UNIT-I

- **Slides are created from the book *Virtualization Essentials* by Matthew Portnoy, third edition.**

Understanding Virtualization

- Virtualization is the core technology behind modern computing infrastructures.
- Virtualization in computing often refers to the **abstraction of some physical component into a logical object.**
- Ex. VLANs provide greater network performance and improved manageability by being separated from the physical hardware.
- This technology lays the foundation for understanding cloud computing and modern data centers.

Everyday Use of Virtualization

- Web browsing, GPS navigation, video streaming, and cloud storage all rely on virtualization.
- End users are often unaware that virtual machines power these services.
- Virtualization allows providers to scale services dynamically.

Definition of Virtualization

- **Virtualization** enables **abstraction** of physical hardware resources into flexible **software-defined entities**.
- Virtualization refers to the abstraction of all physical computing resources.
- A single physical machine can host multiple virtual environments.
- Each environment behaves as if it has dedicated hardware.

Why Virtualization Became Necessary

- Traditional computing models led to inefficient use of resources.
- Rapid growth of applications caused server sprawl.
- Virtualization emerged to address cost, scalability, and management challenges.

Evolution of Computing Models

- Mainframes dominated early centralized computing.
- Personal computers introduced distributed computing.
- Cloud computing represents pooled, virtualized resources.

Disruptive Nature of Virtualization

- Virtualization fundamentally changed server deployment models.
- It challenged the assumption that one server must run one application.
- Budgets and operational practices were reshaped.

Meaning of the Term 'Virtual'

- The term virtual has expanded beyond computing.
- Virtual environments simulate real-world experiences.
- **In computing, virtual means logical rather than physical.**

Virtualization as Abstraction

- Physical components are represented as logical objects.
- Abstraction increases flexibility and utilization.
- Examples include virtual networks and virtual storage.

Focus on Server Virtualization

- Biggest focus remains on Server Virtualization.
- Server virtualization abstracts entire computers.
- Operating systems run inside **V**irtual **M**achines.
- This is the primary focus of enterprise virtualization.

Virtual Reality Analogy

- Virtual machines experience a simulated hardware environment.
- Applications are unaware they are not on physical hardware.
- This **transparency is key** to virtualization success.

Historical Origins

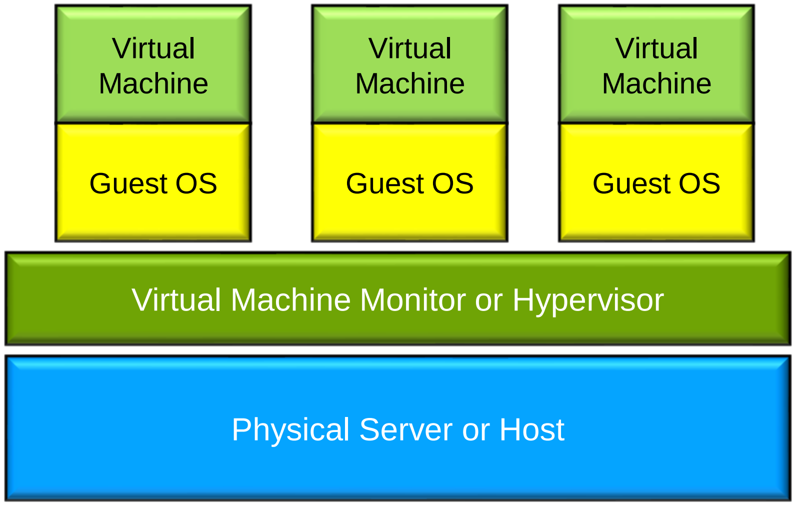
- IBM pioneered virtualization on mainframes in 1960.
- Formal theory introduced by **Popek and Goldberg**.
- Their principles still guide modern hypervisors.

Virtual Machine (VM)

- A VM is a software-defined computer, represented in the form of files.
- It includes OS, applications, and virtual hardware.
- VMs are isolated from each other.

Virtual Machine Monitor (VMM)

- The VMM controls access to hardware.
- Also known as a hypervisor.
- Ensures isolation and efficient resource sharing.



Popek–Goldberg Criteria

- **Fidelity** The environment it creates for the VM is essentially *identical to the original* (hardware) physical machine.
- **Isolation** *guarantees safety*. The VMM must have complete control of the system resources.
- **Performance** *minimizes overhead*. There should be little or no difference in performance between the VM and a physical equivalent.
- *Most VMMs satisfy first two properties*

Efficient Virtualization

- Efficient VMMs meet all criteria.
- Modern CPUs support hardware-assisted virtualization (will study later in the course).
- This enables near-native performance.

Rise of Microsoft Windows

- Windows became the dominant OS since 1980.
- Applications migrated from mainframes to servers/Desktops.
- This increased server deployments.

Client–Server Era

- Applications moved closer to users.
- Servers supported business processes.
- Management complexity increased.

One Server One Application

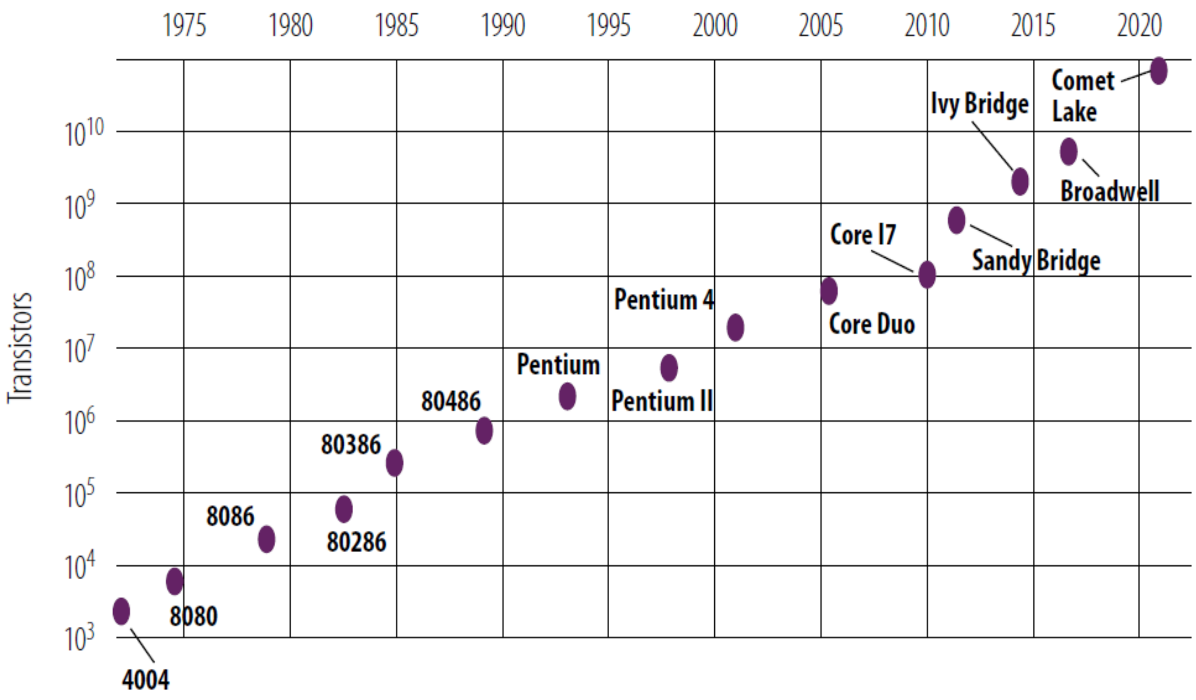
- Avoided software conflicts.
- Led to massive underutilization.
- Increased costs significantly.

Corporate Politics

- Departments demanded isolated systems.
- Resulted in duplicated infrastructure.
- Capital and operational costs increased.

Hardware Cost Reduction

- Moore's law reduced hardware prices.
- Servers became affordable.
- Infrastructure sprawl accelerated.



Growth of Data Centers

- Dedicated spaces for servers emerged.
- Cooling and power became critical.
- Operational costs escalated.

Internet Boom

- Web-enabled applications multiplied, "E-business or out of business"
- Companies like Amazon and Google emerged.
- Server farms expanded rapidly.

Energy Crisis in Data Centers

- Power consumption doubled rapidly.
- Cooling required massive energy.
- Sustainability became a concern.

Lost Servers

- Servers with unknown owners existed.
- They could not be shut down.
- Indicated management inefficiency.

Moore's Law Explained

- Processing power doubles every 18 months.
- Applies to memory and storage.
- Drives exponential growth.

Server Replacement Cycles

- Servers replaced every 3–5 years.
- New servers far exceed workload needs.
- Excess capacity accumulates. This extra capacity is also known as *headroom*.

Underutilization Problem

- Average utilization often below 15%.
- Most servers idle most of the time.
- **Virtualization targets this inefficiency.**

Virtualization Solves Underutilization

- Multiple VMs share one server.
- Higher utilization achieved.
- Hardware efficiency improves.

Virtualization Solves Underutilization

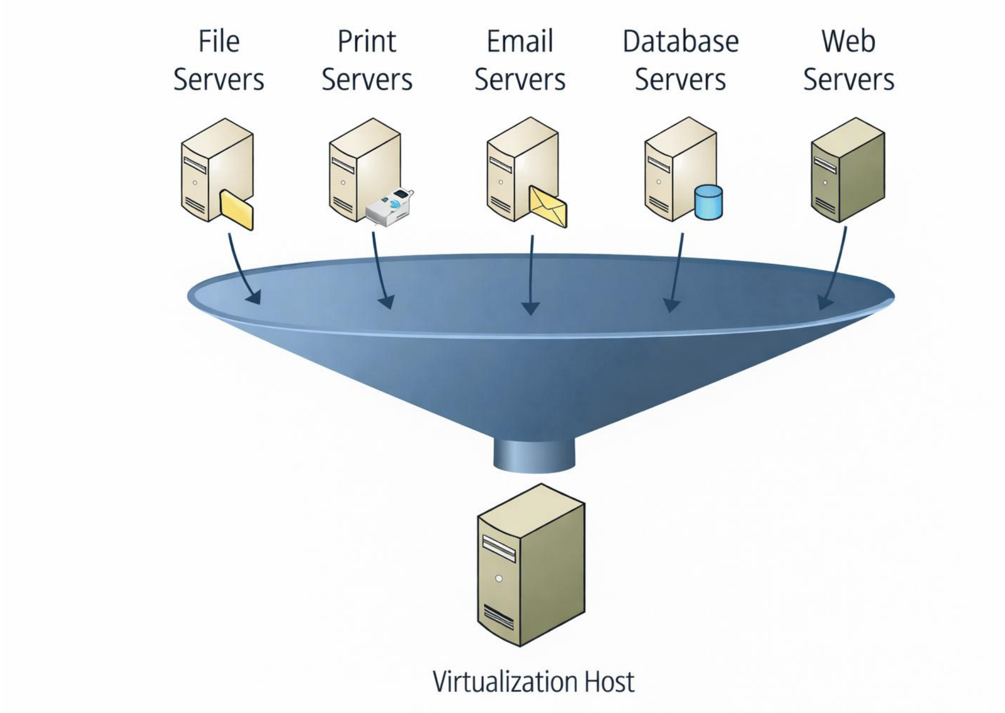
- The first commercially available solution to provide virtualization for x86 computers came from ***VMware in 2001***.
- An open-source offering called ***Xen*** arrived two years later. It took the form of a layer of software that either lived between an OS and the virtual machines or was installed directly onto the hardware, or bare metal, just like a traditional operating system such as Windows or Linux.

Server Consolidation

- Due to Virtualization physical servers reduced.
- The ability to condense multiple physical servers into fewer servers that would run many virtual machines, allowing those physical servers to run at a much higher rate of utilization.
- This condensing of servers is called *consolidation*.

Server Consolidation

- Consolidation ratio measures density (8:1).
- Major cost savings realized (cost of ownership of hardware server is much higher)



Containment Strategy

1. **Workload Isolation:** Confines applications or VMs to prevent mutual interference.
2. **Resource Control:** Limits CPU, memory, and I/O usage per workload.
3. **Fault Containment:** Restricts crashes or failures to the affected environment.
4. **Security Boundaries:** Prevents unauthorized access and attack spread.
5. **Safe Multi-Tenancy:** Enables secure sharing of physical infrastructure.

Adoption Strategy

- **Adoption Strategy** is a step-by-step plan used by organizations to gradually implement virtualization, starting with **low-risk workloads** and progressing to critical systems.
- Start with low-risk workloads.
- Gradually migrate critical systems.
- Build confidence and expertise.

Virtualization-First Policy

- A **Virtualization-First Policy** is an IT policy in which all new server or application requirements are fulfilled using virtual machines by default, and physical servers are used only if virtualization is proven unsuitable.
- Default to virtual deployment.
- Physical servers only when necessary.
- **Speeds provisioning.**

High Availability

- VMs can migrate live.
- No downtime for maintenance.
- Improved resilience, which is a system's ability to prevent, withstand, and quickly recover from disruptions.

Disaster Recovery

- VMs are file-based.
- Easy replication to secondary sites.
- Virtual machines can be cloned, upgraded, and even moved from place to place, without ever having to disrupt the user applications.
- Fast recovery possible.

Virtualization and Cloud

- Virtualization enables cloud models.
- Resources pooled and automated.
- Users consume services on demand.

Virtual Data Center

- Logical equivalent of physical DC.
- Highly scalable and flexible.
- Foundation of IaaS cloud.

Hyperconverged Infrastructure

- Compute, storage, network combined.
- Simplified management.
- Optimized for virtual workloads.
- Hardware vendors design and offer devices that contained the computer, networking, and storage resources already connected and preconfigured, and that could be managed as a single unit. This architecture is described as converged infrastructure.
- These prebuilt blocks allow rapid scalability in a data center.

Desktop Virtualization

- Desktops run in data centers.
- Accessed via thin clients.
- Lower management and power costs.

Application Virtualization

- Applications packaged and isolated.
- Simplifies deployment.
- Avoids conflicts.

Containers

- Lightweight virtualization.
- Share host OS.
- Ideal for modern applications.

Changing IT Roles

- Traditional silos are fading.
- Virtualization admins manage end-to-end.
- Broad skillsets required.

Key Takeaways

- Virtualization transformed IT infrastructure.
- Improves efficiency, agility, and availability.
- Foundation for cloud and future computing.