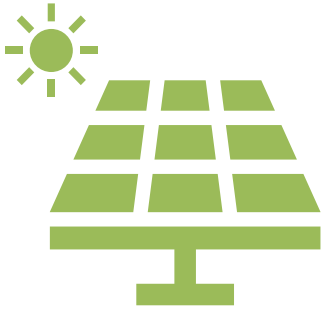


CE644 Cloud Computing and Applications

Unit III

Cloud Computing Economics

Cloud computing economics refers to the financial aspects and considerations associated with utilizing cloud computing services.

It encompasses various factors, including cost structures, cost-saving opportunities, return on investment (ROI), and overall financial benefits of adopting cloud technologies.

Public cloud computing emphasizes economy of scale, offering standardized resources at affordable rates to customers and providers alike.

Enterprise cloud computing prioritizes resource efficiency and agility, aiming to serve both business and IT needs promptly.

Private cloud computing combines aspects of public and enterprise models, integrating public cloud resources into the organization's data center.

To select a cloud model that is economical for an organization, consider the following steps:

REVIEW CONTRACT AND PRICING DOCUMENTS: PRIORITIZE REVIEWING CONTRACTUAL AND PRICING DOCUMENTS EARLY ON TO UNDERSTAND THE TERMS AND CONDITIONS, INCLUDING PRICING STRUCTURES AND SERVICE LEVEL AGREEMENTS.

EVALUATE TOTAL COST AND INVESTMENTS: ASSESS THE TOTAL COST OF OWNERSHIP AND INVESTMENTS REQUIRED FOR THE CHOSEN SERVICE MODEL. CONSIDER POTENTIAL COST SAVINGS THROUGH ECONOMIES OF SCALE AND ALIGN WITH BUDGET CONSTRAINTS.

MAINTAIN STANDARDS: ENSURE ALIGNMENT WITH INDUSTRY STANDARDS AND REGULATIONS SET BY THIRD-PARTY ORGANIZATIONS. ADHERING TO ESTABLISHED STANDARDS CAN ENHANCE INTEROPERABILITY AND COMPLIANCE.

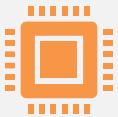
TROUBLESHOOTING AND SUPPORT: EVALUATE THE TROUBLESHOOTING AND SUPPORT MECHANISMS PROVIDED BY THE CLOUD PROVIDER. OPT FOR MODELS THAT OFFER SYNCHRONIZED AND EFFICIENT TROUBLESHOOTING, TRANSFERRING RESPONSIBILITY FROM INDIVIDUAL USERS TO THE NETWORK.

PERFORMANCE CONSIDERATIONS: ANALYZE THE PERFORMANCE ADVANTAGES OFFERED BY THE CLOUD MODEL, INCLUDING HIGH-PERFORMANCE BANDWIDTH AND LATENCY. CHOOSE A MODEL THAT MEETS THE ORGANIZATION'S PERFORMANCE REQUIREMENTS.

Privacy and Control Policies: Review privacy policies and access controls related to information privacy, data ownership, and compliance with relevant laws and regulations. Ensure the cloud model provides sufficient privacy and control options.

Risk Management: Assess the risk management features provided by the cloud model, including control mechanisms, troubleshooting capabilities, and ownership arrangements. Mitigate risks associated with data security, availability, and compliance.

Network Dependency: Consider any dependencies within the network resources and services provided by the cloud model. Evaluate the reliability and scalability of network infrastructure to support organizational needs effectively.



By following these steps, organizations can select a cloud model that not only meets their economic requirements but also aligns with their operational and security needs.

PUBLIC CLOUD

A multi-tenanted environment operated by a third-party service provider in which businesses pay for provisioned services.

ADVANTAGES

- No capital cost
- Low IT overheads
- Infinite scalability

DISADVANTAGES

- Lack of customization
- Governance issues
- Potential latency

PRIVATE CLOUD

A single-tenanted environment over which businesses have complete control with regard to architecture and configuration.

ADVANTAGES

- Fully customizable
- Higher level of security
- Superior performance

DISADVANTAGES

- Capital cost
- Underutilization
- High IT overheads

HYBRID CLOUD

A combination of public and private environments, offering the advantages of both with fewer disadvantages.

ADVANTAGES

- Greater flexibility
- Resilience to outages
- No capacity ceiling
- Fewer IT overheads
- Manageable security

DISADVANTAGES

- Compatibility

COMMUNITY CLOUD

A collaborative effort where infrastructure is shared and jointly accessed by several organizations from a specific group.

ADVANTAGES

- Cost is shared between organizations
- Customizable according to the community's needs

DISADVANTAGES

- Security issues are hard to deal with
- Poor scalability
- Less popular than the other models

Understanding Cloud vs. In-House Infrastructure Costs

Cloud computing offers **flexibility and scalability** without requiring companies to invest heavily in hardware upfront. However, the actual costs depend on **usage patterns** and **specific business needs**.

Comparing Costs – Cloud vs. In-House Servers

1 Cloud Infrastructure Costs (Amazon EC2 Example)

•Cloud pricing starts at **$0.10 per CPU-hour** and **$0.10 per GB of storage per month**.

•Larger servers cost more, such as an **"extra-large" EC2 server at $0.68 per CPU-hour**.

•Costs vary based on the resources used—companies only pay for what they need.

2 In-House Server Costs

•At first, buying a physical server may seem **cheaper per core-hour**.

•However, it involves additional costs like:

- **Power and cooling** (electricity bills for running and maintaining servers).
- **Manpower** (IT staff to maintain and update servers).
- **Hardware underutilization** (if the server is not used at full capacity).

Why Cloud Can Be More Cost-Effective?

✅ **Better Utilization:**

•A company's own server may **only be used at 40% capacity**, leading to wasted resources.

•A cloud server can **run at 80% efficiency**, meaning the company gets more value for its money.

✅ **Lower Maintenance Costs:**

•No need to **spend extra on electricity, cooling, and IT staff**—cloud providers handle this.

✅ **Scalability & Flexibility:**

•If demand increases, companies can **instantly scale up cloud resources** instead of buying new hardware.

•This is useful for businesses with **fluctuating demand**, such as an **e-commerce store** that gets more traffic during sales.

✅ **Storage & Network Cost Comparison:**

•Cloud storage (Amazon S3) is **only slightly more expensive** than in-house storage but comes with **automatic backups and replication**.

•Network costs are **often lower in the cloud** due to built-in optimizations.

📌 **If a company has a steady workload and already owns a data center, maintaining in-house servers may be a better option.**
📌 **If a company needs flexibility, scalability, and lower maintenance costs, the cloud is often the better choice.**

Example Scenario

🔷 Imagine an online **education platform** that sees more students during exam months and fewer at other times.
🔷 If they buy physical servers, they'll have **extra capacity sitting idle** most of the year.
🔷 If they use cloud computing, they can **increase or decrease server capacity as needed**, paying only for what they use.

Conclusion

Even though cloud computing may **seem more expensive at first**, when factoring in **better resource utilization, lower maintenance costs, and scalability**, it **often proves to be the more cost-effective solution**.

IaaS economics

- Let us consider, as a simple example,

TABLE 6.1 Infrastructure cloud economics

	In-house server	Cloud server
Purchase cost	$9600	
Cost/hr (over 3 yrs)	$0.36	$0.68
Price: Cloud/In-house	1.88	
Efficiency	40%	80%
Cost/Effective-hr	$0.90	$0.85
Power and cooling	$0.36	
Management cost	$0.10	$0.01
Total Cost/Effective-hr	$1.36	$0.86
Cost ratio: In-house/Cloud	1.58	

When comparing the cost of running an **'extra-large' Amazon EC2 server** versus buying and maintaining an **in-house server**, it may **seem** like the in-house option is cheaper at first. However, a deeper analysis shows that **cloud computing is often more cost-effective**.

1 **Server Utilization**

- **In-house servers** often operate at **40% utilization**, meaning a lot of computing power goes unused.
- **Cloud servers** can be scaled dynamically and **run at 80% utilization**, making better use of resources.
- When considering this utilization difference, the **cost per hour for both options becomes nearly the same**.

2 **Additional Costs**

- **Power & Cooling:** Running an in-house server requires **electricity** and **cooling systems**, adding to costs.
- **Maintenance & IT Staff:** In-house servers need a team for **management, repairs, and upgrades**, increasing expenses.

3 **Total Cost Advantage**

- After including all expenses, cloud computing on EC2 is about **1.6 times more cost-effective** than in-house servers.

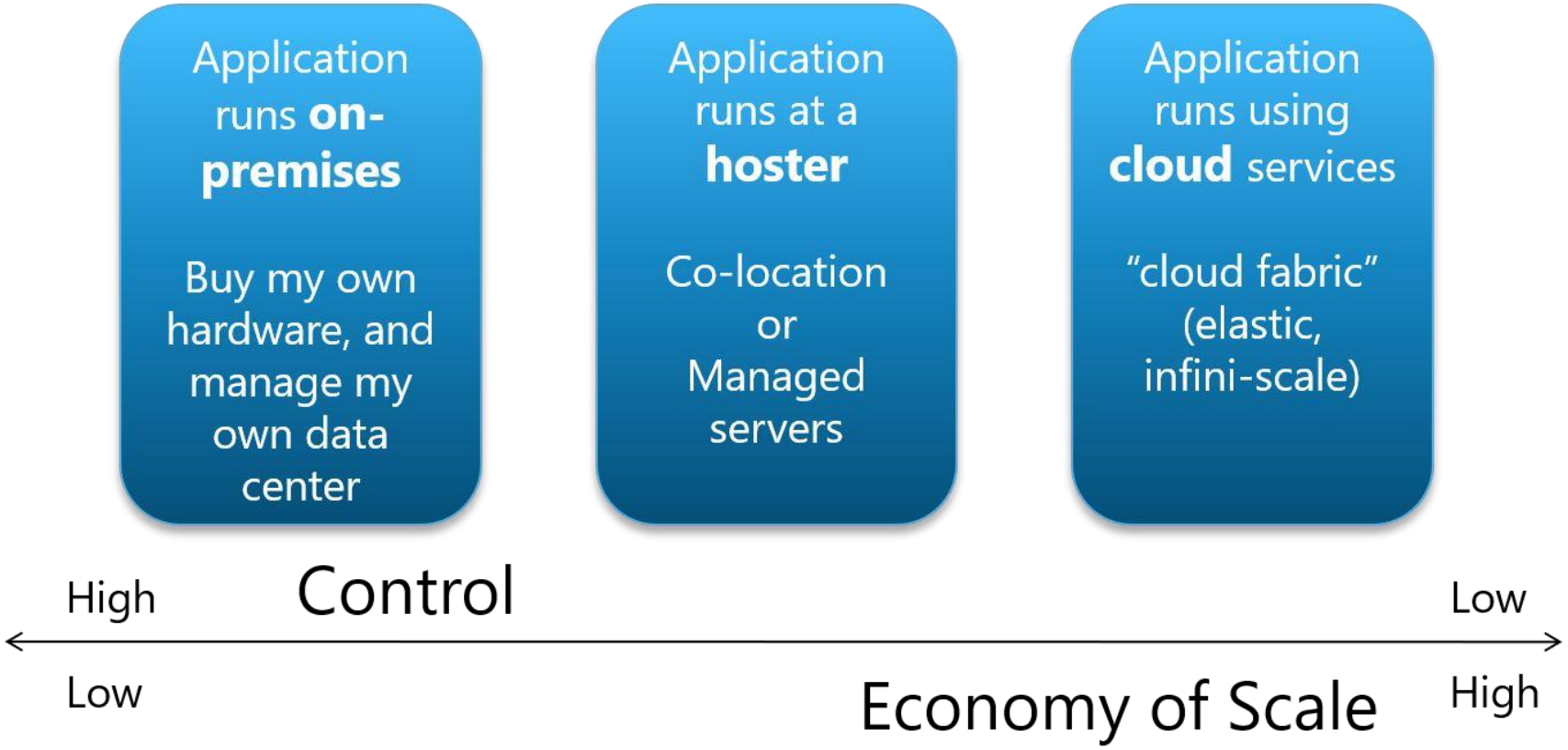
4 Storage & Network Costs

- In-house storage is **slightly cheaper**, but cloud storage (Amazon S3) offers **automatic backups** and **reduces network costs**.
- **Total cost of ownership** leans in favor of the cloud when considering **scalability, maintenance, and storage efficiency**.

Final Conclusion

Even though cloud computing may **seem expensive at first**, the overall benefits—**better resource utilization, lower maintenance costs, and scalability**—make it a **more cost-effective solution** than in-house infrastructure.

IAAS vs PAAS vs SAAS



Economics of PaaS vs. IaaS

PaaS Model:

- Example offerings: Google App Engine, Microsoft Azure

Cost advantages:

- Deployment of applications is often free or incurs minimal costs.
- No upfront provisioning of servers is required, making it ideal for highly unpredictable or variable transaction volumes.
- Resources scale automatically to meet demand, minimizing performance degradation during sudden spikes in usage.

Suitable for:

- Low or variable-volume web-based services where availability is crucial.
- Applications with unpredictable or rapidly varying transaction volumes.

Scenario: A Startup Developing a Food Delivery App
A small startup wants to launch a **food delivery application** but has **limited resources** and expects **unpredictable traffic**.

Solution: Using a PaaS like Google App Engine or Microsoft Azure

- The startup **develops and deploys** its app on **Google App Engine** without worrying about server setup or maintenance.
- Since PaaS **automatically scales**, if many users order food during peak hours, the platform **allocates more resources** to handle the load.
- During off-peak hours, resources **scale down**, reducing unnecessary costs.
- The startup **doesn't need to hire a dedicated IT team** for infrastructure management, saving money and effort.

IaaS Model:

- Example offerings: Amazon EC2, Google Compute Engine

Cost considerations:

- Requires upfront provisioning of servers, leading to potential over-provisioning to accommodate spikes in demand.
- Additional time and cost may be incurred for provisioning additional servers during sudden spikes in demand.
- Better suited for heavier, back-end applications such as batch processing or those behind web front ends.

Suitable for:

- Applications with consistent or predictable workloads that justify the upfront provisioning of resources.
- Heavier computational tasks or applications that require specific configurations not easily accommodated by PaaS offerings.

Scenario: A Data Analytics Company Processing Large Datasets
A **financial firm** needs to run **complex risk analysis models** on massive datasets. These computations require **high-performance servers** and **specific configurations** that are not easily handled by PaaS solutions.

Solution: Using IaaS like Amazon EC2 or Google Compute Engine

- The firm **provisions high-performance virtual machines (VMs)** on **Amazon EC2** to run their analytics software.
- Since risk analysis requires **consistent and predictable computing power**, they **pre-allocate servers** to ensure continuous processing.
- If needed, they can **scale up** by adding more servers manually or through automation.
- They **customize** the infrastructure, installing specific operating systems and software configurations

	Pay-per-use model; costs depend on compute, storage, and network usage	Often free for deployment, with costs for additional resources and scaling
	Higher: Requires provisioning of virtual machines and storage upfront	Lower: No need for provisioning, as the platform handles infrastructure automatically
	Scaling requires adding/removing instances, which may incur additional costs	Automatic scaling; costs increase only when usage grows significantly
	Requires IT management for OS, middleware, security, and scaling	Lower operational costs as the provider manages the platform and runtime environment
	More control over infrastructure but requires manual setup and maintenance	Limited control but easier to deploy applications without worrying about infrastructure
	More control over infrastructure but requires manual setup and maintenance	Limited control but easier to deploy applications without worrying about infrastructure
	Applications with **predictable workloads**, requiring **custom configurations** and high computing power	Applications with **variable workloads**, where developers want to focus on coding rather than infrastructure

Combining IaaS and PaaS for a Cost-Effective Hybrid Architecture

In many cases, organizations can benefit from a **hybrid approach** that leverages both **IaaS and PaaS**, optimizing **cost, performance, and scalability**.

Why Combine IaaS and PaaS?

1.Optimized Cost Management – Use **PaaS for development and deployment** while using **IaaS for backend processing** and high-performance computing.

2.Scalability with Control – PaaS provides **automated scaling**, while IaaS allows **fine-tuned control** over critical infrastructure.

3.Flexibility & Performance – Running **standard applications on PaaS** while using **IaaS for custom configurations** enables **optimal performance** without excessive cost.

Example: Hybrid IaaS-PaaS Usage
A **video streaming platform** could use:

- **PaaS (e.g., Google App Engine)** to handle the **web-based interface** and scale automatically during traffic spikes.

- **IaaS (e.g., Amazon EC2)** to manage **backend video processing, storage, and custom machine learning models** for recommendations

SOFTWARE PRODUCTIVITY IN THE CLOUD

Cloud computing enhances **software productivity** through the use of:

1. **Public Cloud Infrastructure (IaaS)** – Provides on-demand computing resources, reducing the need for **hardware investments and maintenance**.
2. **PaaS Offerings** – Offers **pre-configured development environments**, allowing developers to **focus on coding rather than infrastructure management**.
3. **Configurable SaaS Platforms** – Enable teams to **collaborate globally**, automate workflows, and integrate tools seamlessly.

Cloud-Based Development: Key Benefits & Approaches

1. Reduced Overhead & Faster Provisioning

•Public cloud **eliminates the need** for on-premise infrastructure.

•**Rapid deployment** of dev/test environments boosts **IT agility**.

2. Cost-Effective & Low-Risk Development

•Pay-as-you-go **minimizes upfront costs**.

•**Temporary testing environments** prevent **resource wastage**.

3. Global Collaboration & Accessibility

•Cloud-based platforms **enable remote teams** to work seamlessly.

•**Shared access to tools** improves productivity.

4. Platform as a Service (PaaS) for Development

•**Examples:** Google Cloud Platform, Microsoft Azure.

•**Built-in APIs & tools** simplify app development.

•Automatic **scaling & management** handled by the cloud.

5. Configurable SaaS for Business Apps

•**Example:** Salesforce.com's Force.com.

•Low-code/no-code **business app creation**.

•**Rapid development** with minimal programming.

🏆 **Why Cloud for Software Development?**

✅ Faster deployment, ✅ Lower costs, ✅ Seamless collaboration,
✅ Scalable & automated infrastructure.

ECONOMIES OF SCALE: PUBLIC VS. PRIVATE CLOUDS

1. Cost Efficiency in Infrastructure Purchasing

✅ **Bulk Hardware Procurement** – Public cloud providers buy computing, storage, and network resources at **large volumes**, significantly reducing per-unit costs.

✅ **3x to 7x Cost Reduction** – Compared to medium-sized enterprise data centers, cloud providers benefit from **lower hardware and operational costs**.

2. Amortization of Server Administration Costs

✅ **Larger Scale = Lower Overheads** – The cost of **server administration is spread** across more servers, reducing the cost per server.

✅ **Automation & AI-driven Management** – High levels of **automation** cut down **manual administrative costs** by up to **7x**, improving efficiency.

3. Lower Power Costs

✅ **Strategic Data Center Locations** – Public cloud providers set up data centers in **regions with cheap electricity** (e.g., Idaho, Washington in the U.S.).

✅ **3x Lower Energy Costs** – Optimized cooling, renewable energy usage, and energy-efficient infrastructure reduce **power consumption expenses**.

4. High Server Utilization

✅ **Better Resource Multiplexing** – Public cloud providers **serve multiple customers simultaneously**, achieving utilization rates of **60% to 80%**, compared to **lower utilization in private data centers**.

✅ **Less Waste & More Efficiency** – Workloads are dynamically distributed, ensuring **optimal resource usage and cost savings**.

✅ **Public Cloud: Scalable, Flexible & Cost-Effective**

•**Highly Scalable & On-Demand** – Resources scale automatically to meet demand.

•**Global Accessibility** – Available **anywhere** with an internet connection.

•**Lower Costs** – No upfront infrastructure investments; pay-as-you-go **Higher Performance** – Optimized data centers ensure **efficient processing** and faster deployments.

⚠️ **Challenges:**

•**Lower Security** – Shared resources can pose risks.

•**Data Privacy Concerns** – Compliance with regulations like **GDPR** may be difficult.

✅ **Private Cloud: Secure, Customizable & Controlled**

•**Enhanced Security** – Dedicated infrastructure **reduces data breach risks**.

•**Greater Customization** – Tailored configurations **meet specific business needs**.

•**Better Compliance** – Ideal for industries with **strict data regulations** (e.g., finance, healthcare).

⚠️ **Challenges:**

•**Higher Costs** – Expensive setup and maintenance.

•**Limited Scalability** – Requires **manual provisioning** for scaling up.

🏆 **Which One to Choose?**

✅ **Public Cloud:** Ideal for startups, growing businesses, and organizations needing **scalability & lower costs**.

✅ **Private Cloud:** Best for enterprises that require **strict security, regulatory compliance, and full control** over infrastructure.

✅ **Hybrid Approach:** A mix of both can balance **cost-effectiveness with security needs**.