Table 4.1 Public Cloud Offerings of IaaS [10,18]

Cloud Name	VM Instance Capacity	API and Access Tools	Hypervisor, Guest OS
Amazon EC2	Each instance has 1–20 EC2 processors, 1.7–15 GB of memory, and 160–1.69 TB of storage.	CLI or Web Service (WS) portal	Xen, Linux, Windows
GoGrid	Each instance has 1–6 CPUs, 0.5–8 GB of memory, and 30–480 GB of storage.	REST, Java, PHP, Python, Ruby	Xen, Linux, Windows
Rackspace Cloud	Each instance has a four-core CPU, 0.25–16 GB of memory, and 10–620 GB of storage.	REST, Python, PHP, Java, C#, .NET	Xen, Linux
FlexiScale in the UK	Each instance has 1–4 CPUs, 0.5–16 GB of memory, and 20–270 GB of storage.	Web console	Xen, Linux, Windows
Joyent Cloud	Each instance has up to eight CPUs, 0.25–32 GB of memory, and 30–480 GB of storage.	No specific API, SSH, Virtual/Min	OS-level virtualizatio OpenSolar

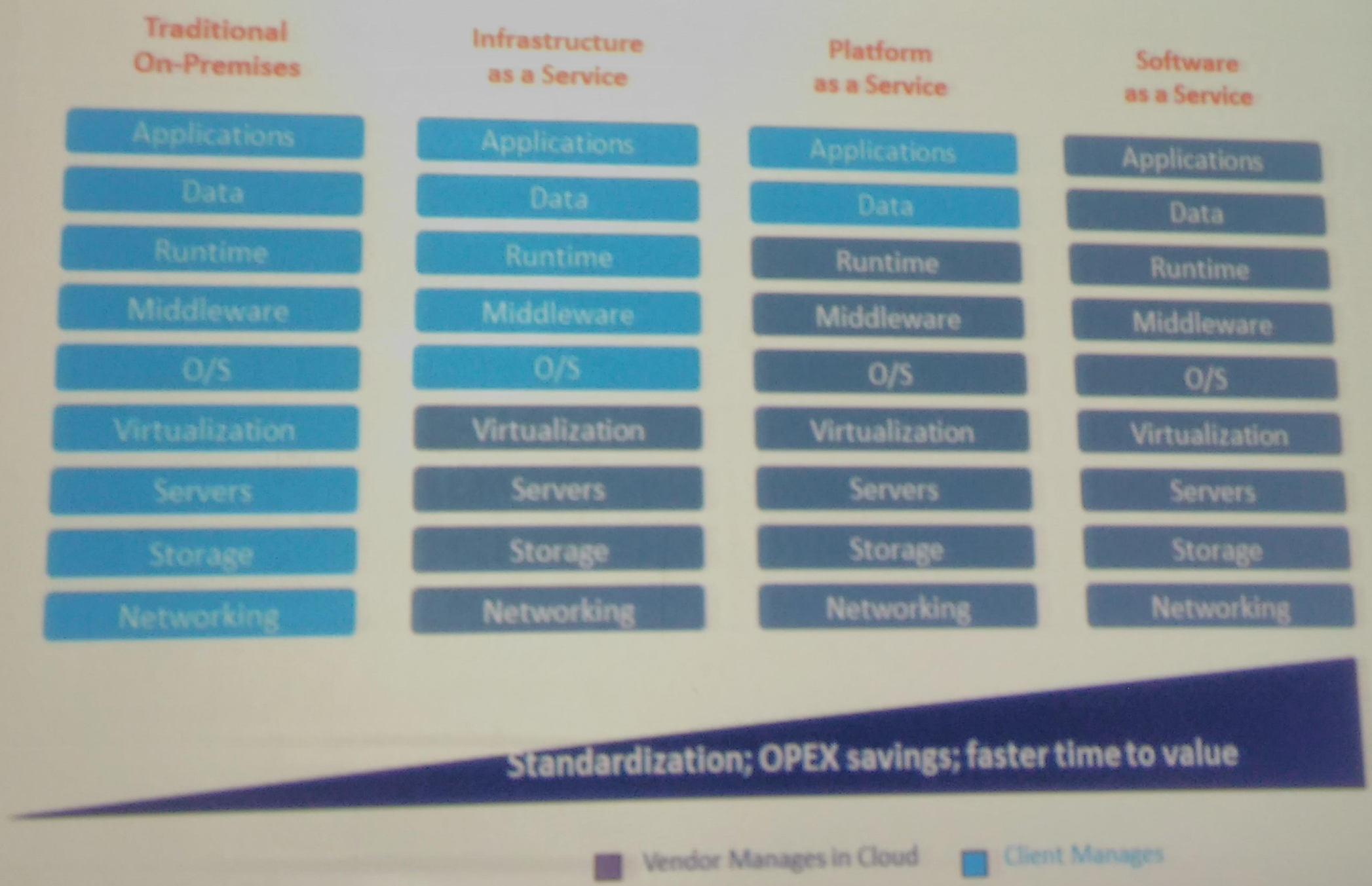
Infrastructure as a service (IaaS)

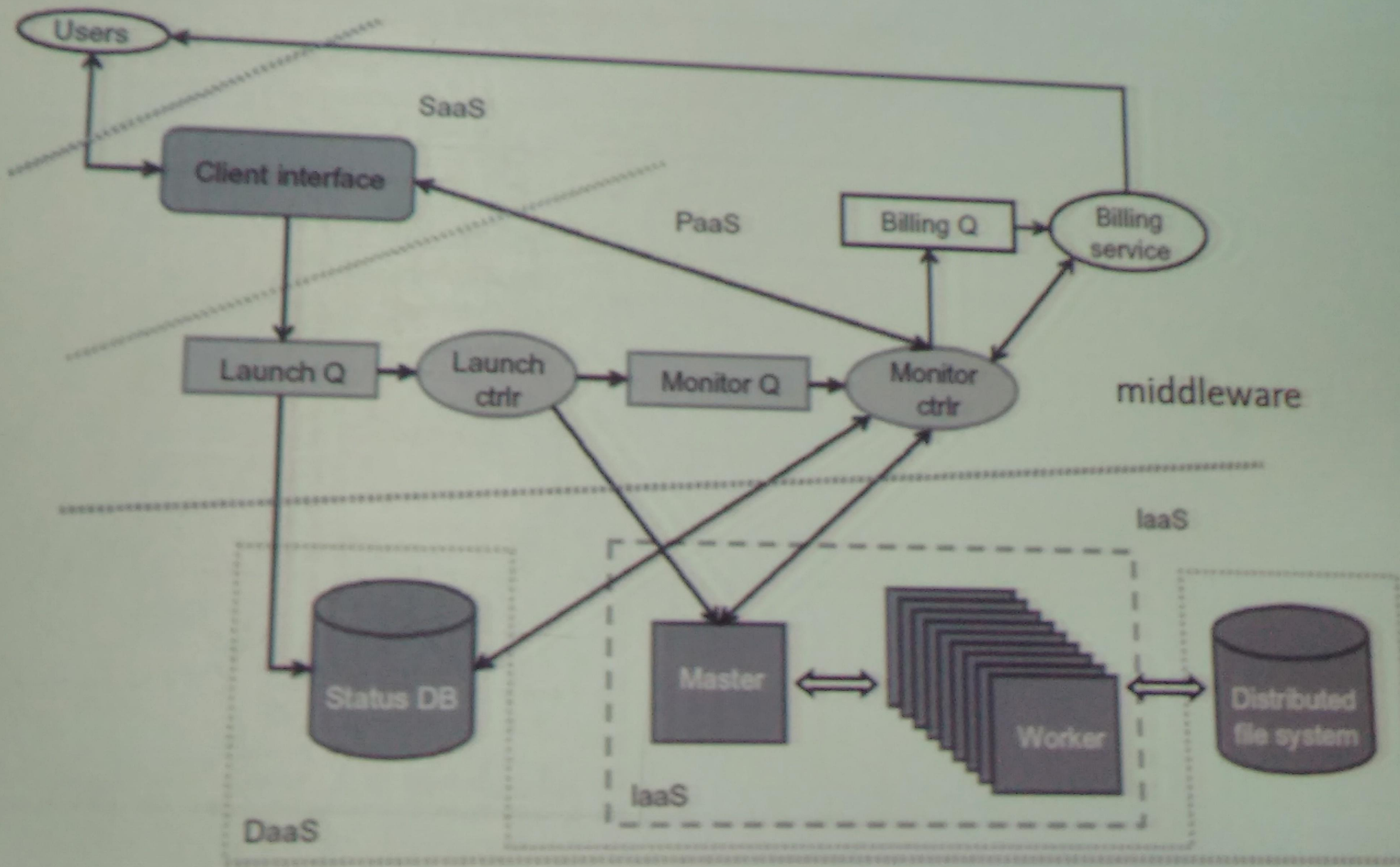
- Most basic cloud service model
- Cloud providers offer computers, as physical or more often as virtual machines, and other resources.
- Virtual machines are run as guests by a hypervisor, such as Xen or KVM.
- Cloud users deploy their applications by then installing operating system images on the machines as well as their application software.
- Cloud providers typically bill IaaS services on a utility computing basis, that is, cost will reflect the amount of resources allocated and consumed.
- Examples of IaaS include: Amazon Cloud Formation (and underlying services such as Amazon EC2), Rackspace Cloud, Terremark, and Google Compute Engine.

Platform as a service (PaaS)

- Cloud providers deliver a computing platform typically including operating system, programming language execution environment, database, and web server.
- Application developers develop and run their software on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers.
- Examples of PaaS include: Amazon Elastic Beanstalk, Cloud Foundry, Heroku, Force.com, EngineYard, Mendix, Google App Engine, Microsoft Azure and OrangeScape

Cloud Service Model

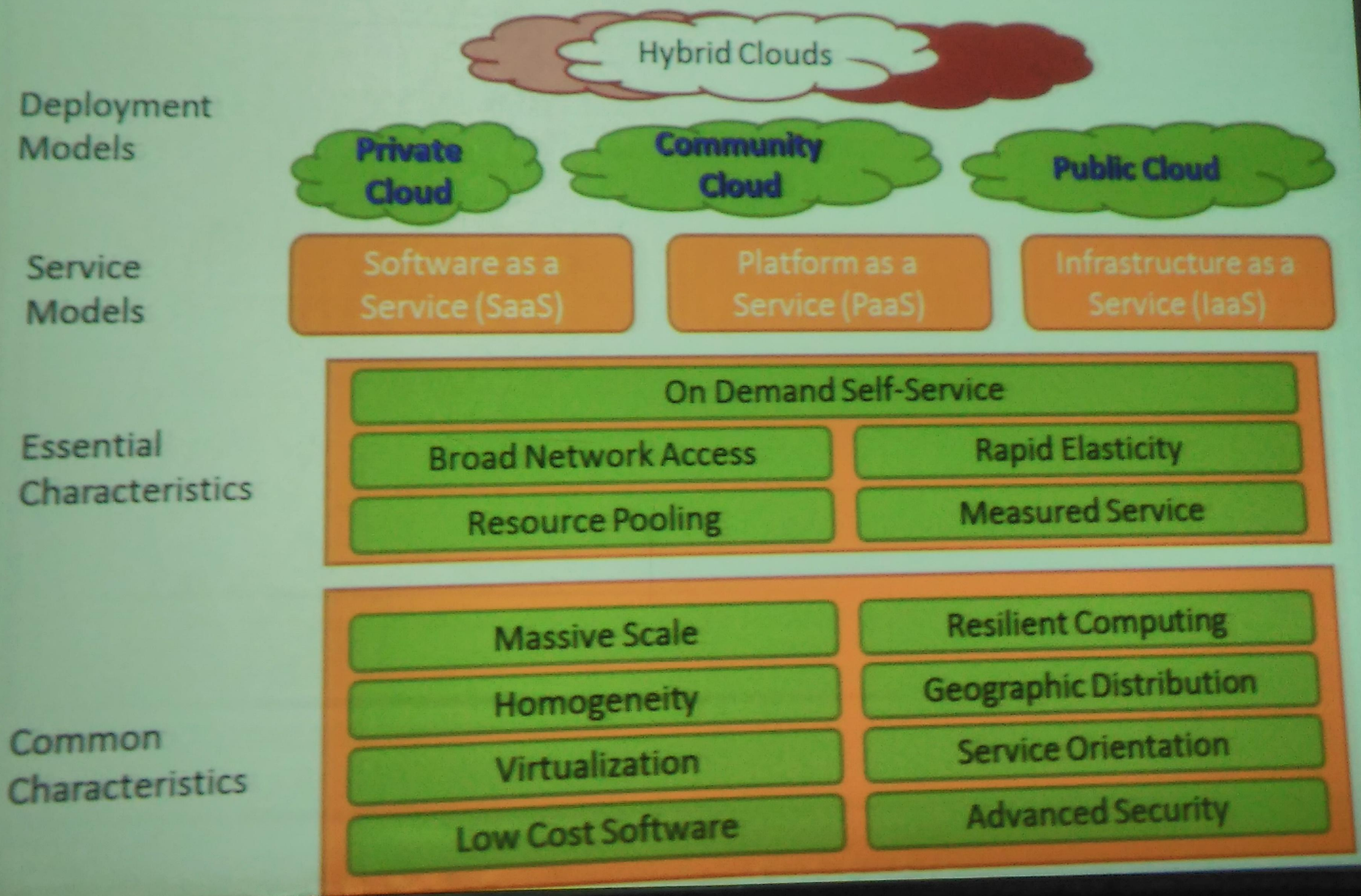




FIGURE

The IaaS, PaaS, and SaaS cloud service models at different service levels.

The NIST Cloud Definition Framework



Platform as a Service (PaaS)

- Users are provided with a container environment to run/test their software components where all of the software required serving the users' purpose have been already installed and configured.
  - Microsoft Azure (http://www.microsoft.com/windowsazure/)
  - Google App Engine (http://code.google.com/appengine/)

- This service model would benefit computer science students and instructors where there would be no need to spend time setting up the development environment.

- Students in need for access to licensed platform (MATLAB, SPSS) that is only available on the on-campus computers can also benefit from this service model by accessing the platform on the cloud from anywhere.

Click to add notes

PaaS Offerings from Public Clouds

Table 4.2 Five Public Cloud Offerings of PaaS [10,18]

Cloud Name	Languages and Developer Tools	Programming Models Supported by Provider	Target Applications and Storage Option
Google App Engine	Python, Java, and Eclipse-based IDE	MapReduce, Web programming on demand	Web applications and BigTable storage
Salesforce.com's Force.com	Apex, Eclipse-based IDE, Web-based Wizard	Workflow, Excel-like formula, Web programming on demand	Business applications such as CRM
Microsoft Azure	.NET, Azure tools for MS Visual Studio	Unrestricted model	Enterprise and Web applications
Amazon Elastic MapReduce	Hive, Pig, Cascading, Java, Ruby, Perl, Python, PHP, R, C++	MapReduce	Data processing and e-commerce
Aneka	.NET, stand-alone SDK	Threads, task, MapReduce	.NET enterprise applications, HPC

Software as a service (SaaS)

- Cloud providers install and operate application software in the cloud and cloud users access the software from cloud clients.

icing model for SaaS applications is typically a
rly flat fee per user, so price is scalable
e if users are added or removed at any

es of SaaS include: Google Apps, innkeypos,
books Online, Limelight Video Platform,
force.com, and Microsoft Office 365.

Opportunities and Challenges

- The use of the cloud provides a number of opportunities:
  - It enables services to be used without any understanding of their infrastructure.
  - Cloud computing works using economies of scale:
    - It potentially lowers the outlay expense for start up companies, as they would no longer need to buy their own software or servers.
    - Cost would be by on-demand pricing.
    - Vendors and Service providers claim costs by establishing an ongoing revenue stream.
  - Data and services are stored remotely but accessible from "anywhere".

Opportunities and Challenges

- In parallel there has been backlash against cloud computing:
  - Use of cloud computing means dependence on others and that could possibly limit flexibility and innovation:
    - The others are likely become the bigger Internet companies like Google and IBM, who may monopolise the market.
    - Some argue that this use of supercomputers is a return to the time of mainframe computing that the PC was a reaction against.
  - Security could prove to be a big issue:
    - It is still unclear how safe out-sourced data is and when using these services ownership of data is not always clear.
  - There are also issues relating to policy and access:
    - If your data is stored abroad whose policy do you adhere to?
    - What happens if the remote server goes down?
    - How will you then access files?
    - There have been cases of users being locked out of accounts and losing access to data.

Advantages of Cloud Computing

- Lower computer costs:
  - You do not need a high-powered and high-priced computer to run cloud computing's web-based applications.
  - Since applications run in the cloud, not on the desktop PC, your desktop PC does not need the processing power or hard disk space demanded by traditional desktop software.
  - When you are using web-based applications, your PC can be less expensive, with a smaller hard disk, less memory, more efficient processor...
  - In fact, your PC in this scenario does not even need a CD or DVD drive, as no software programs have to be loaded and no document files need to be saved.

Advantages of Cloud Computing

- Improved performance:
  - With few large programs hogging your computer's memory, you will see better performance from your PC.
  - Computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory...
- Reduced software costs:
  - Instead of purchasing expensive software applications, you can get most of what you need for free!
    - most cloud computing applications today, such as the Google Docs suite.
  - better than paying for similar commercial software
    - which alone may be justification for switching to cloud applications.

Advantages of Cloud Computing

- Instant software updates:
  - Another advantage to cloud computing is that you are no longer faced with choosing between obsolete software and high upgrade costs.
  - When the application is web-based, updates happen automatically
    - available the next time you log into the cloud.
  - When you access a web-based application, you get the latest version
    - without needing to pay for or download an upgrade.

- Improved document format compatibility.
  - You do not have to worry about the documents you create on your machine being compatible with other users' applications or OSes
  - There are potentially no format incompatibilities when everyone is sharing documents and applications in the cloud.

Advantages of Cloud Computing

- Universal document access:
  - That is not a problem with cloud computing, because you do not take your documents with you.
  - Instead, they stay in the cloud, and you can access them whenever you have a computer and an Internet connection
  - Documents are instantly available from wherever you are

Advantages of Cloud Computing

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  - Documents are instantly available from wherever you are
- Latest version availability:
  - When you edit a document at home, that edited version is what you see when you access the document at work.
  - The cloud always hosts the latest version of your documents
    - as long as you are connected, you are not in danger of having an outdated version

Advantages of Cloud Computing

- Unlimited storage capacity:
  - Cloud computing offers virtually limitless storage.
  - Your computer's current 1 Tbyte hard drive is small compared to the hundreds of Pbytes available in the cloud.
- Increased data reliability:
  - Unlike desktop computing, in which if a hard disk crashes and destroy all your valuable data, a computer crashing in the cloud should not affect the storage of your data.
    - if your personal computer crashes, all your data is still out there in the cloud, still accessible
  - In a world where few individual desktop PC users back up their data on a regular basis, cloud computing is a data-safe computing platform!

Advantages of Cloud Computing

- Easier group collaboration:
  - Sharing documents leads directly to better collaboration.
  - Many users do this as it is an important advantages of cloud computing
    - multiple users can collaborate easily on documents and projects
- Device independence.
  - You are no longer tethered to a single computer or network.
  - Changes to computers, applications and documents follow you through the cloud.
  - Move to a portable device, and your applications and documents are still available.

Disadvantages of Cloud Computing

- Requires a constant Internet connection:
  - Cloud computing is impossible if you cannot connect to the Internet.
  - Since you use the Internet to connect to both your applications and documents, if you do not have an Internet connection you cannot access anything, even your own documents.
  - A dead Internet connection means no work and in areas where Internet connections are few or inherently unreliable, this could be a deal-breaker.

Disadvantages of Cloud Computing

- Stored data might not be secure:
  - With cloud computing, all your data is stored on the cloud.
    - The questions is How secure is the cloud?
  - Can unauthorised users gain access to your confidential data?
- Stored data can be lost:
  - Theoretically, data stored in the cloud is safe, replicated across multiple machines.
  - But on the off chance that your data goes missing, you have no physical or local backup.
    - Put simply, relying on the cloud puts you at risk if the cloud lets you down.

Virtual Hands-on Laboratories

- Used to address many of the challenges faced by educators struggling with the desire to
  - provide their students with realistic learning environments.
  - protecting production systems from undesirable and potentially illegal interference.

- In this usage model, a number of VMs are allocated to each students to test of execute a certain scenario.

- Ease up the process of creating scenarios as VMs can be archived or deployed by simply copying the files.
- Ease up the process of exchanging scenarios where the configured VMs can be stored on a CD or DVD.

- provide their students with realistic learning environments.
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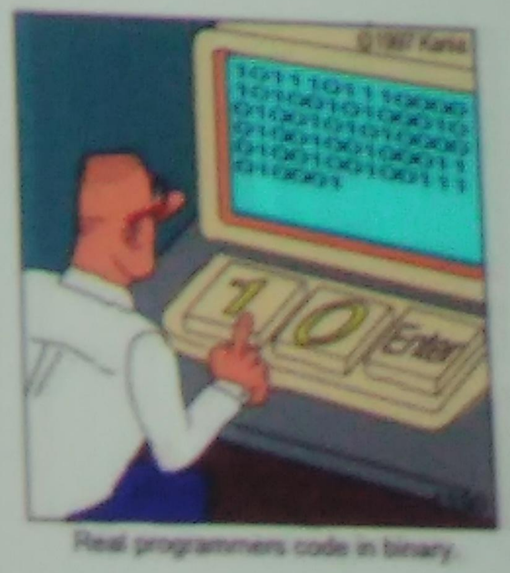
- Ease up the process of creating scenarios as VMs can be archived or deployed by simply copying the files.
- Ease up the process of exchanging scenarios where the configured VMs can be stored on a CD or DVD.
- Same concepts are also applied in providing testing environments in software companies.

- Example: Moodle - Open-source learning platform

Software As A Service (on-demand software)

- Users access applications and its associated data directly from the cloud without getting them installed on their machine using a thin client like web browsers over the Internet.
  - Solving many compatibility issues
  - Reducing universities' IT complexity and cost
  - Providing anywhere anytime access.



- **Examples:**

- A number of examples of using SaaS in educational institutes based on Google Apps - Education Edition(http://www.google.com/apps/intl/en/edu/university.html) were introduced showing major benefits gained from using this approach as in the paper mentioned below.

- ZOHO Projects (https://projects.zoho.com) is another example currently used in Faculty of Computers and Information - Cairo University to manage some graduation projects.

Platform as a Service (PaaS)

- Users are provided with a container environment to run/test their software components where all of the software required serving the users' purpose have been already installed and configured.
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Infrastructure as a Service (IaaS)

- Virtualization is used to provide computational resources to users though the user is the one responsible for installing and configuring all needed software.

- This usage model is the closest to the Grid concept.

Examples:

-Amazon EC2 (http://aws.amazon.com/ec2/)

[illegible] University TeraGrid and Wispy Project http://www.rcac.purdue.edu/teragrid/resources/#cr

- K. [illegible], R. Figueiredo, J. Fortes, T. Freeman, and M. Tsugawa. "**Science Clouds:** Early Experiences in Cloud Computing for Scientific Applications." Proceeding of Cloud Computing and Its Applications. Chicago, IL, USA, 22-23 October 2008.

Future Solution for E-governance

- Using cloud computing and service-oriented architecture in the public sector should improve the conditions for development and deployment of e-government solutions.
  - Cloud computing permits to uniformly cover the whole country with e-government solutions, independently of divergence of local administrative units.
  - Service-oriented architecture facilitates provision of compound services covering whole customer processes where a customer may be a citizen or an enterprise.

Cloud in Health Sector

- **Cost :** Cloud programs, platforms and storage take the IT strain away from individual organizations instead of having everything in-house and paying for server capacity and programs that you might only use occasionally.

- **Scalability :** Cloud computing can be instantly and almost infinitely expandable. Instead of whenever you want to use a new program it has to be installed or upgraded and tested on multiple machines.

- **Ubiquity :** Cloud computing can help by making the same application available over a large geographic area, without the need for "custom plumbing" to connect all the disparate systems.
- Home monitoring, whereby data from measurement devices (e.g., a glucometer) are streamed to a provider's private cloud with end-to-end encryption.

Collaboration : Storing patient data in centralized databases for restricted access by authorized persons (e.g., for research purposes). Storing practice guidelines in public clouds and exchange experience.

Risk : Cloud automates the process of providing multiple, geographically dispersed backups, meaning that even a natural disaster in one area is unlikely to take down your IT systems.

27.3.18

Cloud Computing

Defn: A style of computing massively scalable IT-related capabilities are provided "as-a-service" using Internet technologies to multiple external customers (— Gartner)

Cloud comp. is using the Internet to access someone else's s/w running on someone else's h/w in someone else's data centre.
(— Lewis Cunningham)

NIST defn

"A model for ~~defining~~ enabling convenient, on demand, network access to a shared ~~pool~~ pool of config. comp. resources (eg networks, servers, storage, appl. and services) that can be rapidly provisioned and released with minimal manag. effort or service provider ~~interac~~ interaction".

Conventional Comp. vs Cloud Comp

Conv.	Cloud
Manually provisioned	self provisioned
Dedicated h/w	shared h/w
Fixed capacity	Elastic capacity
pay for capacity	Pay for use
Capital & Operational Expenses	Operational Expense
managed via Sysadmins.	Managed via APIs

Features of Cloud Comp.

- Availability & on-demand service

Pay for capacity
Capital & Operational Expenses
Managed via Sysadmins.

Operational Expense
Managed via APIs

Features of Cloud Comp.

- Scalability & on-demand service
- User centric interface
- Guaranteed Quality of Service (QoS)
- Autonomous Sys.
- Pricing

~~Cloud Service Model~~

Essential Cloud Characteristics

- On demand self service — comp. capab. as needed autom.
- Broad network acc. — serv available over net using desktop, mobile etc.

Essential cloud charac.
- Resource Pooling — loc. indep., provider resources pooled to serve multiple clients
- Rapid elasticity — Ability to quick scale service
- measured service — control, optimise serv. based on metering

Common Cloud Charac.

massive scale, Homogeneity, Virtualisatn, Resilient comp, low cost sto, geographic distributn, service orientatn, Adv. security technologies

NIST Cloud Defn. Framework

Hybrid Clouds

Deployment models	Private	Community	Public
Service models	Sftw as a service (SaaS)	Platform as a service (PaaS)	Infrastructure as a service (IaaS)

Private Cloud

- Single org only
- managed by org or 3rd party
- on or off premise

Community cloud

- Shared infrstr. for specific community
- Several orgs that have shared concerns
- managed by org or a 3rd party

Public Cloud

- sold to public, mega-scale infrastructure
- available to general public

Hybrid cloud

- composition of two or more clouds
- bound by std or proprietary technology
- Fog technology

Need for fog computing

- available to general public

Hybrid cloud
- composition of two or more clouds
- bound by std or proprietary technology
- Fog technology

Need for fog computing
- why can't do ~~it in~~ all in cloud?
- cloud comp forces the end user for many details
- This bliss becomes a prob. for latency-sensitive appli.
- why can't do all in end systems?
- Physical constraints : Energy, space etc.

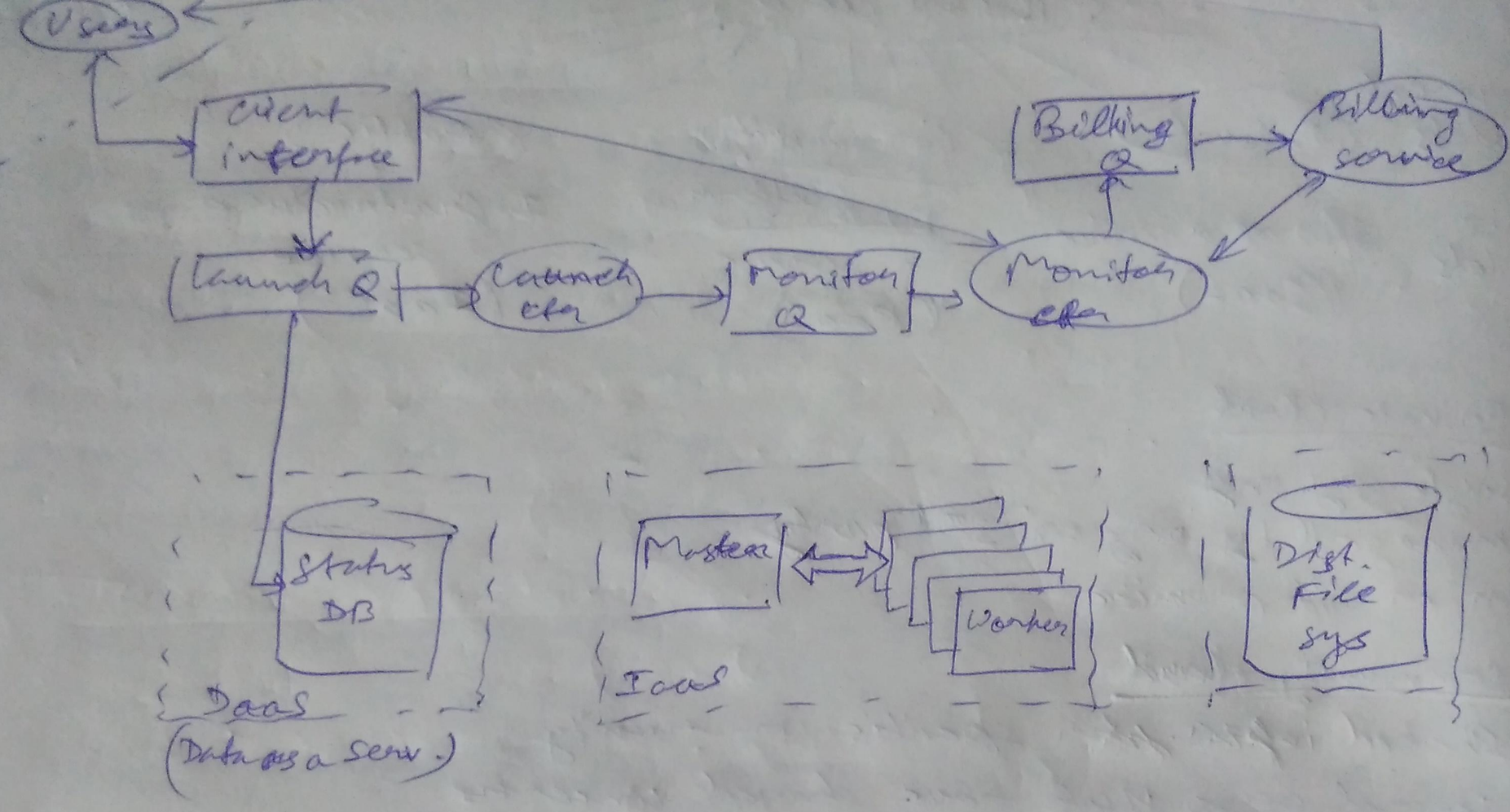
Key ~~attribs~~ attribute of Fog computing -
- Appl. that req. low & predictable latency (STLS, SCV)
- Geo dist. appl. (pipelining monitoring, STLS)
- Fast mobile appl. (smart connected vehicle, ~~STLS~~ grail)
- Large-scale Dist cloud control sys. (STLS, smart grid)
- IoT also brings Big Data with ~~at~~ a twist : rather than high volume, the no. of data sre. dist. geographically.

Cloud Service Model

✗ - Vendor manages in cloud ✓ - client manages

Traditional on Premises	Infra as Serv.	Platform as Serv.	Software as Serv.
Appl. ✓	✓	✓	✗
Data ✓	✓	✓	✗
Runtime ✓	✓	✗	✗
Middleware ✓	✓	✗	✗
O/S ✓	✓	✗	✗
Virtualization ✓	✗	✗	✗
Servers ✓	✗	✗	✗
Storage ✓	✗	✗	✗
Networking ✓	✗	✗	✗

Customization, OPEX savings, time to ~~evaluate~~ → increase



~~Infrastructure as~~ IaaS

- H/W is virtualized in cloud
- The service vendor owns the equip: servers, storage, network, infra and so forth.
- The developer creates virtual H/W on which to develop appl. & services.
- The developer interacts with IaaS model to create virtual priv. servers, virt priv. storage, virt. priv. network.
- populates virt sys. with appl. & services it needs to complete its solns.
- the virt. resources are mapped to real sys.
- when client interacts with IaaS servs and requests resources

its soln.

- the virt. resources are mapped to real sys.
- when client interacts with IaaS serv. and requests resources from virt. sys., those requests are redirected to the real servers that do the actual work.

IaaS Workloads

- fundamental unit of virt. client in IaaS deployment.
- simulates ability of certain type of real ~~&~~ or physical server to do an amount of work.
- work done can be measured by no. of Transactions per Minute (TPM)
- workload has certain other attrib. such as Disk I/O measured in I/O per sec. (IOPS), the amount of RAM consumed under load in MB, network throughput & latency, and so forth.

IaaS Offerings

PaaS

- Cloud providers deliver comp. platform....
- Appl. dev. develop & run their s/w on cloud platform....
- Eg - Amazon Beanstalk, Cloud Foundry, Google App Engine.

PaaS Offerings

SaaS

- Cloud providers install & operate appl. s/w in cloud & cloud users access s/w from cloud clients.

for per user, so price is scalable and adjustable if users added/removed.

- Eg - Google apps, Salesforce.com, Microsoft office 365, Limelight video platform.

Opportunities & Challenges -

- The use of cloud provides no. of opportunities -
- enables services to be used without understanding of infra.

Advantages of Cloud Computing -

Disadvantages of Cloud Computing -

- Internet connection.

Usage Models -

Five diff. cloud models -

- Cloud based storage - facilitate collab. b/w students by allowing them to work on same documents. dropbox, google.
- Virtual Hands on Laboratories

Used to address many of the challenges by struggling with desire to provide.

- Software as a service (on demand s/w)
- PaaS
- IaaS.

Cloud comp. in E-governance -

Cloud in Health sector -