

# ABCD Analysis of Industries Using High-Performance Computing

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### ABSTRACT

**Purpose:** *High-Performance Computing (HPC) is the technique of increasing the overall processing capacity of the system, and achieving high performance in solving large problems in science, engineering, or business. This research paper investigated the High-Performance Computing industry using exploratory research methodology and a listing of ABCD analysis is done. Along with this, the identification of various applications and grand challenges in HPC and various Software Tools required for industry-specific application areas of HPC is done.*

**Design/Methodology/Approach:** *Qualitative exploratory research methodology to perform Industry Analysis of High-Performance Computing using ABCD Analysis. This research paper is written with the literature review of High-Performance Computing (HPC) industries and various software tools available to use in those industries.*

**Findings/Results:** *Finding of this research paper is the identification of various grand challenges in HPC industries like healthcare and medical field, engineering and design, aerospace sector, urban planning, and infrastructure, finance, and business. It also lists different HPC software tools that can be used to solve these challenges, along with the findings of ABCD analysis of HPC industry.*

**Originality/Value:** *Listing of ABCD Analysis (Advantages, Benefits, Constraints, and Disadvantages) of High-Performance Computing industry.*

**Paper Type:** *Industry Analysis research paper*

**Keywords:** *High-Performance Computing, ABCD Analysis, Industry Analysis*

### 1. INTRODUCTION :

High Performance Computing (HPC) is the technique and methodologies of solving large and complex problems with less time and at less cost in comparison with conventional computing techniques. It can be the tools for designers, engineers, data scientists, and other researchers while processing scalable problems. HPC uses the concept of parallel processing and supercomputers together to implement powerful and complex application programs. HPC systems are majorly used to develop parallel processing applications by combining architectural and computation methods. HPC systems are designed and developed to handle scalable problems with high processing speed. HPC combines different technologies like computer architecture, system software, data structures, algorithms, and programs into a single unit, to solve problems with complex processing requirements and needs processing of big data which are scalable; quickly, and efficiently.

Majority of industrial domains in the current era like Financial Technology (FinTech), Medical Technology (MedTech), Education Technology (EdTech), etc. uses modern digital technologies like Artificial Intelligence (AI), Internet of Things (IoT) and Machine Learning (ML). These technologies which are in use will produce a high volume of data that demands advanced data analytics with high processing speed. Thus there is a need to use HPC based solutions in these industries to provide optimum solutions to various challenges and problems and a need to study these industries.

**2. LITERATURE REVIEW :**

Systematic literature review is conducted on the topic of HPC based industries and listed in Table 1. It consists of literature review on topics like:

- Various elements required to design HPC solutions (Sr. No 1 to 4).
- To understand various industries of HPC and possible grand challenges in these industries (Sr. No 5 to 20).
- To know different Software Tools available to implement HPC systems (Sr. No 21 to 25).

**Table 1:** Scholarly literature review on High Performance Computing

S. No.	Area & Focus of the Research	Outcome of the Research	Reference
1	Developing and applying advances in computing for medical research and healthcare communities.	Finding is that during COVID-19 pandemic, telemedicine was ready to meet demand.	Ackerman, M. J., Howe, S. E., & Masys, D. R. (2022). [1]
2	New parallel computing method for processing GNSS network datasets.	Faster parallel method over serial scheme for processing GNSS network datasets.	Cui, Y., Chen, Z., Li, L., Zhang, Q., Luo, S., & Lu, Z. (2021). [2]
3	To compare serial and shared distributed parallelization in Knapsack problem.	Comparative analysis of algorithms were used.	Sin, S. T. T. (2021, January). [3]
4	Methods to find the scalability of a parallel algorithm and its measurement procedure	Derived methodologies and procedures to measure the scalability of a parallel algorithm.	Sokolinsky, L. B. (2021). [4]
5	Methods to provide customized medical services for the patients.	Message processing delay of tenants can be reduced by 82%.	Zhang, Y., Sun, Y., Jin, R., Lin, K., & Liu, W. (2021). [5]
6	Use of Artificial Intelligence for the paradigm change in cancer care.	Depicts the procedure for the usage of Artificial Intelligence in Cancer Care Clinic.	Bhinder, B., Gilvary, C., Madhukar, N. S., & Elemento, O. (2021). [6]
7	To address computational challenges in genome analysis.	GenStore is implemented with three modern SSDs. It can be used to improve the read mapping.	Ghiasi, N. M., Park, J., Mustafa, H., Kim, J., Olgun, A., Gollwitzer, A., ... & Mutlu, O. (2022). [7]
8	To design new lighter aircraft structures.	During the creation of a model through CAD (Computer-Aided Design) tool, how numerical computation can be used. Also FEA (Finite Element Analysis) performed on the same.	Zenowicz, P. (2021). [8]
9	Investigated challenges faced by HPC scheduling.	Proposed an intelligent scheduling framework for HPC.	Fan, Y. (2021). [9]
10	Evaluates the proficiencies and the technical viability of sensors in autonomous vehicles.	Sensor fusion object detection techniques are developed as hardware and software solutions.	Yeong, D. J., Velasco-Hernandez, G., Barry, J., & Walsh, J. (2021). [10]

11	To perform the valuation of green space modification detection using GPU.	Over the period of fifteen years around 50% of green space was diminished.	More, N., Nikam, V. B., & Banerjee, B. (2020). [11]
12	Methods to discover solar radio burst before the solar flare event.	Solar radio burst detection system was developed which is highly dependable and accurate in measurement.	Mohd, M. R. S., Johari, J., & Ahmat, F. (2020, November). [12]
13	To develop VASPKIT, that analyse various material properties of raw data.	Bash scripts model that can be used to perform various analysis on raw data sets.	Wang, V., Xu, N., Liu, J. C., Tang, G., & Geng, W. T. (2021). [13]
14	To develop a prototype of an urban digital twin town.	It supports participatory and collaborative processes in urban planning.	Dembski, F., Wössner, U., Letzgun, M., Ruddat, M., & Yamu, C. (2020). [14]
15	Design methods for assessing adsorption and membrane-based gas separation as a computational procedure.	Computations procedures using MOFs for different gas separations were identified and listing of its opportunities and challenges are done.	Daglar, H., & Keskin, S. (2020). [15]
16	To summarise the development procedure, research methods and features of plant phenotypes.	It recommends vital methods for present plant phenotypes.	Fan, J., Zhang, Y., Wen, W., Gu, S., Lu, X., & Guo, X. (2021). [16]
17	To measure performance inconsistency of high performance computing (HPC) methods.	Data investigative framework is implemented to model data collected from extensive trials for measuring performance inconsistency in HPC systems.	Xu, L., Lux, T., Chang, T., Li, B., Hong, Y., Watson, L., ... & Cameron, K. (2021). [17]
18	To determine the criteria and infrastructure for the introduction of HPC techniques in countries of Danube sections.	The loads of standards and their corresponding positions were performed using the fuzzy PIPRECIA method.	Tomašević, M., Lapuh, L., Stević, Ž., Stanujkić, D., & Karabašević, D. (2020). [18]
19	To design a High performance Bitcoin transaction foretelling method to investigate the Bitcoin payment trades.	Developed the model that achieved ~100% classification detection and precision.	Al-Haija, Q. A., & Alsulami, A. A. (2021). [19]
20	To model and design a vertical setting, hence define the philosophies of modelling high-rise design ideas.	Use of spatial modelling concepts on scalable high-rise designs.	Braun, S., Peters, M., & Burnell, A. (2021). [20]
21	To compare the performance of various packages like:- GROMACS, OpenMM MD and LAMMPS with different GPU backends on Nvidia Volta and AMD Vega20 GPUs.	Outcomes indicate significant advantages for AMD GPUs over the OpenCL backend.	Kondratyuk, N., Nikolskiy, V., Pavlov, D., & Stegailov, V. (2021). [21]
22	To prepare Ginkgo math library for Intel GPUs by designing and implementing a kernel based on the DPC++ programming techniques.	Analyse the performance of building blocks against procedures of Intel's oneMKL library.	Tsai, Y. M., Cojean, T., & Anzt, H. (2022). [22]

23	To develop a process dispatcher appropriate for large and heterogeneous systems; that are running complex applications.	Developed the dispatcher that solves the entire dispatching problem using Constraint Programming (CP) principles.	Galleguillos, C., Kiziltan, Z., & Soto, R. (2021). [23]
24	To List various applications, constraints and challenges of high performance computing in genomics.	Reviewed applications of HPC in genomics.	Jiang, M., Bu, C., Zeng, J., Du, Z., & Xiao, J. (2021). [24]
25	To design and develop the Jespipe Open MPI framework which acts as a plugin module. This framework is parallel in working that can evaluate the robustness of machine learning models.	The Jespipe framework is better for the development of machine learning algorithms in comparison with the Jupiter notebook.	Alemany, S., Nucciarone, J., & Pissinou, N. (2021, December). [25]

Literature review is conducted on the topic of ABCD (Advantages, Benefits, Constraints and Disadvantages) Analysis of different industries and listed in Table 2. This is done to know the method of performing ABCD Analysis for any specific industry so that the knowledge of this could be used in analysing the HPC industry.

**Table 2:** Scholarly literature review on ABCD Analysis

S. No.	Area & Focus of the Research	Outcome of the Research	Reference
1	ABCD analysis framework to study the efficiency of organic food products and its impact on buying intent.	Identified 98 key elements that fulfil the efficiency of organic food products and its impact on buying intent.	Mendon, S., & Aithal, P. S. (2022). [26]
2	To identify the suitability of ABCD analysis in the analysis of education for corporate sustainability disclosures.	Identified the most important elements and its significance in the modern education system.	Nayak, P., & Kayarkatte, N. (2022). [27]
3	ABCD framework to analyse business models, concepts, technology, systems, and strategies.	ABCD analysis of a system or concept from different stakeholder point of view.	Aithal, P. S. (2021). [28]
4	To use the ABCD Analysis framework as a research tool in company analysis.	Listing of various recommendations for using the ABCD analysis framework as a research tool in company analysis is done.	Aithal, P. S. (2017). [33]
5	To perform the comparison of various case study company analysis tools.	The ABCD Analysis framework is compared with other case study analysis tools like SWOC, CPM and PESTLE.	Aithal, P. S. (2016). [34]
6	To perform the case analysis of Stage model for different courses at SIMS institute.	Identified various importance of using ABCD analysis in stage models is performed.	Aithal, P. S., Shailashree, V., & Kumar, P. M. (2016). [35]
7	To perform ABCD analysis on Private University functioning and its excellence.	One Hundred and Ninety-Two features that contribute to the excel of Private University are identified.	Aithal, P. S., Shailashree, V., & Kumar, P. M. (2016). [36]



8	To perform factor analysis of Theory A.	The usage of ABCD analysis in factor analysis is done.	Aithal, P. S., & Kumar, P. M. (2016). [37]
9	To perform ABCD analysis on green banking practices.	Identified elements of green banking products and its impact in usage is done.	Prabhu, N., & Aithal, P. S. (2023). [38]
10	To perform ABCD analysis in identifying various elements that affect to reduce food waste.	Listing of different elements that affect reducing food waste is done.	Salins, M., & Aithal, P. S. (2022). [39]
11	To perform ABCD analysis on Base of the Pyramid market.	Identified the feasibility of doing BoP business in India.	Raj, K., & Aithal, P. S. (2022). [40]
12	To identify a new list of research indices for finding the research productivity of an individual.	Identified research indices for research productivity of an individual using the ABCD framework.	Aithal, P. S. (2017). [41]
13	To find the application of IEDRA Model in campus placement activity.	Hypothesis testing of IEDRA model using ABCD analysis is done.	Shenoy, V., & Aithal, P. S. (2017). [42]
14	To find the solution for the critical shortage of trained healthcare professionals using task-shifting methods.	Various determinant related to the task shifting is identified using ABCD framework	Aithal, A., & Aithal, P. S. (2017). [43]
15	To identify various constitutional elements of using nanotechnology as green technology.	Importance of using nanotechnology as green technology is done with the ABCD framework.	Aithal, P. S., & Aithal, S. (2018). [44]

Through the literature review, we identified research possibilities in performing ABCD analysis on the HPC industry. Identifying and listing the Advantages, Benefits, Constraints, and Disadvantages of HPC industry, will ease researchers in selecting the HPC methods of solving the problems over conventional methods of computing. There is a need to identify the elements, design types, industries that can use HPC systems, and various software tools available to implement HPC systems to make it a choice for solving the computing problems.

### 3. OBJECTIVES :

This research paper has the following objectives:

- (1) To find out the key elements of High-Performance Computing.
- (2) To identify different design types of High-Performance Computing systems.
- (3) To identify various industries of HPC and identify the possible challenges/applications in these industries.
- (4) To study HPC Software Tools and its usage in different industrial domains.
- (5) To perform ABCD (Advantages, Benefits, Constraints, and Disadvantages) Analysis of HPC industries.

### 4. RESEARCH METHODOLOGY :

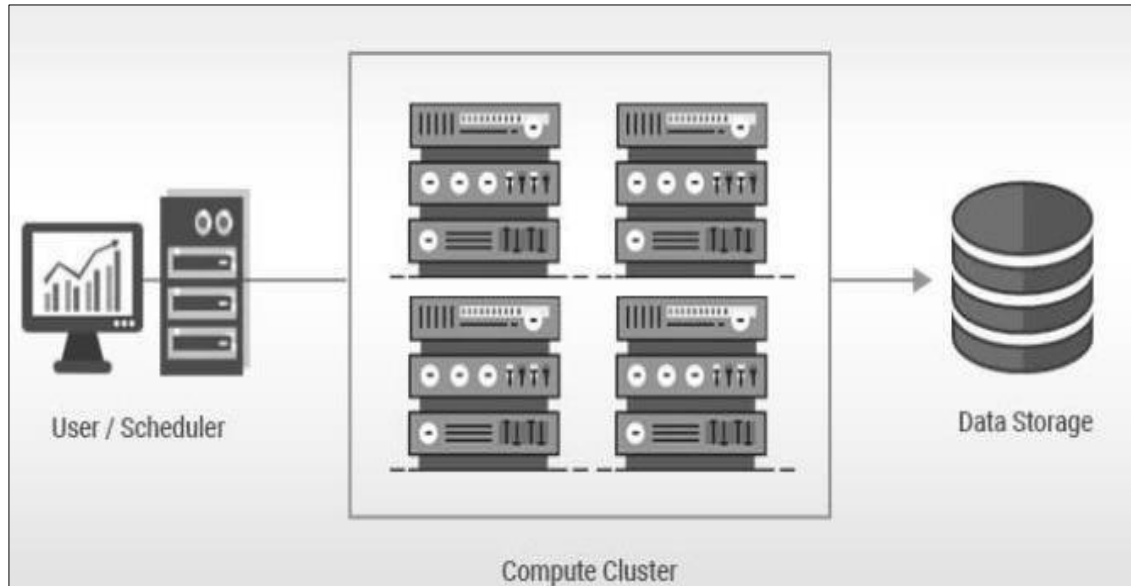
This research paper is prepared with the qualitative exploratory research methodology.

- Major objective of the paper is to perform ABCD Analysis of HPC industry, which is qualitative in nature.
- As HPC techniques are an emerging concept with major uses in scalable data science, ABCD analysis on HPC industry is a newer concept which has not been studied in detail before.
- Case study based secondary source of data collection is used while collecting the necessary data. Systematic literature review is done by considering the objectives of the study using various online resources like ResearchGate, IEEE Xplore, and Google Scholar.

- To perform the ABCD Analysis of High-Performance Computing Industries, various industrial websites are referred to know how HPC will influence and affect the various industrial domains and what are the challenges that HPC can address in these industries.

### 5. ELEMENTS OF HIGH PERFORMANCE COMPUTING :

HPC systems have basic three elements like: Computer Cluster, Data Storage, and Scheduler as shown in Fig. 1 and all these three elements are connected through a network system.



**Fig. 1:** Elements of High-Performance Computing System. **Source:** [30]

- Any HPC systems require a cluster of servers that can be formed by connecting multiple computer servers through a network.
- HPC systems logic needs to be designed through programs that can be executed concurrently or parallel on the servers in the cluster. Multiple servers work together to solve a particular problem, by dividing the problems into subparts and providing a partial result by each server. The partial result from each server needs to be combined to form the final solution at the end.
- Common data storage is required to share the results among multiple servers at each level of problem-solving.
- Each element of the HPC system must work in coordination with other elements to get higher performance, and it can be managed through a scheduler.

### 6. HIGH PERFORMANCE COMPUTING DESIGN TYPES :

HPC systems can be used in scalable data science, as it provides solutions which are powerful and less time consuming over traditional methods of computing. HPC gains its features through its design and there are three major design types available for HPC systems: parallel computing, cluster computing, and grid distributed computing.

#### (1) Parallel Computing:

Parallel computing is the method of dividing a big problem into smaller problems that can be processed independently and simultaneously by multiple processors that can communicate with each other using shared memory. The result of each sub task or problem can be combined to get the overall result at the end. Fig. 2 shows the difference between serial and parallel computing where in serial computing a single problem is solved by considering it as whole whereas in parallel it is divided into three sub tasks.

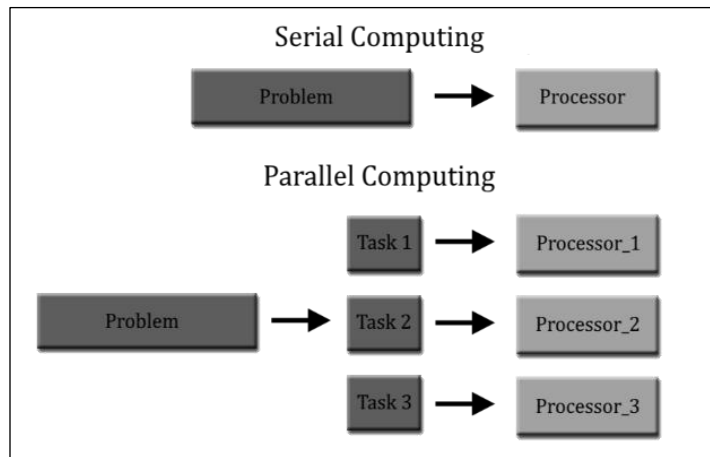


Fig. 2: Serial Vs Parallel Computing Source: [29]

**(2) Cluster Computing:**

Cluster computing contains numerous connected computers that are controlled by servers to solve a particular problem. Each server in cluster computing is known as a node that controls a set of computers to perform the operations all together thus acting like a single unit. Cluster computers provide faster processing speed. Fig. 3 shows a cluster computing system with two nodes (server1 and server2), where server1 does the load balancing between computers named 1 to 6.

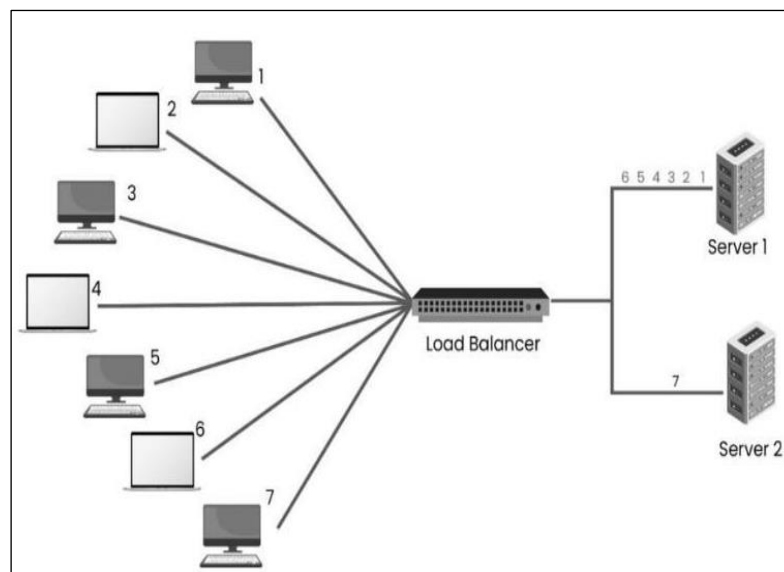


Fig. 3: Cluster Computing Source: [31]

**(3) Grid and Distributed Computing:**

Grid computing is a network of computers that are designed to perform a huge task, which are not possible to solve using a single machine.

Distributed computing system is a collection of different software components working on multiple computers, but operates like a single system.

Both Grid and Distributed computing systems can have homogeneous or heterogeneous computers that combine the computing power of multiple computers to form virtual supercomputers.

Fig. 4 system shows that the task is shared among four computers with individual processing and storage capacity.



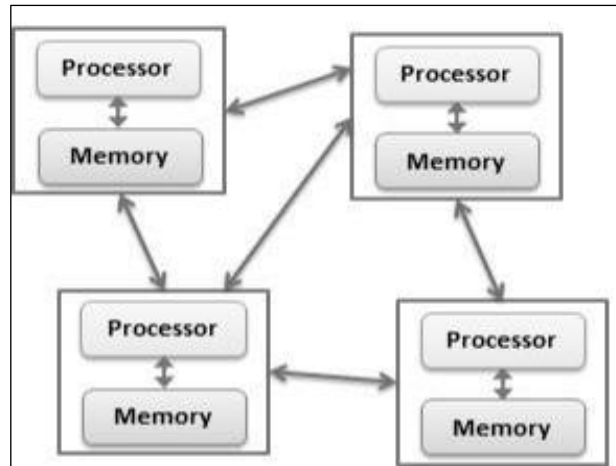


Fig. 4: Distributed Computing Source: [32]

## 7. INDUSTRIES OF HIGH PERFORMANCE COMPUTING AND CHALLENGES :

Major industries that are using HPC solutions are: Healthcare and Medical field, Engineering and Design, Aerospace sector, Urban planning and Infrastructure, Finance and Business. HPC can find solutions to many grand challenges in these industries that are identified and listed below: -

### (a) Healthcare and Medical Field

In the Healthcare system, computer applications are already in place for storing patient details, medical diagnostics, and drug details. HPC provides added features to the medical field that highly complex procedures like genome sequencing and drug testing can be performed effectively. HPC provides various applications in different domain of healthcare facilities as mentioned below:

- **Faster Healthcare**

HPC can manage with scaled data or big data operations for healthcare data computing. For example, Hewlett Packard Enterprise provides various HPC-based solutions integrated with AI technologies for healthcare consulting services. The services allow medical specialists to process big data in actual time and provide various diagnostics and clinical trials results.

- **Cancer Treatment**

HPC allows researchers to process petabytes of data to identify the relations between cancer patient's genomes and their tumours. HPC can provide enough computational capabilities to analyze cancer genomics data while providing security measures to the sensitive patient genomic datasets. HPC provides computing power to different fields of cancer treatment, like drug development, diagnosis, and for providing personalized treatment plans.

- **Genomic Sequencing**

In 2003, sequencing the first human genome took around 13 years. But as of now by using HPC based technology tools like DRAGEN Platform genomic sequencing can be performed faster than before. The DRAGEN Platform offers hardware based methodologies of genomic analysis algorithms, such as BCL conversion, mapping, alignment, sorting and duplicate marking.

### (b) Engineering and Design

Major aim of engineering is to enhance the machine's real-world performance, and this often requires testing of new designs in massive computer simulations. These simulations run on HPC systems with real world parameters like gravity, heat, wind etc. as per the experiments need to carry out as mentioned below:

- **Lighter Aircrafts**

It requires running massive optimization functions on HPC based systems.

- **Streamlined Bikes**

Rescale's HPC platform is used to precise the aerodynamics of bikes in Trek Bicycles.

- **Fuel Conservation**

HPC tools can be used to analyze engineering designs and its fuel consumption, which can lead to various changes in the design and leading to fuel conservation.

- **Autonomous Vehicle Technology**

Self-driving automobiles recognize when to stop at a signal, due to the decisions made through complex machine learning algorithms sustained through HPC. Microsoft's Azure HPC technology has aided to carry out perception authentication and decision-making for autonomous automobiles, and crash test simulations.

(c) **Aerospace Sector**

HPC techniques are useful in aerospace satellites information gathering and analysis to understand the where about of our Universe in the following fields:

- **Space Research**

It involves the analysis of the existing state of the universe in order to interpret its origin through the cosmic microwave background. This demands HPC based supercomputers to process huge amounts of data; like a few gigabytes of data on a day to day basis that need to be managed in real time.

- **Solar Flare Detection**

Solar flares occur when storms on the Sun's surface pass a beam of charged elements into the Earth's atmosphere that may interfere or disrupt wireless communications, power grid and interrupt GPS systems. To take precautions during such uncertainty HPC based deep-learning algorithmic prediction of solar flare detection methods are needed.

- **Aircraft Flight Simulation**

HPC based simulation software Simulia, can be used to simulate environments in the aircraft flight with the techniques of computational fluid dynamics. This helps designers to test and verify flight dynamic conditions and make measures to alter design and development of aircraft itself. This helps in reducing time, cost and resources rather than doing testing of aircrafts and flight in a real environment.

(d) **Urban Planning and Infrastructure**

Smart Cities collect various data through sensors like weather, traffic pattern, noise levels etc. that helps in making decisions quickly and act accordingly. This demand HPC processing to handle such big data in cases like:

- **Smog Level Forecasting**

HPC based models are capable of forecasting smog incidents much faster than traditional methods by collecting various data like smog cloud movement, weather predictions and air-quality.

- **Internet of Things as Array of Objects**

Internet of Things as array of objects is a system of daily routine objects that can share and receive digital data amongst electric cars, smart light, etc. that make urban planning smarter with the help of sensors for tracking various concerns related to climatic conditions and infrastructure facilities. These array of IoT sensors are capable of collecting data related to various measures like temperature, humidity, atmospheric pressure, day-light, traffic congestions, atmospheric carbon dioxide and carbon monoxide levels, etc. to process these enormous amounts of data in real-time needs HPC.

- **Construction**

HPC is useful in modeling construction projects and reducing the total cost involved in the construction, by simulating different parameters involved in the same like finding the right building material and locating them, and managing the transportation of goods to the construction site.

- **Skyscraper Planning**

Skyscraper planning involves simulation and modeling of energy and water, examination of structural reliability and safety, and many other building measurements and its assessment. Handling these many different parameters and computing these parameters to assess and identify the optimum value require HPC systems.

(e) **Finance and Business**

HPC system architecture and solutions work much faster than normal desktop computers. Thus usage of HPC solutions in finance and business domain give them a commercial benefit while considering the product development and daily business processes.

- **Bitcoin**  
Bitcoin mining is a complex computational process, and the time taken for the same can be reduced to 10 minutes with the usage of proper hardware architecture and software solutions. This demands the HPC processing and solutions in Bitcoin.
- **Computational Problems in Finance**  
HPC systems can scale the performance of various computational problems in finance like: - investment banking, stochastic trading models, automated trading algorithm, Portfolio liquidation, risks in insurance etc.

### 8. HIGH PERFORMANCE COMPUTING SOFTWARE TOOLS AND ITS USAGE :

There are various software tools that can be used to find solutions to different challenges in industrial problems. Table 3 shows a major list of HPC software tools that are used in the industry and its usage in solving industrial problems.

**Table 3:** HPC Software Tools and its uses

S. No.	HPC Software Tools	Usage of HPC Tool
1	CUDA	CUDA (Compute Unified Device Architecture) is a programming language that uses Graphical Processing Unit (GPU) for parallel computing systems. This programming architecture is based on graphical processing units (GPUs). The power of GPUs allows CUDA to develop scalable and powerful solutions.
2	Intel oneMKL	Intel one Math Kernel Library API is a library of optimized math functions for science, engineering, and financial applications. Various math functions available in Intel oneMKL are: - <ul style="list-style-type: none"> <li>▪ BLAS</li> <li>▪ ScaLAPACK</li> <li>▪ LAPACK</li> <li>▪ Sparse solvers</li> <li>▪ Fast Fourier Transforms</li> <li>▪ Vector math</li> </ul>
3	Altair HPC	Altair HPC solutions are used to optimize many parameters of complex computing solutions like advanced scheduling for CPUs and GPUs, Input/output and memory requirements. It can handle: - <ul style="list-style-type: none"> <li>▪ Workload Management &amp; Cloud Computing</li> <li>▪ Usability &amp; Visualization</li> <li>▪ License Management</li> </ul>
4	HPE GreenLake	Hewlett Packard Enterprise GreenLake is the open and secure edge-to-cloud platform that delivers business outcomes faster.
5	DRAGEN	Illumina DRAGEN (Dynamic Read Analysis for GENomics) is a HPC solution framework for computational Biology. It can be used to process a whole genome in under 25 minutes and an exome in < 8 minutes, reducing turnaround times and processing more data in less time.
6	Rescale	Rescale is a software establishment that provides Intelligent Computing for digital research and development solutions. It provides services in areas like: - <ul style="list-style-type: none"> <li>▪ High Performance Computing</li> <li>▪ Cloud Management</li> <li>▪ Computer Aided Design</li> </ul>
7	OpenMPI	Open MPI is an open source Message Passing Interface that allows to extend the features, computing techniques and resources amongst HPC platforms to build best MPI libraries. Open MPI is

		developed and maintained by associates of academic, research, and industry.
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## 9. ABCD ANALYSIS OF HIGH-PERFORMANCE COMPUTING INDUSTRY :

ABCD analysing technique refers to examining a system, model, or concept through focusing on its advantages, benefits, constraints, and disadvantages by narrowing to determinant factors, key factors, and critical constituent elements [37]. ABCD analysis method allows the researcher to interpret the given concepts, ideas, technologies, models, systems, solutions of any problems, strategies, products or services of an organization, resources including material, machine, men, money, and information, systematically by considering various determinant issues related to the problem under analysis [44]. ABCD analysis is a case study based research tool that can be used in an industry or company analysis, that represent each term as mentioned below: -

- A - Advantages
- B - Benefits
- C - Constraints
- D – Disadvantages

ABCD analysis done on a particular industry can provide an extensive list of the industry analysis results with various advantages, benefits, constraints and disadvantages of the specific industry as a system matrix.

### 9.1. Advantages of High-Performance Computing Industry:

(1) Reduced physical testing:

HPC can be used to simulate in many engineering applications that eliminate the need for physical tests. For example, in automobile industries for understanding the effect of automotive accidents, it is easier to perform simulations through HPC rather than the physical test.

(2) Speed:

HPC systems will be able to perform high-end mathematical, scientific, and engineering computations quite faster than conventional methods with modern machine components like CPU, Graphics Processing Units (GPUs), Remote Direct Memory Access (RDMA) and techniques like parallel processing.

(3) Cost:

Faster answers mean less wasted time and money. Cloud-based HPC becomes convenient for small to medium size businesses, as it allows the payment for the services which are used and the services can be added as and when required with additional payment.

(4) Innovation:

HPC drives innovations across every industry, as the progress in computing power will automatically lead the progress in business that uses HPC techniques. Thus changes in HPC domain directly influence the innovative operational procedures in its related industries.

### 9.2. Benefits of High Performance Computing Industry:

(1) Business Excellence:

Increased processing capacity of HPC systems provides benefits to various business domains that require big data analysis or solve engineering calculations. Thus industries using HPC systems will be more powerful and faster when compared to their competitors.

(2) Profit Margins:

Businesses using HPC systems can provide results faster when compared to conventional processing methods, which leads to better profit margins by saving total time of business deliverables.

(3) Streamline Processes:

HPC systems can perform conflicting processes much faster and provide results much quicker to the IT professionals working with the system, which helps in the earlier detection of weak processes in the system and fix with appropriate measures.

(4) Data is the new Currency:

Today's business runs with data and data processing; HPC systems can analyze and produce results at much faster rates, making it a choice for data modeling in various industries and Govt. organizations like:

- Designing of products in the automobile industry
- Identifying the consequences of climate change
- Analysis of clinical trials
- Fraud detection and mule detection in financial industry

### **9.3. Constraints of High-Performance Computing Industry:**

- (1) Shift in the scientific and engineering community to adopt the High-Performance Computing Paradigm:  
It takes enough time and training for the users to adapt to the HPC Paradigm over conventional computational methods that are currently in use.
- (2) Funding for the development of HPC computational tools:  
Development of any computational tools takes many years, substantial man hours of labour and sizable investments before it is available for the ROI (Return on Investment).
- (3) Design and Implementation of HPC based application codes:  
It is challenging the programmers, as HPC demands scalable algorithms that suit parallel computer architecture and a larger domain of complexity.
- (4) Difficulty in Handling Scalable Data Science:  
Any massive HPC system will produce terabytes of data due to parallel computations. Thus extracting information from such large datasets is a challenge.
- (5) HPC demands improved computer performance:  
The HPC system required high memory latency, random access to memory, floating and integer arithmetic etc. to solve any scientific problems. HPC demands high performance standards due to massive parallelization.

### **9.4. Disadvantages of High-Performance Computing Industry:**

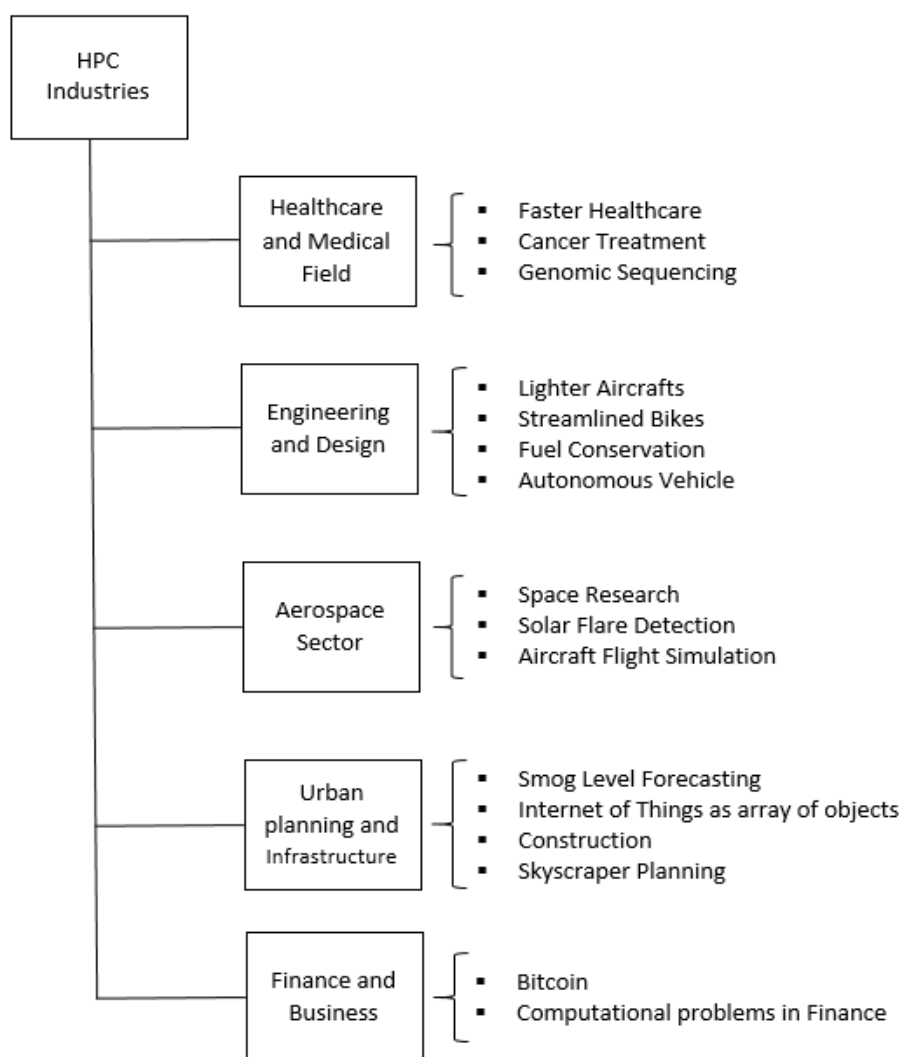
- (1) High Initial Investment to set HPC environment:  
There is high initial investment involved in setting up an HPC environment with many supercomputers that small to medium companies cannot afford.
- (2) Maintenance Cost:  
Maintaining supercomputers will lead to high operational cost.
- (3) Upgradation/Hardware Cost:  
The infrastructure required for the HPC environment needs continuous upgradation to keep the level of performance.  
Higher the number of nodes in the working environment, higher the chance to failure, correction of such failures will lead to higher hardware maintenance cost.
- (4) Software Portability:  
Programs developed for one HPC environment most likely do not work for another, leading to the development of new versions of programs as per environmental changes.
- (5) Employment Issues:  
Lack of experienced workforce to work for HPC environment, will lead to low employee retention or higher wages to the existing members may lead to unhealthy business set up.

## **10. SUGGESTION AND RECOMMENDATIONS :**

Based on the ABCD Analysis of HPC industry, following suggestions are proposed as recommendations:

- (1) HPC systems and applications can be designed and implemented using limited resources and elements.
- (2) Alternate models or designs can be used in HPC systems like parallel computing, cluster computing, grid and distributed computing. This gives an opportunity to a wide range of programmers and users to work with HPC based industrial applications.

- (3) High Performance Computing is the field of study with many industrial applications in the industrial domain of Healthcare and Medical field, Engineering and Design, Aerospace sector, Urban planning and Infrastructure, Finance and Business.
- (4) HPC software tools like CUDA, Intel oneMKL, Altair HPC, HPE GreenLake, DRAGEN, Rescale and OpenMPI can be used to solve problems in various industrial domains that can improve the overall performance of the system.
- (5) Advantages and benefits of HPC in industry make it useful as the next generation technology to solve computational problems with better performance and scale.
- (6) Constraints and disadvantages of HPC in industry do not limit it from being the future industrial domain.
- (7) HPC can be utilized to solve many grand challenges in the following industrial sectors as indicated in Fig. 5



**Fig. 5:** Industries of High-Performance Computing and its grand challenges **Source:** [Author]

## 11. CONCLUSION :

HPC applications can be used to find solutions to many grand challenges like molecular modelling, genome sequencing, simulating car crashes, aircraft flight simulation, skyscraper planning, bitcoin, etc. in industries like healthcare and medical field, engineering and design, aerospace sector, urban planning and infrastructure, finance and business. Various HPC software tools like CUDA, Intel oneMKL, Altair HPC, HPE GreenLake, DRAGEN, Rescale and OpenMPI HPC can be used to find solutions to these grand challenges. The advantages and benefits that are identified with the ABCD analysis on industries that are using HPC technologies shows that it will be the choice for problem solving over conventional



methods. As HPC adds processing power and scalability to the system, the constraints and disadvantages identified do not limit HPC from becoming the next generation technology that needs to handle big data with high processing speed.

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