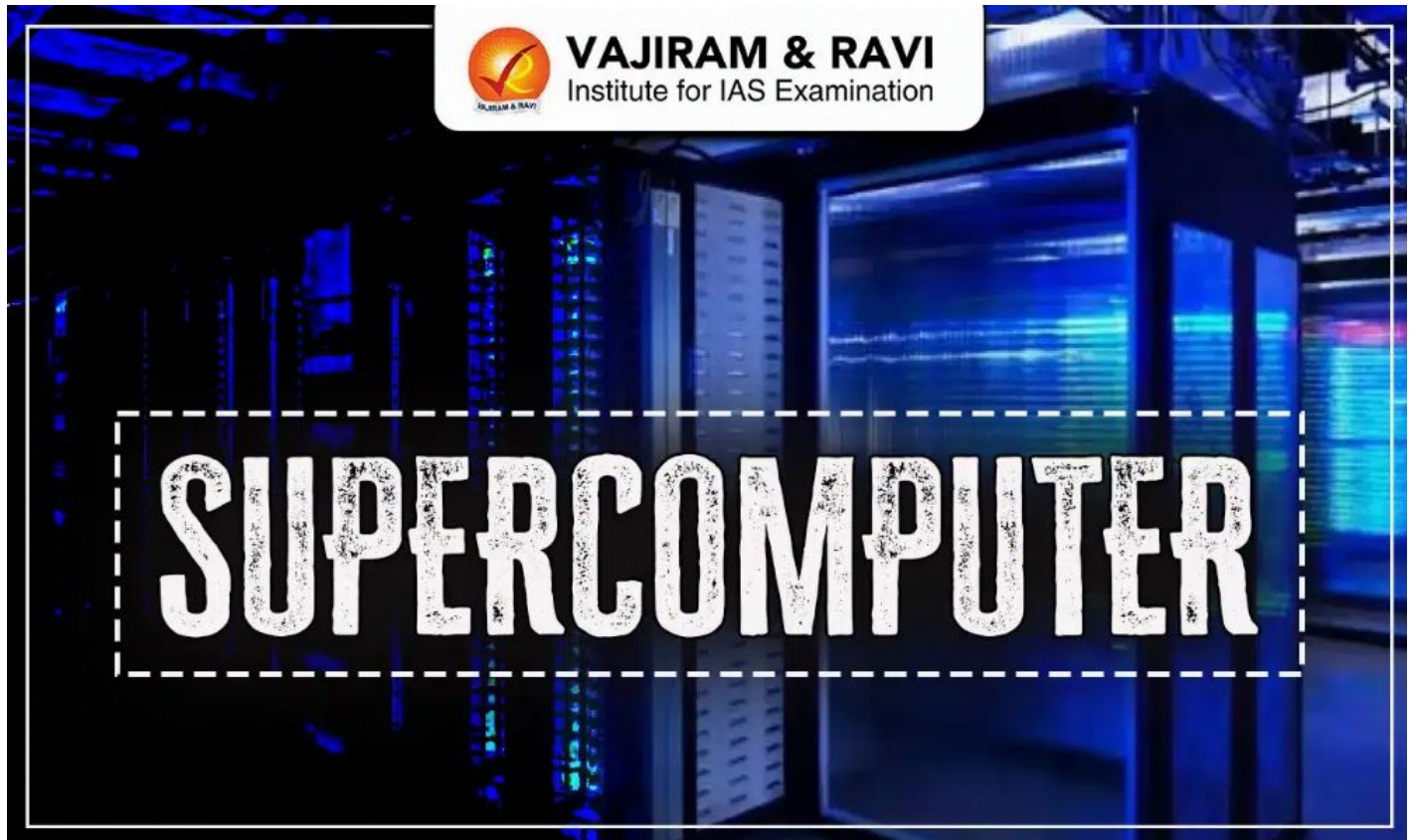


Supercomputer - Uses, Examples, Supercomputers in India

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Supercomputers are high-performing computers, designed to tackle complex computational challenges. They encompass multiple central processing units that break down the required tasks into multiple parts and process them simultaneously, which effectively results in high-speed computation. The performance of supercomputers is measured in terms of **floating-point operations per second (FLOPs)**.

Supercomputers can be utilised for general purposes as well as special purposes such as Belle, Hydra, and Deep Blue for playing chess.

Features and Working of Supercomputers

Supercomputers possess multiple distinctive features that set them apart from conventional computers. These are described below:



- **Multiple CPUs:** Supercomputers incorporate more than one CPU.
 - Each CPU contains circuits for interpreting program instructions and executing arithmetic and logic operations.
- **Speed:** These computers can support the high computation speed of CPUs.
- **Storage:** It has a very high storage capacity. Rapid retrieval of stored data and instructions is crucial to support high computational speed.
- **Vector Arithmetic:** By using Vector Arithmetic, they can operate on **pairs of lists** of numbers rather than on mere pairs of numbers.
- **Multi-Users:** A supercomputer allows multiple users to access supercomputing simultaneously.

History of Supercomputers

The trajectory of supercomputing was set in motion during the **late 1950s** when the U.S. government initiated consistent funding for the development of high-performance computer technology, primarily aimed towards military applications.

- **Key events:**

- In 1976, the **Cray-1** was introduced which was the first successful implementation of vector processing.
- In 1985, a four-processor **Cray-2** became the first computer to exceed one billion FLOPS.
- **Roadrunner**, exceeding 1,000 TFLOPS or 1 petaFLOPS, was built by IBM.

Contemporary Supercomputers

- Currently, the **IBM Summit** holds the title of the **world's fastest supercomputer** according to the TOP-500 supercomputer list.
- Following closely is another American supercomputer, **Sierra**, which has a peak speed of 125 petaFLOPS.
- Other significant supercomputers on the list include **Sunway TaihuLight** in Wuxi (China), **Tianhe-2** in Guangzhou (China), **Dell Frontera** in Austin (USA), **Piz Daint** in Lugano (Switzerland), and **AI Bridging Cloud Infrastructure (ABCI)** in Tokyo (Japan).
- The **United States** dominates the top 10 with five supercomputers, while **China** follows with two.

Supercomputers in India

In 1987, the USA denied India's request to purchase the Cray **X-MP** for **academic** and **weather** forecasting purposes, which compelled India to promote its supercomputing programme.



- **Agencies involved:** Centre for Development of Advanced Computing (C-DAC), Centre for Development of Telematics (C-DOT), National Aerospace Laboratories (NAL), Bhabha Atomic Research Centre (BARC), and Advanced Numerical Research and Analysis Group (ANURAG) took the lead in this direction.
 - **C-DOT** developed "**CHIPPS**", a high-performance Parallel Processing System.
 - **BARC** created the **Anupam** series of supercomputers.
 - **ANURAG** created the **PACE** series of supercomputers.
- **Param Series:** PARAM supercomputers are designed and assembled by the Centre for Development of Advanced Computing (C-DAC) in Pune, India.
- PARAM means "**supreme**" in Sanskrit, and also creates an acronym for "**PARAllelMachine**".

- The **PARAM 8000** was a success for C-DAC in delivering a **gigaFLOPS** range parallel computer. It was launched in **1991**.
- In 1993, the **PARAM 9000** series was released, which had a peak computing power of 5 GFLOPS.
- In 1998, the **PARAM 10000** series had a sustained performance of 38 GFLOPS on the LINPACK benchmark.
- The **AI Supercomputer 'AIRAWAT'** and PARAM Siddhi – AI are currently the fastest supercomputers in India. AIRAWAT has been ranked **75th** in the world as of June 2023.

Indian Supercomputers in Top 500 List

As of June 2023, there are 4 systems based in India on the TOP 500 supercomputer list.

Rank	Site	Name	Rmax (TFlop/s)	Rpeak (TFlop/s)
75	Centre for Development of Advanced Computing	AIRAWAT - PSAI	8.5	13.17
131	Centre for Development of Advanced Computing	PARAM - Siddhi AI	4.62	5.27
169	Indian Institute of Tropical Meteorology	Pratyush (Cray XC40)	3.76	4.01
316	National Centre for Medium-Range Weather Forecasting	Mihir (Cray XC40)	2.57	2.81

National Supercomputing Mission

The **Ministry of Electronics and Information Technology** in **2015** announced a "National Supercomputing Mission" (NSM) to install **73 indigenous supercomputers** throughout the country by 2022.

- **Objectives:** The primary goal of the mission is to establish a cluster of geographically distributed high-performance computing centres connected by a high-speed network, forming the National Knowledge Network (NKN).
 - It aims to enhance both **capacity and capability** in high-performance computing across academic and research institutions in India in their respective Domains.
- **Characteristics:**
 - **Infrastructure:** It involves the deployment of high-performance computing centres, including three **petascale supercomputers**.
 - **Financial Investment:** The mission spans a **seven-year program** with a budget of **\$730 million (Rs. 4,500 crores)**, indicating a significant financial commitment to advancing supercomputing capabilities in the country.
 - **Localisation:** It aims to produce all the components within India.
 - **Implementing Agencies:** **Centre for Development of Advanced Computing (C-DAC) and the Indian Institute of Science.**
- **Achievements:**

- PARAM Shivay, the first supercomputer of India under NSM was installed in 2020 at IIT, BHU.
- Other installed supercomputers are PARAM Pravega (IISc, Bangalore), PARAM Utkarsh (C-DAC, Bangalore), PARAM Ananta (IIT, Gandhinagar), PARAM Himalaya (IIT, Mandi), PARAM Siddhi-AI (C-DAC, Pune), and PARAM Vidya series.

Applications of Supercomputers

Supercomputers are being used in multiple fields and have several applications such as:

- **Weather Forecasting and Climate Research:** When the supercomputer is fed with data gathered via satellites, radars and weather balloons, field experts become better informed on how atmospheric conditions affect us.
 - They become better equipped to advise the public on weather-related topics.
 - For example, the **Derecho** supercomputer is being used to explore the effects of solar geoengineering and how releasing aerosols influences rainfall patterns.
- **Genome Sequencing:** It is a type of molecular modelling which scientists use to get a closer look at a virus' DNA sequence that helps them diagnose diseases.
 - The supercomputer can perform DNA sequencing in a few hours.
 - For example, Researchers at Stanford University scored the **Guinness World Record** title for the fastest genomic sequencing.
- **Aviation Engineering:** Supercomputing systems in aviation have been used to **detect solar flares**, **predict turbulence** and approximate **aeroelasticity** to build better aircraft.
 - For example, **Frontier** has been recruited by GE Aerospace to **test open fan engine architecture** designed for the next generation of commercial aircraft that can reduce carbon dioxide emissions significantly.
- **Space Exploration:** Supercomputers can take the massive amounts of data collected by **satellites**, **probes**, **robots** and **telescopes** and use it to **simulate** outer space conditions earthside.
 - For example, at NASA, **Aitken** is used to create high-resolution simulations in preparation for upcoming **Artemis moon missions**.
- **Nuclear Fusion Research:** They can create simulations to **predict energy loss and optimise performance in plasma**, used in the tokamak research.
 - **Example:** **Frontier** and **Summit** for a project led by scientists at General Atomics, USA.
- **Oil and Gas Exploration:** They can be used to collect huge quantities of geophysical seismic data to aid in finding and developing oil reserves.
- **Military and defence:** Supercomputing can allow the military to perform **virtual testing of nuclear explosions** and ballistic weapons.
- **Smog prediction:** Many scientists and climatologists use supercomputers in the laboratory to **predict fog and other pollution** and smog levels in a particular region.
 - **Example:** Tianhe-1A of China.

Disadvantages of Supercomputer

The following are a few disadvantages of the supercomputers:

- **Physical Size:** Supercomputers are physically large. Hence, they require lots of space.
 - A supercomputer typically takes more than 1000 square feet of area.
- **Maintenance:** For this purpose, **special software** and expertise are needed to detect failures and the computer's overall usage.
- **Storage:** To acquire the full capacity of a supercomputer, it should be equipped with enough storage space to accommodate all the produced data.
 - Without sufficient storage space, the supercomputer simply cannot perform calculations.
- **Heat Release:** A supercomputer is equipped with a large number of processors all of which can generate a significant amount of heat during their operations.
 - Due to this heat, most devices tend to get damaged easily.
- **Power Consumption:** Supercomputers typically consume large amounts of electricity.
 - In general, a supercomputer needs around 4 megawatts (MW) of electricity.

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