# TARGET PRELIMS 2024
# BOOKLET-5; S&T-5
# COMPUTER & IT - 2

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## 2. SUPERCOMPUTERS

- A supercomputer is a **computer with a high-level computational capacity compared to a general-purpose computer** or Supercomputer is a computer with **great speed and memory**. They are usually thousands of time faster than ordinary personal computers made at that time.

- As per the 62nd edition of TOP500 released in Nov 2023, following are the **most powerful supercomputers currently**:
  - » **USA's Frontier** is the most powerful supercomputer in the world reaching **1194 petaflops** (1.194 Exaflops)
  - » **USA's Aurora** system is at 2nd spot with a capacity of **585.34 PFlop/s**.
    - **Note:** Aurora is currently being commissioned and will reportedly exceed Frontier with a peak performance of 2 EFLops/s when finished.
  - » **Eagle** (installed in the Microsoft Azure Cloud in the USA), is at 3rd Spot. This is the highest rank a cloud system has ever achieved. It has the capacity of **561.2 PFlop/s**.
  - » **Fugaku (of Japan)** is now ranked 4th (it was ranked second till July 2023 and ranked one till Nov 2021). It's capacity is that of 441.02 PFlop/s.
  - » **LUMI (of European Union, Finland)** is ranked 5th with a capacity of 379.70 PFlops.

- **Uses:** Super computers are generally used for scientific and engineering applications that must **handle very large databases or do a great amount of computation** (or both). Some of the key areas where supercomputers contribute are:
  - » Weather forecasting
  - » Climate research (E.g. Pratyush at IITM, Pune)
  - » Code-breaking
  - » Genetic analysis
  - » Oil and gas exploration – Seismic processing in the oil industry: Supercomputers help to detect and accelerate deeper geological insights.
  - » Molecular modelling
  - » Other jobs that need many calculations including engineering, product design, complex supply chain optimization (actually any kind of optimization), Bitcoin mining etc.

### 1) SUPERCOMPUTING IN INDIA

- In India, Indigenous development of Supercomputers began in 1980s. India's first Supercomputer was Param 8,000 which was created in 1991.
- Currently, as per the 62nd edition of TOP500 released in Nov 2023, the most powerful supercomputer in India is **AIRAWAT – PSAI** which is ranked 75 with a total capacity of 13.17 Petaflops. Thus in **terms of supercomputing power** India is way behind the world leaders.

#### A) AIRAWAT – PSAI

- C-DAC has implemented AI Research Analytics and Knowledge Dissemination Platform (AIRAWAT) of 200 AI Petaflops at C-DAC, Pune under the initiative of Ministry of Electronics and IT, GoI.
- C-DAC has designed and commissioned the converged HPC-AI dense GPU infrastructure integrated with the existing PARAM SIDDHI AI (PSAI) system to make the cumulative compute capacity of **410 AI PF (13.17 PF DP).**

- The system is installed under the **National Program on AI** by GoI.

- **Note**: AI FLOPS refers to the floating-point operations per second **specifically dedicated to AI workload**. It refers to FLOPS required for training an AI Model.

### B) OTHER IMPORTANT SUPERCOMPUTERS OF INDIA

- **Param Pravega** (3.3 Petaflops); setup under National Supercomputing Mission
- **Param Siddhi AI** (4.6 petaflops) (210 AI Petaflops); Setup under National Supercomputing Mission
- **Pratyush (IITM)** and **Mihir** (National Centre for Medium Range Weather Forecasting) (NCMRWF), Noida are other fast super computers in India.

### C) NATIONAL SUPERCOMPUTING MISSION (NSM)

- A visionary program, launched in 2015, to enable India to leapfrog to the league of world class computing power nations.
- The mission is jointly steered by DST and MEITy.
- **Implemented by** Centre for Development of Advanced Computing (C-DAC); Indian Institute of Science (IISc), Bangalore.
- **Super Computing Grid**: The mission envisages empowering our national academic and R&D institutions spread over the country by installing a vast supercomputing grid comprising of more than **70 high performance computing facilities**.
- **Human Resource**: The mission also includes development of highly professional High-Performance Computing (HPC) aware human resource for meeting challenges of manpower scarcity in the sector.
- **Recent Developments**
  - **BullSEQUANA Super Computer:** French Company **Atos** have signed an agreement with C-DAC (Centre for Development of Advanced Computing) for designing, building and installing BullSequana – the super computer in India
  - The supply of Bullsequana XH200 will be used for creating the network of 70 high performance computing facilities under NSM.
  - The total computing power of the Bullsequena will be greater than 10 petaflops.

## 3. QUANTUM COMPUTER

- **Basics**: How classical computers work:
  - **Classical Computers** have **bit** as a fundamental unit which can be **0 or 1.** These computers take a series of bits (e.g., 11001100110101) and switch some of these bits to give us output. Here a bit must be processed in an exclusive binary state at any point of time i.e., either 0 or 1. The **millions of transistors and capacitors at the heart of the computer can only be in one state at any point**. **There is a limit as to how quickly these devices can be made to switch state**.

- Classical computers have enabled the information revolution that we are part of today. But these **classical computers can't do a number of things** including Optimization, Simulation of large molecules, factoring of large numbers etc.

- **But** Quantum computing may help us solve the above problems someday.

- **Quantum computers are based on the principle of quantum theory.** They gain enormous processing power due to the ability of quantum computer to perform task using all possible permutations simultaneously.

- **Quantum Computers** use **qubit** (Quantum bit). These qubits can take values 0 or 1 or any of the infinite **superpositions** between 0 and 1. When Qubits are in superposition, it has some probability of being in state 0 and some probability of being in state 1.
  - **Qubits** are usually made of things like electrons, photons or even a nucleus. In case of electron spin up correspond to state 0 and spin down correspond to state 1.
  - According to quantum law, the particle then enters a **superposition** of states, in which it behaves as if it were in both states simultaneously. Each qubit utilized could take a superposition of both 0 and 1. **Thus, the number of computations that a quantum computer could undertake is 2^n**, where n is the number of qubits used
  - Quantum computing also borrows inspiration from another property of quantum mechanics called **entanglement**, wherein the two qubits could be connected in such a way that the state of one qubit intrinsically affects the state of the other qubit.
  - Each operation of a quantum computation is performed by a **quantum gate**, which like classical gate, changes the state the qubits are in.

- **Quantum Supremacy:** It refers to quantum computers being able to solve a problem that a classical computer cannot. The term was coined by theoretical physicist **John Preskill** of the Caltech in 2012.
  - **Google** recently used a 53 Qubit processor (Sycamore) to generate a sequence of millions of numbers, that conform to an algorithm generated by google. A classical supercomputer checked some of these values and they were correct.
  - **Google's Quantum computer claimed** 'Supremacy' because it reportedly did the task in 200 seconds that would have apparently taken a supercomputer 10,000 years to complete.

- **Some Problems faced by Quantum Computing Sector:** While the above concept sounds promising, but there are still tremendous obstacles to be overcome.
  - **Interference:** During the computation phase of a quantum calculation, the slightest disturbance in the quantum system (a stray photon or a wave of EM radiation) causes the quantum computation to collapse, a process known as **Quantum Decoherence**.
  - **Error Corrections:** Because truly isolating the quantum system has proven so difficult, error correction systems for quantum computing have been developed.
  - **Output observance:** Observing the final output also risks corrupting the data.

- **The breakthroughs in the last 20 year** including the **quantum supremacy** achieved by Google have increased the chances of developing practical quantum computing mechanisms. However, it is not clear whether the practical application is less than a decade away or a hundred years into the future.

- **Examples of Quantum Computers**: While the idea governing quantum computers have been around since the 1990s, the actual machines have been around since 2011, most notably built by Canadian company **D-Wave systems**.

- The recent Google's **53 qubit Quantum computer** is called **Sycamore**. Google is also spending billions and targets to build its own working quantum computer by 2029.
- **IBM** plans to have a 1,000-qubit quantum computer. For now, IBM allows the use of its machines by those research organization, institutions etc which are part of its **quantum network**.
- **Microsoft** also offers companies access to quantum technologies via its **Azure Quantum Platform**.

- **Applications:** The potential that this technology offers are attracting tremendous interest from both the governments and the private sector. The quantum computers have the potential to easily tackle computational problems that may be tough for the classical computer. The basic advantage is speed as it can stimulate several classical computers working in parallel.
  - **Military Applications** include breaking of advanced encryption using brute force searches.
  - **Advanced Cryptography:** Quantum uncertainties could be used to create private keys for encrypting messages to be sent from one place to another.
  - **Climate Change and Weather Forecasting**
  - **Faster Data analysis in industrial science applications** will enable faster solution to business problems in the era of big data.
  - » **Improved Optimization** for complex problems like **NP-hard problems**. This may lead to faster optimization of very large-scale problems involving complex network structures, computational biological science, and physical sciences.
  - » **Transform Healthcare and Medicine:** Drug Development and Discovery
  - » **Other civilian applications** include **DNA Modelling** and **complex material science analysis**.
  - » **Improved Machine Learning Outcomes** by enabling more efficient optimization of these algorithms so that ML capabilities become more efficient, accurate and fast.
  - » **Teleporting the information from one location to another** without physically transmitting the information. Entangling of quantum particles allow us to achieve this.

- **India and Quantum Computing:**
  - » There are no quantum computers in India yet.
  - » **Cabinet Approves Rs 6003 Crore National Quantum Mission** (April 2023)
  - » In **Budget 2020-21**, government has announced **National Mission on Quantum Technologies and Applications** which will be allocated Rs 8,000 crore over the next 5 years.
  - » Although the amount is low to begin with but given the advances in technology and India's ability to create low-cost solutions, the money may suffice.
  - » In Aug 2021, India launched **QSim** to aid Quantum Computing research in India.

## 1) NATIONAL QUANTUM COMPUTING MISSION (APRIL 2023)

- **NQM**, planned during 2023-2031, will mainly work towards **strengthening India's research and development in the quantum arena** alongside indigenously building quantum-based computers.

- It entails **development of satellite-based quantum communication** between ground station and receiver located 3,000 kms away during the first three year.
- For long distance communication, tests will be conducted in coming years.

- Under NQM, there would be **four broad themes**:
  - » Quantum Computing

» Quantum Communication
» Quantum Sensing and Meteorology
» Quantum Material and Devices

- **Thematic hub for each will be established** at research institutes and R&D centres who are already working in the field of research.

- **Department of S&T (DST)** will lead the mission, supported by other departments.

- The mission puts India among the **top six leading nations involved in the R&D in quantum technologies**. Presently, R&D work in quantum tech is underway in USA, China, Canada, France, Finland and Australia.

## 2) QUANTUM ENTANGLEMENT

» **What is quantum entanglement?**
  - Two particles, having 'interacted' with each other at some stage, were found to have got 'entangled' in a way that the behaviour of one produced an instantaneous reaction in the other even if the two were no longer connected in any way and were separated by large distances.

» **2022 Nobel Prize in Physics** has gone to Alain Aspect (France), John F Clauser (USA) and Anton Zeilinger (Australia). These three scientists over the last four decades, **have conclusively established that the 'entanglement' phenomenon observed in quantum particles was real**, not a result of any 'hidden' or unknown forces, and that it **could be utilized to make transformative technological advances in computing,** hack-free communication, and science fiction like concept of '**teleportation**'.

» **Details of their contribution:**
  - The first half of the 20th century, saw the **development of Quantum Physics** which explained the seemingly bizarre behaviour of sub-atomic particles with remarkable accuracy.
  - Quantum theory explained many phenomenon of quantum particles such as Superposition and Entanglement which were completely against everyday experience.

  - **Albert Einstein,** in particular was **very uncomfortable with this**. His Special theory of relativity prohibited any signal from travelling faster than the speed of light. The seemingly instantaneous communication due to entanglement went against Einstein's theory. Therefore, **Einstein proposed that something was missing and the Quantum theory was incomplete.**
  - **However**, experimentalists were discovering that almost every prediction made by quantum theory were being obeyed by sub-atomic particles. Till, that time, experiment to test entanglement didn't appear feasible.

  - **In 1964**, John Bell showed how phenomenon of entanglement could be established by experimentalists.
    - » The famous **Bell's inequality**, if maintained in the results of the experiment, would mean that Einstein was right. **If violated, it would provide the predictions of quantum theory**.

  - **John Clauser** was the first person to set up an experiment to test entanglement. In 1972, his experiments produced results that were clear violations of Bell inequality

- **Alain Aspect** is credited with **vastly improving the set-up of Clauser** and removing all the loopholes critics had found. His experiments also produced results that violated Bell's inequality.

- **Anton Zeilinger** meanwhile had already **started using entanglement property to open up new technological possibilities**. He demonstrated that it was **possible to teleport the quantum states of particles** to another location without the particle moving anywhere and without a medium.
- **These experiments conducted by Clauser, Aspect and Zeilinger have decisively demonstrated that entanglement was real and in accordance with quantum theory** and it was not being driven by any hidden forces as suggested by Einstein and others.

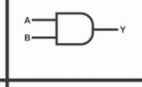
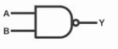
» **The satisfactory theoretical explanation of phenomenon**, however, continue to elude scientists.

**Application:** The entanglement property is now being utilized to build the next generation of computers called quantum computers which exploit the quantum behaviour of particles to overcome the challenges considered unsurmountable. It is also being used for quantum cryptography.

## 3) QUANTUM GATES: DEVICES THAT TRANSLATE QUANTUM EFFECTS TO COMPUTING AWESOMNESS

- **A gate** (**in traditional computer**) is a circuit that changes the states of bits in a predictable way. The speed with which the gate works determine how fast the computer is.

- **Understanding the limitation of these gates**:
  - » Modern computers use semiconductor transistors to build circuits that function as gates. A semiconductor chip hosts more than 100 million transistors on 1 sq mm.
  - » As transistors become smaller, they become more susceptible to quantum effects. This is not desirable as this will make **existing technology unreliable** for computational tasks. **So, there is a limit to how many transistors** a computer can have.

| LOGIC FUNCTION | LOGIC SYMBOL | BOOLEAN EXPRESSION | TRUTH TABLE | | |
|---|---|---|---|---|---|
| | | | INPUTS | | OUTPUTS |
| | | | B | A | Y |
| AND |  | A+B=Y | 0 | 0 | 0 |
| | | | 0 | 1 | 0 |
| | | | 1 | 0 | 0 |
| | | | 1 | 1 | 1 |
| OR |  | A+B=Y | 0 | 0 | 0 |
| | | | 0 | 1 | 1 |
| | | | 1 | 0 | 1 |
| | | | 1 | 1 | 1 |
| inverter |  | $A=\bar{A}$ | | 0 | 1 |
| | | | | 1 | 0 |
| NAND |  | $\overline{A+B}=Y$ | | 0 | 1 |
| | | | 0 | 1 | 1 |
| | | | 0 | 0 | 1 |
| | | | 1 | 1 | 0 |
| NOR |  | $\overline{A+B}=Y$ | 1 | 0 | 1 |
| | | | 0 | 1 | 0 |
| | | | 0 | 0 | 0 |
| | | | 1 | 1 | 0 |

- **A Quantum gate** is a physical process or circuit that changes the state of qubit or a collection of qubit.
  - » In quantum computers, quantum gates act on qubits to **process information**. For e.g., a quantum **NOT** gate changes the state of qubit from 0 to 1 and vice versa.
  - » It can be an electromagnetic pulse which changes the state of qubit.

## 4) **QSIM –** (CLASS DISCUSSION)

## 4. CLOUD COMPUTING

- **Intro**
  - Cloud computing is a type of Internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources which can be rapidly provisioned and released with minimal management efforts.
  - E.g.
    - Computer networks, Storage (OneDrive, Google Drive etc.), Servers, applications, and services
- **Advantages –** Reduced upfront cost; focus on core business; Faster deployment of application; Scalability and Elasticity; pay as you Go model; Agility; Device and Location independence; Maintenance, Multitenancy, Performance and Better Security.

» **Concerns**
  - Loss of control over certain sensitive data
  - Limited customization options

    E.g., a restaurant with a limited menu is cheaper than a personal chef who can cook anything you want.

- **Technology behind cloud:** There are two vital technologies at the heart of Cloud Computing:
  - **Virtualization**: It lets computer resource to be shared through multiple virtual machines.
  - **Network**: It lets data requests flow to and from the datacenters or the Cloud through the Internet.

  In cloud computing hardware resources are distributed across multiple locations and there is diverse choice of software that is available to consumers.

- **Service Models:** IaaS, PaaS, SaaS etc represent various cloud service models. They offer different levels of service and control.
  - **Infrastructure as service (IaaS)**
    - It provides on-demand access to fundamental resources like **Virtual Machines, storage, networking, and servers**.
    - These are online services that **abstract the user from the details of infrastructure** like physical computing resources, location, data partitioning, scaling, security, back up etc.
    - E.g. AWS, Microsoft Azure.
    - It is ideal for companies with strong technical team and need for high customization.
  - **Platform as Service (PaaS)**
    - The provider typically develops **toolkit and standards for development and channels for distribution and payment**.
    - In PaaS model, cloud providers deliver a computing platform, typically including **operating system, programming-language**, execution environment, database, and web server.
    - E.g. **Google App Engine**.
  - Software as a Service (SaaS)

- User gain access to **application software and databases** (e.g. Google Photos – In this consumer pays based on the giga-bytes that is required to store photos, Gmail etc.)
- Cloud providers manage the infrastructure and platforms that run the applications.

## 5. EDGE COMPUTING (CLASS DISCUSSION)

## 6. WEB BROWSERS: HOW DO THEY FUNCTION?

- **Why in news?**
  - » How do web browser work? (Dec 2023: Source - TH)

- **Definition:**
  - » A web browser is software that allows you to find and view websites on the Internet. They translate code into the dynamic webpage that forms the backbone of our online experience.

  - » **Different Browsers over the years**:
  - » In 1990, the English Computer Scientist Tim Berners-Lee introduced the concept of World Wide Web and with it came the first web browser, also known as **WorldWideWeb**.

  - » The next watershed moment was **Mosaic browser in 1993**. It was developed by US National Centre for Supercomputing Application. It introduced the concept of **displaying images** alongside text. It revolutionized our interaction with the web and made internet visually engaging.

  - » **In 1994** came the **Netscape Navigator** and it became the most popular browser of its time. It brough features like bookmarks and user-friendly URL bar. It simplified the navigation and made the web more accessible.

  - » **Late 1990s** saw the period of the '**Browser Wars**'. Microsoft's **Internet Explorer (IE)** and Netscape Navigator were the primarily contenders. This competition led to a lot of innovation in various browsers. But, by 2,000 IE emerged as undisputed leader mostly on the back of the success of Windows operating system which generally shipped with IE as default browser which most of the people used. But this monopoly also led to stagnation and lack of innovation.

  - » **In 2004-05**, this monopoly was broken with the arrival of **Mozilla's Firefox.** Firefox was developed by a community of volunteers and was based on open-source principles. It introduced groundbreaking features like tabbed browsing, and pop-up blocking. It also allowed users to extend their personal browsers with add-ons.

  - » **In 2008**, Google launched **Chrome**, which swiftly gained in popularity for its speed and minimalist design. It also revitalized the browser market and encouraged innovation across the board.

  - » **Today**, the most popular browsers are Google Chrome, Firefox, Microsoft's Edge and Apple's Safari.

- **How do Browsers work?**

Modern web browsers have multiple core components, each of which is a complex technology in itself.

**A) Request and Response**

- When you enter a website's address (in the form of Uniform Resource Locator (URL)) into your browser's address bar (or when you click a link), you set in motion **a sequence of digital communication**. The browser sends a request to a server, asking for the contents of the specific web browser you're interested in. This request travels through a network of servers, like dispatching a letter through a series of post offices. Upon reaching the server, the request is received and processed.
- The server then formulates a response containing the information (or data) required to construct the web pages. This response embarks on its journey back to your browser, carrying the digital blueprint for the page you requested.

**B) Deconstructing The Response**

- The response from the server is an amalgam of various files. Typically, these files have information encoded in three languages: **HTML, CSS, and JavaScript**. Each set of information plays a pivotal role in shaping the final presentation of the web page.
- **HTML (Hyper Text Markup Language)** provides the architectural blueprint of webpage. It defines structure of the webpage, outline elements like headings, paragraphs, images, and links. HTML is the foundation on which browser construct a visual layout.
- **CSS** (Cascading Style Sheets) imparts style and aesthetics to the HTML structure by controlling attributes like color schemes, fonts, spacing, and positioning. CSS ensures that webpages come with its unique identity.
- **JavaScript** is a dynamic engine, making webpages interactive and responsive. It allows interactive elements like pop-ups, forms, animations, and Realtime updates, creating an engaging user experience.

**C) Rendering**

- With HTML, CSS and JavaScript in hand, a browser begins the process of rendering. This involves deciphering the HTML to understand the structural arrangement, applying CSS for stylistic finesse, and executive JS to infuse interactivity.
- The process is remarkably swift, assembling the final webpage and presenting it to user in a cohesive and visually appealing manner in much less than a second, depending on the amount of data.
- **Rendering engines** are in themselves a key piece of technology that enables screens to display graphics.

**D) Managing Data**

- Browsers serve as adept custodians for your digital footprint, so they also implement instruments like **cookies** and **cache** to enhance your online experience.
- **Cookies** are small snippets of data stored on your computer by websites you visit. They retain information such as login status, site preference, and shopping cart content. This allows you to navigate seamlessly, without having to re-login to a site when you close and reopen it in a short span of time.
- **Cache** is a repository of frequently accessed files. When you revisit a webpage, the browser checks its cache to see if it already has a copy of the required files. If so, it retrieves them from the cache itself rather than re-downloading them from the server.

**E) Security**

- Web browsers use an array of security measures to protect your data as they fly between your computer to various servers, via the internet, and even when they're stored on your computer. They do this by using **encryption protocols**, such as **HTTPS**, to create secure tunnels for data exchange shielding the information from prying eyes.

- Browsers also use warning systems to alert you about potentially malicious websites, preventing inadvertent exposure to threats.

**Future of Internet Browsers**:

- As technology hurtles forward, web browsers evolve in tandem. They are embracing new technologies like **Web Assembly**, a format that enables near-native performance within the browser environment.
    - **Note**: Web Assembly is a type of code that can run on modern webbrowsers – it is low-level assembly-like language with a compact binary format that runs with near native performance and provides languages such C/C++ with a compilation target so that they can run on web. It is also designed to run along JavaScript, allowing both to work together.

- **Support for VR and AR** experience is also on the horizon, promising immersive online interactions.
- **Privacy features** are being bolstered, providing users a greater control over their digital footprint.

## 7. INTERNET OF THINGS (IOT)

- **Introduction**
    - IoT is a network of physical objects embedded with sensors, software, and other technologies for connecting and exchanging data with other devices and systems via the internet.
    - **A thing** on the internet of Things, can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile with a built-in-sensors to alert the driver when tire pressure is low - or any other natural or manmade object that can be **assigned an IP address** and provided with **the ability to transfer data** over a network.

- This is achieved by **sensors** and finally fabricated **micro-controllers**.
    - Microcontrollers are small computers themselves and are used internally by various single board computers like Arduino and Raspberry Pi.
    - **Sensors** are used to detect and collect information and micro controllers to transport information.
    - Together, they can make anything to a thing in IoT.

- **Movement from IPV4 (**32 bit address) **to IPV6 (**128 bit address**)** also played a role in making IoT possible.

- **Advantages**
    - **Reduce waste, loss, and cost** -> by early detection of problems and taking corrective steps
    - We would know what things needed **replacing, repairing, or recalling** and whether they were fresh or past their best. This helps in increasing the **reliability** of a device.

- **Applications**
  a. **Health Care Sector:** IoT can improve the reliability and performance of the life-critical system. For e.g., the IOT based devices can be used in combination with cardiact monitor to raise an alarm to the doctors in case of abnormality.
  b. **Agriculture Sector**: IoT can be used to gather **live pedological data** that can be used by scientists to improve the yield of the land. It can also help in implementing **precision agriculture**.
  c. **Transportation Sector**:
     - **Early detection of wear and tear** (preventing accidents)
     - Self-Driving Cars – will need IOT for real time decisions
     - Traffic Management – real time traffic data -> better traffic management.
  d. **Energy Management**
     - Managing temperature in a Nuclear Power Plant (using sensors and IoT)
     - Real time efficiency analysis of Solar Power panels.
  e. **Research and Development**:
     - E.g. – Recent development of wireless communication system for satellites by NASA through which Satellites can communicate with each other.
  f. **Safety and Security**
     - Real time tracking of criminals – using tagging and IoT.

- **Some Limitations of IoT**
  » **High Initial cost of set up** -> Since IoT is based on expensive sensors
  » **Increased cyber security concerns** -> with increased number of devices connected to internet
  » **Compatibility issues** -> due to lack of the international standardization on IoT devices.

## 8. INDUSTRIAL REVOLUTION 4.0

- The **First Industrial Revolution** used water and steam power to mechanize production.

- The **Second** used electric power to create mass production.

- The **Third** used electronics and information technology to automate production.

- Now a **Fourth Industrial Revolution is building on the Third**. It is characterized by a **fusion of technologies that is blurring the lines between the physical, digital, and biological spheres**.
  - It is characterized by integration of advanced technologies such as AI, IOT, Robotics, big data, and more into various industries and aspects of society.
  - It combines Machine to Machine Communication, Industrial Big Data Analytics technology, cyber security, and automation. It's driving new levels of efficiency and productivity.

- **Three reasons** why 4th IR is not merely a prolongation of the 3rd IR, but rather the arrival of a Fourth and distinct one: **Velocity, Scope and Systems impact**.
  - The **speed** of current breakthroughs has no historical precedent. The 4th Industrial Revolution is evolving at an exponential rather than a linear pace.
  - It is disrupting almost every industry in the country.
  - The breadth and depth of these changes herald the transformation of entire systems of production, management, and governance.

- **Need of Industry 4.0**:
  - Impetus to next surge of growth
  - Harness the potential of Big Data, AI etc in every field.
  - Improve governance by using new age tech.

## 9. BIG DATA

- **Intro**
  - Big Data is a collection of data that is huge in volume (petabytes and exabytes of data) yet growing exponentially with time. It is a data with so large size and complexity that none of the traditional data management tools can store or process it efficiently. Big Data can be structured, semi-structured and Unstructured. But they generally have potential to be mined for information.

  - **Examples of Big Data:**
    - BSE which generates Gigabytes of data per day
    - Social media – Around 500+ terabytes of new data get ingested into the database of social media site Facebook every day.
    - Data from search engines (like Google, Bing etc.) and Online portals like Amazon.

- **Challenges** include capture, analysis, data curation, search, sharing, storage, transfer, visualization, querying, updating, and information privacy.

- Big data is **characterized by 3 Vs – Volume, Velocity and Variety**.

- **Advantages – Accuracy, Better Correlation**

- **Key areas where it can be used**
  - Internet
  - Finance
  - Urban Informatics
  - Business informatics
  - Meteorology
  - Genomics and healthcare
    - Find new cures, optimize treatment, and even predict diseases before any physical symptoms appear
  - Complex physical simulations
  - Environment research
  - Improve the performance of Individuals
    - (At sports, at home or work), where data from wearable sensors in equipment and wearable devices can be combined with video analytics to get insights that traditionally where impossible to achieve)

  - Security Agencies
    - To prevent cyber attack
    - Detect credit card frauds
    - Foil terrorism

- Even predict criminal activity

» Improve our homes, cities, and countries
  - Optimizing heating and lighting in our homes
  - Optimizing traffic flow in our cities
  - Optimizing Energy Grid across the country

- **Relation between cloud computing and big data**
  » Cloud computing is very important in BIG data analytics due to its application sharing and cost-effective properties

## 10. NET NEUTRALITY

- **Why in news?**
  » 120+ startups have written to TRAI opposing Telecom Service Providers (TSPs) push for regulating over the top (OTT) services (Oct 2023)

- Net Neutrality (also network neutrality, internet neutrality or net equality) is the principle that ISPs and Governments should treat all data on the internet equally, not discriminating or charging differentially by **user**, **content**, **site**, **platform**, **application, type** of attached equipment, or mode of communication.
- The term was coined by Columbia University media law professor **Tim Wu** in 2003 as an extension of the long-standing concept of a common carrier.

- **Arguments for Net Neutrality**
  » **Free Flow of Data**

  » **User Intolerance for slow loading sites**

  » **Competition and Innovation**
  » **Preserving Internet Standards**
  » The advocates also argue that authorizing network providers to override a transport and application layer separation on the internet would signal the decline of fundamental internet standards and international consensus authority.
  » **Preventing Pseudo Services**
  » **End to End Principle**
    - Network neutrality is needed in order to maintain the end-to-end principle. It is this simple but brilliant end to end aspect that has allowed the internet to act as a powerful force for economic and social good.
- **Arguments against Net Neutrality**
  » **Financing Infrastructure Improvements**
  » **Counterweight to server-side non-neutrality.**
  » **May prevent overuse of bandwidth.**
  » **May prevent access to useless websites.**

- **Net Neutrality in India**:

» In 2016, TRAI banned **Free Basics service (Internet.Org)** in India based on "Prohibition of Discriminatory Tariffs for Data Services Regulations".

» In Sep 2020, TRAI recommended the creation of a multi-stakeholder body (MSB) to ensure that Internet access providers adhere to the provisions of net neutrality. TRAI also said that the net neutrality principles adopted by DoT were technology neutral and would apply equally to 5G technology.

## 11.TOPICS TO BE COVERED IN FUTURE BOOKLETS

- Encryption/Decryption – Public Cryptography, Digital Signature
- Quantum Cryptography
- BlockChain – BitCoin- Other Crypto Currencies
- NFTs
- AR/VR/Meta Verse
- Web 3.0
- Wireless Communication (5G/6G), Bluetooth, WiFi, NFC, RFID etc.
- Optical Fiber Communication / FSOC
- Electronics – Basics
- Semiconductor manufacturing in India
- LED; (OLED) (PMOLED), Flexible LED Display
- LASER and other optoelectronics
- Wireless Charging
- 3D Printing
- BarCode / QR Code