TECHLAV

Seminar:
Introduction to Cloud Computing

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ECE ELECTRICAL & COMPUTER ENGINEERING

Autonomous Control Engineering UTSA

Outline

1. **Motivation: Growth and carbon footprint**
2. **Cloud 101: Important concepts that define cloud**
3. **Energy Optimization**
4. **Current Cloud Research**
5. **The Open Cloud Institute**

Part 1
Motivation

Motivation: Challenges in Cloud Computing

- In 1995 there were 18,000 websites
- By 2009, 125 million websites and growing
- Green movement forcing hand of Cloud Data Centers (CDC) operators to become more efficient

Motivation: Challenges in Cloud Computing

- Cost per Virtual Machine (VM) lower the larger the CDC becomes.
- This drives Cloud Providers to build larger and larger CDCs.
- In 2011, CDCs consumed 1.5%+ of total US electricity consumption, ~31GW

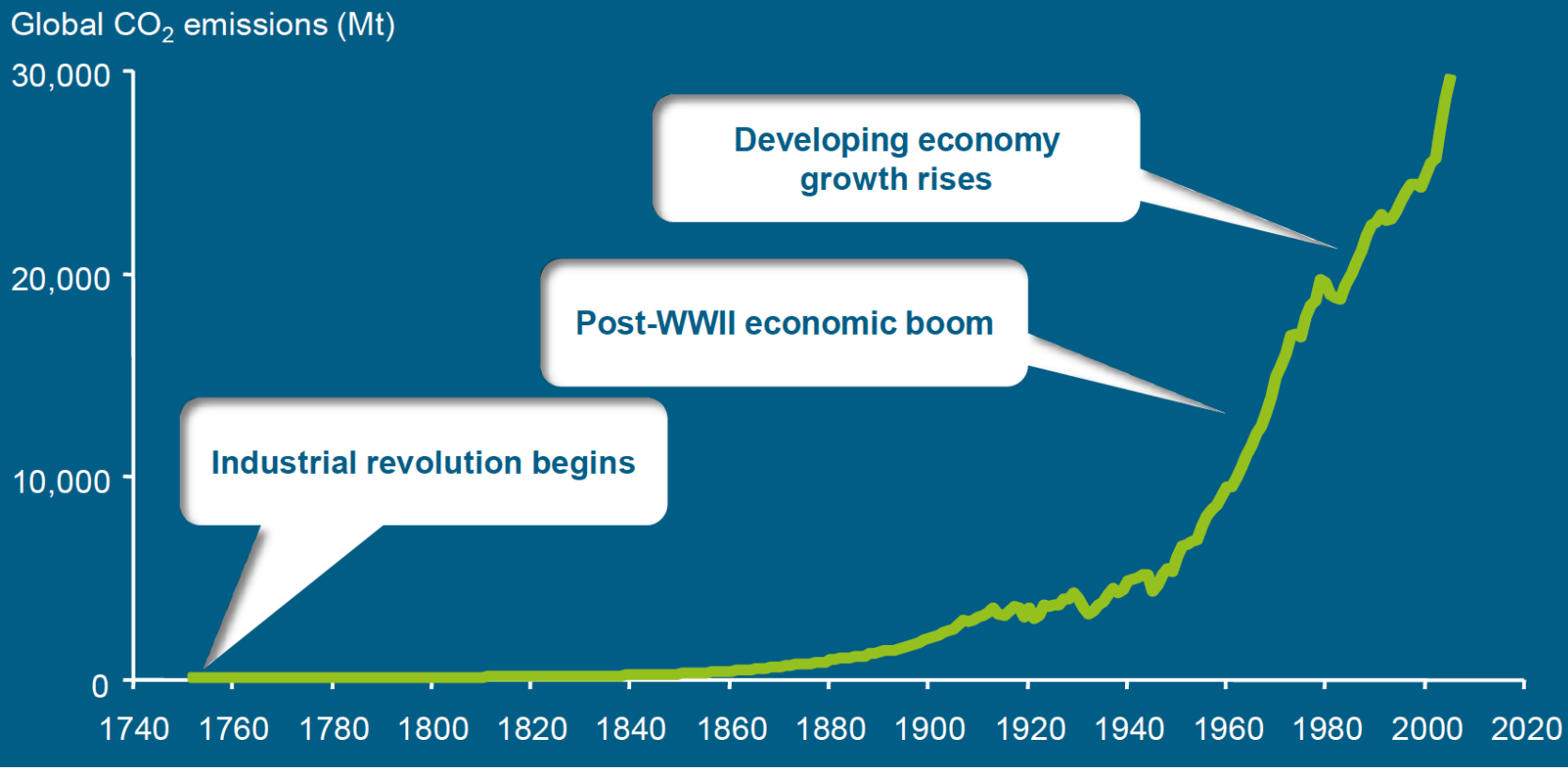
Motivation: Challenges in Cloud Computing

- Microsoft said it had over 1M servers in 2013
- Google has even more!
- …not to mention Amazon, Rackspace, Yahoo…

But the Cloud promises to actually save energy

Study done to re-calculate the total reduction in carbon that can potentially be saved by technology such as Cloud Computing

Human activity combined with limited emissions abatement has pushed CO_2 emissions to nearly 32,000 Mt in 2009



The potential for information technology to reduce global carbon emissions has been under-estimated until now

9.1 $GtCO_2e$

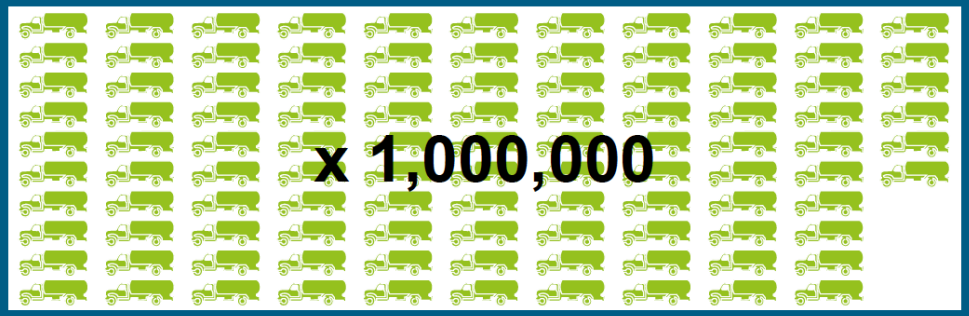
Total abatement potential of ICT-enabled solutions in 2020

16.5%

% of global GHG emissions in 2020

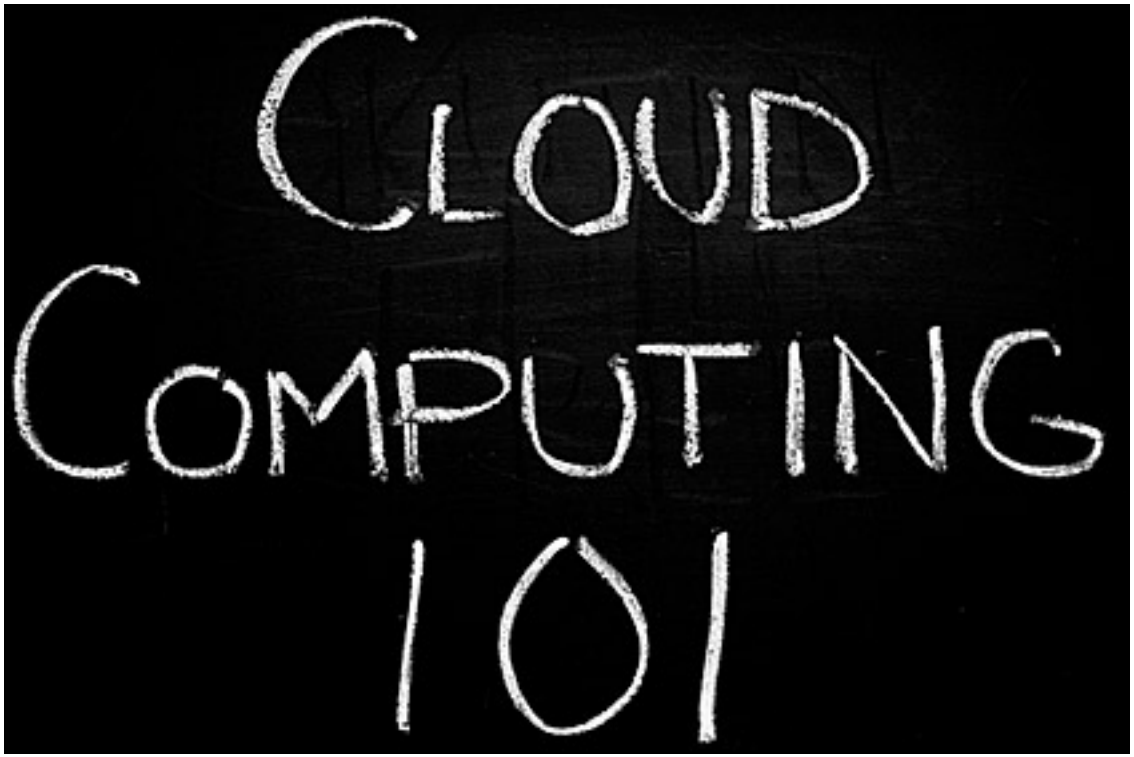
9.1 gigatons of GHG emissions amounts to USD1.9 trillion in gross energy and fuel savings

Savings of 21.6 billion barrels of oil[1]



Equivalent to GDP of the Russian economy[2]

Part 2
Cloud 101



So what is the "Cloud"?

"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

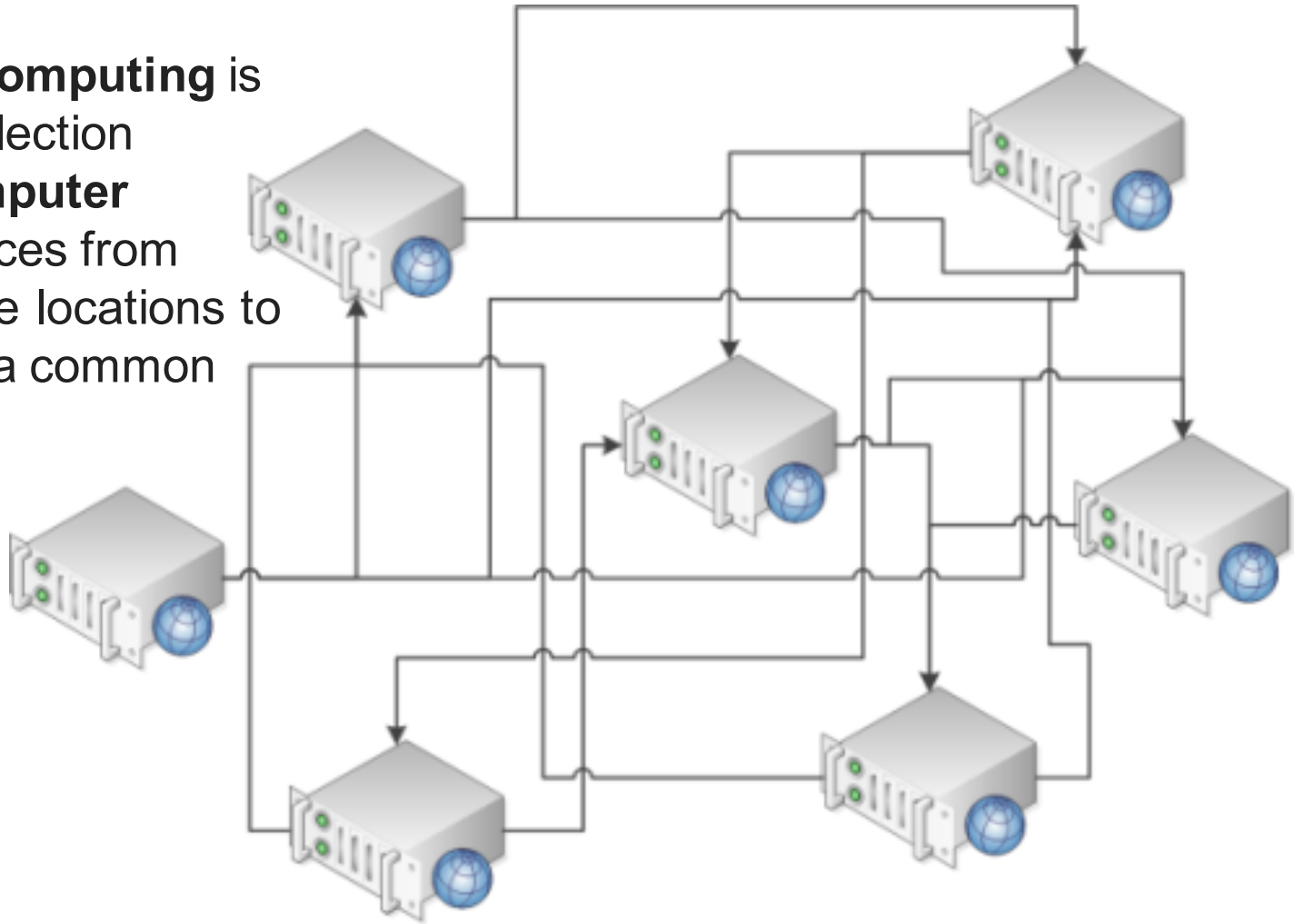
–National Institute of Standards and Technology (NIST)

To be Cloud, you need…

- ✓ On-demand self-service
- ✓ Broad network access
- ✓ Resource pooling (Grid Computing)
- ✓ Rapid elasticity (Virtualization)
- ✓ Measured service (Utility Based Pricing Model)

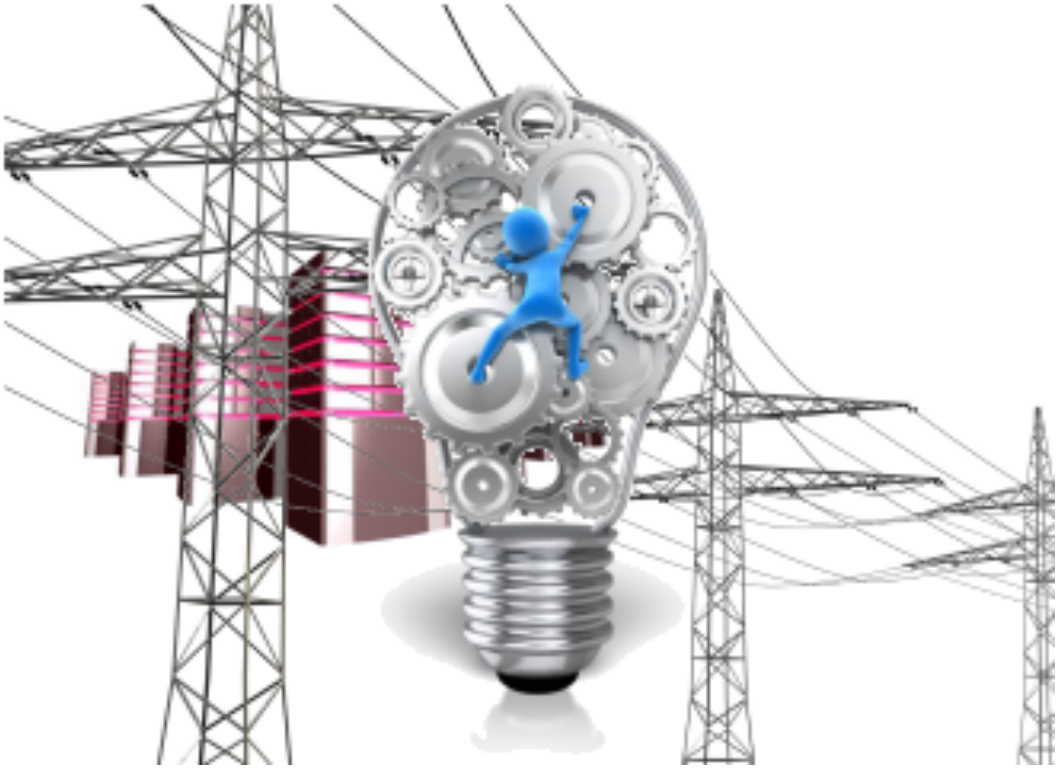
*Cloud Computing Concepts: **Grid Computing***

Grid computing is the collection of **computer** resources from multiple locations to reach a common goal.



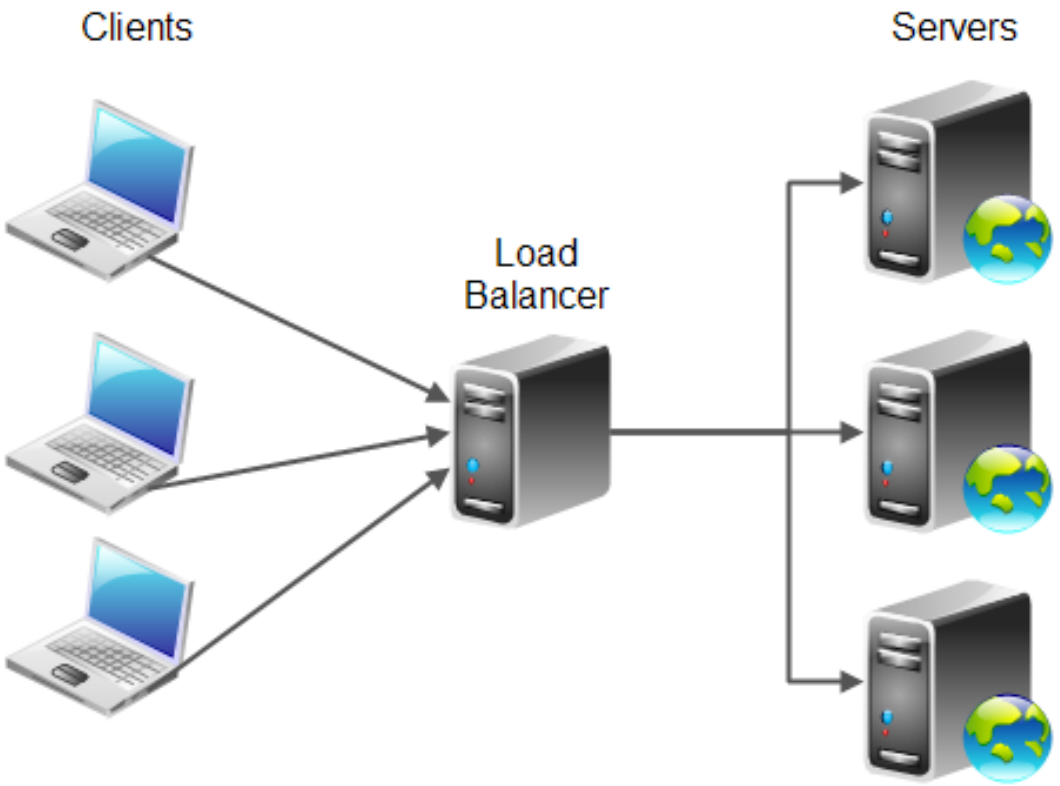
*Cloud Computing Concepts: **Utility Computing***

Utility computing is a service provisioning model in which a service provider makes **computing** resources and infrastructure management available to the customer as needed, and charges them for specific usage rather than a flat rate.



*Cloud Computing Concepts: **Load Balancing***

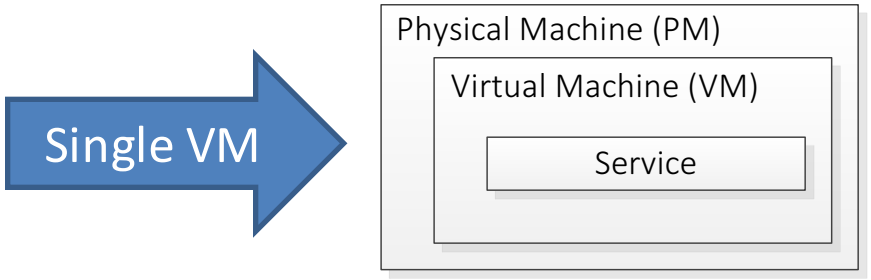
Load balancing is dividing the amount of work that a computer has to do between two or more computers so that more work gets done in the same amount of time and, in general, all users get served faster.

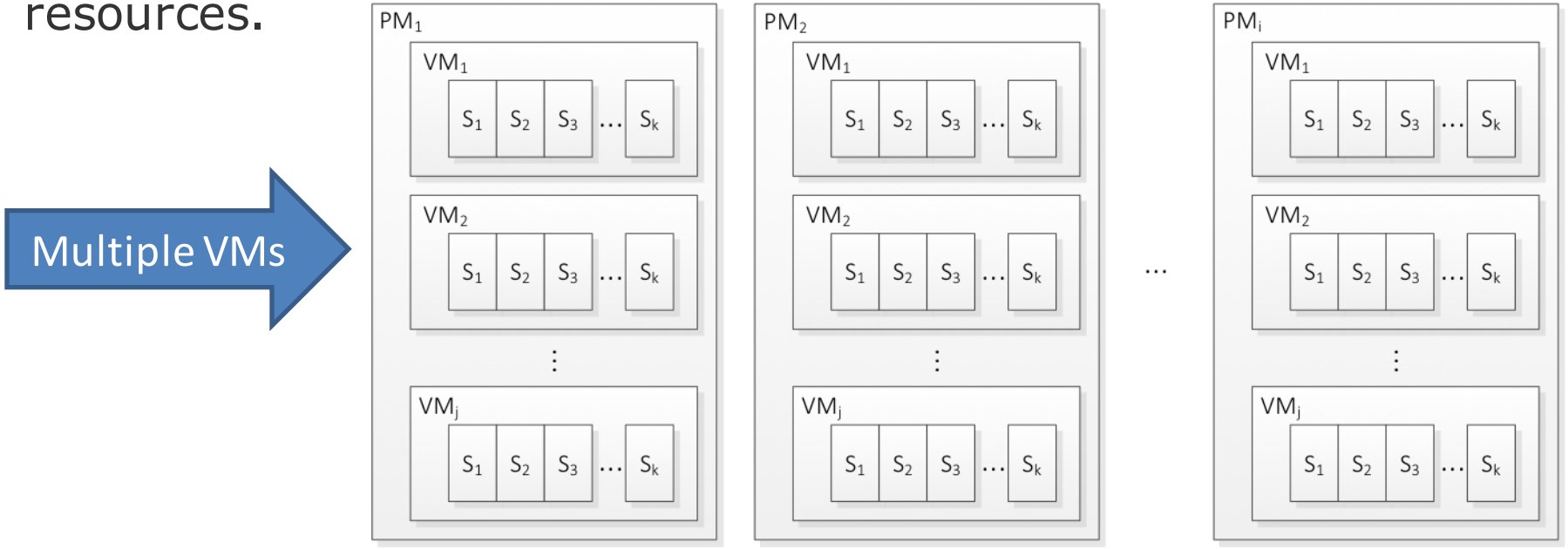


Load balancing can be implemented with hardware, software, or a combination of both.

Cloud Computing Concepts: Virtualization

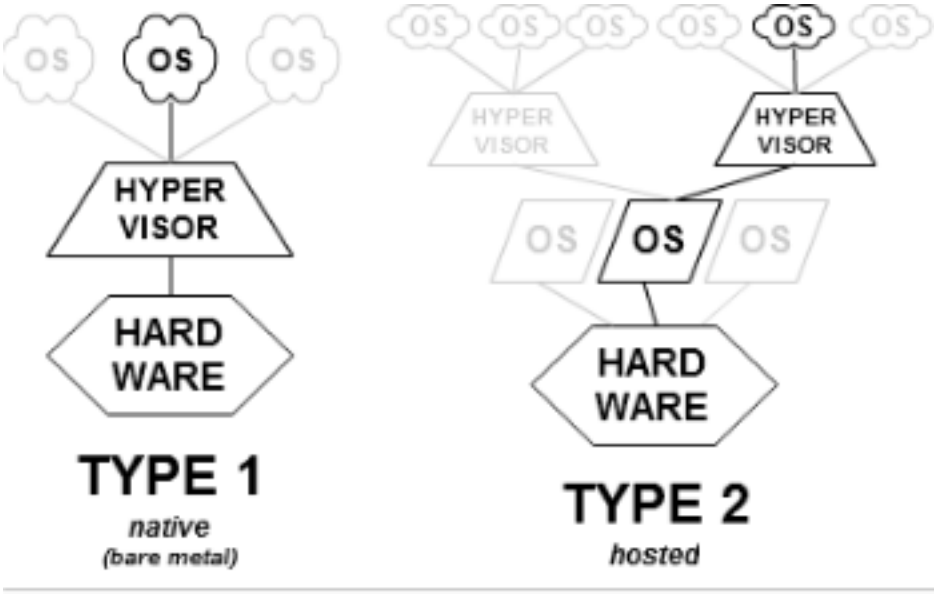
Virtualization is the creation of a virtual (rather than actual) version of something, such as an operating system, a server, a storage device or network resources.





Cloud Computing Concepts: Virtualization

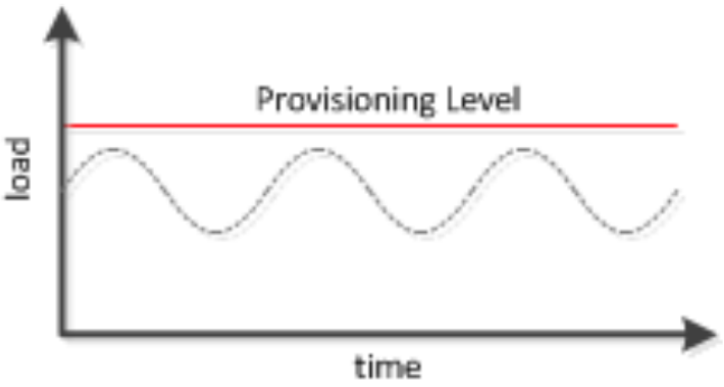
Hypervisor is the software that manages the virtual layer in a physical machine.



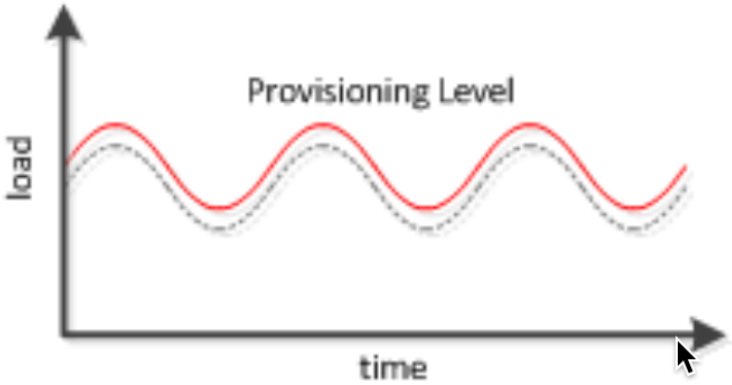
*Cloud Computing Concepts: **Elasticity***

Elasticity is defined as the degree to which a system (or a particular cloud layer) autonomously adapts its capacity to workload over time.

Old way

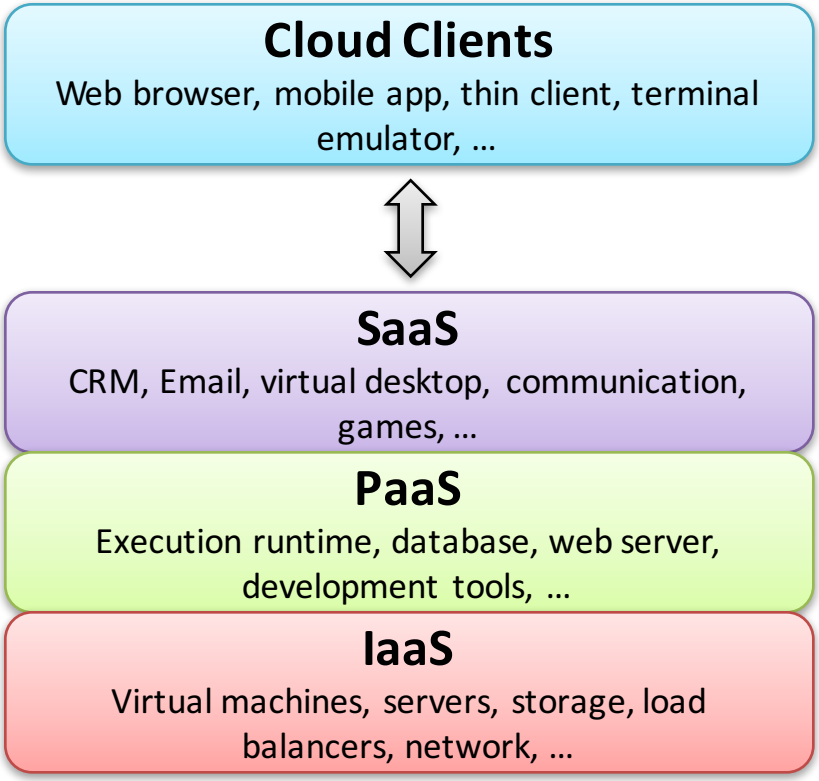


Cloud way



Cloud Computing Service Layers

The Cloud computing layered model



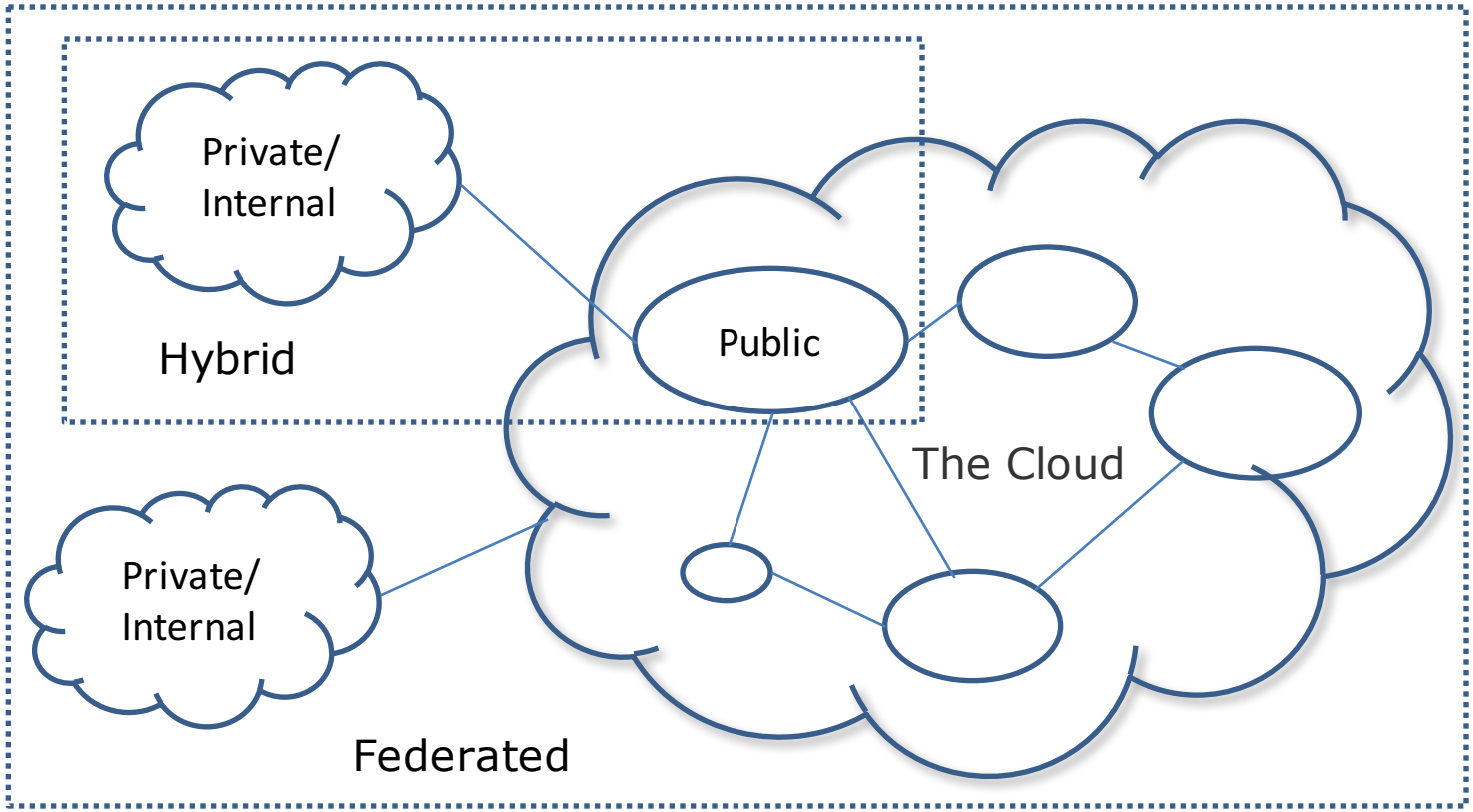
Use Provider's applications over a network.

Create and deploy customer- created applications to a cloud.

Rent Processing, storage, network capacity and other fundamental computing resources.

Types of Cloud Computing

On Premises/
Internal

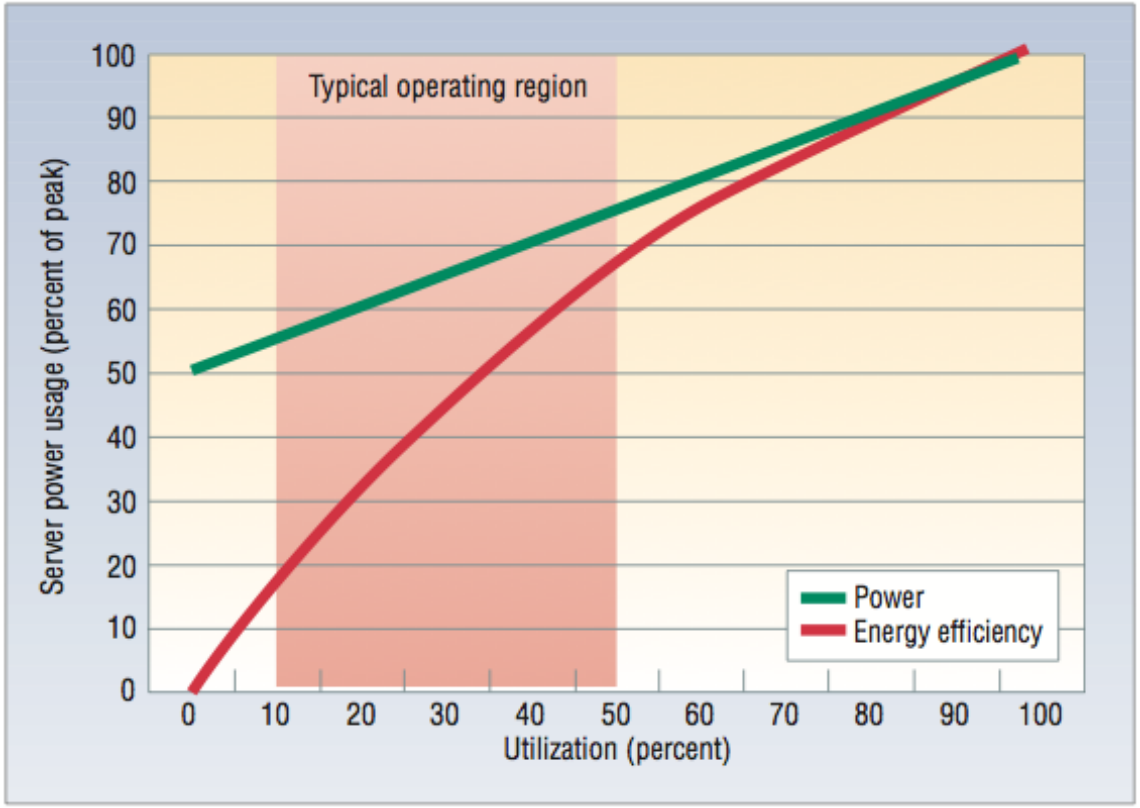


Cloud Computing Leaders

- Amazon EC2
- Google Cloud Services
- Microsoft Windows Azure
- Rackspace Public Cloud

Part 3: Energy

Typical Cloud Server Energy Use

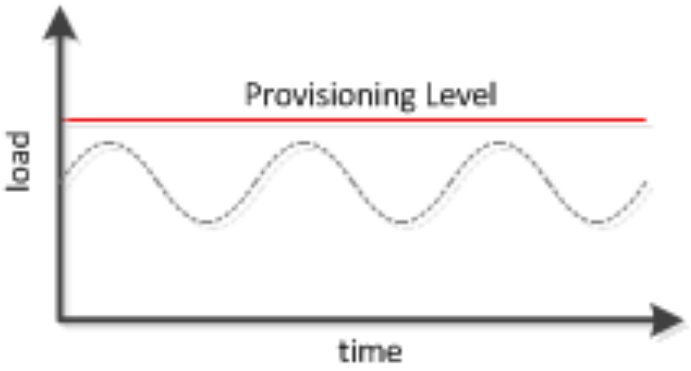


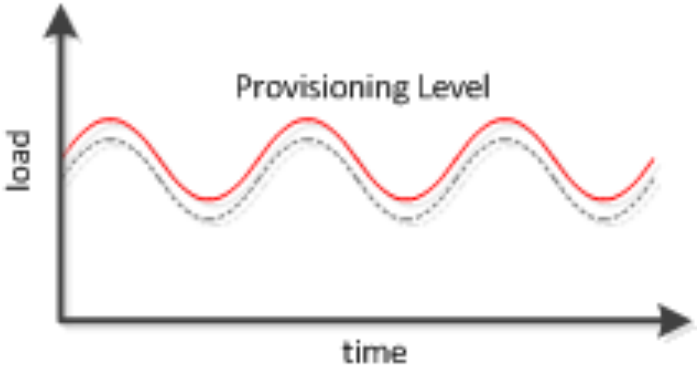
Typical Data Center servers run between 10% and 50% utilization, and consume between 55% and 75% of their peak power.
[Barroso 2010]

Idle servers waste energy.

★ Servers in "sleep" state consume ~10% of their peak power.

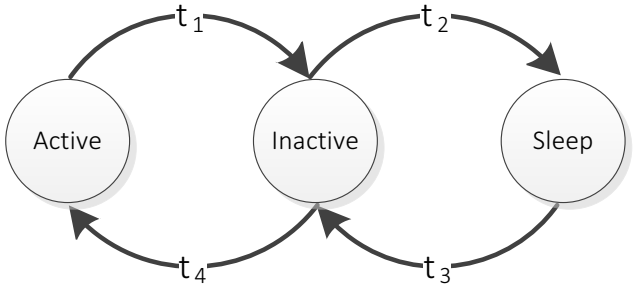
Should change the way we run servers



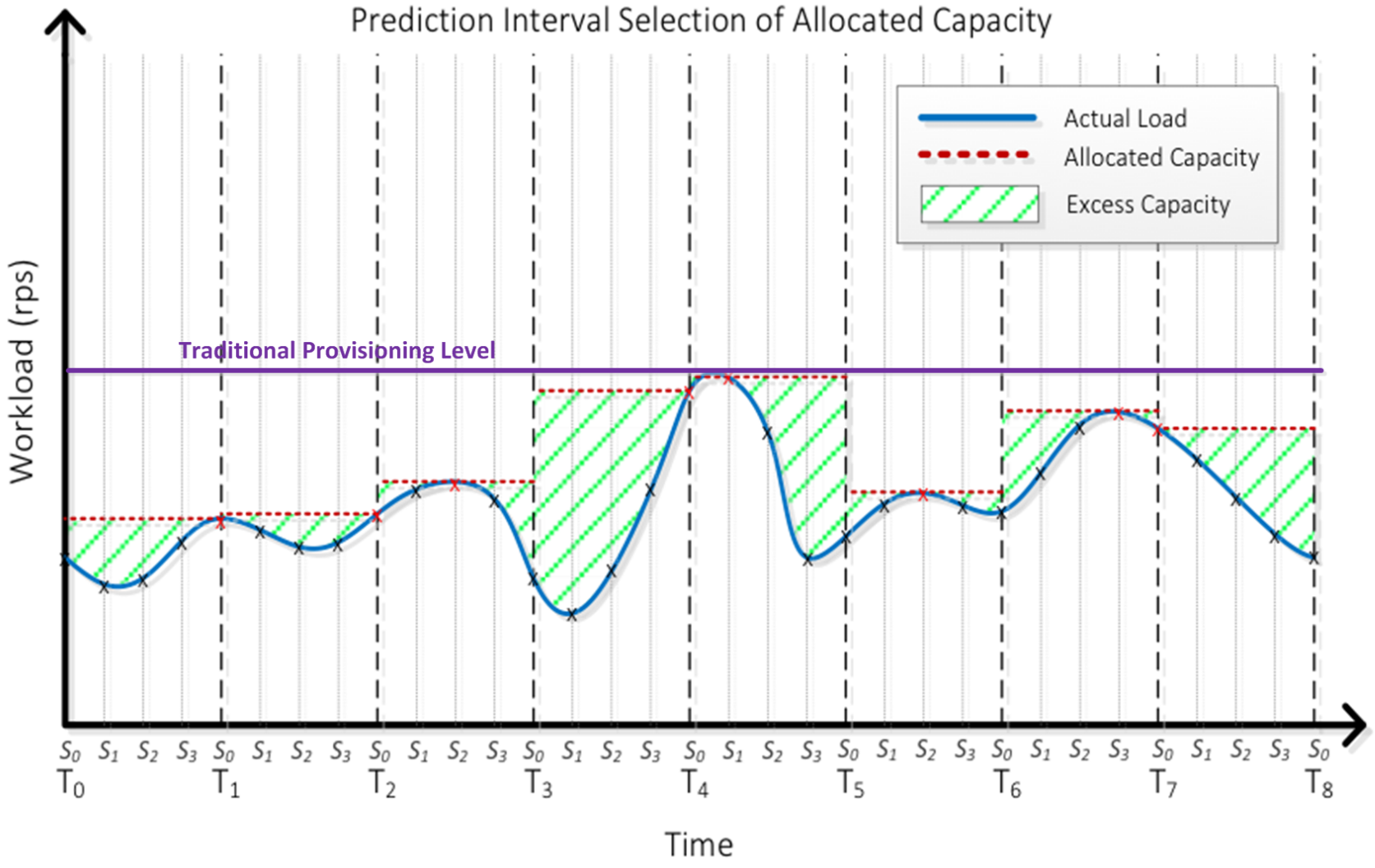


How can we achieve an optimal state?

Change Server state to ***Sleep*** when conditions allow



Results are lower energy consumption



Current Research in Cloud

- Cloud Based Control of Robots (distributed control problem) - *TECHLAV*
- Cloud Based Communications (C-RAN: Baseband Modulation in the Cloud)
- Bioinformatics (Brain Research, Genomics, Proteomics)
- Cloud Advanced Modeling (airframes, geologic topology)
- Quantum Cryptography (Key Distribution) for advanced security in Cloud

Cloud Robotics and Automation

✤ Why should we connect robots to the cloud?

- **Shared Information:** To provide access to global libraries of images, maps, object data, all eventually annotated with geometry and mechanical properties.
- **Computation Power:** Allow for massively-parallel computation on demand for demanding tasks like optimal motion planning and sample-based statistical modeling.
- **Cooperative Control:** Sharing of outcomes, trajectories, and dynamic control policies.
- **Common Knowledge:** Human sharing of "open-source" code, data, and designs for programming, experimentation, and hardware construction.
- **Man-In-The-Loop:** On-demand human guidance (think "call-centers") for exception handling and error recovery.
- **Optimized Compute**: Distributed processing for optimal calculations (offload big tasks to the cloud, keep low-latency tasks onboard robot

Part 4: OCI

The Open Cloud Institute at UTSA

- Established Feb. 26th 2015
- Initial ~10 million seed grant
- Part of NSF Cloud Grant (10M total grant)
- Open Compute Project Testing Lab
- Part of the Intel Innovation Center, a partnership between Rackspace and Intel

The Open Cloud Institute

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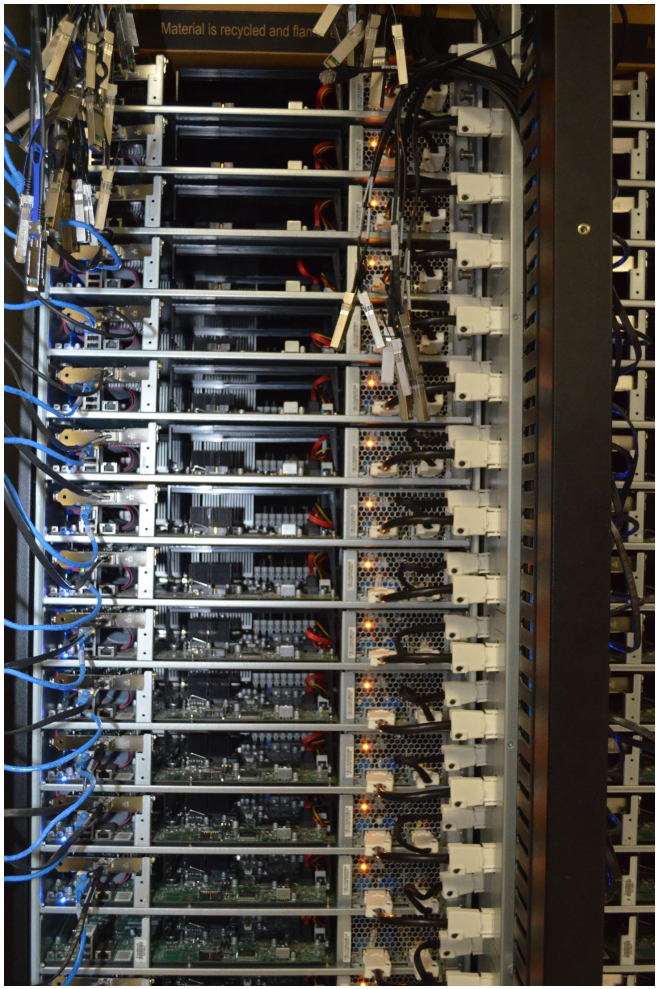

The Open Cloud Institute

Thank You!

"'Tis the set of the sails,
And not the gales,
That tell us the way to go."

- *Ella Wheeler Wilcox*
(from The Winds of Fate)