

Unit 05

APPLICATION OF COMPUTER SCIENCE



After completing this lesson, you will be able to:

- describe technologies that are the foundation of IoT systems, Cloud Computing, and Blockchain.
- evaluate how different stakeholders' culture, values, and (sometimes conflicting) interest affect AI system design.



UNIT INTRODUCTION

This unit is dedicated to different technologies that have enabled Internet of Things (IoT) and Blockchain applications. It also discusses how different stakeholders' culture, values and (sometimes conflicting) interests affect AI System designs.

5.1 Introduction to Internet of Things

Internet of Things (IoT) is made up of two words, that is, Internet and Things. Things here means physical devices such as, smart mobiles, smart watches, smart security systems, medical sensors, home appliances, smart light bulb, smart door bell, smart door lock, smart TV, etc. Internet is through which these devices are connected for communication. These devices are smaller in size, have higher processing power and use longer battery power, due to advancement in technologies. The wireless technologies used for creating IoT networks are Wi-Fi, Bluetooth, Zigbee and NFC (Near Field Communication).

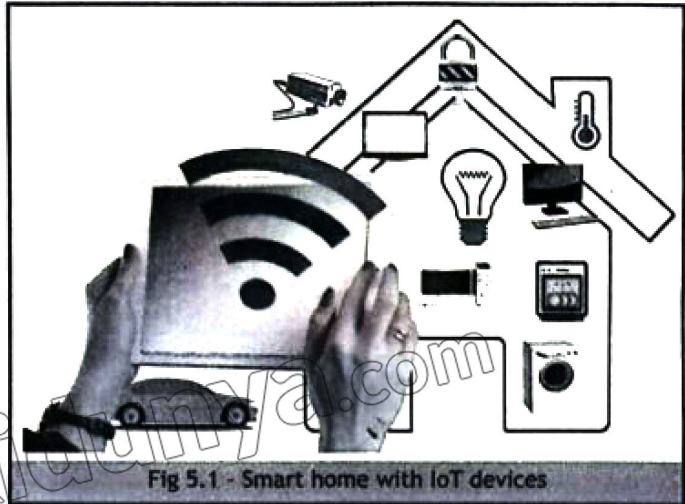


Fig 5.1 - Smart home with IoT devices

Bluetooth, Zigbee and NFC (Near Field Communication). Smart home with IoT devices is shown in Fig.5.1.

5.2 Technologies that Enabled Internet of Things

The following are the technologies that enabled Internet of Things.

- **Wireless Sensor Networks (WSNs)**
- **Cloud Computing**
- **Big Data Analytics**
- **Communication Protocols**
- **Embedded Systems**



Teacher's Guide

“How the Internet of Things Works”

<https://www.ibm.com/cloud/iotagen>
<https://www.ibm.com/cloud/definition/interconnected-things-iiot>

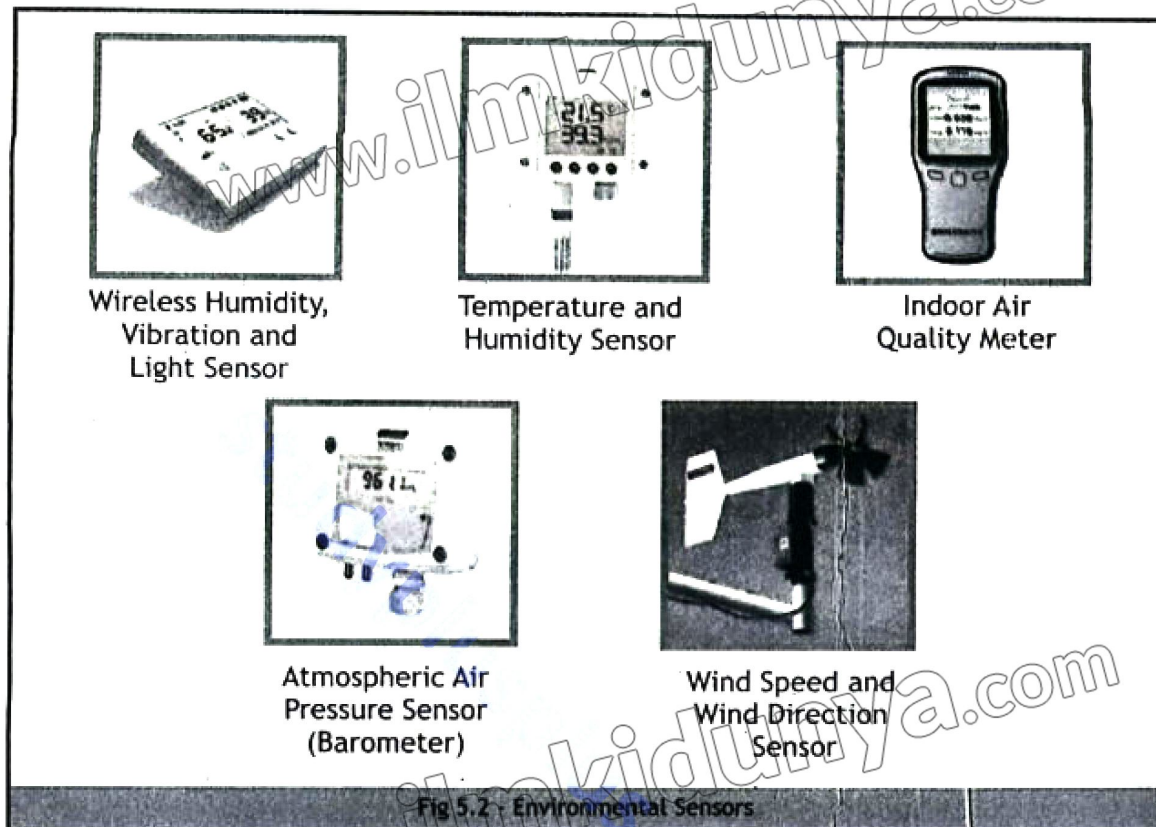
This Computerworld article enlightens about the technical aspects of IoT.

5.2.1 Wireless Sensor Network

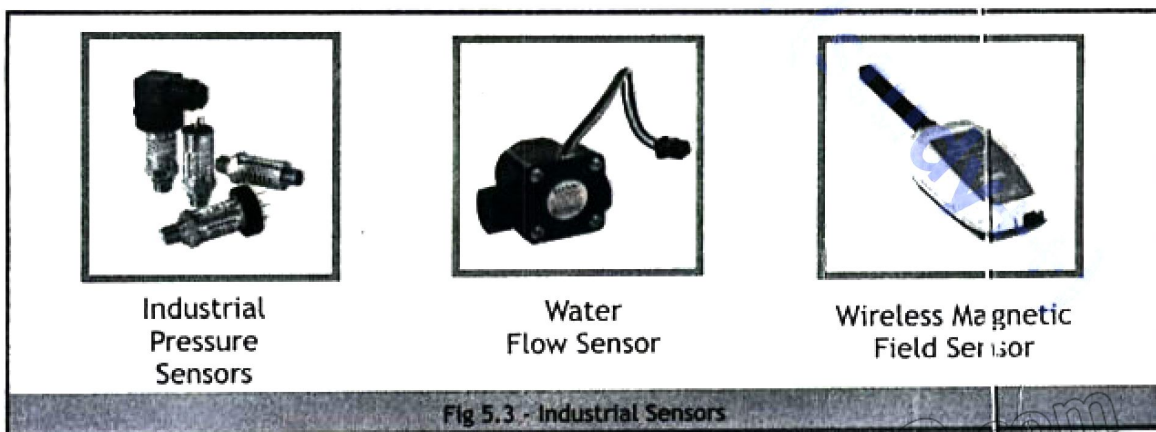
It is a network of physical devices, appliances, machines and physical objects that can communicate through wireless channels. The devices of a WSN are embedded with sensors and software. Three types of sensors are used to monitor environmental and physical conditions. These are environmental sensors, industrial sensors and motion detection sensors.

Environmental sensors are used for measuring and monitoring environmental conditions. These include sensors such as temperature, humidity, air quality, air pressure, wind speed and

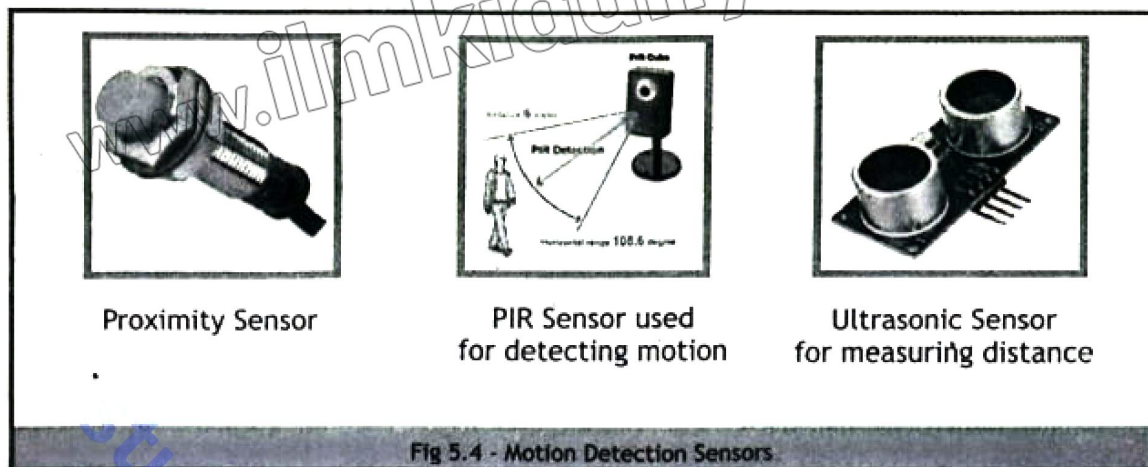
light sensors as shown in Fig. 5.2.



Industrial sensors are used for measuring and monitoring of physical quantities in manufacturing process. These include heat, pressure, gas, vibration, viscosity, fluid flow and magnetic field sensors.



Motion detection sensors are used to detect movement of humans or objects in its surrounding. These are commonly used to prevent unauthorized movement in restricted areas. These include ultrasonic, proximity, vibration, Passive Infrared (PIR) sensors.



Some examples of WSNs used in IoT systems are:

- Surveillance systems
- Weather monitoring systems
- Structural health monitoring systems in civil engineering
- Smart grid electricity network to monitor and manage the transport of electricity

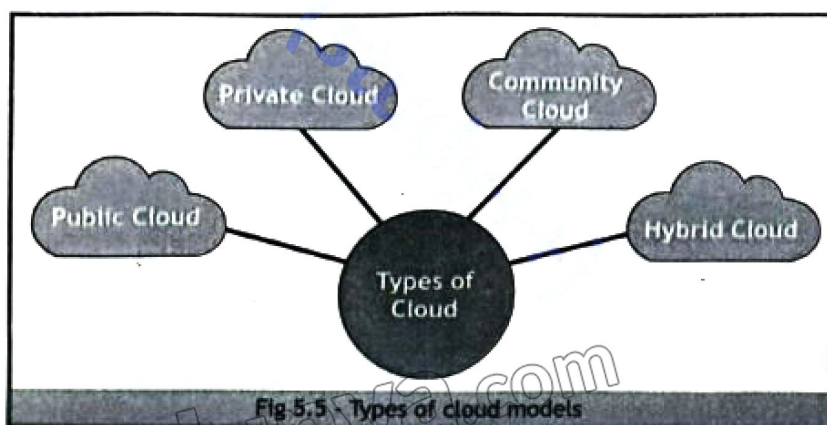
5.2.2 Cloud Computing

It is an IT infrastructure that provides data storage, databases, servers, networking and application software services over the Internet.

There are four types of cloud computing models, public cloud, private cloud, community cloud and hybrid cloud as shown in Fig.5.5.

 **Teacher's Guide**

"Cloud Computing for Kids"
<https://cloudacademy.com/>
 This resource provides engaging interactive activities and games especially tailored to introduce children the concept of cloud computing in an accessible manner.



Public Cloud

In this cloud computing model, resources are owned and operated by a cloud service provider instead of being installed in-house on local devices. The resources that are delivered to

businesses and organizations over the Internet include servers, software and storage. These resources are managed and maintained by the cloud service provider. Public cloud service providers offer security to customers because of sensitive data stored in the cloud. Public cloud provides high speed connectivity to ensure rapid access to applications and data.

It provides services to remote users all over the world. The services can be free or offered on pay-per-usage or on subscription charges. Some examples of cloud computing are Amazon Web Services (AWS), Microsoft Azure and Google Cloud.

Private Cloud .

This cloud computing model runs on a privately owned IT infrastructure that is used inside a single organization. In other words, cloud computing is dedicated to a single organization. This computing model requires huge investment as opposed to public cloud computing model. The user organization is responsible for the operation and maintenance of infrastructure (hardware, software, network, etc.). Private cloud solution provides more control over servers and computer network. It offers better performance, reliability and greater flexibility compared to public cloud.

Community Cloud

Community cloud model is a cloud infrastructure that provides access and services to multiple organizations to share information. It is suitable for organizations who have common concerns or needs such as application, security, policy, mission and compliance. It is owned, managed and operated by one or more organizations in the community or a third party. It can be on-site or off-site. It is cost effective as it is shared by many organizations. It is more secure than public cloud but less secure than private cloud.

Hybrid Cloud

Hybrid cloud is a combination of public and private cloud. This cloud computing model uses technology that allows data and applications to be shared between public and private clouds. The organizations use public cloud for performing certain tasks and store their sensitive and critical data and applications on the private cloud for fast access and security reasons.

5.2.3 Big Data Analytics

Big data analytics is concerned with collecting extremely big data from various resources and using analytics software to find out market trends, patterns and insights. It is used to make better business decisions and design smart solutions to provide better customer services and generate more revenue.

Huge volume of data is created in our daily life from various digital resources. These include banking transactions, customer databases, medical records, emails, mobile apps, etc. which cannot be handled by traditional databases. The data gathered by IoT devices is transformed into actionable information by big data analytics to improve decision-making.

The following are some areas of big data analytics.

- Healthcare industry
- Transport industry
- Banking and financial services
- Weather patterns and trends
- Insurance industry
- Digital marketing
- Media and entertainment
- Business insights
- Government sector

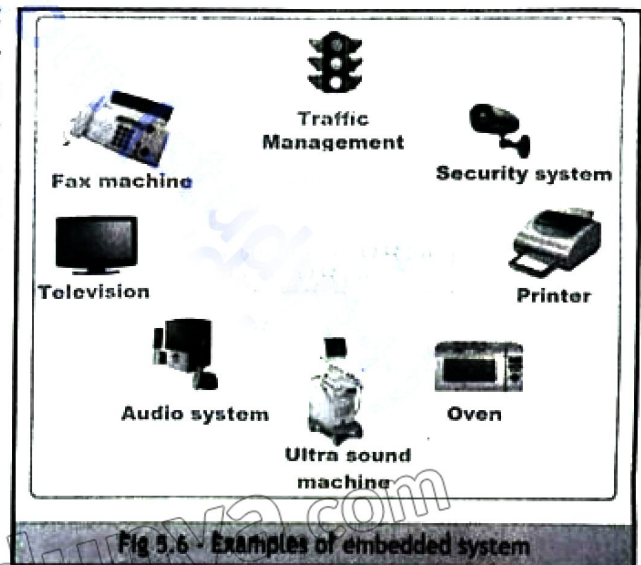
5.2.4 Communication Protocols

IoT communication protocol is a set of rules that govern how data is transferred and understood between physical devices, sensors and the end users. Protocols provide exchange of information and methods of connection between IoT devices and end users. It is needed for proper functioning of IoT-enabled devices.

5.2.5 Embedded Systems

Embedded systems are small electronic devices which are combination of hardware and firmware. Firmware is software that is permanently installed in a device or electronic machine. Embedded systems have a microcontroller or a microprocessor that controls the operation of embedded systems through firmware. Embedded system is designed to perform a specific task. Some embedded system are shown in Fig.5.6.

Embedded systems have various applications in IoT such as they can monitor a room's temperature and automatically adjust the thermostat. Embedded systems are used in a large variety of devices. These include medical equipment, home appliances, point-of-sale terminals, vending machines, ticket scanners, automotive devices and industrial equipment. Embedded systems help in implementing various IoT solutions.



5.3 Blockchain

5.3.1 Introduction to Blockchain

A Blockchain is a digital ledger (database) of transactions that is shared and maintained by network users. The ledger is a list of continuously growing records, known as blocks. The blocks are chained together as shown in Fig.5.7, using cryptography. Cryptography ensures that the transaction data is secure and immutable. It cannot be hacked or altered.

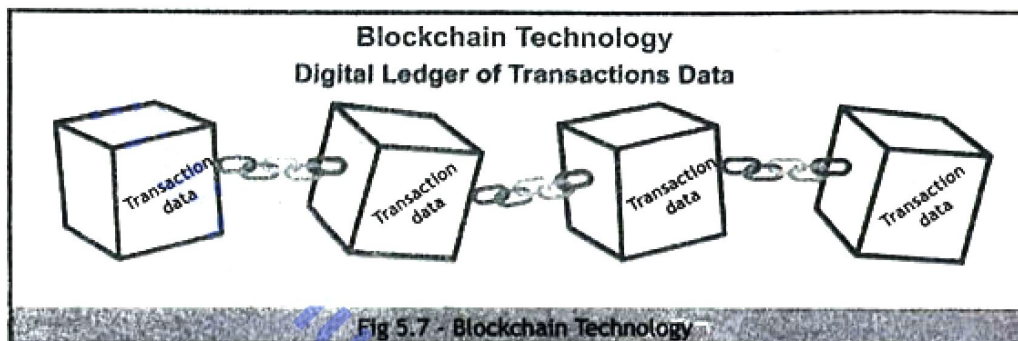


Fig 5.7 - Blockchain Technology

5.4 Technologies that Enabled Blockchain

There are three technologies that enabled Blockchain.

- Cryptography
- Blockchain networks
- Transaction process on the network

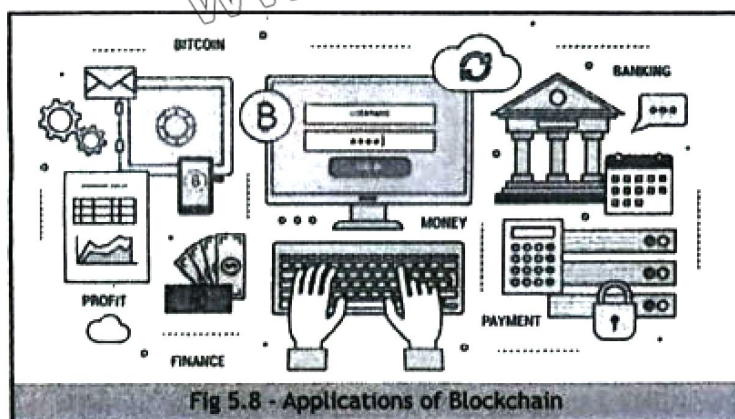


Fig 5.8 - Applications of Blockchain



Teacher's Guide

"Blockchain for Kids: A Gentle Introduction"

<https://coinmarketcap.com/currencies/save-the-kids/>

CoinMarketCap utilizes a narrative-driven approach in this resource to elucidate blockchain to younger audiences, introducing essential concepts in an enjoyable and captivating manner.

5.4.1 Cryptography

Cryptography is technology that protects information and communications by coding it in such a way that only those for whom it is intended can read and process it. Cryptography provides confidentiality, integrity and authentication. The topic of cryptography is explained in Unit 1.

5.4.2 Blockchain Networks

There are different ways of building Blockchain networks. These are public, private, permissioned and consortium networks as shown in Fig.5.9. The purpose of all these networks is to share the ledger among all the participants using Blockchain.

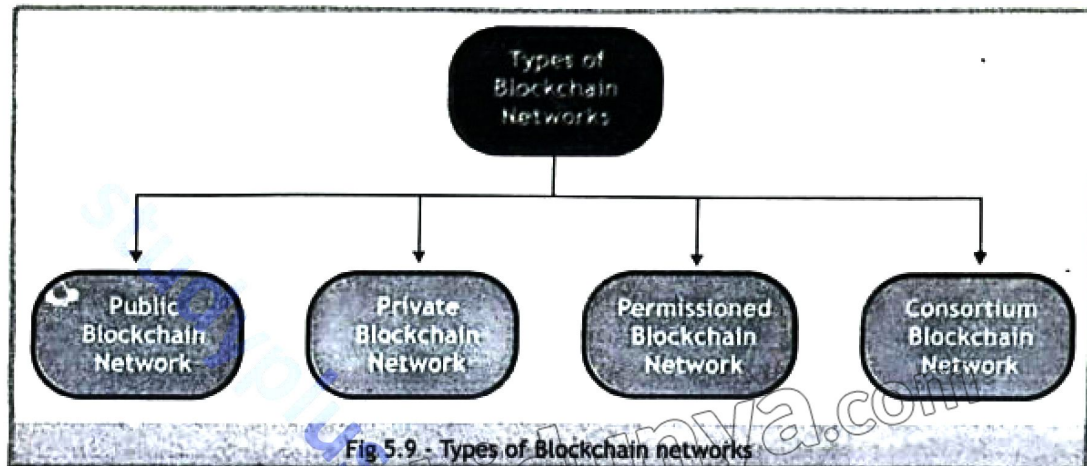


Fig 5.9 - Types of Blockchain networks

Public Blockchain Network

Public Blockchain Network is one that **anyone** can join in the world. It is an open platform for the public in which data is distributed across all the participants. It is adapted by many organizations as it is open to public. It requires substantial **computing** power and security is weak.

Public Blockchain network is used for exchanging **cryptocurrency** such as Bitcoin. Cryptocurrency is a type of digital currency used by people to make **direct** payments to each other through an online system without the need for a bank.

Private Blockchain Network

Private Blockchain Network is managed by a single organization or **private** business. Public access to private Blockchain network is restricted. Organizations or private businesses can customize user access and authorization as it is administered by a single entity. It is **more** secure compared to public Blockchain network.

Private Blockchain networks are often used by businesses, organizations, and government agencies to implement secure and transparent record-keeping systems.

Permissioned Blockchain Network

Permissioned Blockchain Network is generally set up by organizations who have built a private Blockchain network. In this network, only authorized individuals are allowed access and can perform or view transactions. In this case, anyone who wants to join needs permission. It is a safe and secure network and has advantage of better transparency.

Permissioned Blockchain networks are used for a variety of applications like supply chain management, trade finance and clearing and settlement of financial assets.

Consortium Blockchain Network

Consortium Blockchain Networks are permissioned Blockchain networks in which multiple organizations are responsible for managing a single consortium Blockchain network. It is more complex to set up because it requires collaboration between several organizations or businesses. It is safe and secure network.

Consortium Blockchain networks are suitable for finance and banking, insurance and asset trading. Banks also use it to form a group that collects and stores needed information on all debtors in a database.

5.4.3 Transaction Process on the Network

The Blockchain technology allows individuals to directly make deals with each other without involvement of intermediaries such as bank or government. Each transaction is verified by the participants in a peer-to-peer network. When a deal is made between two participants, the transaction is permanent. It is added to the ledger and is irreversible. Blockchain facilitates faster transactions than traditional databases as there are no intermediaries. Blockchain uses decentralization of data. The data is stored in millions of computers all over the world that are connected to the Blockchain.

5.5 Integration of Blockchain and IoT

Unimaginable number of IoT devices are interconnected all over the world. These devices collect and exchange vast amount of data through sensors which is vulnerable to Cyber-attacks. Therefore, it is crucial to take security measures against Cyber-attacks such as hacking and breaches.

The decentralized ledger systems of Blockchain technology provides transparency and immutable recording of transactions. Blocks containing information about transactions linked together through cryptography store and transmit transactions in a more secure format. Blockchain technology does not allow transaction data to be altered.

The integration of IoT and Blockchain technologies allow to enhance the overall performance and reliability in managing the IoT networks. Moreover, the merger of IoT with Blockchain provides faster communication between the devices as it does not require intermediaries.

Integration of IoT and Blockchain technologies are providing security and enhancing connectivity in many areas including supply chain, energy grid, healthcare, automotive sector, agriculture, and water management as show in Fig.5.10.

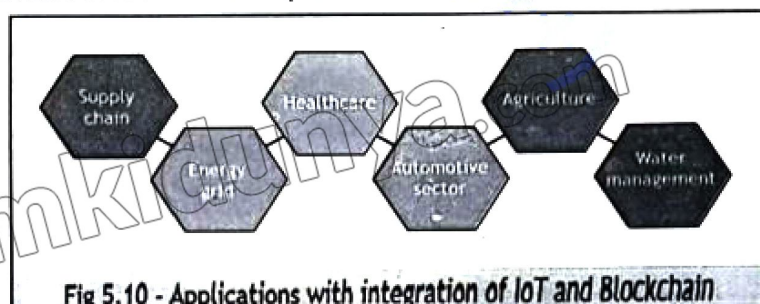


Fig 5.10 - Applications with integration of IoT and Blockchain

5.6 Stakeholders Interests in AI Systems

Artificial Intelligence (AI) is a branch of computer science to make computer-controlled machines that can intelligently perform human-like tasks. Using AI-based machines is like fixing an intelligent brain in the machines that has decision-making capabilities to solve complex problems.

5.6.1 Stakeholders in AI Systems

Stakeholder is an individual or a group who are affected by AI system or have interest in its social impact. AI is transforming the world in various areas but it also poses ethical, social and legal challenges that affect the stakeholders. Stakeholders may be end users, developers, customers, suppliers, employees, regulators, funders, owners, policy makers and the community.

5.6.2 Positive and Negative Impacts of AI Systems

The decision-making capabilities of AI are replacing human-decision making across all the industries. AI is like we have installed an intelligent brain in the computer that can make intelligent decisions to solve complex problems. However, there is no guarantee that all the predictions made by the AI algorithms will be correct as these are based on data pattern and machine learning. Therefore, we can say that AI systems have both positive and negative impact.

Positive Impact of AI Systems

- Unbiased Decisions

Decisions made by AI are based on reason and logic rather than driven by emotions. Therefore, it does not have biased views. For example, AI-based recruitment system will hire job applicants based on their skills and qualification, not ethnicity or demographics.

- Around the Clock Availability

AI systems can work 24x7 without any breaks with high efficiency and accuracy which is not possible for human being. For example, online customer support Chatbot can provide assistance to customers anytime around the clock by answering their common questions.

- Zero Risk

AI robots can perform many tasks to overcome risks in hazardous environments such as defusing a bomb or in manufacturing facility.

- Reduction in Human Error

Properly programmed AI systems reduce human errors and provide high accuracy in performing various tasks. For example, robotic surgery systems can perform complex operations with precision ensuring patient's safety and healthcare.

Negative Impact of AI Systems

- Less Creativity and Emotions

AI systems cannot be creative in decision-making. AI does not have the ability to experience

emotions or personal connections. AI relies on algorithms and data inputs to make decision, while human creativity is influenced by experience, emotions and imagination. Humans have the ability to generate ideas for innovation and progress which is not possible with AI.

• Lack of Employment

Robots are being utilized in various industries to replace humans which may increase unemployment. For example, robots are replacing humans in manufacturing industry. Robots are also replacing humans in hotels by carrying out tasks such as cleaning, restocking bathrooms supplies, checking rooms and luggage transportation.

• Ethical and Moral Concerns

It is difficult to incorporate ethics and morality into AI systems. People are concerned that one day, AI may grow uncontrollably and eventually destroy humanity.

• High Cost

Creating machines that simulate human intelligence is very costly as it requires plenty of time, resources and also latest hardware and software.

5.6.3 Conflicting Requirements of Stakeholders in the Development of AI Systems

AI application developers have to consider and manage many conflicting requirements of stakeholders to avoid failure of the resulting software. Stakeholders of an AI application of a specific area, such as, healthcare, education, supply chain, marketing, etc., may have many diverse expectation, desires and goals in conflicting situations. Conflicts among the stakeholders should be resolved, not suppressed. Conflicts in requirements between different stakeholders are unavoidable. They express their views or disagreements on some decisions or values proposed in an AI application. Different stakeholders may have similar needs but may differ on how to implement them. Conflicts can be due to different interpretation or understanding of the given problem. Conflicting requirements of stakeholders make the developers' task of AI application design more difficult as they have to satisfy all the stakeholders.

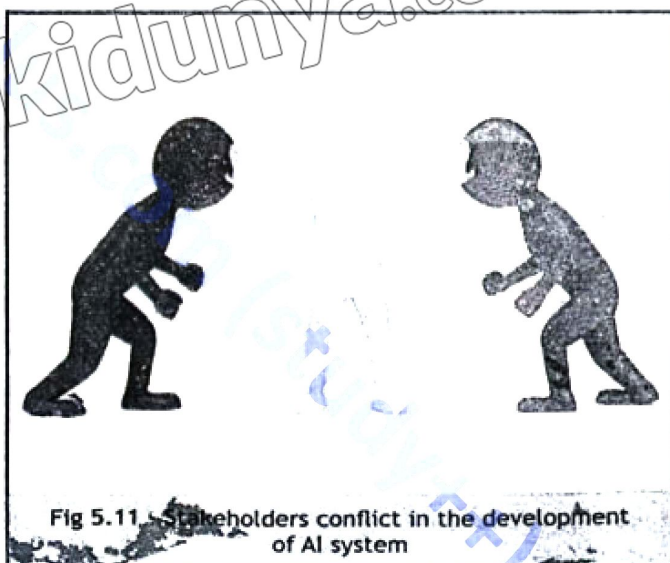


Fig 5.11 Stakeholders conflict in the development of AI system

Summary

- Internet of Things (IoT) is made up of two words, that is, Internet and Things. Things here means physical devices such as, smart mobiles, smart watches, smart security systems, medical sensors, home appliances, smart light bulb, smart door bell, smart door lock, smart TV, etc. Internet is through which these devices are connected for communication.
- Wireless Sensor Network (WSN) is a network of physical devices, appliances, machines and physical objects that can communicate through wireless channels. The devices of a WSN are embedded with sensors and software.
- Environmental Sensors are used for measuring and monitoring environmental conditions. These include sensors such as temperature, humidity, air quality, air pressure, wind speed and light sensors.
- Industrial Sensors are used for measuring and monitoring of physical quantities in manufacturing process. These include heat, pressure, gas, vibration, viscosity, fluid flow and magnetic field sensors.
- Motion Detection Sensors are used to detect movement of humans or objects in its surrounding. These are commonly used to prevent unauthorized movement in restricted areas. These include ultrasonic, proximity, vibration, Passive Infrared (PIR) sensors.
- Cloud Computing is an IT infrastructure that provides data storage, databases, servers, networking and application software services over the Internet.
- In Public Cloud computing model, resources are owned and operated by a cloud service provider instead of being installed in-house on local devices. The resources that are delivered to businesses and organizations over the Internet include servers, software and storage. These resources are managed and maintained by the cloud service provider.
- Private Cloud computing model runs on a privately owned IT infrastructure that is used inside a single organization. In other words, cloud computing is dedicated to a single organization. This computing model requires huge investment as opposed to public cloud computing model. The user organization is responsible for the operation and maintenance of infrastructure (hardware, software, network, etc.).
- Community Cloud model is a cloud infrastructure that provides access and services to multiple organizations to share information. It is suitable for organizations who have common concerns or needs such as application, security, policy, mission and compliance considerations. It is owned, managed and operated by one or more organizations in the community or a third party.
- Hybrid Cloud is a combination of public and private cloud. This cloud computing model

uses technology that allows data and applications to be shared between public and private clouds. Hybrid cloud is a combination of public and private cloud. This cloud computing model uses technology that allows data and applications to be shared between public and private clouds.

- Big Data Analytics is concerned with collecting extremely big data from various resources and using analytics software to find out market trends, patterns and insights.
- IoT Communication Protocol is a set of rules that govern how data is transferred and understood between physical devices, sensors and the end users. Protocols provide exchange of information and methods of connection between IoT devices and end users.
- Embedded Systems are small electronic devices which are combination of hardware and firmware. Firmware is software that is permanently installed in a device or electronic machine. Embedded systems have a microcontroller or a microprocessor that controls the operation of embedded system through firmware.
- A Blockchain is a digital ledger (database) of transactions that is shared and maintained by network users. The ledger is a list of continuously growing records, known as blocks. The blocks are chained together using cryptography. Cryptography ensures that the transaction data is secure and immutable.
- There are different ways of building Blockchain networks. These are public, private, permissioned and consortium networks. The purpose of all these networks is to share the ledger among all the participants using Blockchain.
- Public Blockchain Network is one that anyone can join in the world. It is an open platform for the public in which data is distributed across all the participants. It is adapted by many organizations as it is open to public.
- Private Blockchain Network is managed by a single organization or private business. Public access to Blockchain network is restricted. Organizations or private businesses can customize user access and authorization as it is administered by a single entity.
- Permissioned Blockchain Network is generally set up by organizations who have built a private Blockchain network. In this network, only authorized individuals are allowed access and can perform or view transactions.
- Consortium Blockchain Networks are permissioned Blockchain networks in which multiple organizations are responsible for managing a single consortium Blockchain network. It is more complex to set up because it requires collaboration between several organizations or businesses.
- Cryptography is technology that protects information and communications by coding it in such a way that only those for whom it is intended can read and process it. Cryptography provides confidentiality, integrity and authentication.



Exercise

Select the best answer for the following Multiple-Choice Questions (MCQs).

1. Fluid flow sensor is a type of:
 - a) Environmental sensor
 - b) Industrial sensor
 - c) Motion detection sensor
 - d) Climate control sensor
2. The cloud model that provides services to multiple organizations is known as:
 - a) Public cloud
 - b) Private cloud
 - c) Community cloud
 - d) Hybrid cloud
3. The cloud model that provides best security of data is:
 - a) Public cloud
 - b) Private cloud
 - c) Community cloud
 - d) Hybrid cloud
4. Exchange of information between IoT devices and end users is provided by:
 - a) Cloud computing
 - b) Big data analytics
 - c) Embedded systems
 - d) Communication protocols
5. The Blockchain network that is most difficult to set up is:
 - a) Public Blockchain network
 - b) Private Blockchain network
 - c) Permissioned Blockchain network
 - d) Consortium Blockchain network
6. The Blockchain network that is open for everyone to join is called:
 - a) Public Blockchain network
 - b) Private Blockchain network
 - c) Permissioned Blockchain network
 - d) Consortium Blockchain network
7. The sensors used to prevent unauthorized movement in restricted areas are called:
 - a) Environment sensors
 - b) Industrial sensors
 - c) Motion detection sensors
 - d) Restricted area sensors
8. Sensors used for measuring humidity, air quality, air pressure, temperature and wind speed are called:
 - a) Environment sensors
 - b) Industrial sensors
 - c) Motion detection sensors
 - d) Measurement sensors
9. Software that is permanently installed in an electronic machine is known as:
 - a) System software
 - b) Application software
 - c) Machine software
 - d) Firmware
10. A digital ledger of transactions shared and maintained by network users is called:
 - a) Database
 - b) Accounting software
 - c) Blockchain
 - d) Network ledger



Give short answers to the following Short Response Questions (SRQs).

1. How IoT can enhance our daily life?
2. Provide 3 examples of WSNs used in IoT system.
3. Differentiate between public cloud model and private cloud models.
4. What is Blockchain? Why data stored in a Blockchain is secure?
5. Why integration of Blockchain and IoT is beneficial?
6. Define permissioned Blockchain network.



Give long answers to the following Extended Response Questions (ERQs).

1. What is Blockchain technology? Describe in detail how transactions are processed using Blockchain technology.
2. Briefly explain the role of following technologies that enabled IoT.
a. Cloud computing b. Communication protocols c. Embedded systems
3. Criticize the negative impacts of AI systems in the domain of education and learning of students.
4. Examine the reasons behind the conflicting requirements among stakeholders during the development of AI systems.
5. Consider creating a cutting-edge system for language learning. The priorities of teachers, learners, and programmers will all differ. How would it help to make the new language learning system better by incorporating the varying priorities? How can AI be added to it?



Activity 1

Take an example of an IoT application and identify how each component of connectivity, processing, AI, cloud computing, and battery power enables that application.



Activity 2

Have the students work through a Blockchain application where the students act like Blockchain users and maintain a ledger through their peer-to-peer network in class.



Activity 3

Have a discussion in class where you divide the class into groups. Each group is further divided into three roles where one role represents advertisers that are trying to sell their products on a social media platform, the second role is using social media to connect with friends, and the third role is the developers who is trying to sign up more users and trying to get the existing users to spend more time on their application. Help the discussion on how each role has different expectations from the AI algorithms being used in the application.