of machine learning to mankind intelligence:

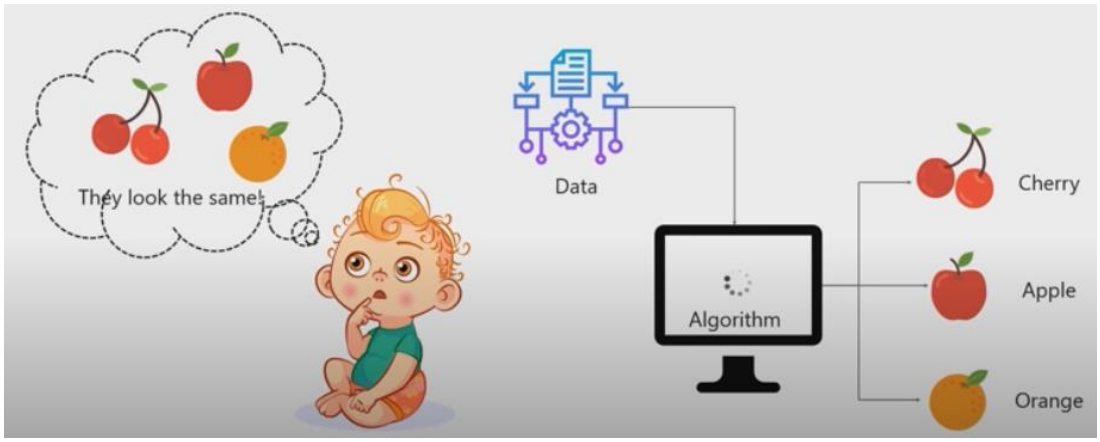
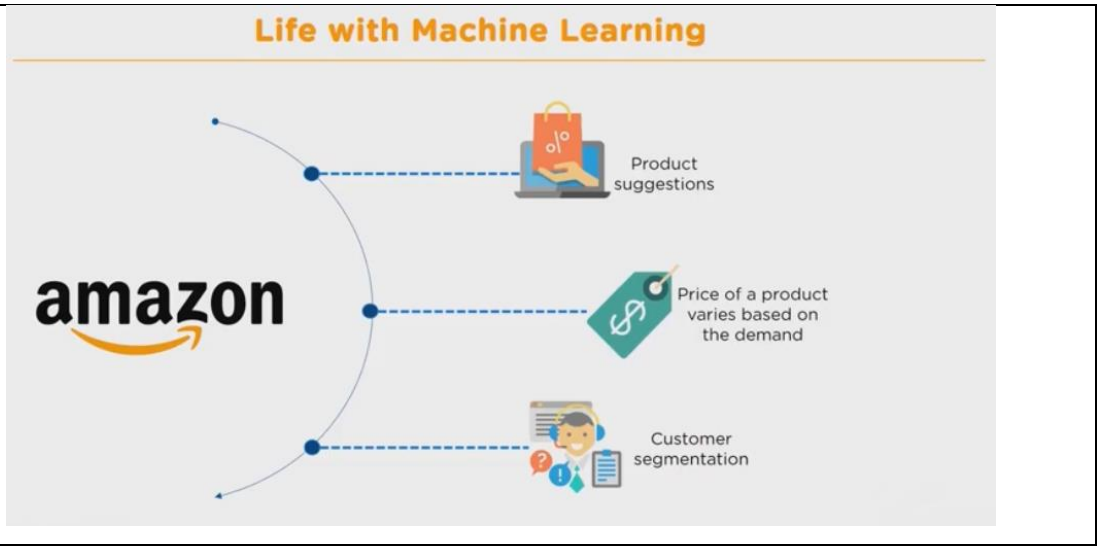


Figure 1.2a

Imagine that there is a new-born baby. It does not know how to distinguish among apple, cherry and orange. It collects more information from surroundings when it grows up and finally it will develop the capability to distinguish various fruits. It is because humans have ability to absorb information to the brain, analyse and identify objects. Similarly, machine learning is feeding data to machine so that it can interpret data, analyse, identify pattern, find out solution to problem. We closely experience machine learning as the following examples.



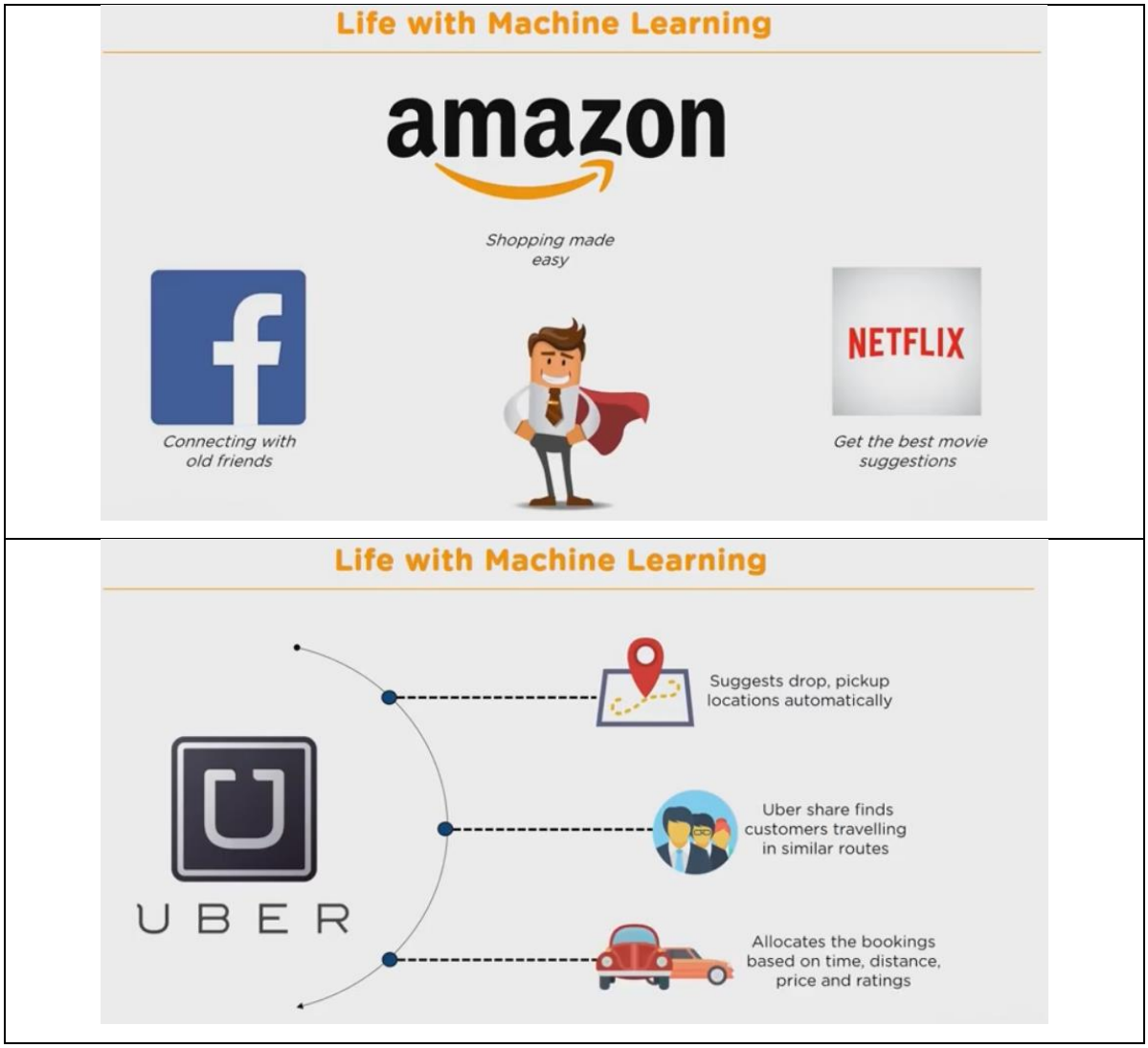


Figure 1.2b

Machine learning process includes inputting data/ old data, analysing data, finding patterns, prediction/decision, and learning from the feedback.

In general, machine learning can be categorized into three types of learning:

- Supervised learning
- Unsupervised learning
- Reinforcement learning

In unsupervised learning, no outcome variable is predicted. Instead, it is to use the variable values to identify relationships between observations.

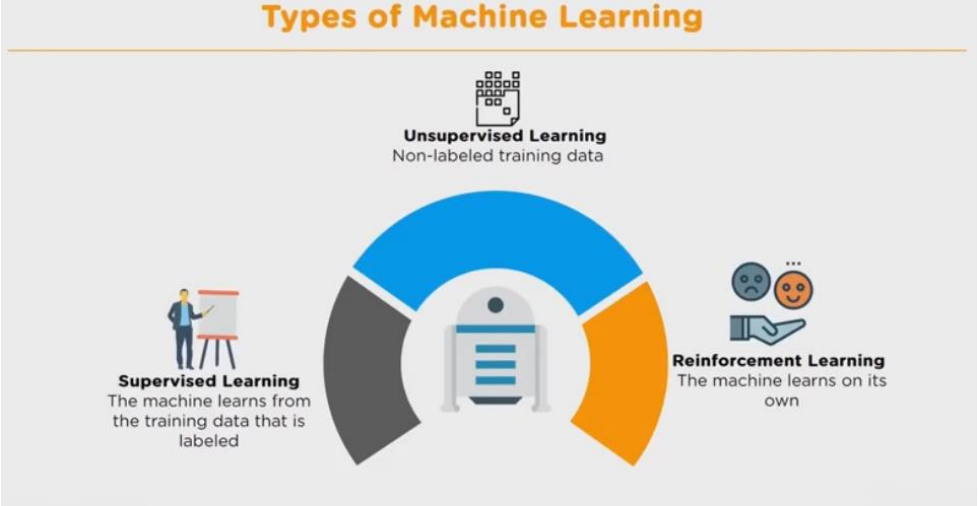
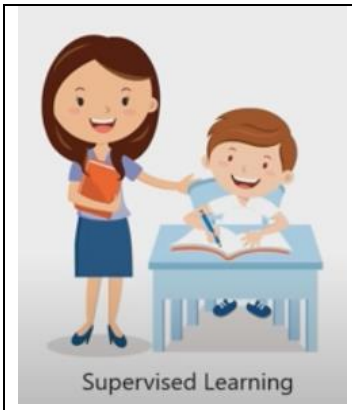
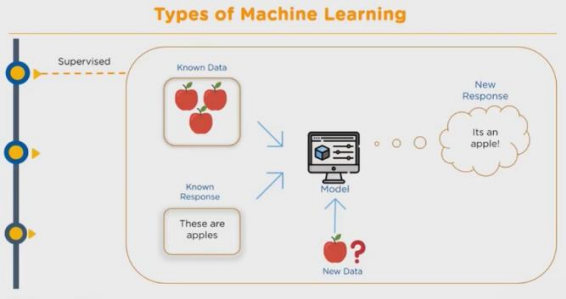


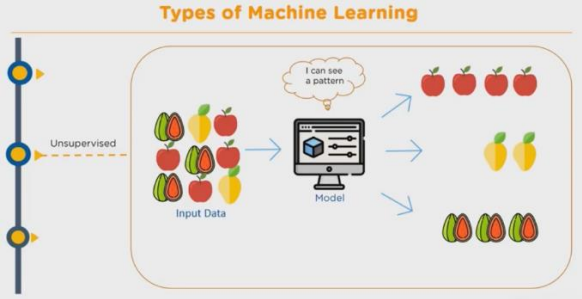
Figure 1.2c

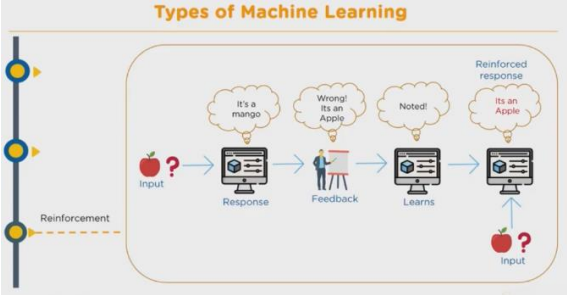
Analogy to understand: (Figure 1.2d)

	In primary and secondary school, students follow teacher's guidance to learn in class and make sure to activity to be done correctly. There is specific right answer. Similarly, in supervised learning, machines learn by feeding them **labelled training data** and clearly define input and output.
	In university, without guidance, students get raw data from market research and find out the market trend or hidden pattern on their own. No right or wrong output. Similarly, in unsupervised learning, machine learning feed in **non-labelled** training data. Machine will analyse data and find out the hidden pattern or trend based on observations. No right or wrong output.

	Imagine that the train is down in the peak hours in the morning. You will find other possible ways of transport to get back to office. Reinforcement learning is that machine will learn from variable surrounding. Next moment movement is affected by last moment surrounding variables. If suddenly there is a barrier at the front, machine will avoid barrier and change to other routes. *(Real case - Xiaomi Mi Robot Vacuum in Chapter 5)*







The purpose of machine learning determines the right machine learning algorithm.

Generally, the machine learning algorithms are classified into three categories:

- Classification
- Regression
- Clustering

Classification should be used when the output is categorical like “Yes” or “No”. Following algorithms can be used.

- K Nearest Neighbour (KNN)
- Decision Tree
- Random Forest
- Logistic Regression
- Naïve Bayes

Regression should be used when a value needs to be predicted like “the stock prices”. Algorithm linear regression can be used.

- Linear Regression

Clustering should be used when the data needs to be organized to find patterns in the case of “product recommendation”. Algorithm K-means can be used.

- K-means

K Nearest Neighbour (KNN)

[5] The k-Nearest Neighbour (k-NN) method can be used either to classify an outcome category or estimate a continuous outcome. Similarity between two different data can be measured with **Euclidean distance**. The shorter distance between two points represents the higher similarity.

Training Set Observations for k-NN Classifier

Observation	Average Balance	Age	Loan Default
1	49	38	1
2	671	26	1
3	772	47	1
4	136	48	1
5	123	40	1
6	36	29	0
7	192	31	0
8	6,574	35	0
9	2,200	58	0
10	2,100	30	0
Average:	1,285	38.2	
Standard Deviation:	2,029	10.2	

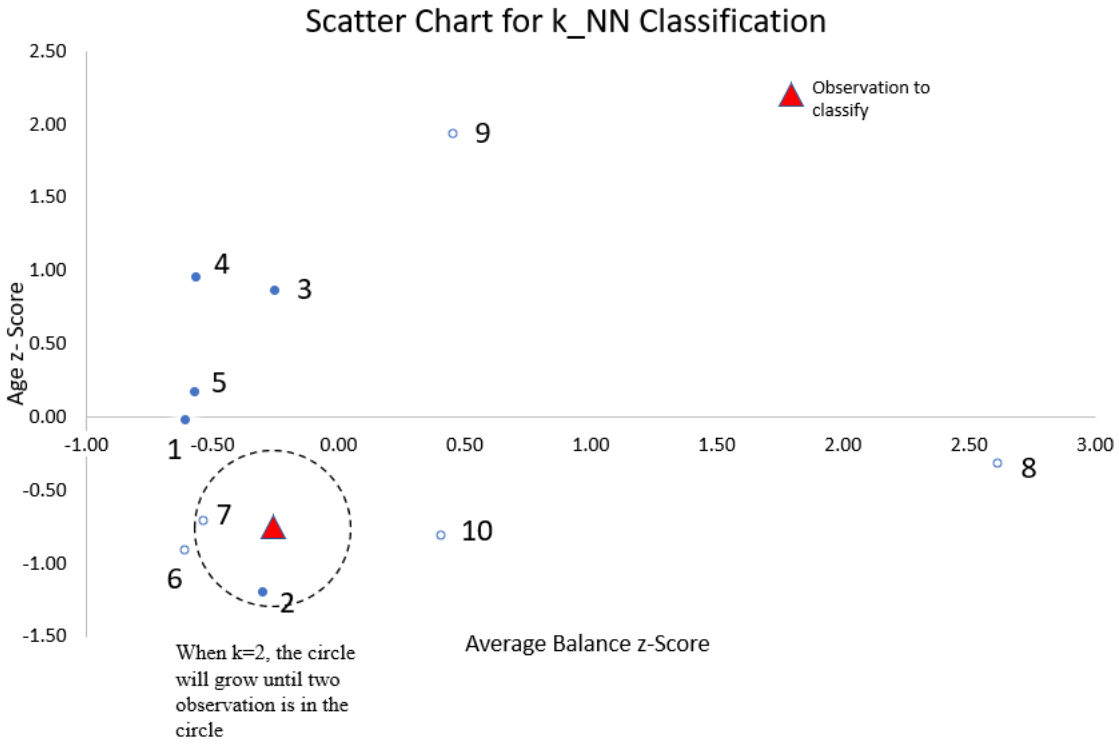


Figure 1.2e

Figure 1.2e displays the 10 training-set observations and the new observation to be classified plotted according to their normalized variable values. To classify the new observation, we will use a **cut-off value** 0.5. For k=1, this observation is classified as a Loan Default (Class 1) because its nearest neighbour (Observation 2) is in Class 1. For k=2, we see that the two nearest neighbours are Observation 2 (Class 1) and Observation 7 (Class 0). Because at least 0.5 *(= 0 + ½)* of the k=2 neighbours are Class 1, the new observation is classified as Class 1 (cutoff value 0.5 will counted as 1).

From Figure 1.2f, K Nearest Neighbours algorithm determines assigning a new data point to a neighbouring group it is the most similar. A new data is positioned to the two-variable coordinate subject to their features such as cost and durability. Then circle will grow and enlarge with the centre at the new data coordinate until the total number of samples inside the circle is equal to K. The data point will be defined to be the cluster of the most one of the K samples. The specified cut-off value is 0.5.

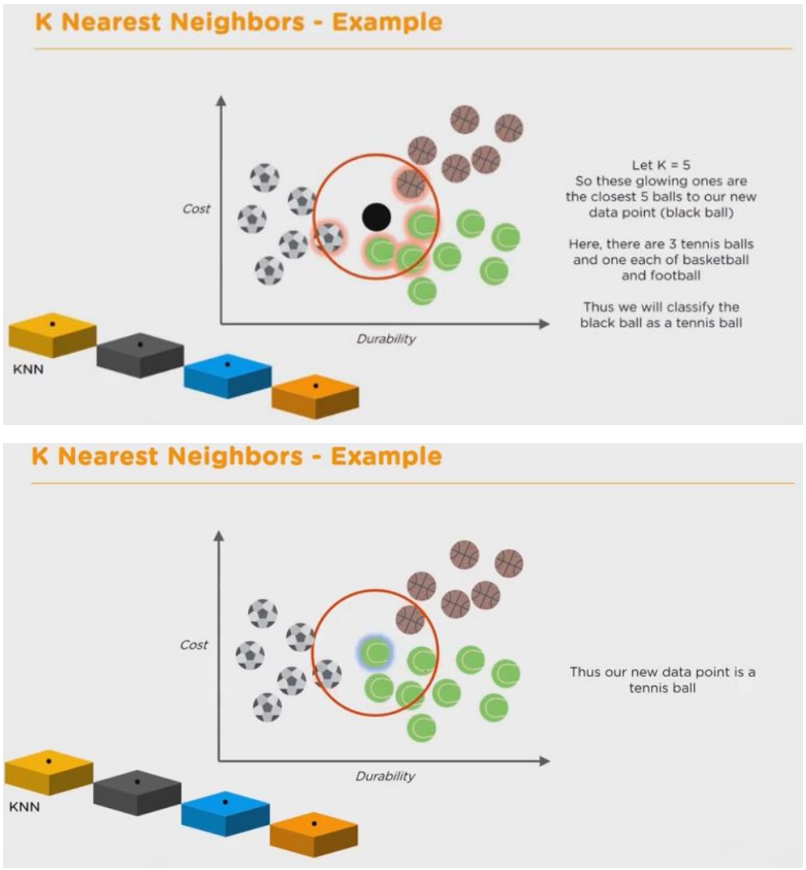
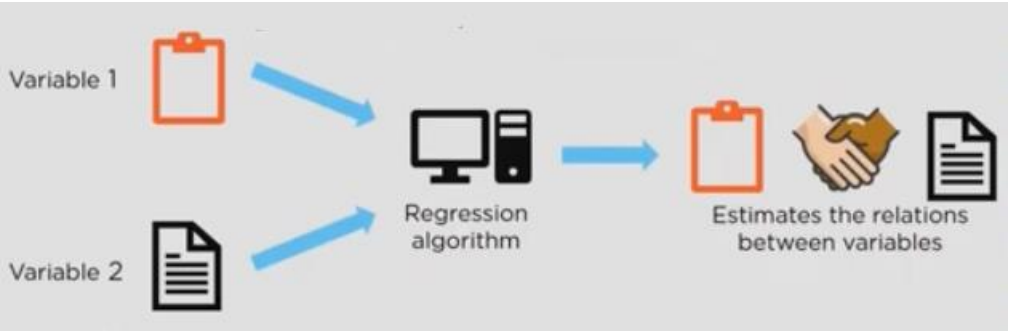


Figure 1.2f

In K Nearest Neighbours, K can be an integer greater than 1. So, for every new data point we want to classify, we compute to which neighbouring group it is the closest to.

Linear Regression

Linear Regression is a process used for estimating the relationships among variables. Here, one of the variables is dependent on one or more independent variables. E.g. “weight” and “height” of people.



The regression line is plotted subject to the minimal sum of vertical distances (errors) of data points to the regression line as Figure 1.2g. Linear regression is a statistical method that has a

wide variety of applications in the business world. Linear regression is widely used for business trend and market forecasts. In a word, it is using data observations to estimate the slope and y-intercept of the estimated regression linear equation. Using the **least-squares method** of estimation, the estimated regression equation is [5]:

$$y = mx + c$$

where

y = dependent variable (the output value for prediction)

c = intercept of the estimated regression equation

m = slope of the estimated regression equation

x = independent variable

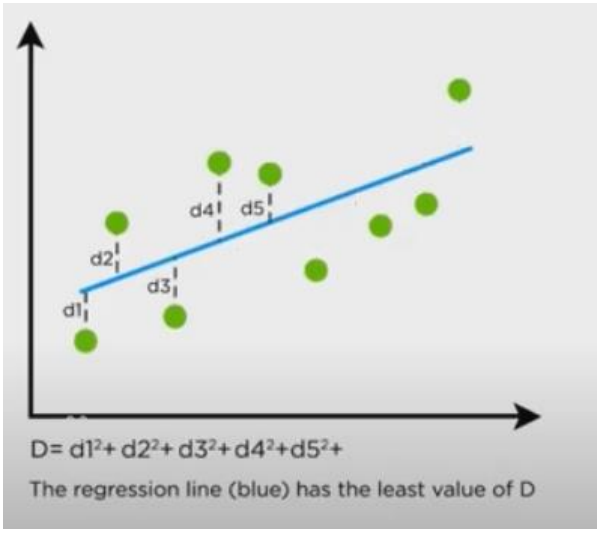


Figure 1.2g

Naïve Bayes

The Naïve Bayes Classifier technique is based on conditional probability and is particularly suited when the complexity of the inputs is high. For instance, the spam email can be effectively identified by this algorithm as in Figure 1.2h.

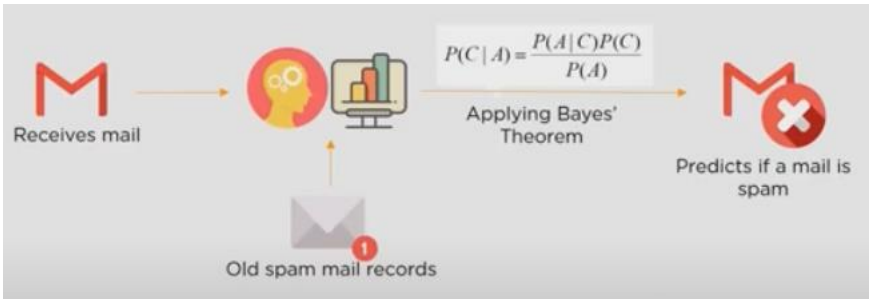


Figure 1.2h

[5] Bayes' Theorem is applicable when events for which we want to compute posterior probabilities are mutually exclusive and their union is the entire sample space. For the case of n mutually exclusive events $A_1, A_2, \ldots, A_n$, whose union is the entire sample space, Bayes' theorem can be used to compute any posterior probability P(A_i|B) as shown in the equation below.

Bayes' Theorem

$$P(A_i|B) = \frac{P(A_i)P(B|A_i)}{P(A_1)P(B|A_1) + P(A_2)P(B|A_2) + \cdots + P(A_n)P(B|A_n)}$$

[5]k-Means Cluster

Given a value of k, the k-means algorithm randomly partitions the observations into k clusters. After all observations have been assigned to a cluster, the resulting cluster centroids are calculated (these cluster centroids are the "means" of k-means clustering). Using the updated cluster centroids, all observations are reassigned to the cluster with the closest centroid. The algorithm repeats this process (calculate cluster centroids, assign observation to cluster with nearest centroid) until there is no change in the clusters or a specified maximum number of iterations is reached.

In general, the larger the ratio of the distance between a pair of cluster centroids and the within-cluster distance, the more distinct the clustering is for the observations in two clusters in the pair as demonstrated in Figure 1.2i.

	Cost (z-Score value)	Quality (z-Score value)	Mean of cost (z-Score value)	Mean of quality (z-Score value)	Cluster centroid	Distance between each observation and centroid	Average of within-cluster distance	Distance between cluster A and B	Similarity to counter cluster
Data of Cluster A (Observations)	2	-1	2.6	-2.1	(2.6, -2.1)	1.253	1.15	5.06	**4.42**
	2	-2				0.608			
	2	-2				0.608			
	3	-1				1.170			
	3	-3				0.985			
	1	-3				1.836			
	2	-1				1.253			
	4	-3				1.664			
	3	-2				0.412			
	4	-3				1.664			
Data of Cluster B (Observations)	6	1	5.7	1.9	(5.7, 1.9)	0.949	1.49		**3.41**
	7	1				1.581			
	4	1				1.924			
	7	3				1.703			
	6	3				1.140			
	5	1				1.140			
	5	2				0.707			
	3	2				2.702			
	7	2				1.304			
	7	3				1.703			

Figure 1.2i demonstration how to calculate similarity between clusters.

CHAPTER 2 – Internet of Things (IoT)

[7] IOT Definition

The term Internet of Things generally refers to scenarios where network connectivity and computing capability extend to objects, sensors and everyday items not normally considered as computers, allowing these devices to generate, exchange and consume data with minimal human intervention. It enables new technology such as ubiquitous connectivity, IP-based networking, advances in data analytics and cloud computing. There are four common communications models: Device-to-Device, Device-to-Cloud, Device-to-Gateway, and Back-End Data-Sharing. These models highlight the flexibility of connecting IoT devices. Cloud computing can be categorized in terms of service and deployment.

2.1 Internet of Things Communication Models

[7] The following discusses how IoT devices connect and communicate in terms of their communication models. There are mainly four types of communication models.

- Device-To-Device Communications
- Device-To-Cloud Communications
- Device-To-Gateway Model
- Back-End Data-Sharing Model

Device-To-Device Communications

The device-to-device communication model is that two or more devices directly connect and communicate among themselves, without an intermediary application server. These devices communicate over many types of networks, including IP networks or the Internet. However, these devices often use protocols like Bluetooth, ZigBee, or Z-Wave for direct device-to-device communications, as shown in Figure 2.1a. The light switch is pairing up with light bulb through Bluetooth.

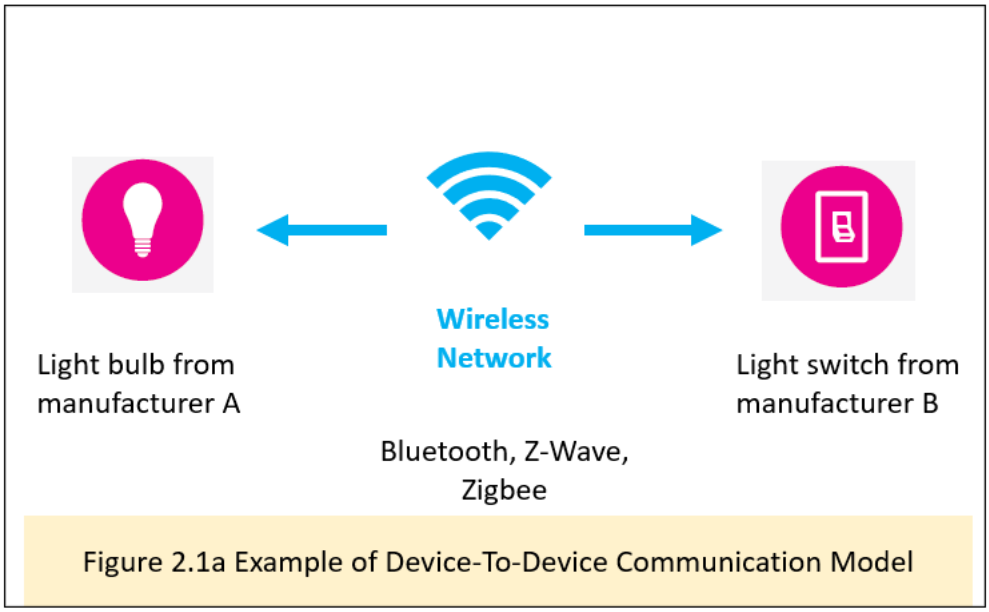


Figure 2.1a Example of Device-To-Device Communication Model

Device-To-Cloud Communications

IoT device directly connects to an Internet cloud service to inter-exchange data. It is like the way of connecting computer to internet by traditional wired ethernet or WIFI connection. The communication model is shown in Figure 2.1b.

The Nest Smart *Thermostat* [17] and the Samsung *SmartTV* are examples of this model. The device transmits data to a cloud database for home energy consumption analysis. Besides this cloud connection enables the user to obtain remote access to their thermostat via a smartphone or Web interface, and it also supports software updates to the thermostat. Similarly, the television uses an Internet connection to transmit user viewing information to Samsung for analysis and to enable the interactive voice recognition features of the TV. In these cases, the device to-cloud model adds value to the end user by extending the capabilities of the device to smarter functions with more interaction with users.

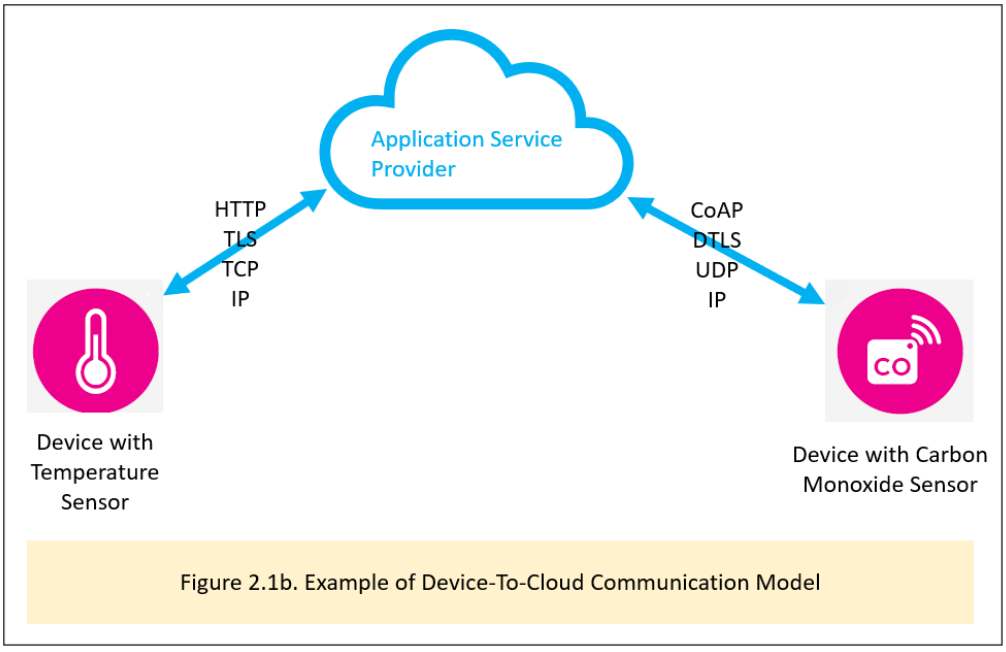


Figure 2.1b. Example of Device-To-Cloud Communication Model

Device-to-Gateway Model

The device-to-gateway model is also named as the device-to-application-layer gateway (ALG) model. An ALG serves as a pipeline to connect the IoT device to a cloud service. In a word, this model means that there is application software operating on a local gateway device between the device and the cloud service. This model also provides security to data translation. The model is shown in Figure 2.1c.

There are two forms for this model.

The first form of this model can be explained as the smartphone running an app to communicate with a device and it conveys data to a cloud service. The smartphone acts as local gateway device.

For instance, Personal fitness trackers use this form of model. These devices themselves do not connect directly to a cloud service. They rely on smartphone application layer to connect the fitness device to the cloud.

The other form of this device-to-gateway model can be explained as the hub in smart home. It serves as a local gateway between IoT device and a cloud service and it can act as intermediary to interoperate with connected IoT devices.

For example, the Xiaomi Smart Home Gateway Hub [29] or the Samsung SmartThings Hub is typically a gateway device that connects and communicates with smart home appliances and devices through Z-wave or Zigbee. It then connects to the Xiaomi cloud or SmartThings cloud, allowing the user to access to the devices by using a smartphone app and an Internet connection.

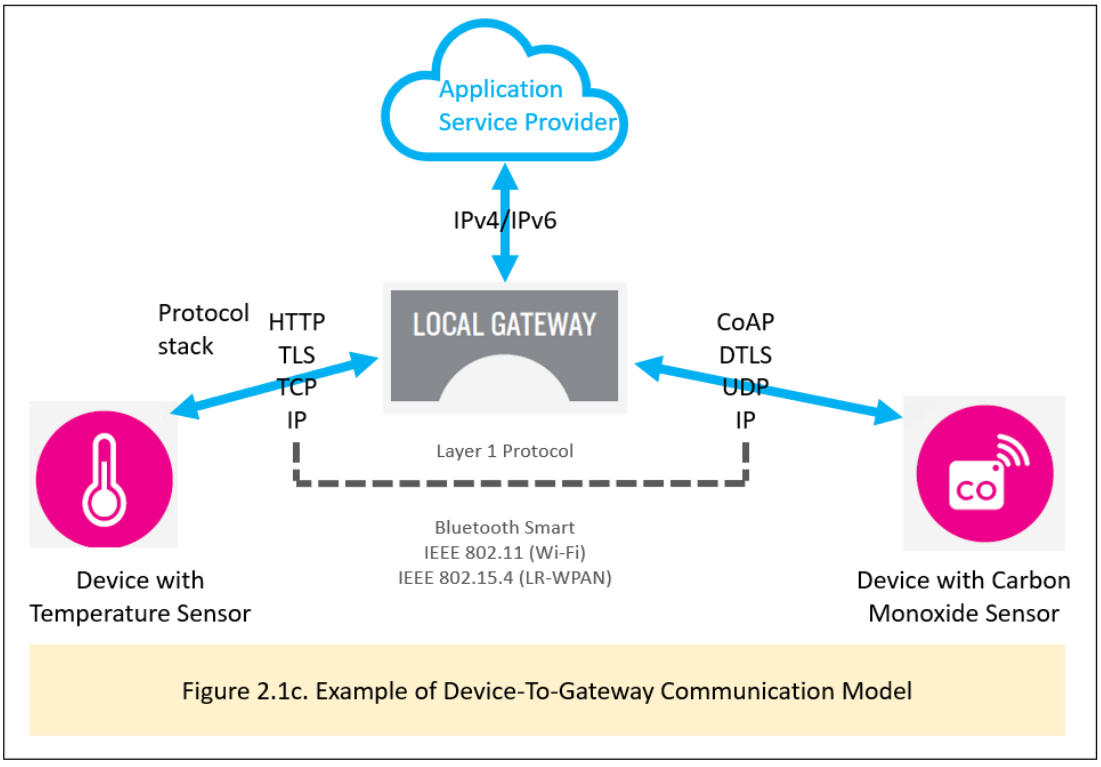


Figure 2.1c. Example of Device-To-Gateway Communication Model

Back-End Data-Sharing Model

The back-end data-sharing model allows users to export smart object data from cloud service and analyse smart device data, combining with data from other sources, such as average body weight benchmark. This communication architecture encourages users to grant access to uploaded data to federated cloud services. When a user receives the average body weight data from federated clouds to analyse his own health, his body weight data will be counted to

federated cloud to work out the average body weight of next moment. This approach is an extension of the single device to- cloud communication model, which IoT devices upload data only to a single application service provider. A back-end data sharing architecture allows the data from a single IoT device to be shared and analysed. An effective Back-End Data-Sharing Model allows users to easily exchange data with the public with grant access.

For instance, an office complex department may consolidate and analyse the total electricity consumption in office from the data sourced from all the IoT sensors and Internet-enabled hardware on the premises when they come up with solution to reduce overhead electricity cost. In the single device-to-cloud model, the data sourced from each IoT sensor or system is often transmitted to an isolated cloud storage. An effective back-end data sharing architecture should allow easily access to data and analyse the data in cloud storage within organisation.

This communication architecture also allows data portability and allows users to configure IoT devices without concerning the data disruption or loss.

A federated cloud services approach or cloud applications programming interfaces (APIs) are suggested to use to achieve interoperability of smart device data hosted in the cloud. This communication model can be represented in Figure 2.1d.

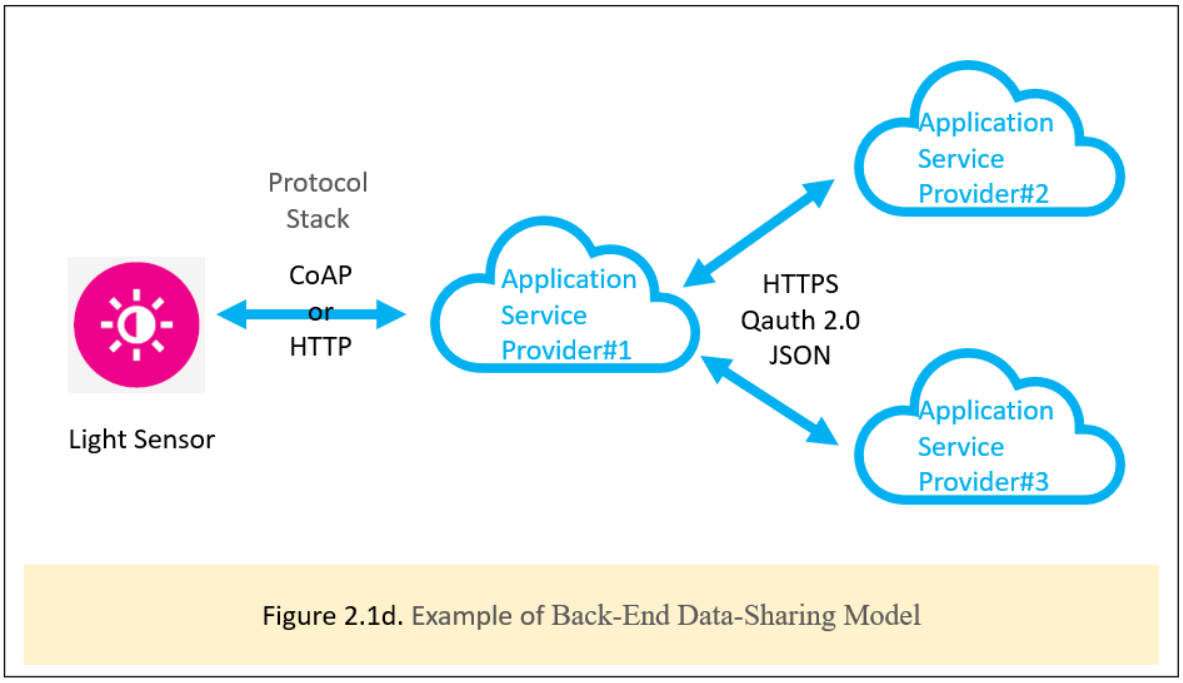
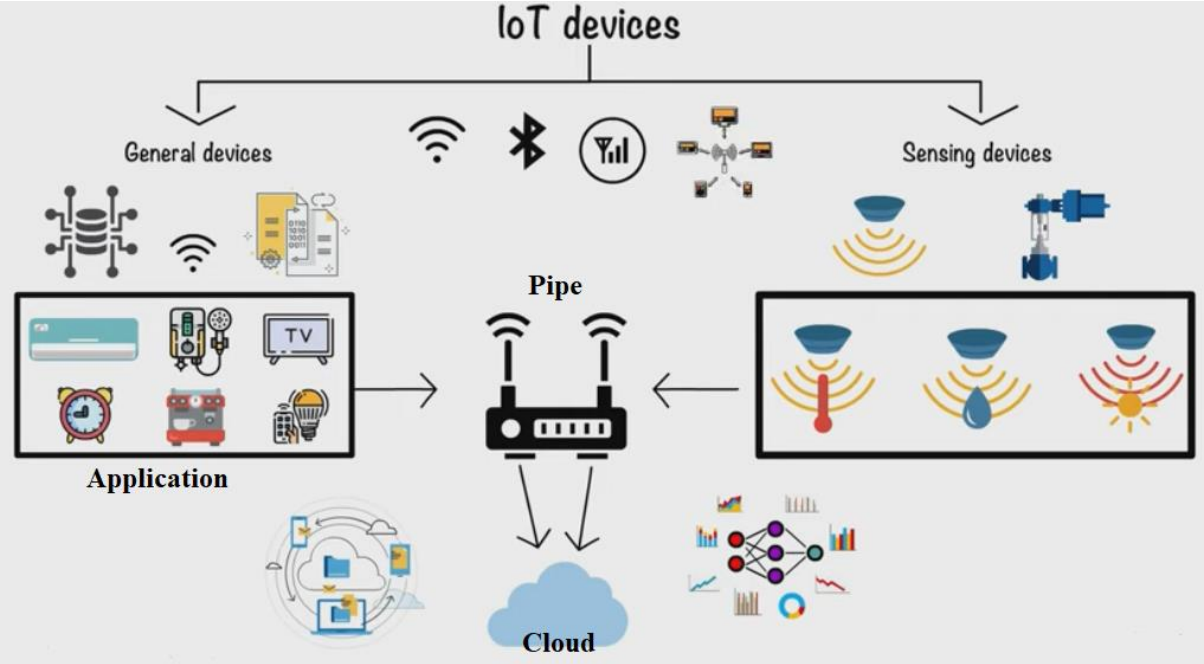
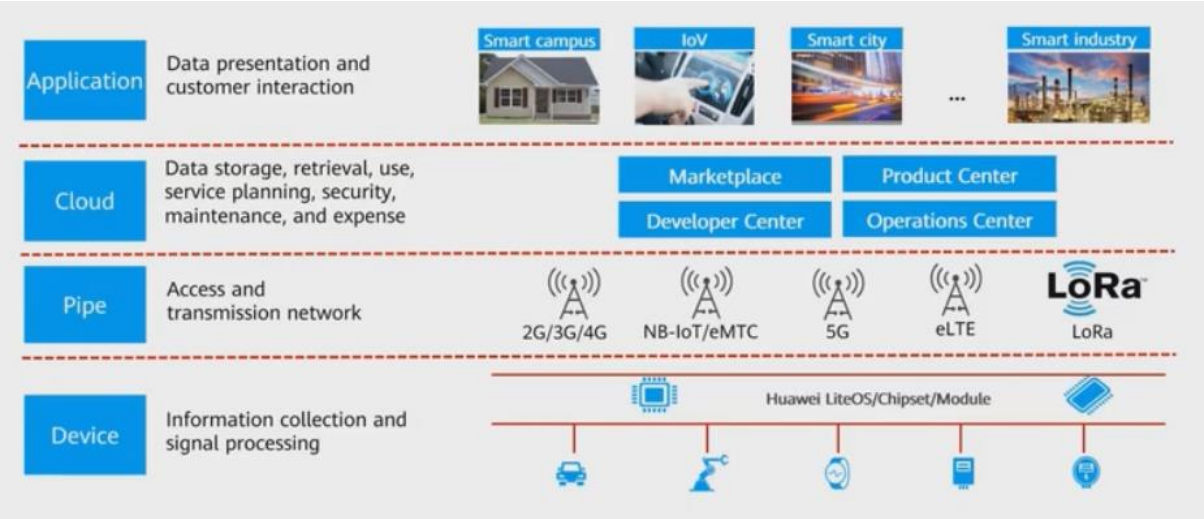


Figure 2.1d. Example of Back-End Data-Sharing Model

In general, architecture of IoT is composed of four layers as below.

- Application – data presentation and customer interaction
- Cloud – data storage, retrieval, use, service planning, security, maintenance, and expense
- Pipe – access and transmission network
- Device – information collection and signal processing





2.2 Analytic techniques for IoT

[9] In the following, we discuss four major data analytics techniques.

Descriptive Analytics

IoT systems can gather data from the Cloud database which collects data from thousands of smart devices. Based on historical data, advanced machine learning can analyse and conduct detailed insights into the past events. All these groups of machine learning algorithm summarizing raw data and doing insight study are called descriptive analytics. Examples include data aggregation, data mining and so on. Descriptive analytics need huge volume of data but IoT Cloud perfectly meet this requirement through processing cloud servers and high-performance computers.

Predictive Analytics

Predictive Analytics is superior to Descriptive Analytics. The former utilizes advanced statistical or machine learning techniques to find out the pattern model based on historical data or observations to predict the possible future trends. It is most likely used to correlate the two or more variables by regression modelling [6]. Cloud or edge computing network can provide huge volume of data for regression analysis. Some good business prediction examples are prediction of price elasticity, supply-demand trend, whatever to find predicted output variables from other input variables. It is very important for predicting future trend to make good decisions.

Prescriptive analytics

Prescriptive analytics is superior to predictive and descriptive analytics. After finding out the future trends based on data analysis, we should suggest how to respond to future events. Optimization is required to maximize or minimize the business outcome. With the optimized solution there are decision variables required to find out for the best decision making corresponding to the objective. From the Prescriptive analytics we can understand different sensitivity level of impact how the predicted outcome will change when we adjust the decision. Prescriptive analytics is generally used to optimize the business outcome with the business intelligence tools through the IoT cloud.

Adaptive Analytics

Actual implementation and prediction are always with gap difference since there are many other changing variables or unknown in real life. In actual implementation we can understand the actual outcome and use the real-time data to refine the existing model continuously to align to real situation. IoT environment can provide the possibility of real time stream data processing and make model refined accordingly. Sometimes we are not allowed to refine the model after actual implementation. In this situation, we can simulate the model by Monte Carlo Simulation which makes sure of random variable. We can test the model with multiple times of simulation and refine the model according to simulated outcomes.

2.3 Cloud computing

[8] Cloud is a computing model where servers, platforms, networks, storage and software/office applications are all enabled through the internet. Traditionally company invest much to IT infrastructure such as expensive and bulky servers and hire IT staff to maintain the systems continuously. Both the start-up and overhead cost are very tremendous expense. Nowadays with the significant advanced computing power and high speed of data transmission, more and more company switch to Cloud computing from traditional on premises IT infrastructure. Company can operate information system only by paying the service charge or monthly subscription fee. No hardware or middleware are required. And company does not risk on premise server broken. Below are five key characteristics for success in cloud computing.

Internet Access

Smooth internet connection is required for “plug and use”.

Measured Service

Cloud services is charged subject to service package. The more service you use, the more you pay.

On-Demand Self-Service

Cloud service can be used immediately after you have paid subscription fee. No complex configuration is required.

Pooling of shared resources

Cloud service often uses the multi-tenancy model. An application service has limited quota to be shared among users.

Rapid Elasticity

Cloud has high elasticity. Company can flexibly change the service package subject to the actual usage. High upkeep is required for on premises configuration.

There are three hierarchies of Cloud services: **Software as a Service (SaaS)**, **Platform as a Service (PaaS)**, and **Infrastructure as a Service (IaaS)** [9]. The Cloud service provider can provide all levels of services when the devices connect to Internet. The term everything as a Service (XaaS) has emerged. It is exactly the meaning of IoT which interlinks all smart devices. Within an IoT network, a massive of generated data is stored and analysed. CTR prediction in JD.com is a typical case and it will be discussed in Chapter 4. Cloud deployment model may vary subject to the privacy level requirement such as public, private, hybrid.[10].

[8] In general, cloud computing is considered as two-dimensional modelling. One dimensional is deployment and another is service.

Deployment Model

The Deployment models which are commonly used include: [23]

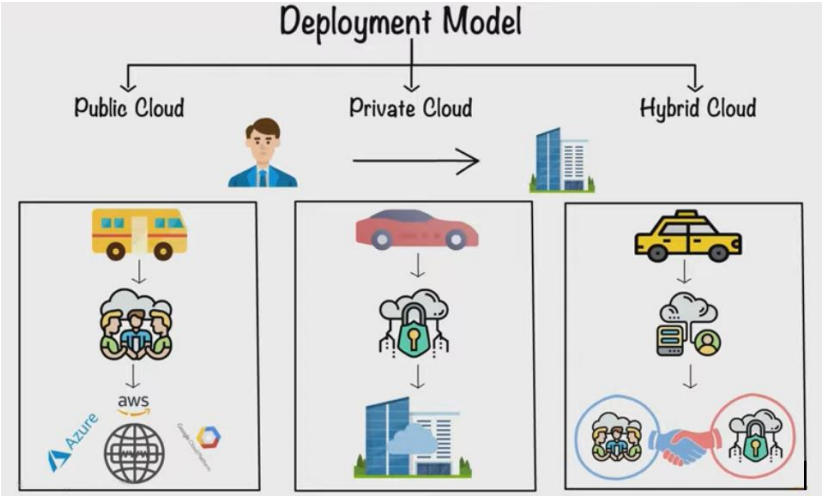
- Private Cloud
- Public Cloud
- Hybrid Cloud

Private Cloud: - It is internal cloud. It is managed and operated by a single organization or a group. It is not open to public and no data access is allowed unless there is specific authorization from the organization. The infrastructure is managed and operated for a single organization only, so that the security, privacy, and governance can remain under control.

Public Cloud: - It is external cloud. It is open available to public. Usually, it is owned and managed by government organization. This model means the public can access for data from the public cloud. The customer can access resources and operate resources paid. Public Cloud can operate individual services and collection of services.

Hybrid Cloud: - A hybrid cloud is generally combined from public and private cloud.

These three deployment models are different in privacy like public bus, taxi and private car.

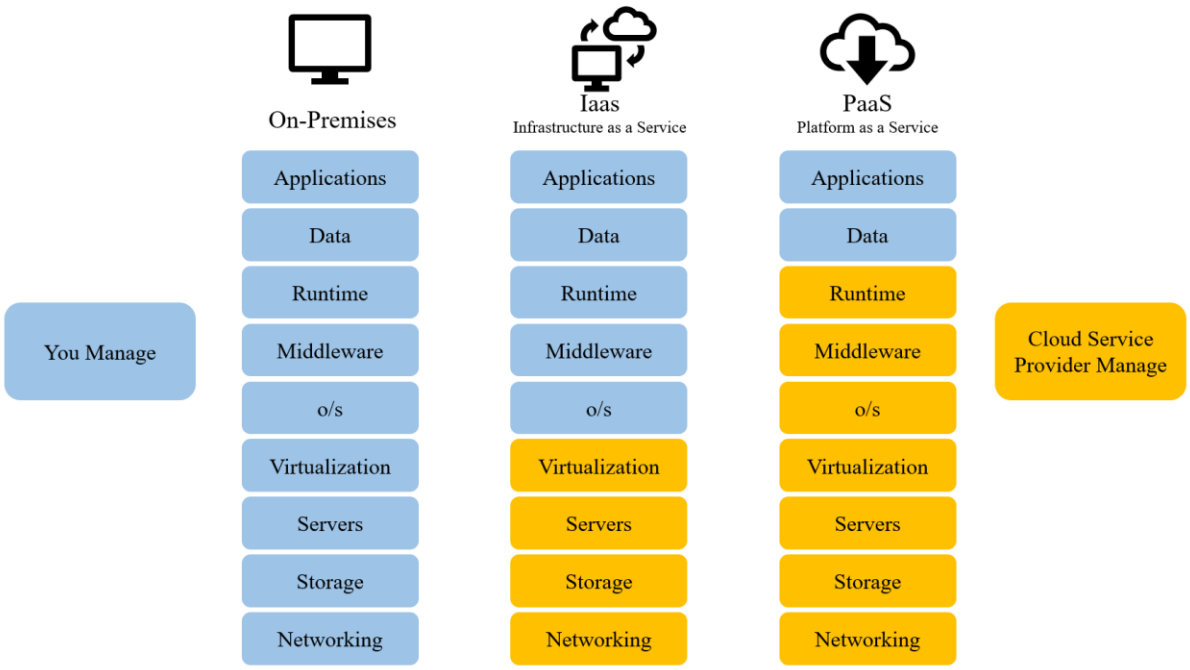


Service Model

[8] The service models which are commonly used include:

- Infrastructure as a Service (IaaS) – only hardware is managed by Cloud provider.
- Platform as a Service (PaaS) – Hardware, middleware and operation system are managed by Cloud provider.
- Software as a Service (SaaS) – Hardware, middleware, operation system and applications all are manged by Cloud provider.

It is somehow like online software service products with different hierarchies of premium service package as shown below. We can pay more for higher level of service.



2.4 Edge Computing

[9] Edge computing means the analytical capability near the edge of the network of the IoT devices. Cloud computing is a centralized way of processing massive data. To resolve the challenges and limitations, edge computing has emerged and is used to process data near the edge of network, without directing to cloud. Sending all massive IoT data to the cloud will increase the overhead due to long distance and constantly require high communication bandwidth and power. Edge computing can do computing near the IoT device. It can significantly diversify the computing workload to central server and resolve the problem of insufficient bandwidth. Besides, edge computing diversifies the risk of a single point failure and increases the computing and analytical efficiency. Edge server is regarded as the tree branch and Cloud service as the tree core stem. Edge server acts as gateway to share the computing workload of central server anytime. In [10], it is said that cloud computing is generally used for high computing power required and complex data analysis, whereas edge computing is suitable for low computing power required and real-time operations. Cloud computing requires significantly more complex deployments than edge computing. Fig. 2.4a shows the structure of an edge-cloud model for IoT network. The edge processing lies between end-devices and cloud processing. It is estimated that approximately 40-50% of the IoT data will be processed with edge-cloud model in next decade [12].

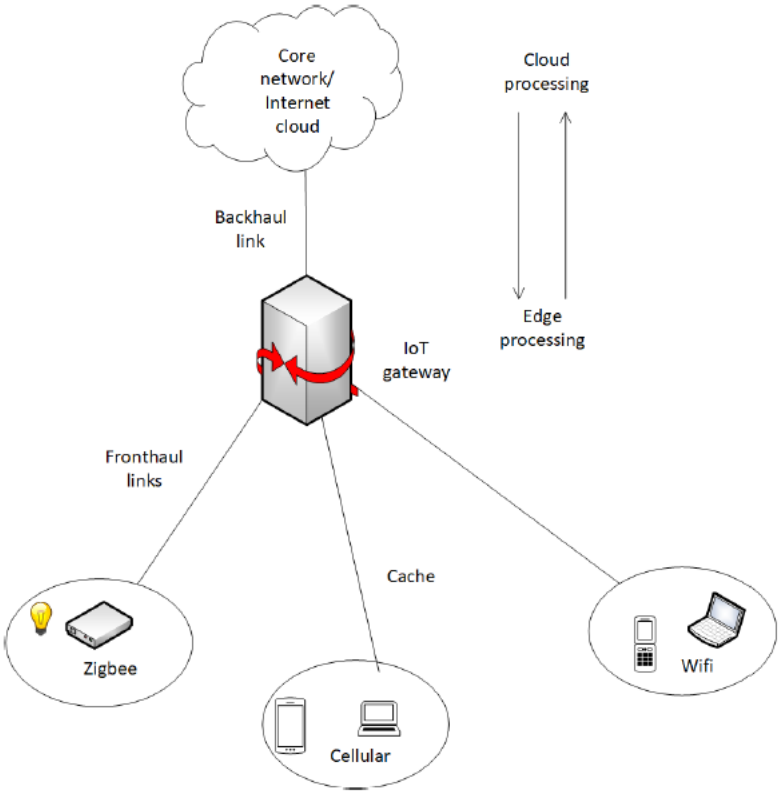


Figure 2.4a Edge-cloud model in IoT networks [10]

2.5 Fog Computing

[9] Fog computing exists between cloud and edge computing and it connects the cloud and edge resources. It can be regarded as a coordinator between cloud and edge to address issues. Edge computing works at the edge of the network for computing function. Fog computing provides networking services between the cloud and end-devices as well as provides computing and storage capability. Data can be stored in cloud for up to years. Fig. 2.5a shows the computing areas of cloud, edge and fog as well as the IoT architecture with components. With high computing power and resources, most of the complex analytics work in the cloud server. Simple online algorithms work in the edge server.

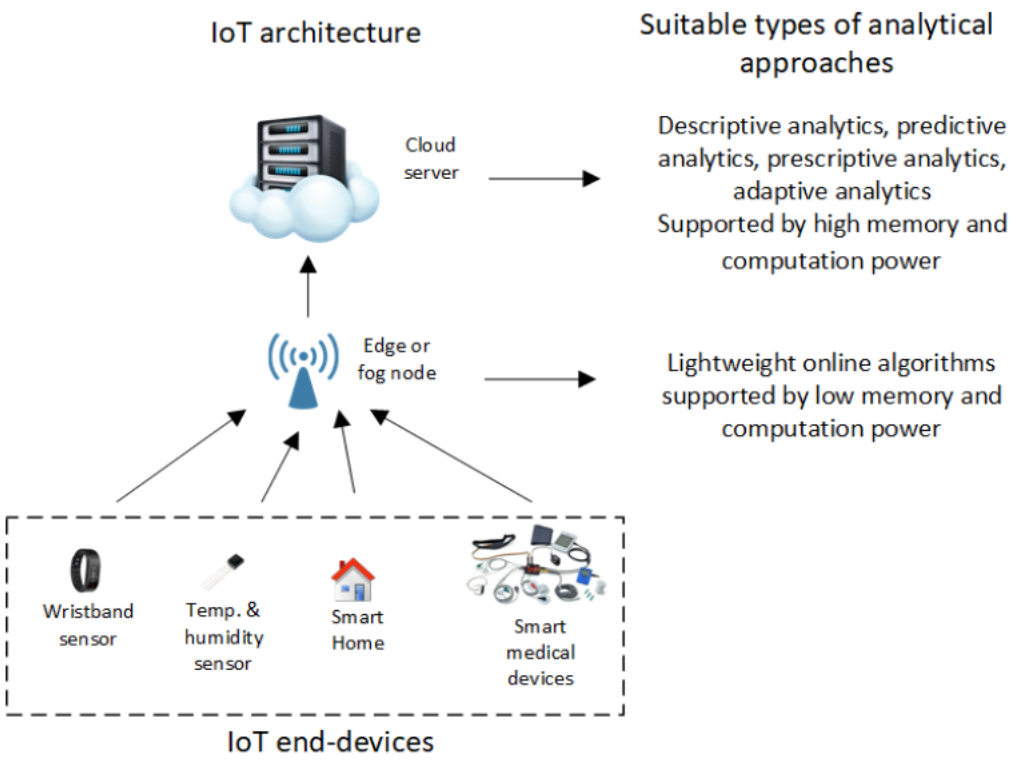


Figure 2.5a IoT architecture and data analytics [9]

Nowadays the IoT application scenarios examples are bicycle sharing, smart queuing, smart parking and smart home.

When we design the IoT infrastructure, we should consider wireless capability, functionality, interoperability, storage security, instant boot capacity, bandwidth and power management.

CHAPTER 3 – Artificial Intelligence of Things (AIoT)

[14] The Artificial Intelligence of Things (AIoT) is the combination of artificial intelligence and the Internet of Things to increase the IoT efficiency, improve human-machine interactions and enhance data management and analytics. AI can be used to convert IoT data into analytics information for improved decision-making and creating foundation for future new technology.

[19] Artificial intelligence can be regarded as the intelligent "brain" of a system. Internet of Things can be treated as the "digital nervous system". As human body, brain interoperates closely with nervous system to do move with the body and limbs. Similarly, combining AI with IoT allows conveying message to connected devices and operate according to human instruction. You can imagine that you speak to an AI-speaker (like google AI) and order them to turn on connected TV, connected air-conditioner and connected washing machine, etc. It is somehow like a housekeeper taking care of you. Similarly, when you summon Siri from iphone, you need to connect to internet first, otherwise, Siri cannot check anything for you.

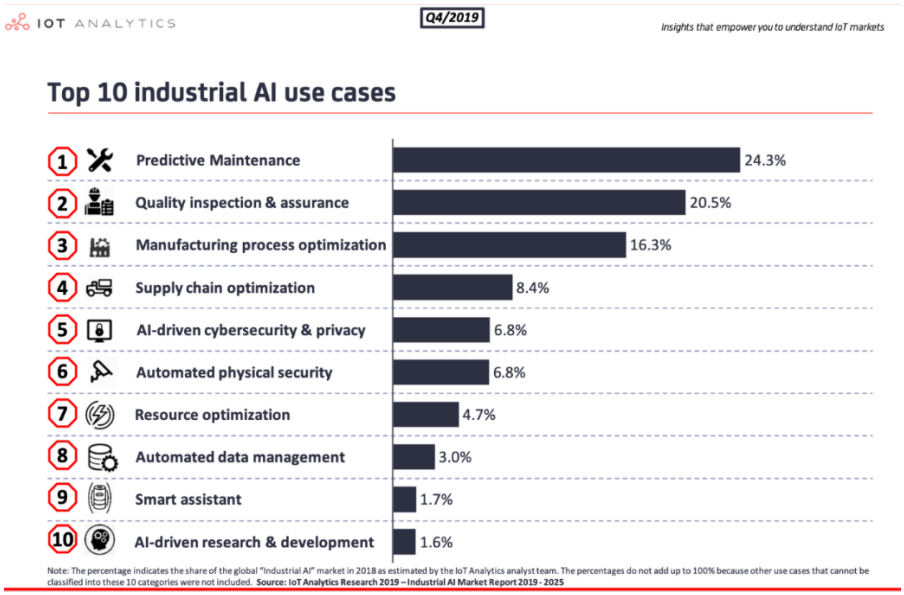


Figure 3a. Top 10 Industrial AI use cases [13]

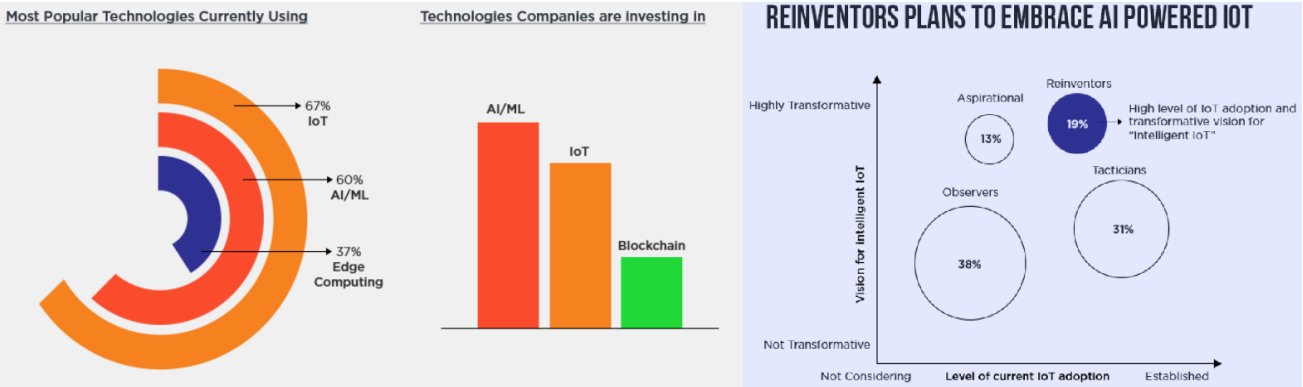


Figure 3b. Technology and Investment Trends [15]

From Figure 3b, 19% executives tend to focus on benefit of AIoT.

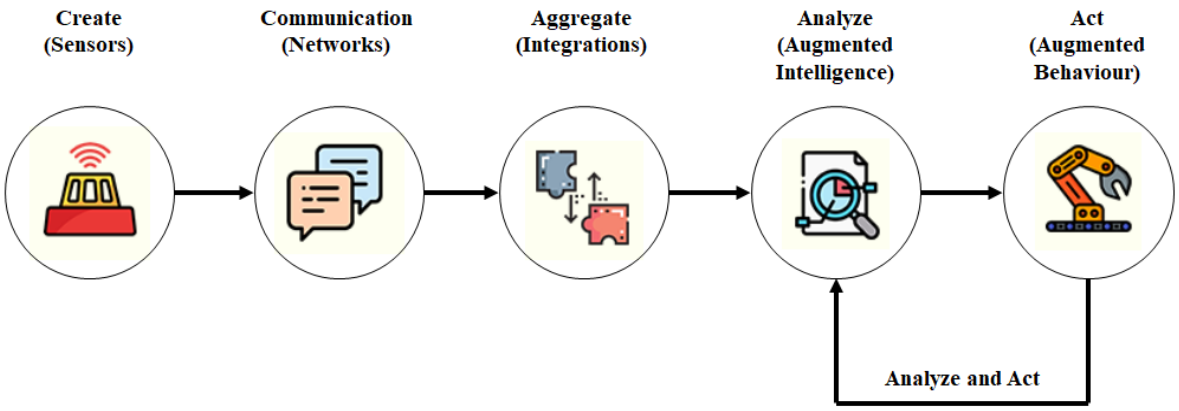


Figure 3c. AI & IoT Functional View [15]

From Figure 3c., Analyze and Act is operated by AI algorithms and the ultimate value is determined by the AI algorithm analysis step. AI does play an important role to unlock the IoT, maximize the value of IoT.

Benefits of AI enabled IoT

AI enabled IoT leads to a wide range of benefits to business. It can offer high computing power of business anlytics, intelligent automation and proactive intervention. Here are some common benefits of combining AI and IoT to business:

Maximize operational efficiency

Along production processes, all the production data will be stored in cloud data and AI will detect the conditions and refine the parameters and patterns to enhance the operation

efficiency based on the previous production data. The variation is reduced and efficiency rises constantly.

Enhance risk management

AI enabled IoT can help business to predict and identify risks. It can effectively predict the risk of loan default, employee safety, financial loss and cyber threats.

For instance, Fujitsu uses AI to analyze data sourced from connected wearable to ensure worker safety.

Enhance products and services

NLP (Natural Language Processing) is advanced to allow people to interact with devices and machine freely. With AI enabled IoT, products can get smarter and more dynamic to humans. New innovative and smart technology in products more likely happens.

For instance, Tesla leverages AI enabled IoT to develop self-driving technology. The stock price of Tesla thus has increased a lot. People can talk to Smart Home assistant to play music or check weather forecast at home.

Increase IoT scalability

IoT devices are in wide range of complexity. The simple one can be a tiny RFID tag. The most complex one can be super PC or smart home appliance. When more and more IoT devices emerge, AI enabled IoT can maximize the benefit within the IoT ecosystem by analyzing and sharing IoT data between devices in IoT network.

For instance, users, to a large extent, understand own body health status through Apple watch and connected body scale.

Change unplanned downtime to be planned

Machine unexpected downtime significantly impact business. The predictive maintence can be done by AI enabled IoT. Machine will be predicted with the approximate breakdown time based on the depreciation data detected in daily production. Order maintenance procedures can be scheduled in advance to minimize impact from unplanned downtime.

Smart Farming

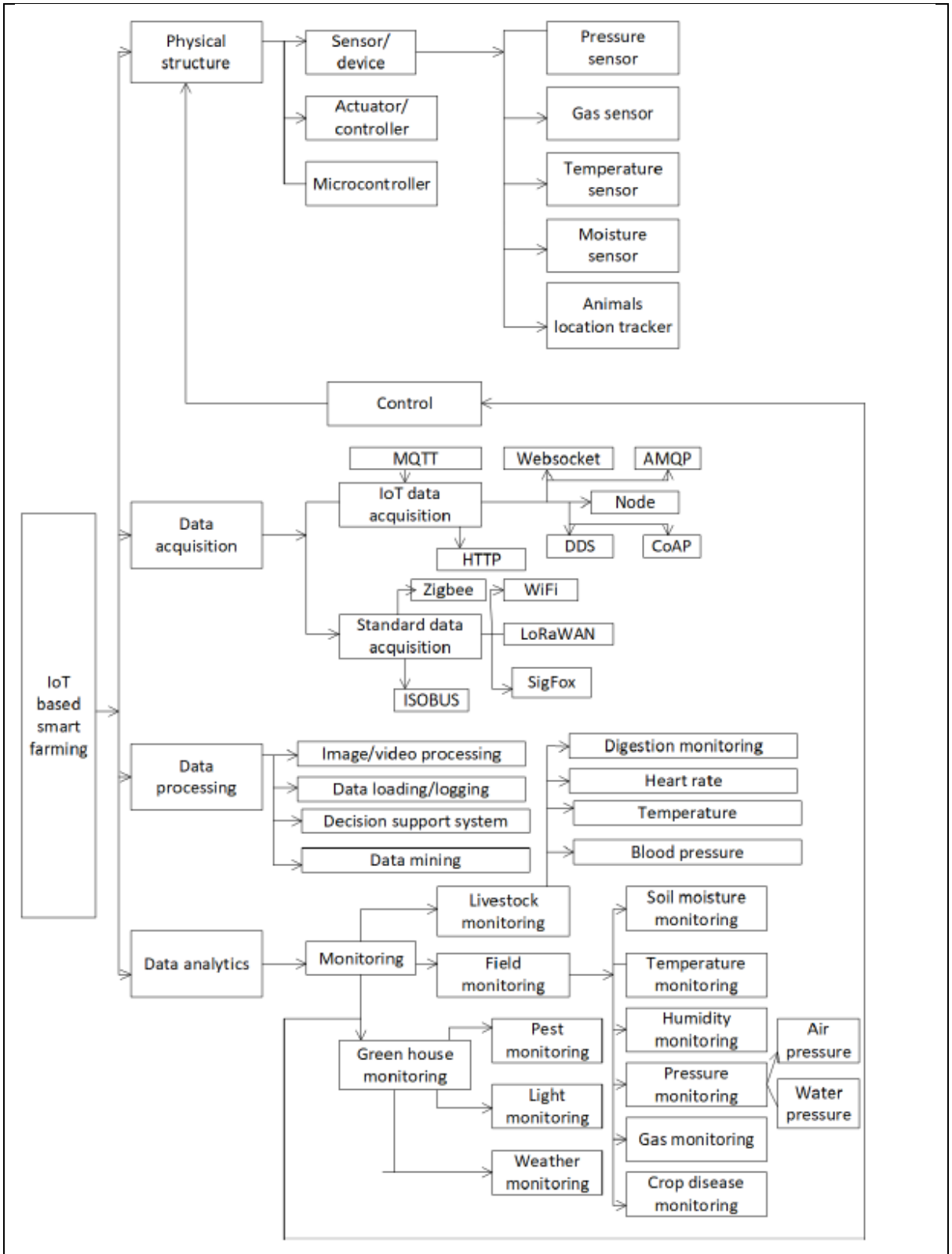


Figure 3d. Architecture of AI enabled IoT smart farming [16]

[16] The smart farming architecture is composed of physical structure, data acquisition, data processing, and data analytics.

The physical structure acts as source to collect surrounding changing data such as air pressure, gas, temperature, air moisture and animal location tracking. The sensor function includes soil sensing, temperature sensing, weather sensing, light sensing, and moisture sensing.

Data Acquisition includes IoT data acquisition and standard data acquisition. The IoT data acquisition component consists of Message Queuing Telemetry Transport (MQTT), Websocket, Advanced Message Queuing Protocol (AMQP), Node, Constrained Application Protocol (CoAP), Data Distribution Service (DDS), and Hyper Text Transfer Protocol (HTTP). The standard data acquisition has used ZigBee, WIFI, Long Range Wide Area Network (LoraWan), SigFox and ISOBUS protocols.

Data processing consists of image or video processing, data loading, decision support system, and data mining as shown in Figure 3d.

Data analytics consists of two main features that are monitoring and controlling. Monitoring involves three main applications Livestock Monitoring, Field Monitoring, and Green house Monitoring.

- Farmers can monitor different animal's diseases like temperature, heart rate, and digestion, etc. based on analytics and change is made if necessary.
- Farmer can monitor the field by understanding soil richness, temperature, humidity, gas, pressure (air pressure and water pressure), and crop disease monitoring. Change is made if necessary.
- Farmer can monitor the greenhouse by knowing the analysis of pest, light and weather. Change is made if necessary.

Smart Healthcare [9]

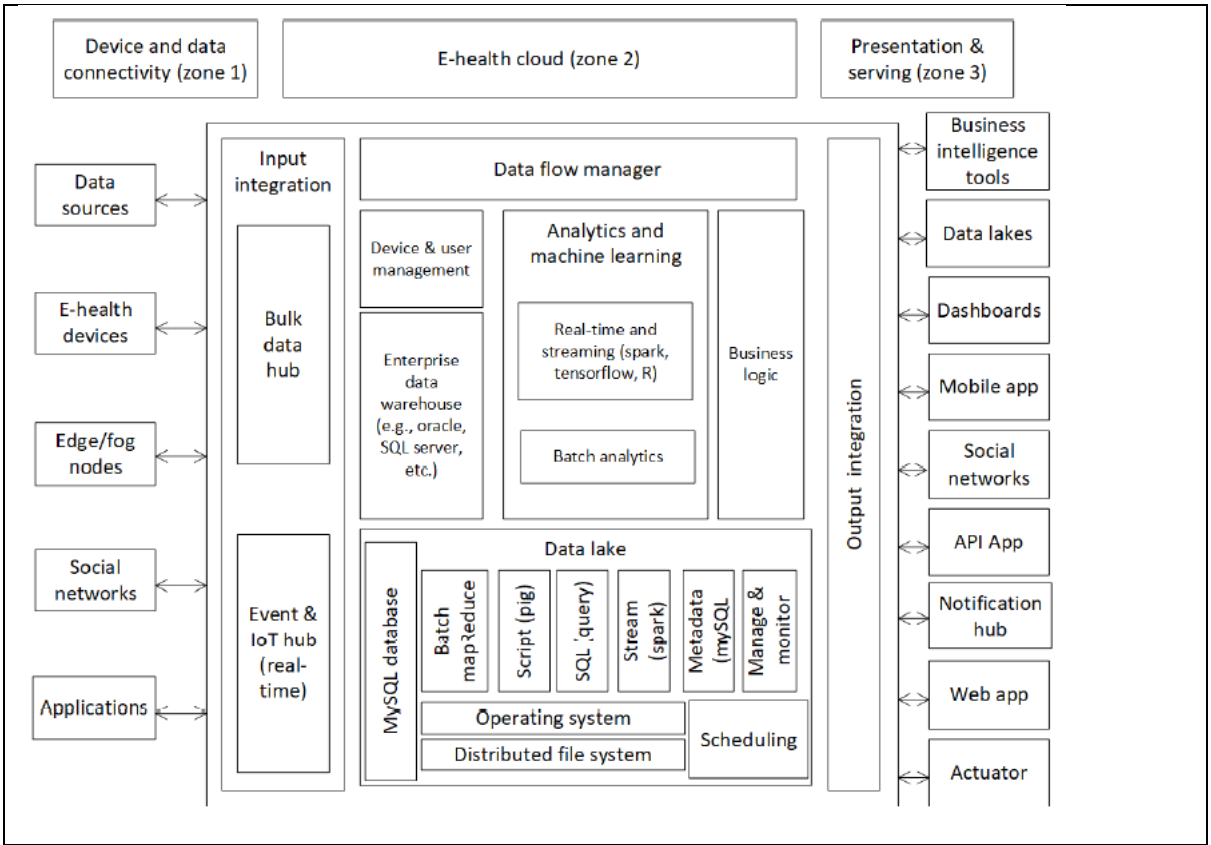


Figure 3e. Infrastructure of the eHealth cloud [9]

Genuine examples

[11] Recently the AI enabled IoT has been more and more popular and there are many genuine applications:

Self-Driving Cars: Tesla has already innovated new self-driving car model and it is predicted that self-driving car technology will be scaled up continuously for the next decade.

Smart thermostat: Google recently released a new smart thermostat called "Nest thermostat". The smart thermostat determines if someone is home by detecting motion. Users can schedule the temperature freely and do pre-cooling before arriving home.

Computing the COVID vaccine formulation: Global pandemic has lasted over a year. When the pandemic exploded in early 2020, there was no vaccine to treat COVID. By using super-computing, scientists could optimize solution to produce vaccine rapidly and the vaccine research & development period was significantly shortened to less than 9 months.

Regularly vaccine R&D period is 5 to 10 years. The success should attribute to AI and IoT since real time patience data can be acquired and analysed easily.

CHAPTER 4 – AIOT practiced in JD.COM and JD Logistics

Figure 4.1 JD.com online retail

Figure 4.2 JD.com application

JD.COM is the leading and 2nd biggest e-commerce in China. It operates the second biggest transactional volume of online retail platform in China. Besides, it operates a subsidiary company called JD Logistics which takes over all logistic demand from transaction in JD.com. JD Logistics is now covering over 90% residential distribution network area in China and is one of the biggest logistic company in China. It owns huge network of warehouses and distribution stations. In other words, JD Logistics is nearly no geographical limitation for the goods delivery in China. High logistic cost is big challenge to JD.COM, so automation is their key success to overcome this problem.

JD Logistics operate automated logistics to minimize the human intervention. It provides supply chain solutions including automated warehousing, order sorting and unmanned goods delivery such as drone delivery program, unmanned distribution vehicles.

Drone delivery program (JD Logistics)

In [25], JD logistic has used drones to dispatch goods ordered online in rural areas. AI algorithm computes out the optimization for the best route to destination. The drone is auto navigated along the programmed route and will drop the parcel to the designated area. The deliveryman will pick up the goods to the exact consignee address with last mile delivery. The drone delivery program is used to maximize the accuracy and efficiency of delivery in urban and rural areas.

Figure 4.3 Drone Delivery in rural areas – JD.com

Unmanned distribution vehicles (JD Logistics)

In [26], JD Logistics has used the unmanned travel list vehicle to carry packages. The unmanned vehicle runs along the scheduled routes to consumers. The vehicle can detect

barrier and avoid vehicles and pedestrians. It applies AI algorithm slam and output of previous moment is the input of next moment. In other words, reinforcement learning is applied in this technology.

Upon arrival the unmanned vehicle will message to package recipient and recipient can confirm receipt by entering code included in the message. It is used for decreasing the logistic costs, supplementing insufficient labour and increasing the delivery efficiency. Unmanned vehicle has completely replaced the human delivery in flat roads without going up stairs.

Figure 4.4 Unmanned vehicle delivery – JD.com

Automated Warehouse (JD Logistics)

In [27], JD Logistics owns fully automated warehouses. In the warehouse, all the order is sorted, scanned and moved by robotic arms and vehicles with slam AI algorithm [28]. This can significantly reduce the variation caused by human mistakes. On one hand, accuracy and efficiency can be largely increased. On the other hand, overhead cost is much decreased since it is free of human labour cost.

Figure 4.5 Automated Warehouse – JD.com

Accurate Click Through Rate (CTR) prediction

[20] Everyday hundreds of millions of customers visit JD.COM retail website. They click the ads and leave interaction logs to the systems. These data will feed into the JD.com advertising system to improve users' experience and advertisers' profit. In other words, they target to the match right ads to right customers. On one hand, customers will not receive unwanted advertising. On the other hand, advertisers can direct to right potential customers more efficiently. This is one type of reinforcement learning which keeps improving the performance from past experiences.

Nowadays e-commerce platform tends to display visual image appealing, rather than textual description. The former is proved to attract customers to click the ads more efficiently. The interaction log data (category and user) is non-visual features. Visual product image is visual features. JD.com advertising system will use the consider both factors to select appropriate ads to customers. AI algorithm called Category-Specific CNN for Visual-aware Click Through Rate (CTR) Prediction is used to improve the accuracy of advertisement to customers. Below is the architecture of CTR Prediction System used in JD.com.

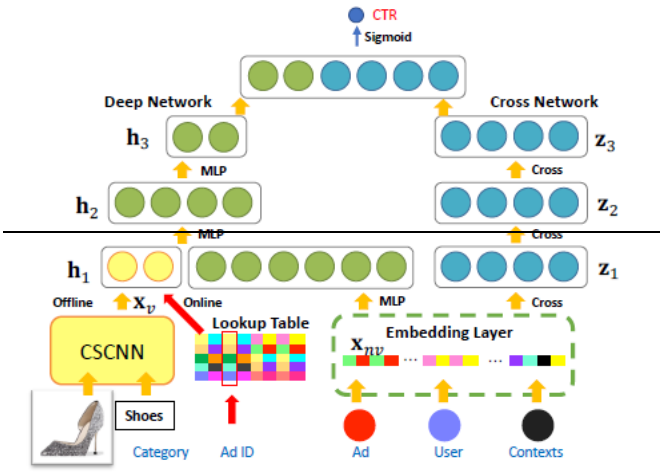


Figure 4.6 The Diagram of CTR Prediction System used in JD.COM

CHAPTER 5 - Core strategy of “AI+IOT” Xiaomi in China

[21] Established in 2012, and then independently developed the MIUI mobile phone system, Xiaomi mobile phone occupied the domestic smartphone market with its unique business model and marketing model. The "AI + Iot" development strategy, that is, "Artificial Intelligence + Internet", has been proposed over recent years marked by the "Internet +" era. This is a historic opportunity for Xiaomi to fulfill its mission, making it possible for everyone worldwide to access to a good life brought about by technology. However, at present, there is still a certain gap between Xiaomi's mobile phone and its proposed development strategy. Therefore, it is of great practical significance to further strengthen the "AI + Iot" core strategic research in the context of the "Internet +" era.

Strategic Analysis

Lei Jun, the CEO of Xiaomi, reiterate that Xiaomi is Internet Innovation company, rather than a simple mobile manufacturer.

Xiaomi is applying cost leading strategy in their hardware products. They save a lot of promotion advertising fee since the sales volume gets easily exploding with cost leading advantage. Once the hardware items sales volume increase, they can continuously expand the active user volume in their AIoT ecosystem network. Once new users get into the MI ecosystem network, they will no longer easily switch to other brand since active users likely get used to the MI AIoT platform. With numerous smart home AIoT devices, the users’ honesty to MI brand will be much higher and they cannot easily leave away from MI brand.

Potential problems

Although Xiaomi has achieved good development and progress in recent years, and is even reputed as the "Myth of Xiaomi", potential problems are involved in Xiaomi's strategic development.

For example, Xiaomi has attracted a large number of mobile phone users, but to some extent it has fallen into the embarrassing situation of "quantity and no profit". First of all, other Chinese mobile phone brands such as Huawei and ZTE continue to introduce low-priced high-end smartphones, which has greatly diminished the market share of Xiaomi mobile phones. Second, the deployment costs of Xiaomi mobile phone are not low, but they are sold at relatively low prices. Although it is not losing money, its profit is very meager, which brings challenges to Xiaomi mobile phones in earning profits. In addition, although the hungry marketing adopted by Xiaomi's mobile phone has played a prominent role, it has made some consumers lose patience to a certain extent, causing Xiaomi's mobile phone to lose a certain number of users.

SWOT Analysis of the Development of Xiaomi's Mobile Phone "AI + Iot" in the "Internet +" Era

The advent of the “Internet +” era has provided significant opportunities for the development and upgrade of Xiaomi “AI + Iot”, posing a certain threat to them. Besides, Xiaomi mobile phones only actively play its advantages and improve its disadvantages. It is important for it to learn from others’ advantage to supplement its own weaknesses, so as to get out of the predicament and obtain "Nirvana".

1. **Xiaomi mobile phone development advantages (Strength)**

Xiaomi's mobile phone has risen within a short period of time because Xiaomi's mobile phone has explored a path suitable for its own development on the basis of cost-effective advantages. First of all, Lei Jun, the founder of Xiaomi Mobile, owns Internet companies such as Jinshan Software, Fanke Eslite, UC Browser, and Sunpin.com, thus enabling Xiaomi Mobile to establish a “terminal + service” operating model very smoothly, making it very seize the Internet's opportunities effectively. Secondly, Xiaomi mobile phone is a typical “latecomer” in the domestic smartphone market, which strives to innovate and surpass products and models. It does not follow the path of other smartphone companies which rely on models and emphasize profits but follows a single model. The manufacturing of smart phones is carefully crafted, and the joint development model of the Internet is actively launched, thus providing good conditions for the development and upgrade of Xiaomi “AI + Iot” mobile phones. Furthermore, Xiaomi mobile phones actively respect consumers’ opinions and attract users to participate in the design and manufacture of Xiaomi mobile phones, capturing a lot of users' "hearts". Thirdly, Xiaomi mobile phones are good at using

the Internet in marketing to improve online sales, thus greatly lowering the costs. This has also pushed Xiaomi mobile phones to become the most cost-effective smart phones with incomparable advantages.

2. **Disadvantages of Xiaomi Mobile Phone Development (Weakness)**

First of all, compared with domestic mobile brand Huawei, Xiaomi's mobile phone is supported by abundant funding and extortionary technology. Although Xiaomi's mobile phone has its own MIUI operating system, it falls far short of Huawei's strengths in such as mobile phone chips and network equipment. Huawei not only owns the chip company, but also successfully developed a new type of quad-core processing chip independently. In contrast, Xiaomi phones rely on MIUI operating system to compete with domestic top smartphone brands such as Huawei. The "AI + Iot" development of mobile phones is subject to people. Secondly, despite of the rapid development of Xiaomi mobile phones in recent years, the annual sales volume of 7 million units is still not far behind the annual sales volume of Huawei and ZTE by 10 million units. In addition, Huawei, ZTE and other mobile phones also have strong servers and network equipment support, which can help avoid the occurrence of greater risks, while the development of Xiaomi mobile phones is lagging behind. In short, by contrast, Xiaomi's "AI + Iot" development lacks effective technical support and is at a disadvantage.

3. **Development Opportunities of Xiaomi Mobile (Opportunities)**

China's "Internet +" era has arrived gradually, giving Xiaomi's future "AI + Iot" development a major opportunity. First of all, "Internet +" makes mobile Internet business more and more diversified, with the number of users of mobile phones with Android system in China exceeding Apple's IOS system. The MIUI operating system of Xiaomi mobile phones is also an Android system that can be deeply customized. On the one hand, further refinement and satisfaction of the user's personalized needs for the operating system can make Xiaomi phones more popular, to help Xiaomi phones obtain new profit through built-in game software. Secondly, with the comprehensive application of "Internet +" and the further popularization of mobile Internet, China's smartphone market will become even more extensive. According to the report of 21st Century Business Herald, the total number of mobile phone users in China reached 1.505 billion in 2018, among whom, the total number of 4G users has reached 757 million. Moreover, this number will grow rapidly as time goes on, indicating that Xiaomi mobile phones face a very large user market. In this broad market,

promoting "AI "+ Iot" development is greatly promising, which brings about a rare development opportunity.

4. Threat of Xiaomi mobile phone development (Threats)

The market segment of Xiaomi mobile phones is mid- to high-end smartphones around 2,000 yuan, occupying the smartphone market with an unbeatable price/performance ratio. However, in recent years, Samsung, Motorola, China's Huawei, and ZTE have also gradually entered this segment and launched a series of mid-to-high-end smartphones around 2,000 yuan. Even more, they have been favoured by a large number of consumers with unique brand awareness, making Xiaomi lose its mobile phone's advantages, as well as posing a very serious threat to its future development. In addition, Xiaomi mobile phones have created the "Xiaomi myth" based on the model of "Internet research and development + online sales + logistics distribution", but with its expansion, many problems have been exposed in this model. For example, its online sales model no longer adapts to the scale of 7 million annual sales. In addition, the lack of physical stores has also resulted in the ineffective guarantee of the after-sales service quality of Xiaomi mobile phones. Failure to address these problems will impose serious threats to “AI + Iot” development model of Xiaomi mobile phones.

Xiaomi AIoT Infrastructure

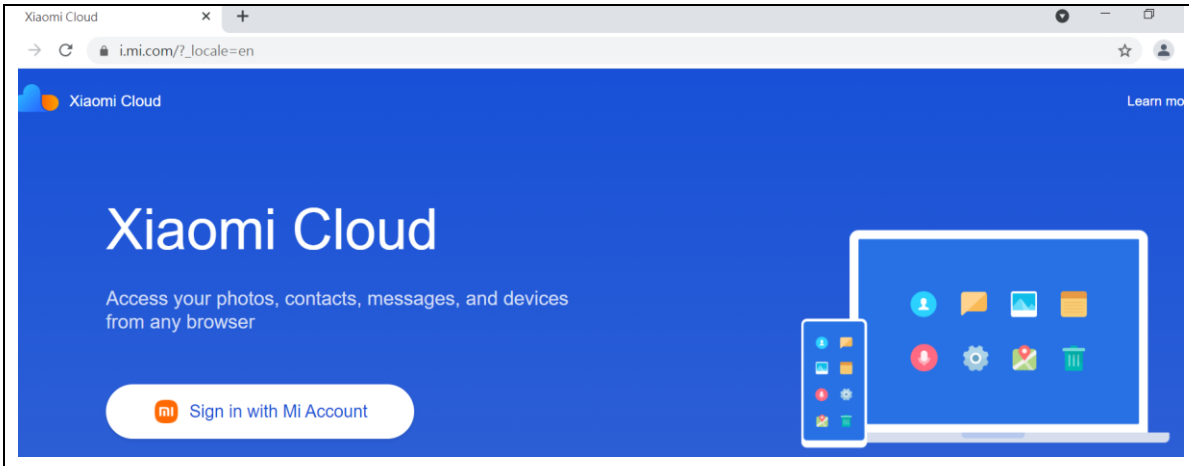
AIoT Infant Caring

	The infant caring device can detect the baby facial expression and weeping sound. It is using AI algorithm and parents will be acknowledged once irregularity is detected.

Xiaomi Mi Robot Vacuum (Slam algorithm)

	This Xaomi product is applying the slam algorithm which is widely used in navigation mapping. NASA, Google unmanned driving is also using slam algorithm [28] for their AI technology.

Xiaomi Cloud



Xiaomi constantly expands their own AIoT ecosystem and cloud computing is the indispensable to their business deployment.

CHAPTER 6 –Pizza Hut's success in Super Bowl

[22] **ABOUT SNOWFLAKE**

Snowflake is a consultant company specializing in data warehouse, data engineering, data science, data exchange and data application. Seriously it is a Platform as a Service (PaaS) company which provides the business intelligence to their customers. They use data sources through IoT, web/log data, enterprise applications and OLTP database. They provide business intelligence services such as data monetization, operational reporting, ad hoc and real-time analysis.

BACKGROUND OF THE RELATED CORPERATE

Pizza Hut is global famous chain restaurant and owned by Yum! Brands, Inc. It operates nearly 20,000 restaurants in the world.

THE CHALLENGE: Scaling resources to meet demand while managing costs

Pizza Hut US's on-premises data warehouse could not scale to meet increasing demands. According to Faisal Kp, Pizza Hut's Senior Manager, Enterprise Data Services, "We couldn't provide business users with the right infrastructure to give them what they were asking for." Increasing capacity was expensive and time consuming, requiring Faisal's team to add hardware and software, as well as perform database administration and tuning.

During the Super Bowl, Pizza Hut's busiest day of the year, its data volumes can sometimes triple. With its legacy data warehouse, Faisal's team did not have unified real-time analytics during the Super Bowl due to limited scalability.

THE SOLUTION: Instant elasticity from the Data Cloud

Pizza Hut implemented a Snowflake Data Cloud proof of concept that rapidly demonstrated positive results. Snowflake's near-instant elasticity immediately addressed the previous scalability issues. The advanced analytics team could perform ad-hoc queries, something that the previous system could not provide.

According to Faisal, "On-premises data platform migrations used to take four to five months. With Snowflake, I had space provisioned up, and running in a day. The entire migration was complete in a few weeks." The ingestion of data into Snowflake was assisted by Snowpipe, which loads data from files as soon as they are available in a stage.

THE RESULT: Democratized data across the organization

Snowflake enables users to answer business questions with data. During the 2020 Super Bowl, Faisal's team created a unified, near real-time view of business analytics, which was not feasible before Snowflake. Data pipelines captured data across systems and fed a dashboard, enabling executives to monitor key metrics and adjust resource allocations.

Data scientists use Python, R, and Spark to query data, *apply machine learning algorithms,* then write data back to Snowflake. These predictive analytics ensure that customers receive the right messages and offers. In addition, Snowflake Data Marketplace provides access to weather and geolocation data sources for Pizza Hut. Faisal's team can correlate weather patterns to customer purchases and use that data to optimize targeted marketing campaigns.

Snowflake enables the team to be more efficient. "I don't have any more DBAs. The system just works. It has enabled business users to be much more independent. They can do their analysis much faster than before," said Faisal.

THE FUTURE: Enhancing compliance and security with data masking

Going forward, Pizza Hut plans to enhance data security and compliance using *data masking*. Dynamic Data Masking is a column-level security feature in Snowflake that uses masking policies to selectively mask data at query time.

SNOWFLAKE DATA CLOUD VALUE

- Real-time analytics help Pizza Hut make quick decisions in the Super Bowl.
- Near-zero maintenance frees the team to focus on strategic business initiatives.
- Separation of storage and compute provides performance stability and cost visibility.
- Snowflake Data Marketplace provides easy access to weather and geolocation data.
- Instant elasticity enables virtually any amount of computing power for any number of users.
- Snowflake Secure Data Sharing provides direct access to partners' data, bypassing ETL and data pipelines.

FEEDBACK OF PIZZA HUT AFTER USING SNOWFLAKE

Pizza Hut win a good success in making real time executive business decision in Super Bowl and earned a good experience of democratizing data across organizations.

CHAPTER 7 – Discussion, Recommendation and Conclusions

Artificial Intelligence is nowadays evolving quickly with IoT applications. From previous Chapters we understand that AI with IoT is integrating more and more into our daily life.

Large scale of machine learning between machines and Internet of Things are integrated to increase the automation and minimize the human intervention in production or daily economy activities.

The machine learning can use algorithm to analyse self-optimization. The production efficiency will get much higher than that of traditional human-oriented economy.

Artificial intelligence is undeniably bringing many benefits to human, however, there are negative consequences simultaneously,

There are some key negative impacts of Artificial Intelligence:

1) AI Bias

Not only AI causes tremendous change to industrial aspects, but also bring a big impact to human life. Human will rely more and more on machinery or robotics which already come true nowadays. The typical example is self-driving technology. In case there is any bugs or unexpected bias in the AI algorithm, there may be undeniably a potential danger to human lives.

2) Loss of Certain Jobs

Artificial Intelligence will take over many traditional human jobs. The most typical example is smart retail [24]. Imagine when you go into a superstore, you only pick up goods to trolley. Trolley will scan goods with RFID and the payment will automatically deducted from your personal credit for payment. No cashiers or store helpers will be hired.

3) Risk of personal confidential information disclosure

Big Data collects more and more information and people information is less privacy than before. People will easily get others' information for unlawful activities such as scamming.

4) AI Terrorism

It is undeniable that AI can benefit much to human in wide range of aspects. AI is very powerful and can increase the human production efficiency and national military powers. However, terrorism become more and more severe after 911 terrorist attack and all nations

should be highly alert to the possibility of AI being used by terrorist, which poses a large danger to the global public safety. Terrorist may use automated drone, automated vehicles or robotic to trigger terrorist attack.

Recommendation and Conclusion

Big Data Compliance should be promoted to regulate information in cloud being accessed without authorisation or consent of persons involved. Legislation action should be taken to regulate all the misbehaviours on using AI and Big Data so that people life and privacy can be secured under the fast-paced advance technology development, otherwise human will suffer from the backfire of advanced technology.

AI compliance should be promoted and prevent any unlawful AI algorithm generation such as terrorist attack robotics.

It is inevitable smart AI and Cloud technology will keep ongoing to replace human professional intelligence and human will benefit more and more from advanced AI technology. Instead, human should shift more focus on learning how to manage well to artificial intelligence and big data as well as rethink more what consequences or potential danger will be posed before making up a new AI algorithm technology. Higher level of risk management is required to ease the impact or potential danger hidden behind.

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