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***Journal of Scientific and Engineering Research*, 2018, 5(11):359-365**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Mainframe Technology

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Abstract Mainframe technology has been a cornerstone of computing for decades, providing robust, reliable, and scalable solutions for a wide range of industries. This paper provides an overview of mainframe technology, including its history, architecture, and applications.

The paper begins by discussing the history of mainframe technology, tracing its origins to the early days of computing and its evolution into the powerful and versatile systems we have today. It explains how mainframes have remained relevant and indispensable in the face of changing technology trends, thanks to their unique strengths in reliability, security, and scalability.

Next, the paper examines the architecture of mainframe systems, including their hardware and software components. It discusses the key features that distinguish mainframes from other computing platforms, such as their ability to handle large volumes of data, support for multiple operating systems, and advanced security features.

The paper also explores the applications of mainframe technology in various industries, including finance, healthcare, government, and manufacturing. It explains how mainframes are used to process vast amounts of data, support critical business applications, and provide high levels of availability and reliability.

In conclusion, this paper emphasizes the enduring importance of mainframe technology in the modern computing landscape. It underscores the unique strengths of mainframes and their continued relevance in an increasingly digital world.

Keywords Mainframe technology encompasses a wide range of concepts, technologies, and practices. Here are some keywords related to mainframe technology:

Key Words in Mainframe Technology

- Mainframe: A large, powerful, and highly reliable computer system designed for processing large volumes of data and supporting critical business applications.
- IBM zSeries: A family of mainframe computers developed by IBM, known for their scalability, reliability, and security.
- z/OS: An operating system developed by IBM for mainframe computers, known for its stability, security, and support for legacy applications.
- COBOL: A high-level programming language commonly used for developing business applications on mainframe systems.
- Natural: A high-level programming language commonly used for developing business applications on mainframe systems.
- ADABAS: Adabas, the adaptable database, is a high-performance, multithreaded, database management system for mainframe platforms where database performance is a critical factor. It is interoperable, scalable, and portable across multiple, heterogeneous platforms including mainframe, midrange, and PC.

- CICS: Customer Information Control System, a transaction processing system developed by IBM for mainframe computers.
- DB2: A relational database management system developed by IBM for mainframe computers.
- IMS: Information Management System, a hierarchical database management system developed by IBM for mainframe computers.
- JCL: Job Control Language, a scripting language used for submitting batch jobs to mainframe systems.
- TSO: Time Sharing Option, an interactive command-line interface for mainframe systems.
- ISPF: Interactive System Productivity Facility, a software package for developing and managing applications on mainframe systems.
- z/VM: A virtualization technology developed by IBM for mainframe systems, allowing multiple virtual machines to run on a single physical mainframe.
- z/TPF: Transaction Processing Facility, a real-time operating system developed by IBM for mainframe systems, used in industries such as airlines and banking.
- z/VSE: Virtual Storage Extended, an operating system developed by IBM for smaller mainframe systems.
- Parallel Sysplex: A clustering technology developed by IBM for mainframe systems, allowing multiple mainframes to work together as a single system.
- GDPS: Geographically Dispersed Parallel Sysplex, a disaster recovery solution developed by IBM for mainframe systems.
- HMC: Hardware Management Console, a management tool for configuring and monitoring mainframe systems.
- LPAR: Logical Partition, a virtualization technology that allows a single mainframe to be divided into multiple logical partitions, each running its own operating system and applications.
- zAAP: z/Architecture Application Assist Processor, a specialized processor for running Java applications on mainframe systems.
- zIIP: z/Integrated Information Processor, a specialized processor for offloading certain workloads from the main CPU on mainframe systems.
- zBX: zEnterprise BladeCenter Extension, a hybrid computing platform that combines mainframe, POWER, and x86 systems in a single chassis.
- z/OSMF: z/OS Management Facility, a management tool for configuring and monitoring z/OS systems.
- z/OS Connect: A software product that allows z/OS applications to expose their data and services as RESTful APIs.
- z/OS Container Extensions: A technology that allows z/OS applications to run in Docker containers.
- z/OS Cloud Broker: A software product that allows z/OS applications to be deployed and managed in cloud environments.
- z/OS Cloud Provisioning Toolkit: A set of tools for automating the deployment and management of z/OS systems in cloud environments.
- z/OS Cloud Management Console: A management tool for monitoring and managing z/OS systems in cloud environments.
- z/OS Cloud Connector: A software product that allows z/OS applications to access cloud services and resources.
- z/OS Cloud Gateway: A software product that allows z/OS applications to communicate with cloud services and resources.
- z/OS Cloud Security: A set of security features and best practices for securing z/OS systems in cloud environments.
- z/OS Cloud Compliance: A set of compliance features and best practices for ensuring that z/OS systems in cloud environments meet regulatory requirements.
- z/OS Cloud Monitoring: A set of monitoring features and best practices for monitoring the performance and availability of z/OS systems in cloud environments.

1. Introduction

The origins of the mainframe can be traced back to the early days of computing, particularly during the mid-20th century when the need for large-scale data processing and computation became apparent. The term "mainframe" itself emerged in the 1960s, but the concept and technology behind it had been developing for several decades prior.

Here are some key milestones and developments that contributed to the origins of the mainframe:

Punch Card Machines: The use of punch card machines for data processing dates back to the late 19th century. These machines were used for tasks such as tabulating census data and processing payroll.

Electromechanical Computers: In the 1930s and 1940s, electromechanical computers such as the IBM Harvard Mark I and the Atanasoff-Berry Computer (ABC) were developed. These machines used mechanical components and electrical circuits to perform calculations.

Vacuum Tube Computers: In the late 1940s and early 1950s, vacuum tube computers such as the ENIAC and the UNIVAC I were developed. These machines were the first to use electronic components for computation, but they were large, expensive, and unreliable.

Transistor Computers: In the late 1950s and early 1960s, transistor computers such as the IBM 7090 and the CDC 1604 were developed. These machines were smaller, faster, and more reliable than their vacuum tube predecessors.

System/360: In 1964, IBM introduced the System/360, a family of compatible computers that marked a significant milestone in the development of mainframe technology. The System/360 was designed to be scalable, allowing customers to upgrade to larger or more powerful models as their needs grew.

Time-Sharing Systems: In the 1960s and 1970s, time-sharing systems such as CTSS and Multics were developed. These systems allowed multiple users to access a mainframe computer simultaneously, making it possible to share computing resources and reduce costs.

Virtualization: In the 1970s and 1980s, virtualization technologies such as IBM's VM/370 and DEC's VAX/VMS were developed. These technologies allowed multiple virtual machines to run on a single physical mainframe, increasing efficiency and flexibility.

Client/Server Computing: In the 1980s and 1990s, client/server computing became popular, leading to the development of distributed computing architectures. However, mainframes continued to play a critical role in large-scale data processing and transaction processing.

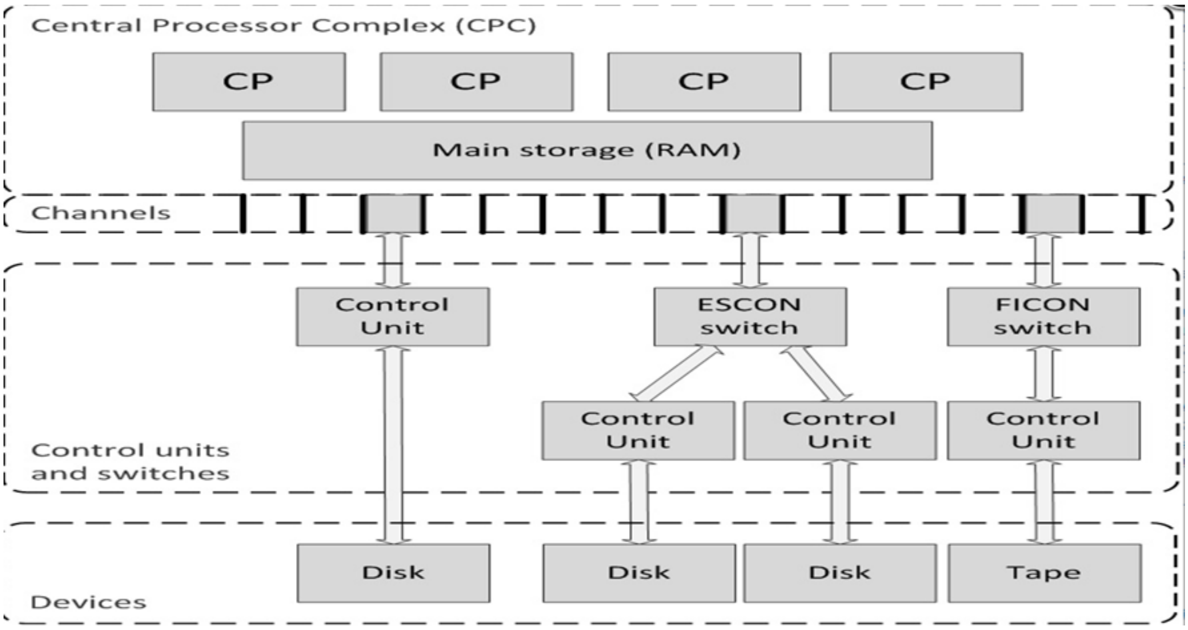
Modern Mainframes: Today, mainframes continue to evolve and adapt to changing technology trends. Modern mainframes, such as IBM's zSeries and zEnterprise systems, are highly scalable, reliable, and secure, making them ideal for mission-critical applications in industries such as finance, healthcare, and government.

Overall, the origins of the mainframe can be traced back to the early days of computing, with key developments in electromechanical, vacuum tube, and transistor technologies paving the way for the modern mainframe. Mainframes have continued to evolve and adapt to changing technology trends, remaining a critical component of the computing landscape.

2. Architecture of Mainframe system

Mainframe architecture

A mainframe consists of processing units (PUs), memory, I/O channels, control units, and devices, all placed in racks (frames). The architecture of a mainframe is shown below



Processing Units

In the mainframe world the term PU (Processing Unit) is used instead of the more ambiguous term CPU. A mainframe has multiple PUs, so there is no central processing unit. The total of all PUs in a mainframe is called a Central Processor Complex (CPC).

The CPC resides in its own cage inside the mainframe, and consists of one to four so-called book packages. Each book package consists of processors, memory, and I/O connections, much like x86 system boards.

Mainframes use specialized PUs (like the quad core z10 mainframe processor) instead of off-the-shelf Intel or AMD supplied CPUs.

All processors in the CPC start as equivalent processor units (PUs). Each processor is characterized during installation or at a later time, sometimes because of a specific task the processor is configured to do. Some examples of characterizations are:

Processor Unit (PU)	**Task**
Central processors (CP)	Central processors are the main processors of the system that can be used to run application running on VM,z/OS, and ESA/390 operating system
CP Assist for Cryptographic Function(CPACF)	CPACF assists the CPs by handling workload associated with encryption/decryption.
Intergrated Facility for Linux(IFL)	IFL assists with Linux workloads: they are regular Pus with a few specific instructions that are needed by Linux
Integrated Coupling Facility(ICF)	This facility excutes licensed internal code to coordinate system tasks
System Assisted Processor(SAP)	A SAP assists the CP with workload for the I/O subsystem,for instance by translating logical channel paths to physical paths.
IBM System z Application Assist Processors(zAAP)	Used for Java code execution
zIIP	Processing certain database workloads
Spares	Used to replace any CP or SAP failure

Main Storage

Each book package in the CPC cage contains from four to eight memory cards. For example, a fully loaded z9 mainframe has four book packages that can provide up to 512 GB of memory.

The memory cards are hot swappable, which means that you can add or remove a memory card without powering down the mainframe.

Channels, ESCON and FICON

A channel provides a data and control path between I/O devices and memory.

Today's largest mainframes have 1024 channels. Channels connect to control units, either directly or via switches. Specific slots in the I/O cages are reserved for specific types of channels, which include the following:

- Open Systems Adapter (OSA) – this adapter provides connectivity to various industry standard networking technologies, including Ethernet
- Fiber Connection (FICON) - this is the most flexible channel technology. With FICON, input/output devices can be located many kilometers from the mainframe to which they are attached.
- Enterprise Systems Connection (ESCON) - this is an earlier type of fiber-optic technology. ESCON channels can provide performance almost as fast as FICON channels, but at a shorter distance.

The FICON or ESCON switches may be connected to several mainframes, sharing the control units and I/O devices.The channels are high speed – today's FICON Express16S channels provide up to 320 links of 16 Gbit/s each.

Control units

A control unit is similar to an expansion card in an x86 or midrange system. It contains logic to work with a particular type of I/O device, like a printer or a tape drive.

- Some control units can have multiple channel connections providing multiple paths to the control unit and its devices, increasing performance and availability.
- Control units can be connected to multiple mainframes, creating shared I/O systems. Sharing devices, especially disk drives, is complicated and there are hardware and software techniques used by the operating system to control updating the same disk data at the same time from two independent systems.
- Control units connect to devices, like disk drives, tape drives, and communication interfaces. Disks in mainframes are called DASD (Direct Attached Storage Device), which is comparable to a SAN (Storage Area Network) in a midrange or x86 environment.

How Does a Mainframe System Work:

Hardware design of mainframe systems accounts for a significantly high number of operations per second. Processing power for these "big iron" machines is measured in MIPS or million instructions per second, which is to be expected as they need to be able to respond to inputs from millions of users simultaneously. They typically have multiple processors and a large memory capacity, allowing them to handle many tasks at once. Mainframes also have extensive security features, which is why they are often used for sensitive data processing. In addition, mainframes are designed for high availability (HI), meaning they can continue operating even if one or more components fail. Currently, 71% of Fortune 500 companies use IBM mainframes. Mainframes may seem like complex machines with many impressive features, but at the end of the day, they are tools that allow us to process large amounts of data quickly and securely.

What Are the Benefits of Using a Mainframe Computer

- A mainframe, by definition, is a type of high-end computer used mainly by large organizations for critical applications. As such, it's still considered a go-to choice for large companies. Here are just a few of the reasons organizations continue to use mainframes:
- Mainframes can handle massive amounts of data. Thanks to their powerful processors and large memory capacity, mainframes can store and quickly process huge amounts of data. This is essential for organizations that rely on data-intensive applications, such as weather forecasting and financial analysis.
- Mainframes are highly scalable. With the ability to add more processors and memory as needed, mainframes can easily keep pace with the growing demands of an organization. The scalability makes mainframes a sound investment for long-term use.
- Mainframes are fault-tolerant. They are designed to minimize downtime in the event of a hardware or software failure. With built-in redundancy and failover capabilities, mainframes can keep mission-critical applications up and running even when there's a problem.

- Mainframes are secure. They use some of the most sophisticated security features, making them ideal for processing sensitive data. In addition, mainframes can be isolated from other systems to reduce security breach risk.
- Mainframe computers offer a unique combination of power, scalability, availability, and security that is unmatched by other types of computers, so it doesn't come as a surprise that so many organizations use them.

What Are the Disadvantages of Using a Computer Mainframe

While mainframes have many advantages, there are also some drawbacks to using this type of computer. Here are some of the disadvantages of using a mainframe:

Mainframes are expensive. Mainframes are complex machines with many features, making them quite costly. The initial purchase price of a mainframe can be hundreds of thousands of dollars, and the ongoing costs of running a mainframe can also be significant. Mainframes require specialized hardware and software. To run a mainframe, you need specialized hardware and software. This can make finding the right equipment and trained personnel a challenge. Mainframes can be difficult to manage and maintain. Mainframes are complex machines that require careful management and maintenance. If something goes wrong, fixing the problem can be very difficult (not to mention expensive).

<u>How Has the Use of Mainframe Computers Changed Over Time:</u>

The use of mainframe technology has changed dramatically over the past few decades. In the early days of mainframe computing, businesses used these massive machines to perform a limited number of tasks, such as payroll and inventory management. However, as mainframes became more powerful, they began to take on a wider range of functions. Today, businesses use mainframes for everything - from managing customer data to powering eCommerce sites. And as the internet of things continues to grow, mainframes will likely play an even more important role in our lives.

Are There Any Alternatives to Using a Mainframe Infrastructure

Yes, there are several alternatives to using a mainframe. However, it's important to note that mainframes still offer some advantages over these other types of computers. For example, mainframes are more powerful and scalable than other computing infrastructures. In addition, mainframes are designed to be highly available and secure. However, if you're looking for something different, here are some of the most popular alternatives to a mainframe:

- Client-Server Architecture
- Client-server architecture is a distributed computing model in which client computers request and receive data from server computers that manage resources for the user. This type of architecture is often used in business applications.
- Cloud Computing
- Cloud computing is an internet-based infrastructure that delivers shared computer processing resources and data on demand. This type of computing is popular for web-based applications.
- Grid Computing
- Grid computing is a type of distributed computing that uses a network of computers to solve a single complex problem. It has many applications in scientific and engineering applications.

Conclusion

While mainframes aren't as prevalent as before, we've seen how indispensable they are in specific industries. They're not going anywhere anytime soon, and the demand for mainframe skills is only growing. A report by IBM found that 65% of organizations plan to increase or maintain their investment in mainframes over the next five years.

Such powerful machines are finding even more applications in data science or big data analytics fields. While only enterprises or well-funded projects can afford such hardware, having it at their disposal is perfect for various research projects, as mainframes can process information in real-time. It's also important to note that mainframes account for around 6% of global IT spending, while it's estimated that they handle 68% of the industry's production workload. The future of mainframes looks bright. Thanks to their power, extensibility, and dependability, mainframes will continue to be a vital part of the IT landscape.

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