# Mainframe OS

# Course Objectives

1. To introduce IBM Z Mainframe Technology.
2. To learn industry-critical enterprise computing skills.
3. To introduce IBM Mainframe Operating System z/Os.
4. To learn z/Os Access and Interaction Basics.
5. To study the Operating System Environment for computing.
6. To learn z/Os REXX, COBOL Programming.

# Course Outcomes

After completion of the course, learners should be able to:

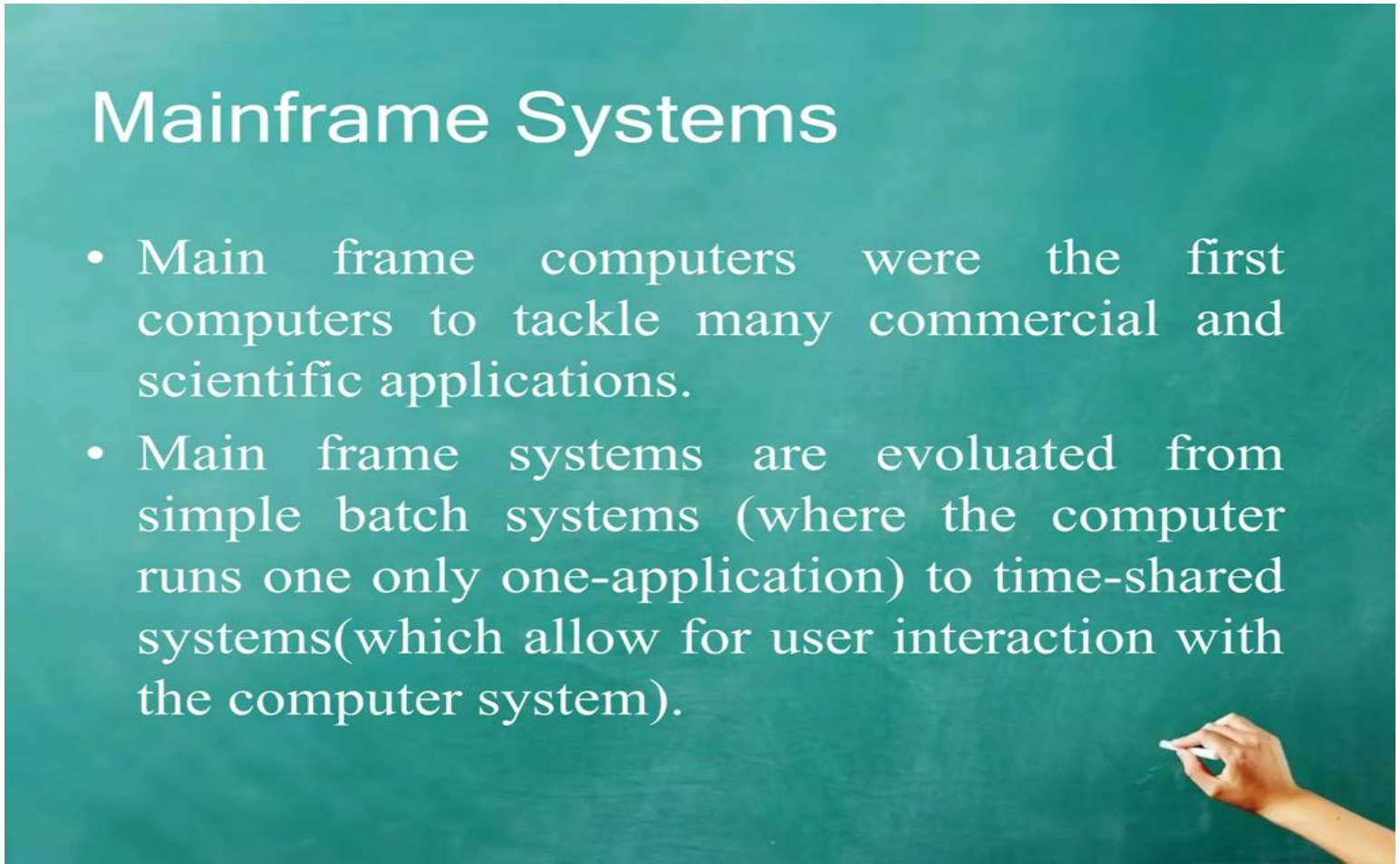
1. CO1: Understanding of IBM Z Mainframe Technology.
2. CO2: Apply the industry-critical enterprise computing skills.
3. CO3: Apply IBM Mainframe Operating System z/OS for Large Enterprise.
4. CO4: Apply z/Os Access and Interaction Basics.
5. CO5: Design and develop a program for Job Control Language using z/OS.
6. CO6: Design and develop a program for REXX, COBOL using z/OS.

# Unit-I:
# Introduction to IBM Z Mainframe Technology

- Introducing IBM Z Hardware, IBM z16, IBM z16 single frame, IBM z16 rack mount.
- IBM z15 T01 and T02 machines, Applications of IBM Z.
- Modern Mainframe innovations: z15 and z16 systems.
- Containerization and Kubernetes on Mainframes.
- Mainframe Hardware components such as Central Processing Unit (CPU), Memory and Storage Systems, Input/Output Devices.
- Case studies of Mainframe implementations.

# Introduction

- A highly Secured computer system designed to continuously run large, mixed workloads at high levels of utilization while meeting user-defined service level objectives



# What are Mainframe operating systems ?

- Mainframe = Computer that can support **thousands of applications and I/O devices** to simultaneously serve **thousands of users**
- Most mainframe computers are sold by IBM, and the operating systems are also provided by IBM
- z/OS, is IBM's foremost **mainframe operating system**

The presence of a mainframe often implies a centralized form of computing, as opposed to a distributed form of computing.

# Why Mainframes ?

The most important features the mainframe provides include:

- Encrypt sensitive data as it crosses the network
- Protect encryption keys
- Provide well-known security configurations that achieve or surpass the industry standard

# Difference between Supercomputer and Mainframe

| Parameters | Supercomputer | Mainframe Computer |
|---|---|---|
| Basics and Implementation | The primary function of a supercomputer is to perform various large computations of mathematics that might be complex in nature. | The primary function of a mainframe computer is the storage of large amounts of databases in them. |
| Invention | Seymour Cray invented the first successful Supercomputer back in 1976- known as the Cray 1. | IBM came up with the first-ever mainframe computer. It is still the most popular company that develops these computers. |
| Speed | These can feasibly perform the execution of billions of floating-point operations in just a second. | These can perform simultaneous execution of millions of instructions at the same time. |
| Size | These are basically the largest computers till today in the world. | These are also pretty large but smaller than the supercomputers in size. |
| Expense | These are the most expensive type of computers in the world. | These are also comparatively more expensive than a majority of computers but cheaper than supercomputers. |
| OS (Operating Systems) | Supercomputers (modern ones) make use of the Linux OS and its derivative variants. | A typical mainframe computer is capable of running multiple OS simultaneously. |
| Performance | The performance of these computers is faster and much better. It is because of their ability to execute billions of operations per second. | These can simultaneously execute and perform millions of operations together- but they are slower and less efficient than supercomputers. |

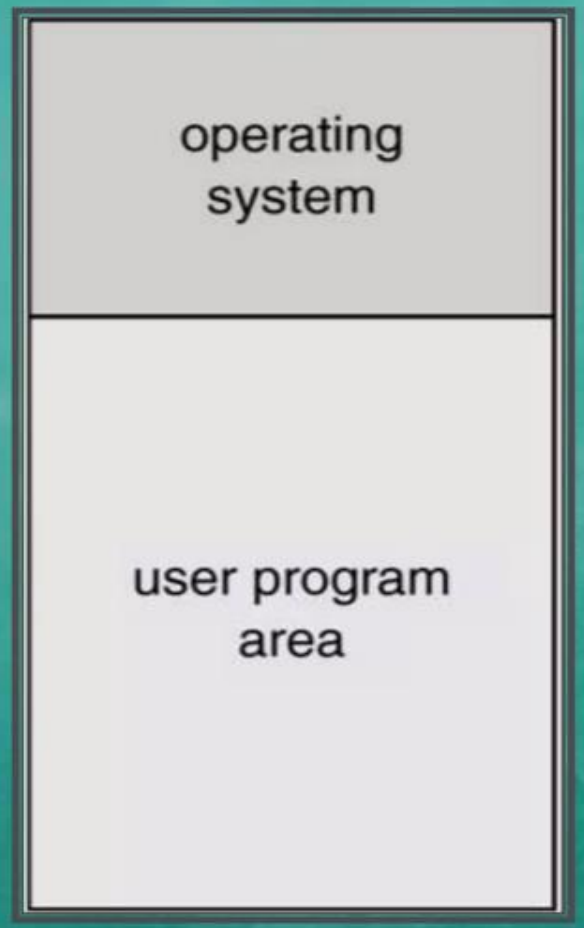
# Mainframe history

- In **1950s**, mainframe computers were physically the largest computers; few businesses could afford them
- In the **1960s**, with standardized mainframe customers could write business applications that didn’t need specialized hardware or software
- In **1964**, the introduction of the IBM System/360 (or S/360™) signalled the start of the 3G : first general purpose computers

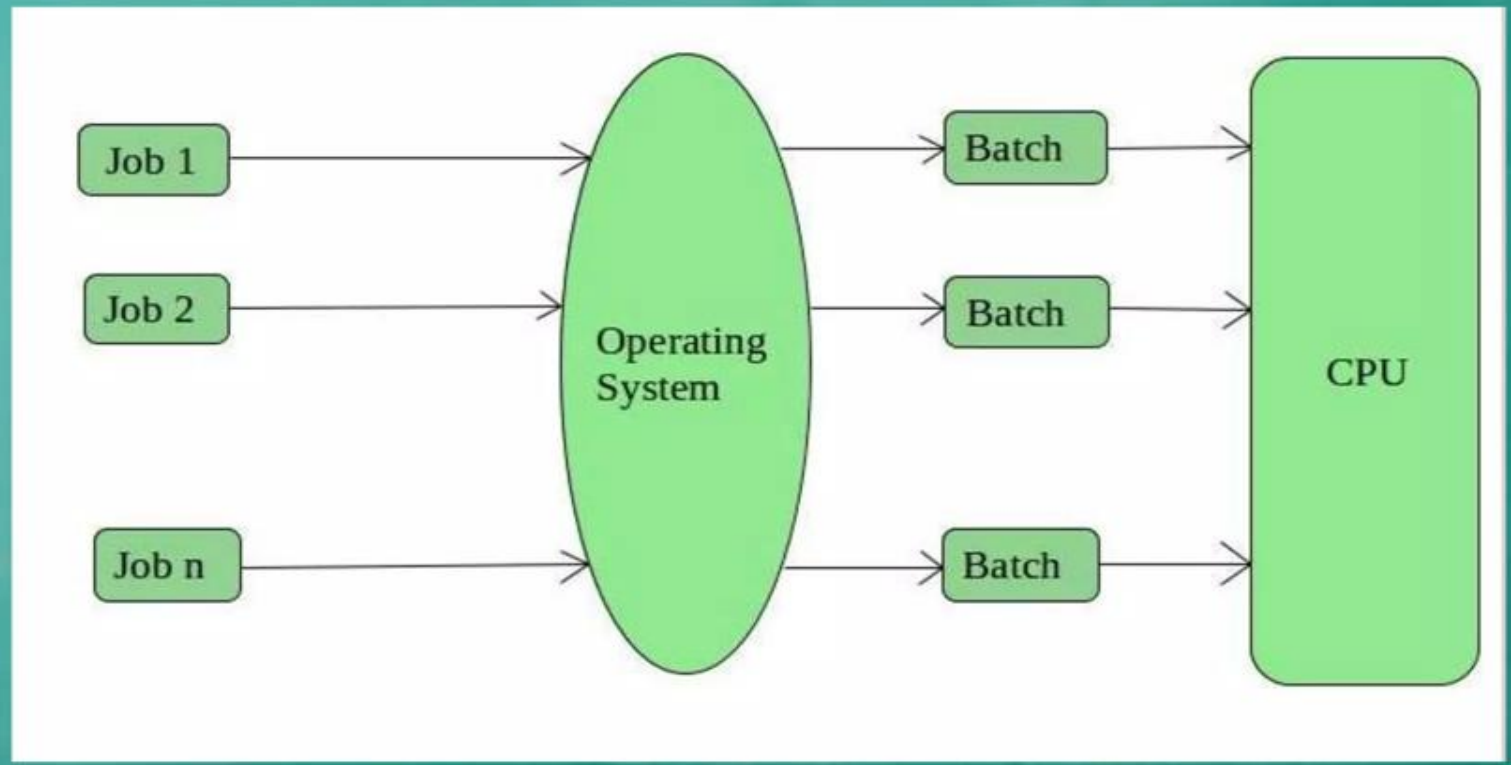
# I. Batch Systems

- The users who using a batch operating system do not interact with the computer directly.
- Each user prepares its job on an off-line device like punch cards and submits it to the computer operator.
- To speed up the processing, jobs with similar needs are batched together and run as a group.
- The programmers exit their programs with the operator and the operator then sorts the programs with similar requirements into batches.
- All the jobs of one batch are executed together.

# I. Batch Systems (memory layout)



# I. Batch Systems



# I. Batch Systems - Advantages

- It is very difficult to guess or know the time required for any job to complete. Processors of the batch systems know how long the job would be when it is in queue.
- Multiple users can share the batch systems.
- The idle time for the batch system is very less.
- It is easy to manage large work repeatedly in batch systems.

# I. Batch Systems - Disadvantages

- The computer operators should be well known with batch systems.
- Batch systems are hard to debug.
- It is sometimes costly.
- The other jobs will have to wait for an unknown time if any job fails.
- All the jobs of a batch are executed sequentially one after the other.
- The output is obtained only after all the jobs are executed.
- Thus, priority can not be implemented if a certain job has to be executed on an urgent basis.
- Batch operating system may lead to starvation.
- There is a lack of interaction between a user and his job.

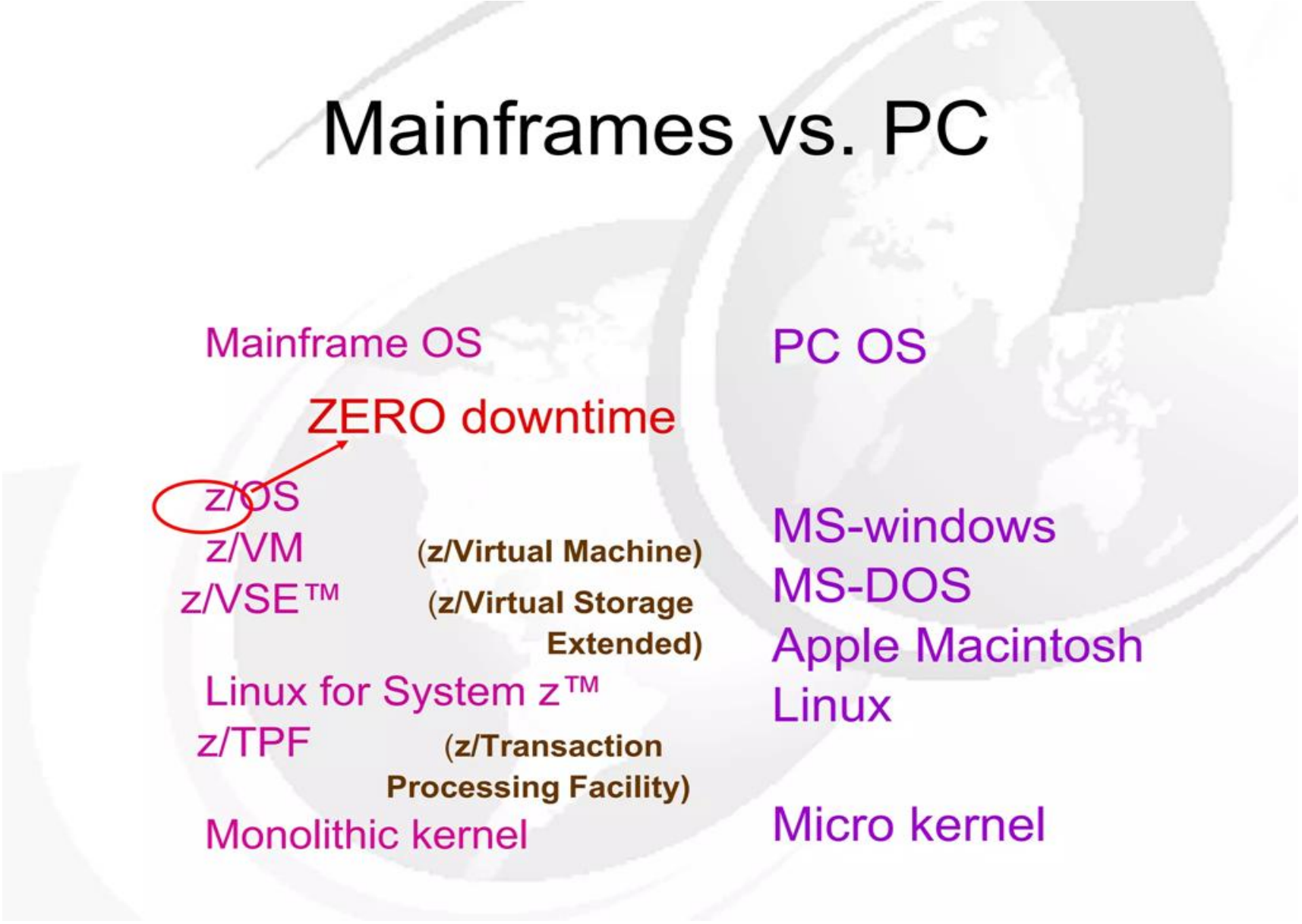
# Factors contributing to mainframe use

- Reliability, availability, and serviceability (RAS-RAS is ubiquitous in the mainframe.)
- Security
- Scalability
- Continuing compatibility
- Evolving architecture
- Extensibility
- Lower total cost of ownership (TCO)
- Environmental friendliness

# Factors contributing to mainframe use

- Reliability: The system's hardware components have extensive self-checking and self-recovery capabilities.
- Availability:The ability to recover from the failure of a component without impacting the rest of the running
- system.
- Serviceability:implies well-defined units of replacement, either hardware or software.
- Security: data security is defined as protection against unauthorized access, transfer, modification, or destruction, whether accidental or intentional.
- scalability:ability of the hardware, software, or a distributed system to continue to function well as it changes in size or volume,both vertical and horizontal scaling
- Compatibility: The ability of a system both to run software requiring new hardware instructions and to run older software requiring the original hardware instructions.
- Evolving architecture: Each new generation of this platform provides a strong combination of past mainframe characteristics plus new functions designed around scalability, availability, and security.
- Extensions can be added through the addition of new functionality or through modification of existing functionality.

# Mainframes vs. PC



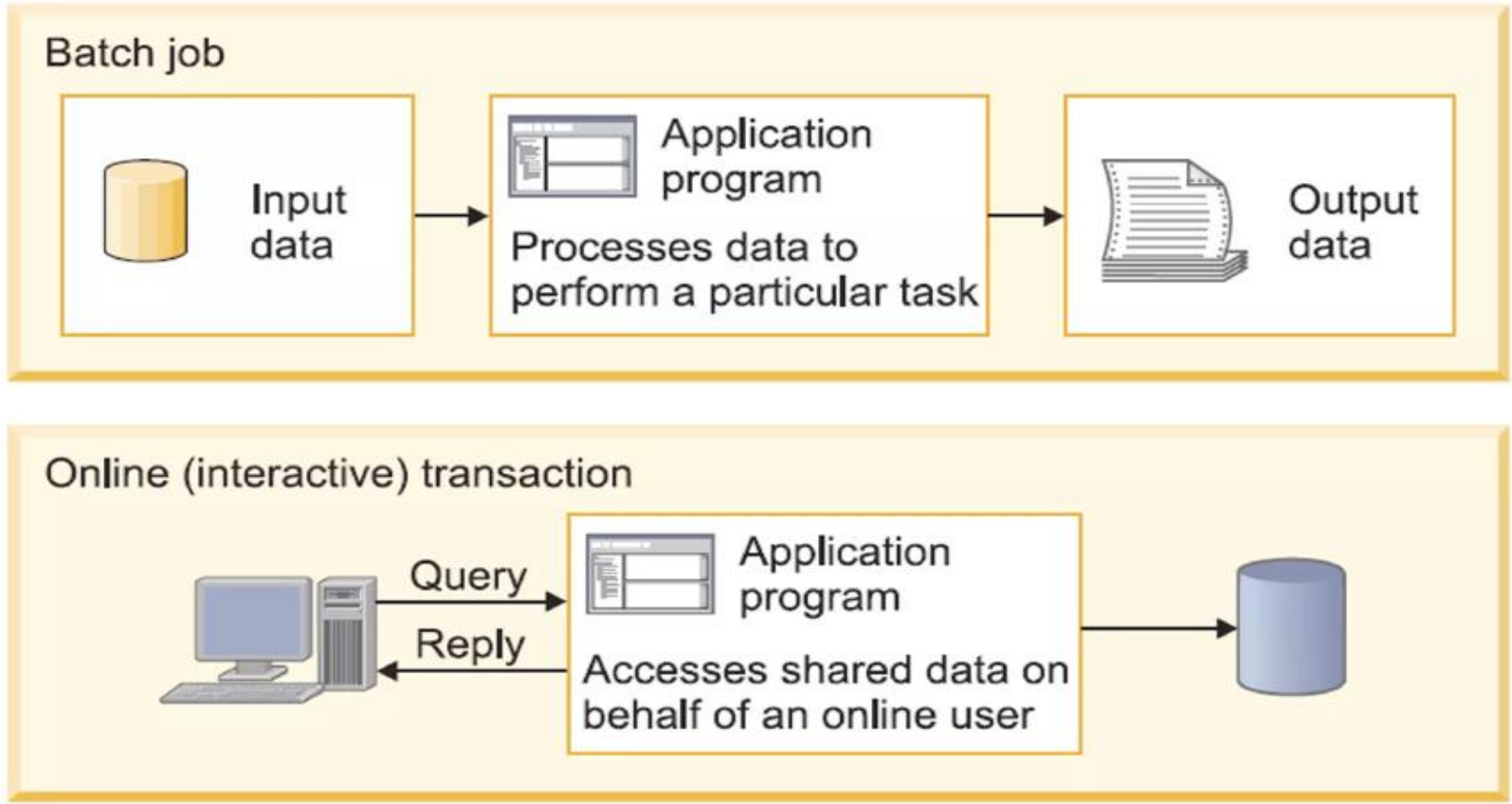

Earlier versions: OS/360, OS/390, and MVS (Multiple Virtual Storage).

# Basics of Mainframe OS

Most mainframe workloads fall into one of two categories:

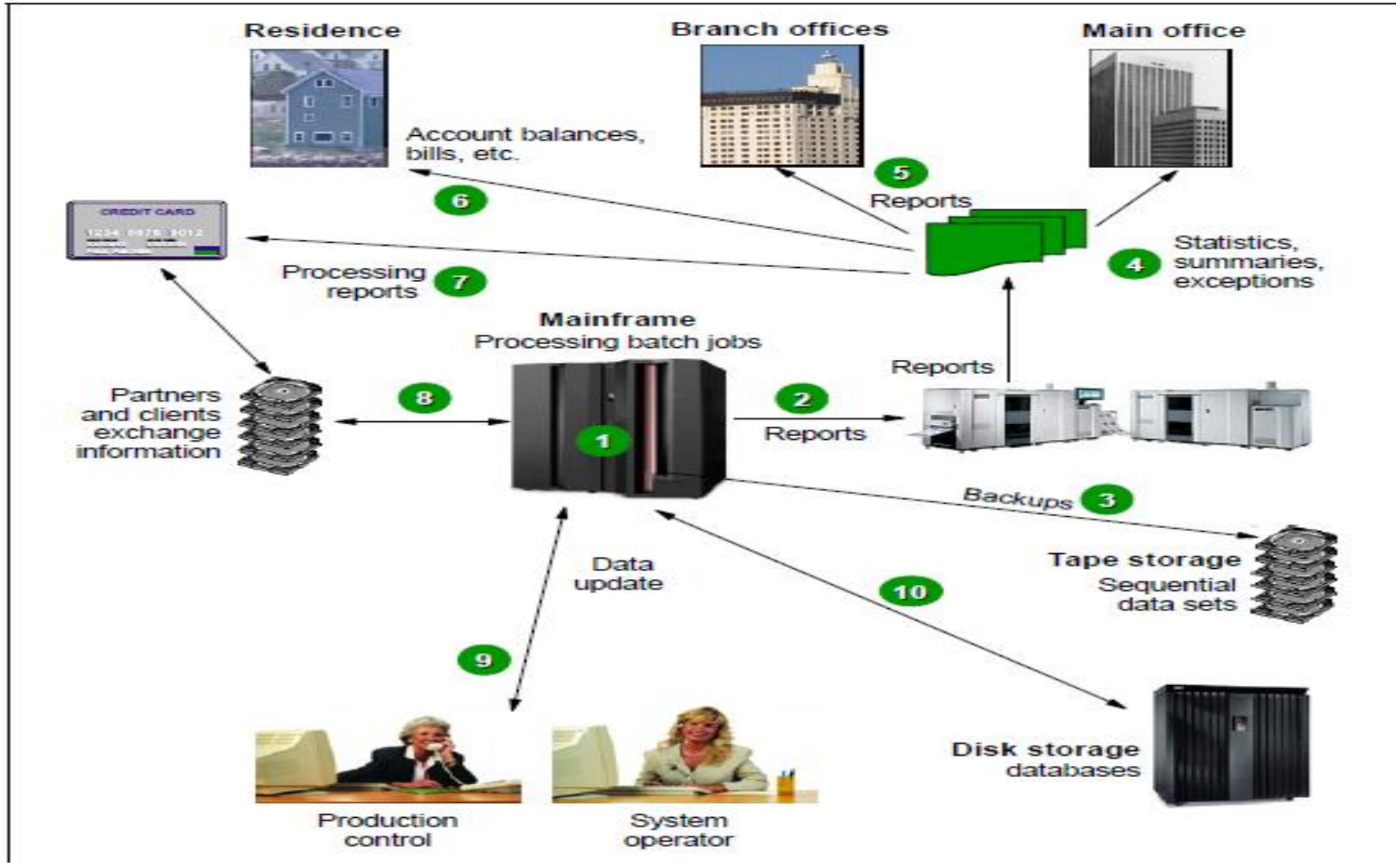
- batch processing or
- online transaction processing-web-based applications

# Mainframe workloads: Batch and online transaction processing



# Batch processing

- Batch processing occurs without user interaction
- Characteristics:
  - A *batch job* is **submitted** on the computer;
  - the job reads and **processes data** in bulk— perhaps terabytes of data
  - **produces output in bulk** — such as customer billing statements
- Scheduled batch process : execution of thousands of jobs in a pre-established sequence.




Today's mainframes can run standard batch processing, such as COBOL, and UNIX and Java programs.

# Batch processing

1. At night, numerous batch jobs running programs and utilities are processed. These jobs consolidate the results of the online transactions that take place during the day.
2. The batch jobs generate reports of business statistics.
3. Backups of critical files and databases are made before and after the batchwindow.
4. Reports with business statistics are sent to a specific area for analysis the next day.
5. Reports with exceptions are sent to the branch offices.
6. Monthly account balance reports are generated and sent to all bank customers.
7. Reports with processing summaries are sent to the partner credit card company.
8. A credit card transaction report is received from the partner company.
9. In the production control department, the operations area is monitoring the messages on the system console and the execution of the jobs.
10. Jobs and transactions are reading or updating the database (the same one that is used by online transactions) and many files are written to tape

# OnLine Transaction Processing

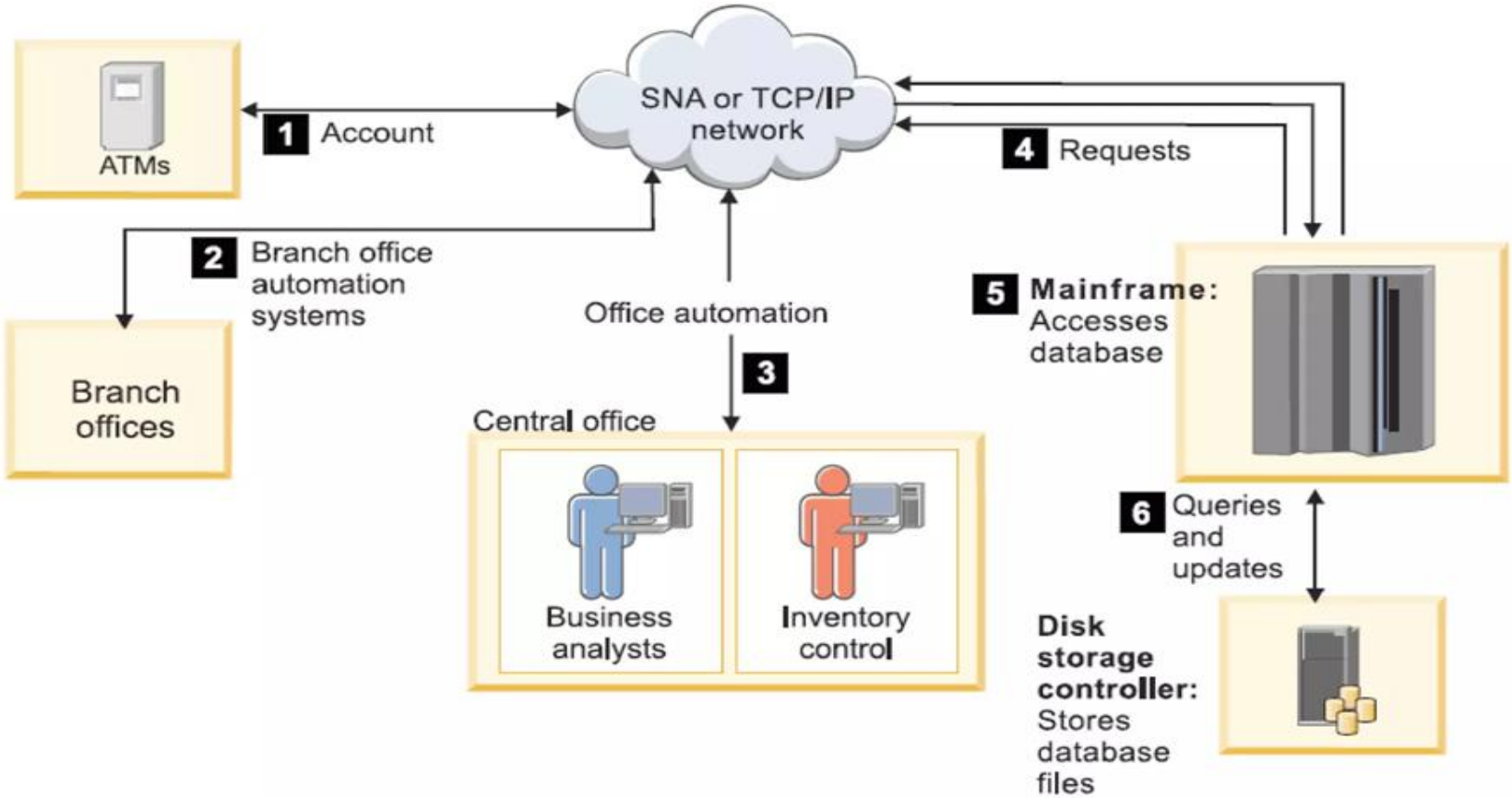
- Transaction processing that occurs interactively with the user is referred to as online transaction processing (OLTP).
- Typically, mainframes serve a vast number of transaction systems.
- continuous availability, high performance, and data protection and integrity are required.
- ATM machine transactions, such as deposits, withdrawals, inquiries, and transfers
- Supermarket payments with debit or credit cards
- Purchase of merchandise over the Internet
- Some industry uses of mainframe-based online systems include:
  - Banks: ATMs, teller systems for customer service, and online financial systems
  - Insurance: Agent systems for policy management and claims processing
  - Travel and transport: Airline reservation systems
  - Manufacturing: Inventory control and production scheduling
  - Government: Tax processing, and license issuance and management

# OnLine Transaction Processing

- Online transactions usually have the following characteristics:
  - A small amount of input data, a few stored records accessed and processed,
  - and a small amount of data as output
  - Immediate response time, usually less than one second
  - A large numbers of users involved in large numbers of transactions
  - Round-the-clock availability of the transactional interface to the user
  - Assurance of security for transactions and user data

**Systems Network Architecture** (SNA) is a data communication architecture established by IBM

# Typical online use



# Online Transaction Processing

1.A customer uses an ATM, which presents a user-friendly interface for various functions: withdrawal, query account balance, deposit, transfer, or cash advance from a credit card account.

2. Elsewhere in the same private network, a bank employee in a branch office performs operations, such as consulting, working with fund applications, and money ordering.

3. At the bank's central office, business analysts tune transactions for improved performance. Other staff use specialized online systems for office automation to perform customer relationship management, budget planning, and stock control.

4. All requests are directed to the mainframe computer for processing.

5. Programs running on the mainframe computer perform updates and inquiries to the database management system (for example, DB2).

6. Specialized disk storage systems store the database files.

# Mainframes vs. PC

| Mainframe | PC |
| --- | --- |
| ✓ Batch jobs | ✗ Batch jobs |
| ✓ Multiuser | ✗ Multiuser |

# Unit-I:
# Introduction to IBM Z Mainframe Technology

- Introducing IBM Z Hardware, IBM z16, IBM z16 single frame, IBM z16 rack mount.
- IBM z15 T01 and T02 machines, Applications of IBM Z.
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- Case studies of Mainframe implementations.

# Introducing IBM Z Hardware

- Mainframes are a technical marvel that play a key role in running commercial businesses across the globe and are very critical to commercial databases, transaction servers and applications that require high resilience, security, and agility.
- The IBM Z Xplore Learning Platform is aimed to equip you with the basics of IBM Z mainframe skills methodically.
- The world of mainframe can be very exciting, and this course will help you understand it in a comprehensive manner.
- IBM has a rich history in computing, known for its pioneering work with mainframes.
- Mainframes play a crucial role in modern enterprise IT, known for their reliability, security, and massive processing power.

# IBM z16

The IBM z16 mainframe is the flagship model, offering the most advanced features and highest performance in the z16 series. It includes:

- **Processor**: High-performance, multi-core processors designed for large-scale enterprise workloads.
- **Memory**: Large memory capacity to support extensive in-memory databases and applications.
- **I/O Capabilities**: Advanced I/O options for high-speed data transfer and connectivity.
- **Security**: Enhanced security features, including pervasive encryption and quantum-safe cryptography.
- **AI Integration**: Built-in AI accelerators to support real-time analytics and machine learning workloads directly on the mainframe.

# IBM z16 Single Frame

The single frame configuration is a more compact version of the IBM z16, suitable for environments where space is limited but high performance is still required. It typically includes:

- **Processor**: Similar high-performance processors as the full z16 but in a smaller form factor.
- **Memory**: Sufficient memory to handle significant workloads within a smaller footprint.
- **I/O Capabilities**: Advanced I/O options, though potentially fewer than the full z16.
- **Security**: Full suite of security features from the z16 line.
- **AI Integration**: AI accelerators included, similar to the full z16.

# IBM z16 Rack Mount

The rack mount configuration is designed for integration into existing data center racks, providing flexibility and scalability. Key features include:

- **Processor**: High-performance processors optimized for rack-mounted environments.
- **Memory**: Adequate memory to support enterprise applications in a rack form factor.
- **I/O Capabilities**: Tailored for rack-mounted systems, with connectivity options for integration into existing infrastructure.
- **Security**: Comprehensive security features, including encryption and quantum-safe options.
- **AI Integration**: AI capabilities integrated into the rack-mounted system for on-premises analytics and machine learning.

The IBM z16 Single Frame and Rack mount Configurations have:

-99.99999% Availability
-Up to 68 Cores
-Up to 16 TB RAM
-AI Acceleration
-Quantum-safe Security
-Flexible Capacity for Cyber Resiliency
-Continuous Compliance
-Rack Mount Bundles
-Compression Accelerator
-Sustainability
-Sort Accelerator
-Flexible Configuration
-Remote Code Load
-Tailored Fit Pricing
-Enhanced System Recovery Boost

- The single frame and rack mount configurations can potentially reduce a client's carbon footprint using partition-level power monitoring capabilities and additional environmental metrics.

# Comparison of IBM z16, IBM z16 Single Frame & IBM z16 Rack Mount

| Feature | IBM z16 | IBM z16 Single Frame | IBM z16 Rack Mount |
|---|---|---|---|
| **Processor** | High-performance, multi-core processors | High-performance, multi-core processors | High-performance, multi-core processors |
| **Memory** | Large capacity for in-memory databases | Significant capacity within smaller footprint | Adequate for enterprise applications |
| **I/O Capabilities** | Advanced I/O options for high-speed data transfer | Advanced I/O, fewer than full z16 | Tailored for rack integration |
| **Security** | Pervasive encryption, quantum-safe cryptography | Full suite of z16 security features | Comprehensive security, including encryption |
| **AI Integration** | Built-in AI accelerators for real-time analytics | AI accelerators included | Integrated AI capabilities for on-premises analytics |
| **Form Factor** | Full-size mainframe | Compact single frame | Rack-mounted configuration |
| **Scalability** | Highest scalability | Moderate scalability | Flexible and scalable within rack infrastructure |
| **Space Requirement** | Dedicated space required | Smaller dedicated space | Fits into existing data center racks |
| **Use Case** | Large-scale enterprise workloads | Enterprises with limited space but high performance needs | Integration into existing data centers with rack systems |

# Key Comparison Factors of IBM z16, IBM z16 Single Frame, & IBM z16 Rack Mount

1. **Form Factor and Deployment:**
   - **IBM z16:** Traditional mainframe chassis
   - **IBM z16 Single Frame:** Compact mainframe for environments with space and power constraints
   - **IBM z16 Rack Mount:** Standard rack-mountable for modern data centers
2. **Performance:**
   - **IBM z16, Single Frame, and Rack Mount:** All offer similar performance capabilities with up to 200 cores and up to 40 TB memory
3. **Power Efficiency:**
   - **IBM z16 Single Frame:** Optimized for power efficiency compared to the standard z16
4. **Flexibility and Scalability:**
   - **IBM z16 Rack Mount:** Offers greater flexibility and scalability for data centers using standard rack configurations
5. **Target Use Case:**
   - **IBM z16:** Enterprises with traditional data center setups
   - **IBM z16 Single Frame:** Enterprises with limited space/power resources
   - **IBM z16 Rack Mount:** Data centers needing mainframe capabilities in rack form factor

# IBM z16 Rack Mount


https://www.youtube.com/watch?v=pEW5fLdAaqE&list=PPSV

# IBM z15

- IBM z16 delivers 1.5x more cache capacity per core over the IBM z15 and reduced average access latency and this is vitally important for the customer base who rely on the transactional processing capabilities of their mainframe systems
- **Network Latency**:If you click a link on a webpage, the time it takes for the page to start loading is influenced by network latency.
- Disk LatencyThe time it takes for a file to open after you double-click it.
- **CPU Latency**:The time it takes for a CPU to process a command after it's issued by a program.
- **I/O Latency**:The delay between pressing a key and seeing the corresponding character appear on the screen.

- The IBM z15 T01 and T02 models are both part of the IBM z15 family of mainframes, but they differ in several key aspects, including performance, features, and intended use cases.
- A **core** is essentially an independent processing unit within a CPU that can execute instructions. Each core has its own set of execution units, registers, and caches. Modern CPUs often have multiple cores, which enables them to perform multiple operations concurrently.

# IBM z15 T01 Machines

- **Processor**: High-performance processors with multiple cores to handle large enterprise workloads.
- **Memory**: Large memory capacity to support extensive applications and in-memory databases.
- **I/O Capabilities**: Advanced I/O options for high-speed data transfer and connectivity.
- **Security**: Features include pervasive encryption, secure boot, and tamper-resistant cryptographic coprocessors.
- **Form Factor**: Standard mainframe size, typically used in dedicated data center spaces.
- **Scalability**: Highly scalable to meet the demands of growing enterprise applications.

# IBM z15 T02 Machines

- **Processor**: Similar high-performance processors as T01 but optimized for different workloads.
- **Memory**: Adequate memory capacity, though typically less than T01, suitable for significant enterprise applications.
- **I/O Capabilities**: Advanced I/O, though potentially fewer options than T01.
- **Security**: Comprehensive security features, including encryption and secure boot.
- **Form Factor**: More compact than T01, allowing for use in space-constrained environments.
- **Scalability**: Moderately scalable, suitable for medium to large enterprise workloads.

# Comparison of IBM z15 T01 and T02 Machines

| Feature | IBM z15 T01 | IBM z15 T02 |
|---|---|---|
| **Introduction** | First model in z15 series | Enhanced version of T01 |
| **Processor** | High-performance, multi-core processors | High-performance, multi-core processors (optimized) |
| **Memory** | Large capacity | Significant capacity, less than T01 |
| **I/O Capabilities** | Advanced I/O options | Advanced I/O, fewer than T01 |
| **Security** | Pervasive encryption, secure boot, tamper-resistant cryptographic coprocessors | Comprehensive security features, including encryption |
| **Form Factor** | Standard mainframe size | More compact, suitable for constrained spaces |
| **Scalability** | Highly scalable | Moderately scalable |
| **Use Case** | Large-scale enterprise workloads | Medium to large enterprise workloads |

# Applications of IBM Z

## Financial Services:

- **Transaction Processing**: Handling millions of transactions per second with high reliability and speed.
- **Fraud Detection**: Real-time analytics and AI capabilities to detect and prevent fraud.
- **Risk Management**: Advanced analytics to manage financial risks and ensure compliance with regulations.

## Healthcare:

- **Patient Data Management**: Securely storing and processing large volumes of patient data.
- **Clinical Research**: Analyzing medical data for research and development of new treatments.
- **Billing and Claims Processing**: Efficient processing of billing and insurance claims.

# Applications of IBM Z

## Retail:

- **Inventory Management**: Real-time tracking of inventory levels and supply chain management.
- **Customer Insights**: Analyzing customer data to improve sales and marketing strategies.
- **E-commerce**: Supporting high-volume online transactions and maintaining website performance.

## Government:

- **Citizen Services**: Managing data and transactions related to public services and benefits.
  including personal records, transaction histories, and service details. integrate data from various sources, such as tax records, social security, and health services, enabling a unified view of citizen information.
- **Tax Processing**: Handling large-scale tax filings and payments securely and efficiently.
- **National Security**: Protecting sensitive data and supporting defense applications.

# Applications of IBM Z

## Telecommunications:

- **Network Management**: Monitoring and managing telecom networks to ensure uptime and performance.
- **Billing Systems**: Processing billing information for millions of customers accurately.
- **Customer Relationship Management (CRM)**: Managing customer data and interactions.

## Transportation and Logistics:

- **Fleet Management**: Tracking and managing transportation fleets in real-time.
- **Supply Chain Optimization**: Enhancing supply chain efficiency through advanced analytics.
- **Reservation Systems**: Handling reservations and ticketing for airlines, trains, and buses.

# Applications of IBM Z

## Insurance:

- **Policy Management**: Administering policies, claims, and underwriting processes.
- **Actuarial Analysis**: Using data to assess risk and determine premiums.
- **Customer Service**: Managing customer interactions and service requests.

## Energy and Utilities:

- **Grid Management**: Monitoring and managing energy grids to ensure reliable service.
- **Smart Metering**: Analyzing data from smart meters for efficient energy usage.
- **Billing and Payments**: Processing billing and payment transactions for utility services.

# Applications of IBM Z

- **Data Warehousing and Analytics**:
  - **Big Data**: IBM Z systems can process and analyze vast amounts of data, enabling real-time analytics and business intelligence.
  - **Predictive Analytics**: Used in industries like finance and healthcare for risk assessment, fraud detection, and predictive maintenance.
- **Cloud and Virtualization**:
  - **Hybrid Cloud**: IBM Z supports cloud-native applications and can integrate with public and private cloud environments, providing a secure and scalable solution for cloud computing.
  - **Virtualization**: High levels of virtualization support allow multiple workloads to run simultaneously with high efficiency and security.

# Modern Mainframe innovations: IBM z15 Systems

**introduced in September 2019, to meet the demands of modern enterprise computing**

1. **Data Privacy Passports**: Enable secure and private sharing of data across the hybrid cloud, controlling who accesses data and ensuring data protection.
2. **Instant Recovery**: Minimizes downtime and accelerates recovery, improving system availability and resilience.
3. **Cloud-native Development**: Supports cloud-native applications with Kubernetes, OpenShift, and other container technologies, enabling faster deployment and management.
4. **Encryption Everywhere**: Provides pervasive encryption to protect data in flight and at rest without impacting performance.
5. **High Performance**: Enhanced processor capabilities and memory to handle intensive workloads efficiently.
6. **Secure Service Container**: Isolates applications and their data from other parts of the system to enhance security.
7. Integrated AI: Built-in support for AI and machine learning workloads, leveraging frameworks like TensorFlow, PyTorch, and IBM Watson Machine Learning.

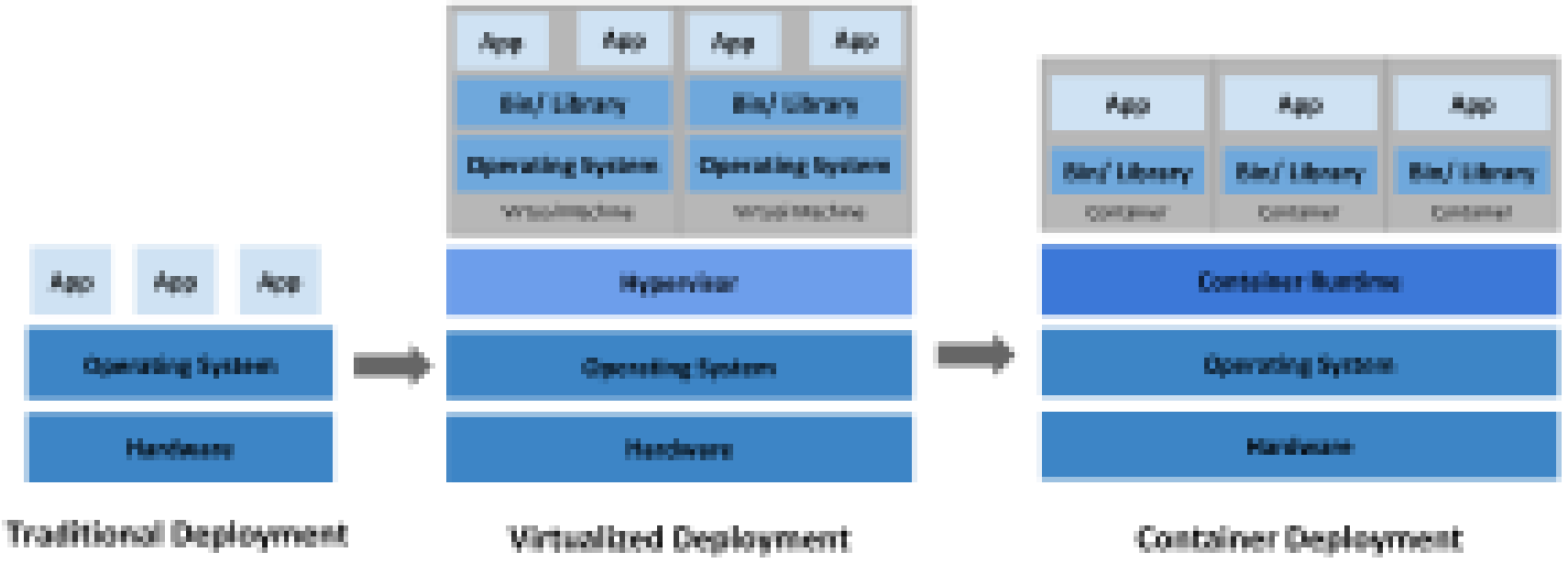
# Modern Mainframe innovations: IBM z16 Systems

1. **AI on-chip**: Integrated AI accelerators enable real-time inference and analytics directly on the mainframe, reducing latency and improving performance.
2. **Quantum-safe Cryptography**: Implements cryptographic algorithms resistant to quantum computing threats, ensuring long-term data protection.
3. **Enhanced Scalability**: Supports larger workloads and greater scalability, ideal for growing enterprise needs.
4. **Improved Data Privacy**: Builds on z15's data privacy features with enhanced capabilities for data protection and compliance.
5. **Advanced Security**: Provides robust security features, including advanced threat detection and response capabilities.
6. **Hybrid Cloud Integration**: Seamlessly integrates with hybrid cloud environments, facilitating easier management and deployment of applications across multiple cloud platforms.

# Comparative Overview: Modern Mainframe innovations: IBM z15 & z16 Systems

| Feature | IBM z15 | IBM z16 |
|---|---|---|
| **Data Privacy** | Data Privacy Passports | Enhanced data privacy features |
| **Recovery** | Instant Recovery | Enhanced recovery capabilities |
| **Cloud-native Support** | Kubernetes, OpenShift | Advanced hybrid cloud integration |
| **Encryption** | Pervasive encryption | Quantum-safe cryptography |
| **Performance** | High-performance processors and memory | Integrated AI accelerators, improved scalability |
| **Security** | Secure Service Container | Advanced threat detection and response |
| **AI Capabilities** | Limited | On-chip AI for real-time analytics |

# Virtualization,Containarization



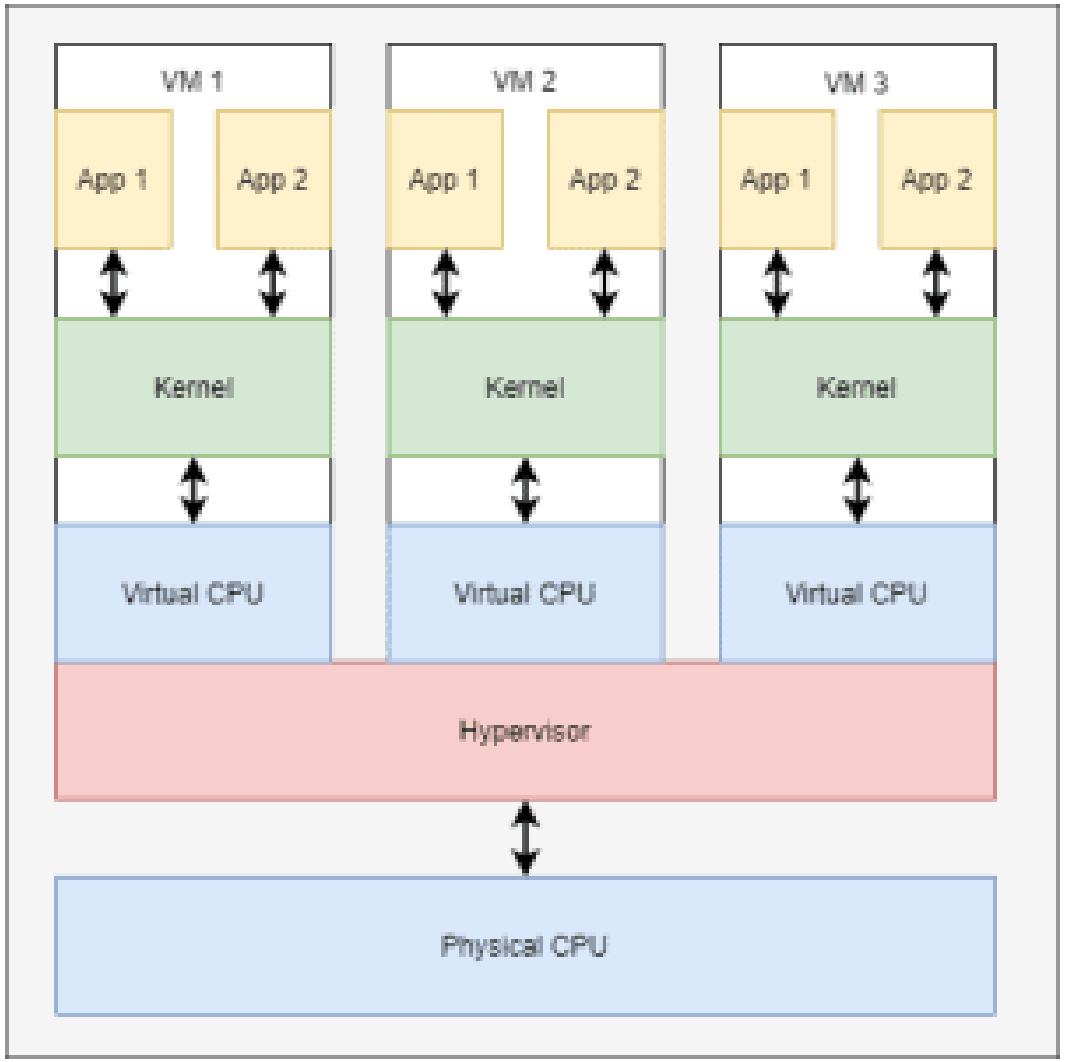
# Virtualization,Containarization

- **Traditional deployment era:**For example, if multiple applications run on a physical server, there can be instances where one application would take up most of the resources, and as a result, the other applications would underperform.
- **Virtualized deployment era:** As a solution, virtualization was introduced. It allows you to run multiple Virtual Machines (VMs) on a single physical server's CPU. Virtualization allows applications to be isolated between VMs and provides a level of security as the information of one application cannot be freely accessed by another application.
- **Container deployment era:** Containers are similar to VMs, but they have relaxed isolation properties to share the Operating System (OS) among the applications. Therefore, containers are considered lightweight. Similar to a VM, a container has its own filesystem, share of CPU, memory, process space, and more. As they are decoupled from the underlying infrastructure, they are portable across clouds and OS distributions.

# Virtualization

- Virtualization **helps us to create software-based or virtual versions of a computer resource**. These computer resources can include computing devices, storage, networks, servers, or even applications.
- It allows organizations to **partition a single physical computer or server into several virtual machines (VM)**. Each VM can then interact independently and run different operating systems or applications while sharing the resources of a single computer.

# Virtualization



# Containerization

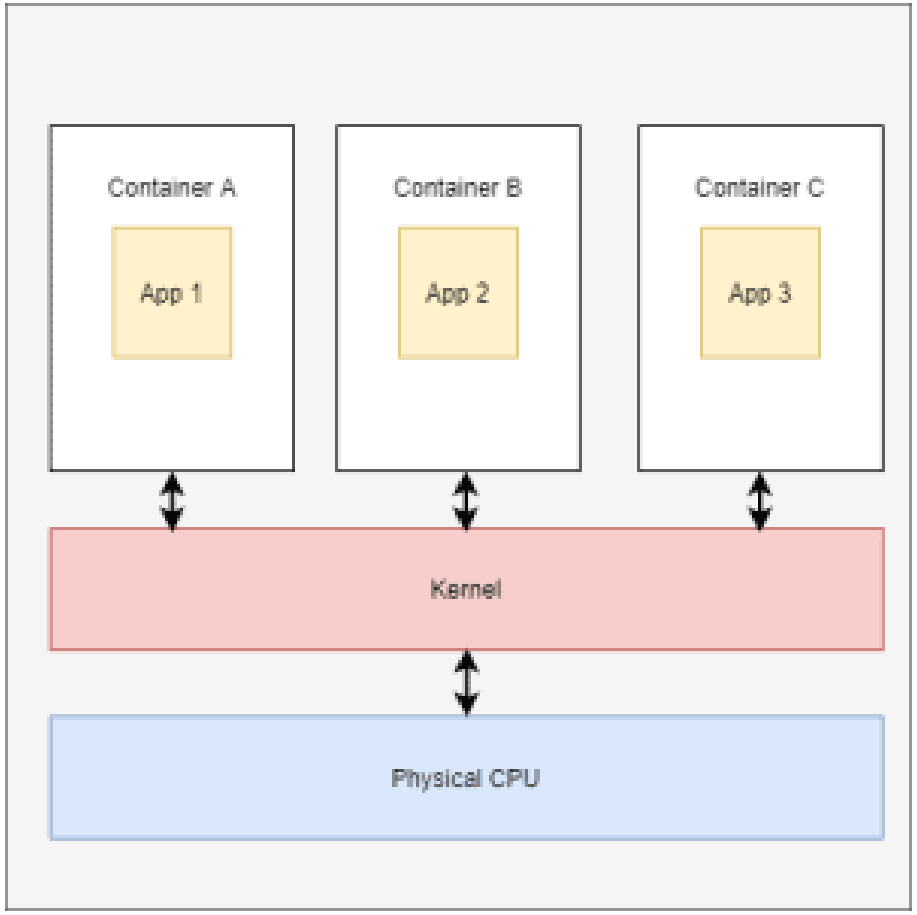
- Containerization is a lightweight alternative to virtualization. This involves encapsulating an application in a container with its own operating environment. Thus, instead of installing an OS for each virtual machine, containers use the host OS
- **Each container is an executable package of software that runs on top of a host OS**.
- A host can support many containers concurrently. For example, in a microservice architecture environment, this set up works as all containers run on the minimal, resource-isolated process that others can't access.

# Containerization

- **Each container is an executable package of software that runs on top of a host OS**. A host can support many containers concurrently. For example, in a microservice architecture environment, this set up works as all containers run on the minimal, resource-isolated process that others can't access.

# Containerization

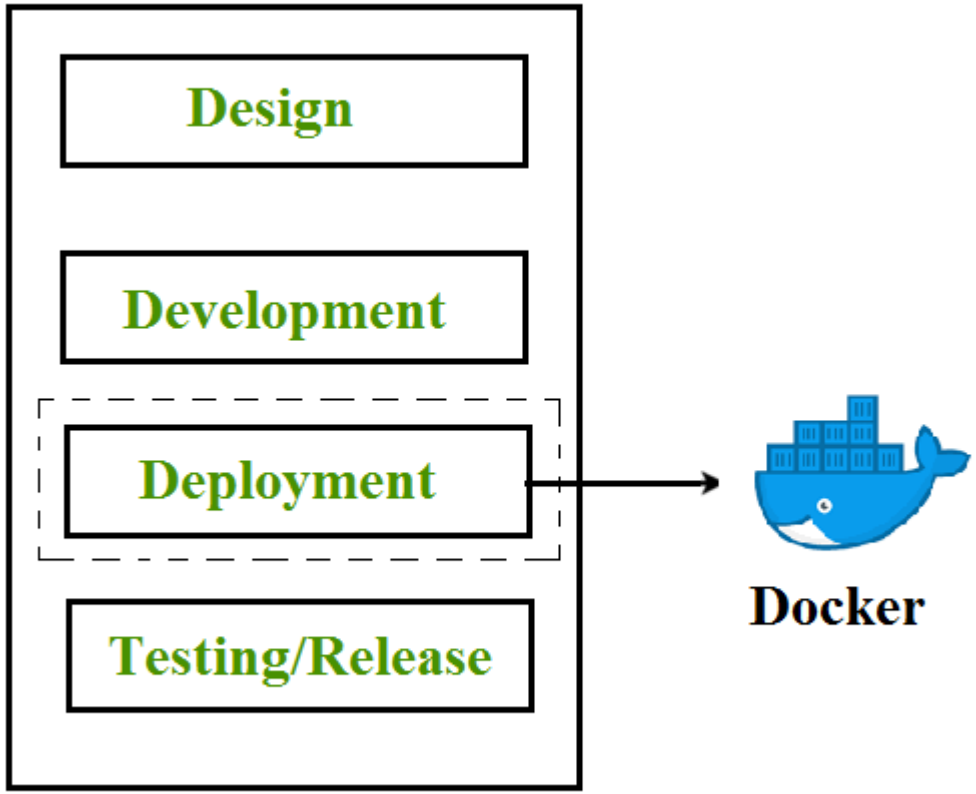
1. At the bottom of the layer, there are physical infrastructures such as CPU, disk storage, and network interfaces
2. Above that, there is the host OS and its kernel. The kernel acts the bridge between the software of the OS and the hardware resources
3. The container engine and its minimal guest OS sits on top of the host OS
4. At the very top, there are binaries, libraries for each application and the apps that run on their isolated user spaces



# Docker

- **Docker** is the containerization platform that is used to package your application and all its dependencies together in the form of containers to make sure that your application works seamlessly in any environment which can be developed or tested or in production. Docker is a tool designed to make it easier to create, deploy, and run applications by using containers.
- launched in 2013 by a company called Dotcloud, Inc which was later renamed Docker, Inc. It is written in the Go language.
- Docker is designed to benefit both developers and system administrators making it a part of many DevOps toolchains

# Docker



# Containerization on Mainframes

- **Containerization** involves packaging applications and their dependencies into containers. Containers are lightweight, portable, and ensure consistency across different environments, from development to production. On mainframes, containerization enables:
- Compare with VM-needs to install
- But uses required resources
- Sequence of operations to create docker images,

1. **Isolation**: Containers isolate applications from each other and the underlying system, enhancing security and stability.
2. **Portability**: Applications in containers can run consistently across various environments, including on-premises, hybrid cloud, and public cloud.
3. **Resource Efficiency**: Containers are lightweight, allowing for efficient utilization of system resources, which is crucial for mainframe environments where performance and resource optimization are paramount.
4. **Simplified Deployment**: Containers streamline the deployment process, reducing the complexity of managing dependencies and configurations.

# Virtualization vs Containerization

| Area | Virtualization | Containerization |
|---|---|---|
| Isolation | Provides complete isolation from the host operating system and the other VMs | Typically provides lightweight isolation from the host and other containers, but doesn't provide as strong a security boundary as a VM |
| Operating System | Runs a complete operating system including the kernel, thus requiring more system resources such as CPU, memory, and storage | Runs the user-mode portion of an operating system, and can be tailored to contain just the needed services for your app using fewer system resources |
| Guest compatibility | Runs just about any operating system inside the virtual machine | Runs on the same operating system version as the host |
| Deployment | Deploy individual VMs by using Hypervisor software | Deploy individual containers by using Docker or deploy multiple containers by using an orchestrator such as Kubernetes |
| Persistent storage | Use a Virtual Hard Disk (VHD) for local storage for a single VM or a Server Message Block (SMB) file share for storage shared by multiple servers | Use local disks for local storage for a single node or SMB for storage shared by multiple nodes or servers |
| Load balancing | Virtual machine load balancing is done by running VMs in other servers in a failover cluster | An orchestrator can automatically start or stop containers on cluster nodes to manage changes in load and availability. |
| Networking | Uses virtual network adapters | Uses an isolated view of a virtual network adapter. Thus, provides a little less virtualization |

# Kubernetes

- Also known as K8s
- Developed by GOOGLE
- donated to CNCF (Cloud Native Computing Foundation )
- Open-source Container Management tool that automates container deployment, container scaling, descaling, and container load balancing (also called a container orchestration tool).
- Works on Orchestration
- Analogy of Orchestra-Master(Kubernetes),players(containers)
- Containers are a good way to bundle and run your applications. In a production environment, you need to manage the containers that run the applications and ensure that there is no downtime.
- For example, if a container goes down, another container needs to start. Wouldn't it be easier if this behaviour was handled by a system?
- That's how Kubernetes comes to the rescue! Kubernetes provides you with a framework to run distributed systems resiliently. It takes care of scaling and failover for your application, provides deployment patterns, and more.

# Kubernetes on Mainframes

Kubernetes provides:

1. **Scalability**: Kubernetes can scale applications horizontally, managing workloads dynamically to handle varying demands.
2. **Self-healing**: Kubernetes automatically restarts, replicates, and manages the lifecycle of containers, ensuring high availability and resilience.
3. **Declarative Management**: With Kubernetes, the desired state of applications is declared, and Kubernetes manages the infrastructure to maintain this state.
   - You declare what you want your application to be like (e.g., "I want 3 instances running").
   - Kubernetes takes care of setting up the infrastructure to make that happen.
   - Kubernetes constantly monitors the system and makes sure that it stays in the desired state.
4. **Service Discovery and Load Balancing**: Kubernetes provides built-in service discovery and load balancing, ensuring efficient traffic distribution and application performance.
5. **Security**: Kubernetes enhances security with features like namespace isolation, role-based access control (RBAC), and network policies, which are critical for mainframe environments handling sensitive data.

# Implementation on IBM Mainframes

•IBM has integrated containerization and Kubernetes support into its z15 and z16 mainframes, providing enterprises with a robust platform for cloud-native development. Key aspects include:

**IBM z/OS Container Extensions (zCX):** Allows Linux-based Docker containers to run directly on z/OS, enabling the use of modern DevOps tools and practices while leveraging the reliability and security of z/OS.

•**Key Benefits**

✓**Linux-based application support:** Run Linux-based applications on the mainframe, without the need for specialized hardware or operating systems.

✓**Containerized deployment**: Deploy and manage Linux containers, which provide a lightweight and flexible way to run applications.

✓**Easy integration:** Integrate Linux containers with existing z/OS applications and services, using standard interfaces and APIs.

✓**Improved security:** zCX provides enhanced security features, such as encryption and access controls, to protect your applications and data.

# Implementation on IBM Mainframes

- **IBM Cloud Pak for Applications**: is a cloud-native, enterprise-ready platform that enables organizations to modernize their applications, data, and infrastructure. It's a hybrid cloud platform that provides a single, integrated environment for developing, deploying, and managing applications.
- **Key features:**

➢**Containerized application development**: Develop and deploy applications using containerized environments, such as Kubernetes and Docker.

➢**Cloud-native infrastructure**: Leverage cloud-native infrastructure, including IBM Cloud services, to deploy and manage applications.

➢**AI and ML integration**: Integrate AI and ML capabilities into your applications to improve decision-making and automation.

➢**Data management and integration**: Manage and integrate data from various sources, including databases, files, and APIs.

➢**Security and governance**: Ensure the security and governance of your applications and data through built-in features, such as encryption, access controls, and auditing.

➢**DevOps integration**: Integrate with DevOps tools, such as Jenkins, GitLab, and CircleCI, to streamline development and deployment processes.

➢**Monitoring and analytics**: Monitor application performance and collect analytics data to improve application performance and user experience.

# Implementation on IBM Mainframes

- **Red Hat OpenShift on IBM Z**: is a containerized platform that allows you to deploy and manage containerized applications on IBM Z mainframe systems. It combines the benefits of Red Hat OpenShift, a leading enterprise-grade Kubernetes platform, with the scalability and reliability of IBM Z.
- **Key Features**
- **Containerized application deployment:** Deploy and manage containerized applications on IBM Z, using Red Hat OpenShift's container orchestration capabilities.
- **Kubernetes-based**: Built on top of Kubernetes, the industry-standard container orchestration platform.
- **IBM Z support:** Optimized for IBM Z mainframe systems, providing a scalable and reliable platform for containerized applications.
- **Secure by design:** Incorporates robust security features, including network policy management, secret management, and identity and access management.
- **Integrated monitoring and logging:** Provides real-time monitoring and logging capabilities to help troubleshoot and optimize application performance.
- **Support for a wide range of applications:** Supports a wide range of applications, including Linux, Windows, and mainframe applications.

# Benefits of Containerization & Kubernetes on Mainframes

1. **Agility and Innovation**: Accelerates application development and deployment, enabling faster time-to-market and innovation.
2. **Cost Efficiency**: Optimizes resource usage and reduces operational costs through efficient workload management.
3. **Reliability and Performance**: Leverages the inherent reliability and high performance of mainframes, ensuring robust and responsive applications.
4. **Security and Compliance**: Maintains the highest levels of security and compliance required for enterprise applications, particularly in industries like finance, healthcare, and government.
5. **Hybrid Cloud Integration**: Facilitates seamless integration with hybrid and multi-cloud environments, providing flexibility in deployment and management.

# Mainframe Hardware components

**1. Central Processing Unit (CPU)**

**The CPU** is the brain of the mainframe, responsible for executing instructions and processing data. Mainframe CPUs are engineered for high performance and efficiency, with features including:

- **Multiple Cores**: Mainframe CPUs often have multiple cores, allowing them to handle numerous tasks simultaneously.
- **High Clock Speed**: They operate at high clock speeds to process instructions quickly.
- **Specialized Instructions**: Mainframes include specialized instructions for specific tasks, such as encryption and compression, to enhance performance.
- **Parallel Processing**: Capabilities for parallel processing to manage large volumes of transactions and data processing.
- **Virtualization Support**: Native support for virtualization, allowing multiple logical partitions (LPARs) to run different operating systems and applications on a single physical machine.

# Mainframe Hardware components

**2. Memory**

**Mainframe memory** is designed to support large-scale applications and databases with features like:

- **Large Capacity**: Mainframes can be equipped with terabytes of RAM to support extensive in-memory processing.
- **High Bandwidth**: High bandwidth memory to ensure fast data access and transfer rates.
- **ECC Memory**: Error-correcting code (ECC) is a type of RAM (Random Access Memory) that is designed to detect and correct data corruption, ensuring data integrity. ECC memory is particularly important in mainframe systems where data integrity and reliability are critical.
- **Memory Interleaving**: memory interleaving is a technique used to improve memory access efficiency and overall system performance. It involves organizing memory modules in a way that allows multiple memory operations to be performed simultaneously, thereby reducing latency and increasing throughput. Better Than sequential access
- **Flash Memory: nonvolatile**, High-speed flash memory for enhanced performance in read-intensive workloads.

# Mainframe Hardware components

**3. Storage Systems**

**Storage systems** on mainframes are critical for data management and include various types:

- **Direct Access Storage Device (DASD)**: type of magnetic storage,Traditional hard disk storage used for high-capacity storage needs.
- **Solid State Drives (SSD)**: Faster storage options for applications requiring high I/O operations per second (IOPS).
- **Tape Storage**: Used for backup /long-term archival storage due to its high capacity and low cost per byte.
- **Hierarchical Storage Management (HSM)**: Manages data across different storage types, moving less frequently accessed data to slower, cheaper storage like such as disk and tape.
- **RAID**: RAID (Redundant Array of Independent Disks) is a data storage technology that combines multiple physical disk drives into a single logical unit, providing improved performance, capacity, and reliability. RAID allows multiple disks to work together as a single storage unit

# Mainframe Hardware components

**4. Input/Output (I/O) Devices**

**I/O devices** facilitate communication between the mainframe and external systems, with components including:

- **Channel I/O**: Specialized processors (channels) manage I/O operations, offloading tasks from the main CPU to improve performance.
- **FICON and ESCON**: Fiber connectivity (FICON) and enterprise system connectivity (ESCON) channels for high-speed data transfer.
- **Network Adapters**: High-speed network interfaces (e.g., Ethernet, Infiniband) for connecting to local and wide-area networks.
- **Disk Controllers**: Manage access to disk storage devices, optimizing performance and reliability.
- **Printers and Card Readers**: Traditional I/O devices still used in some legacy systems for printing and card reading tasks.
- **Terminal**, **Magnetic tape**, **Disk storage**, **Graphics terminal, Optical storage**

# Mainframe Hardware components

**5. Specialized Accelerators**

Mainframes often include specialized hardware accelerators to enhance specific tasks:

•These accelerators are designed to offload specific workloads from the mainframe CPU, allowing it to focus on other tasks and improving overall system performance.

- **Crypto Processors**: Dedicated hardware for encryption and decryption to enhance security without impacting performance.
- **AI and ML Accelerators**: Built-in accelerators for artificial intelligence (AI) and machine learning (ML) workloads, enabling real-time analytics and decision-making.
  These accelerators are designed to offload complex AI and ML computations from the mainframe CPU, allowing for faster processing, improved performance, and reduced latency.
  On-chip accelerators are specialized hardware components integrated into a microprocessor or system-on-chip (SoC) that accelerate specific tasks or workloads

**Neural Network Accelerator**: accelerates the processing of neural networks, which are commonly used in AI and ML applications.
**GPU Accelerator:**accelerates the processing of graphics-intensive workloads, including AI and ML applications.
**Tensor Processing Unit (TPU) Accelerator**: accelerates the processing of tensor-based workloads, including those used in AI and ML applications.
**Quantum Accelerator**: accelerates the processing of quantum computing workloads, including those used in AI and ML applications.

# Mainframe Hardware components

- Here are some examples of specialized accelerators in mainframe systems:
- **Compression Accelerators:** Compression accelerators are designed to accelerate data compression and decompression operations, reducing storage requirements and improving data transfer times.
- **Sorting Accelerators**: Sorting accelerators are designed to accelerate data sorting and merging operations, which are commonly used in mainframe applications such as database management and data warehousing.
- **Data Compression/Decompression Accelerators:** Data compression/decompression accelerators are designed to accelerate data compression and decompression operations, which are commonly used in mainframe applications such as data backup and restore.
- **Transaction Processing Accelerators:** Transaction processing accelerators are designed to accelerate transaction processing operations, such as online transaction processing (OLTP) and online analytical processing (OLAP).
- **Database Accelerators:** Database accelerators are designed to accelerate database operations, such as query processing and data retrieval, by offloading these tasks from the mainframe CPU.
- **Message Processing Accelerators**: Message processing accelerators are designed to accelerate message processing operations, such as message queuing and message routing, by offloading these tasks from the mainframe CPU.

# Mainframe Hardware components

**6. Redundancy and High Availability Components-RAS**

Mainframes are designed for maximum uptime and include components for redundancy and high availability:

- **Multicore multiprocessor system**
- **Redundant Power Supplies**: Ensures continuous operation even if one power supply fails.
- **Redundant Cooling Systems:** Multiple cooling systems that can maintain a safe operating temperature for the system in case one or more cooling systems fail.
- **Hot Swappable Components**: Allows replacement of failed components without shutting down the system.-Storage,Power Supplies, NICs, HDDs
- **Fault-tolerant Design**: Multiple pathways and components to ensure continuous operation despite hardware failures.

# Case Studies of Mainframe Implementations

**1. Banco do Brasil: Enhancing Customer Experience with IBM Z**

over 30 million customers and a network of over 5,000 branches.

**Challenge:** Banco do Brasil, one of the largest financial institutions in Latin America, faced the challenge of modernizing its IT infrastructure to enhance customer experience and support new digital banking services. The bank needed to improve transaction processing speed, reliability, and security.

**Solution:** Banco do Brasil implemented IBM z15 mainframes to overhaul its core banking systems. The new infrastructure leveraged the IBM Z platform's high processing power and reliability, integrated with hybrid cloud environments to support digital banking initiatives.

**Results:**

- **Improved Transaction Speed**: The bank achieved faster transaction processing, significantly reducing the time customers spent on banking activities.
- **Enhanced Security**: With pervasive encryption and advanced security features, Banco do Brasil ensured customer data protection and compliance with regulatory requirements.
- **Scalability**: The IBM z15 allowed the bank to scale its operations seamlessly, handling peak transaction volumes without performance degradation.
- **Customer Satisfaction**: Enhanced digital services led to increased customer satisfaction and loyalty.

# Case Studies of Mainframe Implementations

**2. Lufthansa Systems: Transforming Airline Operations with IBM Z**

is a leading provider of IT solutions for the airline industry,

**Challenge:** Lufthansa Systems needed to modernize its IT infrastructure to handle the growing complexity and volume of airline operations data. The company required a solution that could provide real-time analytics, high availability, and seamless integration with existing systems.

Solution: Lufthansa Systems adopted IBM z14 mainframes integrated with LinuxONE to transform its airline operations. The mainframes supported real-time data processing and analytics, enabling efficient flight scheduling, crew management, and customer service operations.

- **Real-time Analytics**: Enabled real-time data analysis, improving decision-making and operational efficiency.
- **High Availability**: Ensured continuous availability of critical applications, reducing downtime and enhancing service reliability.
- **Cost Efficiency**: Consolidated multiple workloads on a single platform, reducing hardware and maintenance costs.
- **Operational Excellence**: Streamlined operations led to better on-time performance and customer satisfaction.

# Case Studies of Mainframe Implementations

### 3. Credit Suisse: Secure and Efficient Banking with IBM Z

**Challenge:** Credit Suisse, a global financial services company, needed to enhance its IT infrastructure to support increasing regulatory requirements, improve data security, and provide seamless banking services across multiple regions.

**Solution:** Credit Suisse implemented IBM z15 mainframes to upgrade its core banking systems. The mainframes provided advanced security features, high processing power, and integration with cloud services to support the bank's global operations.

**Results:**

- **Regulatory Compliance**: Meet stringent regulatory requirements with advanced encryption and secure data handling capabilities.
- **Enhanced Security**: Improved data protection with pervasive encryption, reducing the risk of data breaches.
- **Operational Efficiency**: Achieved faster processing of banking transactions and improved overall system performance.
- **Global Integration**: Enabled seamless integration with cloud services, supporting global banking operations and digital transformation initiatives.

# Case Studies of Mainframe Implementations

**4. Aetna: Modernizing Healthcare IT with IBM Z**

**Challenge:** Aetna, a leading healthcare insurance provider, faced the challenge of modernizing its IT infrastructure to handle increasing data volumes, enhance security, and improve the efficiency of claims processing and customer service.

**Solution:** Aetna deployed IBM z14 mainframes to modernize its healthcare IT infrastructure. The mainframes supported advanced analytics, high-volume transaction processing, and secure data management.

**Results:**

- **Efficient Claims Processing**: Improved the efficiency of claims processing, reducing turnaround times and operational costs.
- **Data Security**: Enhanced data security with advanced encryption, ensuring compliance with healthcare regulations such as HIPAA.
- **Scalable Infrastructure**: Provided a scalable infrastructure capable of handling increasing data volumes and transaction loads.
- **Customer Satisfaction**: Improved customer service through faster processing and enhanced data accuracy.

# Case Studies of Mainframe Implementations

**5. State of California: Government IT Modernization with IBM Z**

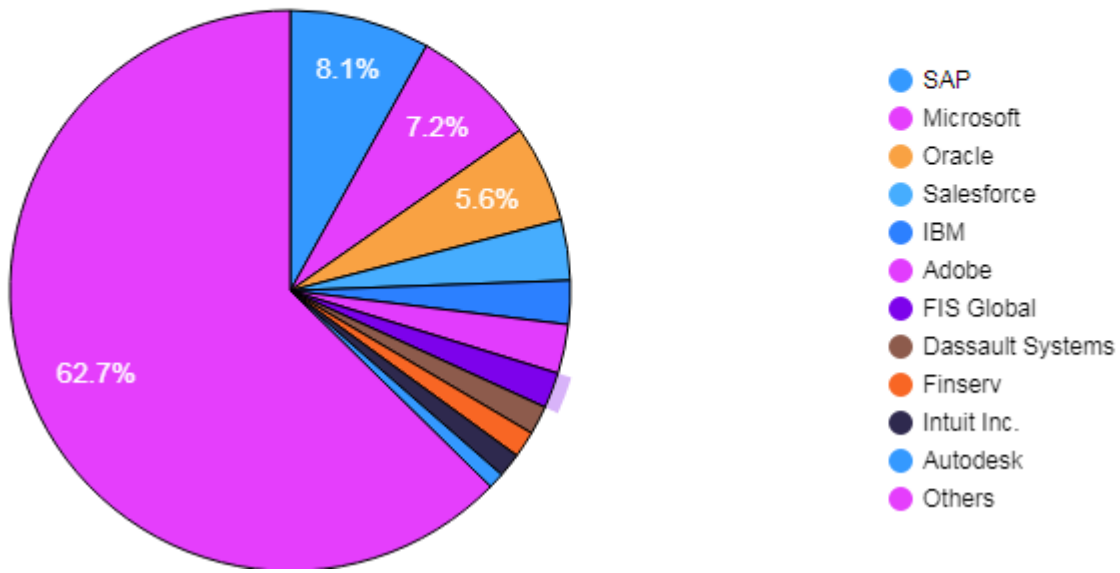
**Challenge:** The State of California needed to modernize its legacy IT systems to improve service delivery, enhance security, and ensure the availability of critical government services to citizens.

**Solution:** The State of California implemented IBM z15 mainframes to modernize its IT infrastructure. The mainframes provided the reliability, security, and scalability needed to support various government applications and services.

**Results:**

- **Improved Service Delivery**: Enhanced the delivery of government services through faster processing and improved system reliability.
- **Enhanced Security**: Protected sensitive citizen data with advanced encryption and security features.
- **Operational Efficiency**: Reduced operational costs by consolidating workloads and improving resource utilization.
- **High Availability**: Ensured continuous availability of critical applications, supporting uninterrupted public services.

## Enterprise Applications Market Share (in %)



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