What does it take to provide the computing infrastructure for a typical company or University?

There are many costs to consider.
- Physical space
- Utilities
  - Electrical, cooling, water, ...
- Physical security
- Redundancy in case of failures
- Networking
- Maintenance
- Upgrades over time
- ...

Looking at a few critical components we see:
1) A room large enough to contain the computers and support equipment
   - Racks to contain computers
   - Electricity (typically 20 - 30A of 2-phase power per rack)
   - Cooling equipment – specialized computer room systems
   - Raised floor to allow cable runs
   - Network switches, routers, and firewalls
   - Separate Corporate/Customer/Developer/User systems?
   - Redundancy???

Looking at a few components we see:
2) Physical Security
   - Access control
   - Logging
   - Monitoring

3) Fire protection

4) Workspace and Office space for technicians

5) Software (OS, applications, databases, …)

6) Network Connection (Internet)

7) ...

Providing computing can be a **VERY** expensive proposition.

Notice, that I split the list of requirements across two slides.

The first slide is primarily data-center items

The second slide is not necessarily data-center centric.

How expensive is it to run a data center?

It is not unusual for a company to spend 20 – 30 thousand dollars a month to maintain a datacenter.

The cost of commercial office space in the U.S. can range from $6 per square foot in low cost regions to over $12 per square foot in New York City. On average, a 50-cabinet data center will occupy about 1,700 square feet. At a median cost of $8 per square foot, the space alone would cost about $13,600 per month.

Power: All data centers consume power for two purposes: first to power the servers and other IT equipment and, second, to power the air conditioning to cool the equipment (which is considerable) and the general environment.

Power requirements generally vary depending on processing loads.

It is not unusual for a data center to consume more than 300kW of electrical power!

Electrical costs are recurring monthly expenses!

In reality, it will probably cost around $1,200 - $1,500 per square foot to build out a data center.

That is over $2M just to build/outfit the space for the computers!

• And we have not even purchased the computers yet!
Providing computing

On top of the initial cost of building a data center there are recurring costs (electricity, computers, maintenance of facilities, network connectivity, software, cost of employees, …) It can be very expensive to build an in-house data center.
So it makes sense to explore other ways of providing computing to the employees and/or students of the company/university.

Providing computing

One method might be to rent space in a co-location center (a shared data-center).
The shared data-center allows economy of scale.
Several companies/universities rent space in the data-center, which reduces costs for everyone.
Rent might cover power, cooling, maintenance, …
But each entity is responsible for purchasing / maintaining their own computers, and software.
Even shared space can be expensive:
$400/month Cabinet + Gige
Includes 42U Cabinet, Power, 1 Gbps Internet bandwidth

Providing computing

- Another way that might be considered is to rent compute time from someone else.
  - Renting resources and services allows for • Scalability:
  - Ability to add more resources in order to increase performance • Elasticity:
  - Ability to add / remove resources on-demand • virtualization
- In essence, this is the foundation of cloud computing.
  » Some entity builds a large data center.
  » They fill it with computers.
  » They install OS and application software.
  » Then they rent time/storage/networking to your organization.
  » Benefit – you do not have to pay for the facility!

Cloud Computing

1. What is Cloud Computing?
2. What are the motivations for Cloud Computing?
3. What Cloud developer platforms have you used?
4. What Cloud services do you regularly use?
5. What are the advantages and disadvantages of the Cloud?
6. What are the ethical concerns with Cloud Computing?

What is cloud computing?

Cloud Computing can be defined as
- delivering computing power( CPU, RAM, Network, Storage, OS, software)
- as a service over a network (usually on the Internet)
- rather than physically having the computing resources at the customer location.

Examples:
AWS, Azure, Google Cloud, Digital Ocean
Some generally accepted characteristics

Most people would agree that true cloud computing is:
- zero up front capital costs
- largely eliminates operational responsibilities (e.g., if a disk fails or a switch loses connectivity, you don’t need to fix it)
- for the most part, cloud computing eliminates knowledge of WHERE one’s computational work is being done; your job is being run “somewhere” out there in the “cloud”
- offers substantial elasticity and scalability
- cloud computing leverages economies of scale

Concerns

<table>
<thead>
<tr>
<th>Challenge/Issue</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>74.8%</td>
</tr>
<tr>
<td>Performance</td>
<td>68.3%</td>
</tr>
<tr>
<td>Availability</td>
<td>68.1%</td>
</tr>
<tr>
<td>Hard to integrate with in-house IT</td>
<td>65.1%</td>
</tr>
<tr>
<td>Not enough ability to customize</td>
<td>64.4%</td>
</tr>
<tr>
<td>Shared environment cost more</td>
<td>60.4%</td>
</tr>
<tr>
<td>Bringing back in-house may be difficult</td>
<td>60.0%</td>
</tr>
<tr>
<td>Regulatory requirements to operate cloud</td>
<td>51.2%</td>
</tr>
<tr>
<td>Not enough major suppliers</td>
<td>44.3%</td>
</tr>
</tbody>
</table>

Benefits of cloud computing

The potential for cost saving is the major reason of cloud services adoption by many organizations.
Cloud computing gives the freedom to use services as per the requirement and pay only for what you use.
Due to cloud computing it has become possible to run IT operations as a outsourced unit without much in-house resources.

Benefits of cloud computing

Following are benefits of cloud computing:
- Lower IT infrastructure and computer costs for users
- Improved performance
- Fewer Maintenance issues
- Instant software updates
- Improved compatibility between Operating systems
- Backup and recovery
- Performance and Scalability
- Increased storage capacity
- Increase data safety

Advantages of cloud computing

Cloud Computing Disadvantages

- Network Connection Dependency
- Limited Features
- Loss of Control
- Security
- Vulnerability to attacks
- Technical Issues
Cloud Computing Disadvantages

Virtualization and cloud computing

The main enabling technology for Cloud Computing is Virtualization. Virtualization is a partitioning of single physical server into multiple logical servers.

Once the physical server is divided, each logical server behaves like a physical server and can run an operating system and applications independently.

Companies’ like VmWare and Microsoft provide virtualization services, where instead of using your personal PC for storage and computation, you use their virtual server.

For software developers and testers virtualization comes very handy, as it allows developer to write code that runs in many different environments and more importantly to test that code.

Virtualization is mainly used for three main purposes: 1) Network Virtualization 2) Server Virtualization 3) Storage Virtualization

Virtualization and cloud computing

Network Virtualization: It is a method of combining the available resources in a network by splitting up the available bandwidth into channels, each of which is independent from the others and each channel can be assigned to a specific server or device in real time.

Storage Virtualization: It is the pooling of physical storage from multiple network storage devices into what appears to be a single storage device that is managed from a central console.

Server Virtualization: Server virtualization is the masking of server resources like processors, RAM, operating system etc, from server users. The intention of server virtualization is to increase the resource sharing and reduce the burden and complexity of computation from users.
Types of service

There are three major types of Cloud Computing Services (and several minor types as well):

SaaS – Software as a Service
IaaS – Infrastructure as a Service
PaaS – Platform as a Service

SaaS – Software as a Service

SaaS is also called “on-demand software” and is priced on pay-per-use basis.
SaaS allows a business to reduce IT operational costs by outsourcing hardware and software maintenance and support to the cloud provider.
SaaS is a rapidly growing market as indicated in recent reports that predict ongoing double digit growth.
Some advantages of SaaS are
- No expensive hardware (server) needed to run the program
- No updates or patches to maintain
- Easier support
- Equal fixed monthly costs

IaaS – Infrastructure as a Service

Infrastructure is the foundation of cloud computing.
It provides delivery of computing as a shared service reducing the investment cost, operational and maintenance of hardware.
Infrastructure as a Service (IaaS) is a way of delivering Cloud Computing infrastructure – servers, storage, network and operating systems – as an on-demand service.
Rather than purchasing servers, software, datacenter space or network equipment, clients instead buy those resources as a fully outsourced service on demand.

PaaS – Platform as a Service

PaaS provides a computing platform and solution stack as a service.
In this model user or consumers creates software using tools or libraries from the providers.
Consumer also controls software deployment and configuration settings.
Main aim is to provide networks, servers, storage and other services.

Cloud Computing

But is it really cheaper...

Research states that “cloud services can initially be more expensive than running on-premise data centers.
However, it also proves that cloud services can become cost-effective over time if organizations learn to use and operate them more efficiently.”
The statement is backed by an example of workload migration for 2,500 virtual machines from an on-premises data center to Amazon Web Services EC2.
The example TCO shows an initial uptake in cloud costs, and a steady decline as soon as organizations learn how to apply cost optimization best practices.
The chart also shows how on-premises costs may have a long tail as organizations take time to actually shut down their data centers.
**Security**

While using cloud computing, the major issue that concerns the users is security. One concern is that cloud providers themselves may have access to customer’s unencrypted data—whether it’s on disk, in memory or transmitted over the network. Some governments may decide to search through data without necessarily notifying the data owner, depending on where the data resides, which is considered a privacy breach (Example Prism Program: USA).

To provide security for systems, networks and data cloud computing service providers have joined hands with TCG (Trusted Computing Group) which is a non-profit organization which regularly releases a set of specifications to secure hardware, create self-encrypting drives and improve network security. It protects the data from root kits and malware. As computing has expanded to different devices like hard disk drives and mobile phones, TCG has extended the security measures to include these devices. It provides ability to create a unified data protection policy across all clouds. Some of the trusted cloud services are Amazon, Box.net, Gmail, Digital Ocean, and many others.

Cloud security consists of a set of policies, controls, procedures and technologies that work together to protect cloud-based systems, data, and infrastructure. These security measures are configured to protect cloud data, support regulatory compliance and protect customers’ privacy as well as setting authentication rules for individual users and devices. From authenticating access to filtering traffic, cloud security can be configured to the exact needs of the business. And because these rules can be configured and managed in one place, administration overheads are reduced and IT teams empowered to focus on other areas of the business.

**Trusting the Cloud**

Because Apple and other devices automatically upload so much to the cloud, by default—including full phone backups, which, if an account is compromised, could be downloaded by an attacker onto another device—these personal cloud services are particularly dangerous. Their usability in terms of content management is poor at best—does anybody really know what’s sitting in Apple’s or Google’s data stores from their phones? This, combined with ongoing threats like carefully-crafted phishing attacks and large-volume password cracking, makes it especially hard to protect mobile data in a world where everything on your phone is already on the Internet, protected only by your login credentials. — Ars Technica

**Leaking in the Cloud**

Hundreds of exposed Amazon cloud backups found leaking sensitive data.
Is my Data Safe in the Cloud?

Is your data safe in your office?
- What happens if your data is in your physical office and there is a fire/flood/hurricane?
- If you’re worried about risk, buy insurance to protect against risk.
- Cloud computing has a lot of insurance built in.
Your data is housed using redundant hardware. The hardware is designed to be risk tolerant. In most cases, you would not even notice a datacenter hardware failure.
Your data is backed up at least daily, probably more often, and you can go back and retrieve any deleted files and projects.
Cloud computing providers are in the business of keeping their client’s data protected. Their systems and practices are more redundant and more secure than 99% of businesses doing it themselves.

Privacy

Privacy presents another strong barrier for users to adapt into Cloud Computing systems.
There are certain measures which can improve privacy in cloud computing.
The administrative staff of the cloud computing service could theoretically monitor the data moving in memory before it is stored in disk. To keep the confidentiality of a data, administrative and legal controls should prevent this from happening.
The other way for increasing the privacy is to keep the data encrypted at the cloud storage site, preventing unauthorized access through the internet; even cloud vendor can’t access the data either.

What happens when it rains?

- Service outages (GitHub, GitLab, Netflix, XBox Live, Gmail)
- Security breaches (Dropbox, iCloud, LastPass)
- Vendor Lock-in (AWS, GAE, Windows Azure)
- Data Lock-in (Google Apps, Office 365)
- Service changes (OneDrive, Netflix)
- Service closure (Zune/PlaysForSure, Rhapsody, Beats Music, Google Reader/Wave/Code/Picasa)

The Cloud means giving up Control.

Do You Trust The Cloud?

What is Private Cloud Computing

There are many companies offering services over the public Internet; these are public Cloud providers.
I am sure you are familiar with many of them, from social networking sites like Twitter and Facebook to strictly business applications like Office 365 and Salesforce CRM.
A Private Cloud solution is also accessed over the Internet or a dedicated private circuit.
In contrast, a private Cloud usually connects two locations, the customer and the provider, and is housed in a private datacenter.
A Private Cloud is generally dedicated to a single company.
A Private Cloud can take the place of premised based servers and desktops.
You can run just about any hardware or software in a Private Cloud.
A Private Cloud is generally more flexible and customizable than a Public Cloud.
You can run your entire business from a Private Cloud environment, not just a single application.
Most companies use a mix of traditional, Public, and Private Cloud services, a Hybrid Cloud.

Grid computing vs cloud computing

“Grid Computing” is an infrastructure that links computing resources such as PCs, servers, workstations and storage elements and provides the mechanism required to access them.
Grid Computing is a middleware to co-ordinate disparate IT resources across a network, allowing them to function as whole.
It is more often used in scientific research and in universities for educational purpose.
For example, a group of architect students working on a different project requires a specific design tool and a software for designing purpose but only couple of them got access to this design tool, the problem is how they can make this tool available to rest of the students.
To make available for other students they will put this design tool on campus network, now the grid will connect all these computers in campus network and allow student to use design tool required for their project from anywhere.

Grid computing vs cloud computing

Cloud Computing
Cloud computing works more as a service provider for utilizing computer resource
Cloud computing is a centralized model Cloud is a collection of computers usually owned by a single party.
Cloud offers more services all most all the services like web hosting, DB (Data Base) support and much more
Cloud computing is typically provided within a single organization (eg : Amazon)

Grid Computing
Grid computing uses the available resource and interconnected computer systems to accomplish a common goal
Grid computing is a decentralized model, where the computation could occur over many administrative model
A grid is a collection of computers which is owned by a multiple parties in multiple locations and connected together so that users can share the combined power of resources
Grid provides limited services
Grid computing federates the resources located within different organization.
Many of the cloud hosting sites have customized development capabilities. For example, they may have one-click appliances to perform tasks such as DNS, Databases, Gitlab, ElasticSearch, Web Servers, ...

In addition, many cloud hosting sites can provide access to multiple computing language environments, debuggers, compilers, software scanning tools, … All of these applications would be very costly if the cloud customers had to provide these packages themselves.

Not every application is suitable for the cloud. Applications not suited for cloud:
- ERP and Other Core Systems of Record
- High Performance/Low latency Computing (stocks, manufacturing)
- Performance Intensive computing (video editing, graphic design)
- Critical/Sensitive Data Processing (HIPPA, FISMA)
- Applications requiring custom software
- High I/O requirements (may be expensive)
- Government (Military) software development
- Specific hardware architecture (RISC, ARM, …)
- Oracle and other large databases using shared disk architecture

Applications suited for cloud:
- Software Development, Testing and Quality Assurance
- Collaboration Apps (email, web conferencing, document sharing)
- Personal Productivity Apps (Office Suite)
- Big Data, Analytics and Other Computing-Intensive Apps
- Disaster Recovery, Business Continuity and Records Retention