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# Cloud Computing (intro)

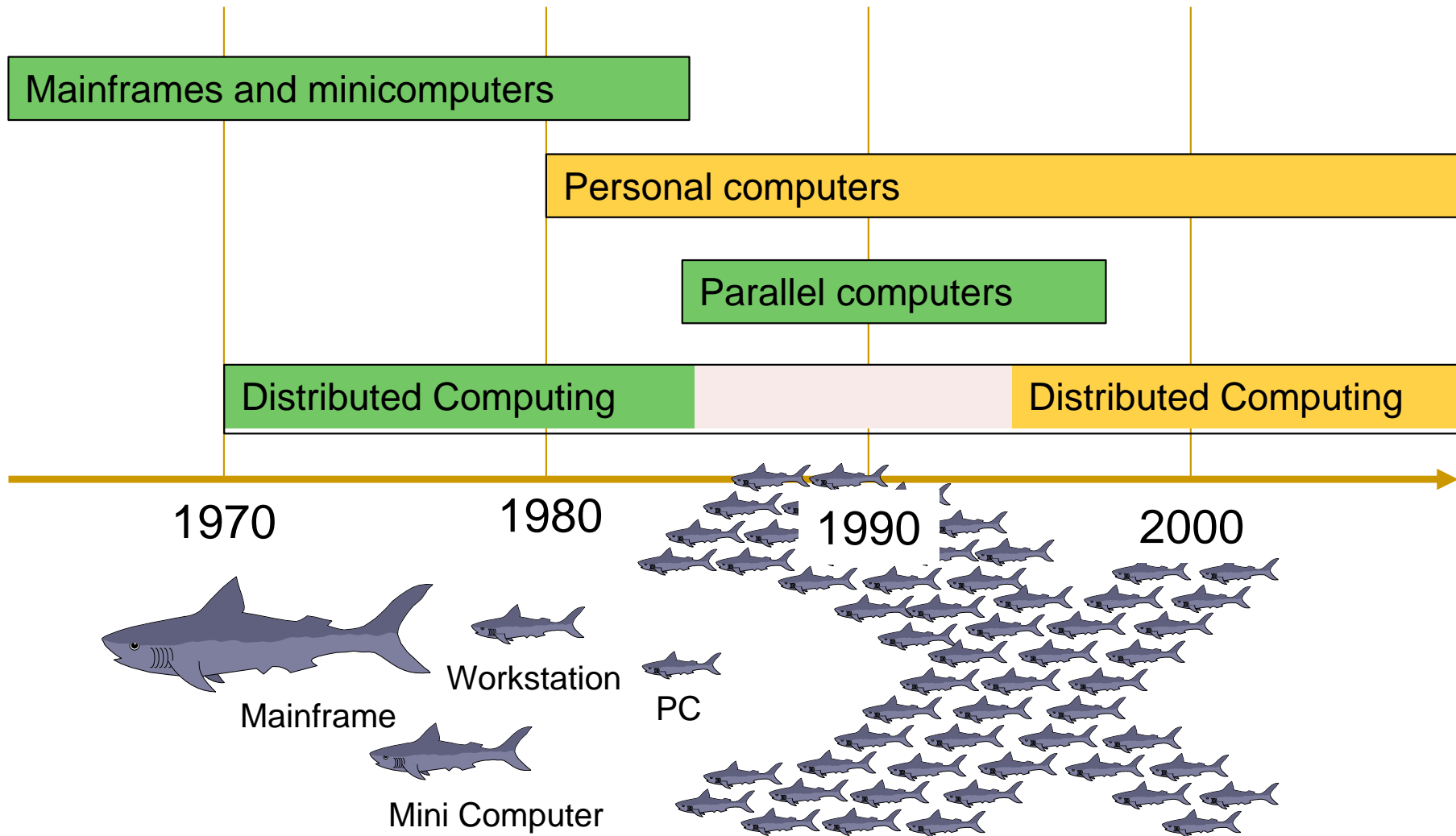
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**Runtimes for concurrency and distribution**

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# Brief history of computing technologies



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# Vision of computing utilities

- 1969, Leonard Kleinrock one of the chief scientists of the original ARPANET:

*“As of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of ‘[computing utilities](#)’ which, like present electric and telephone utilities, will service individual homes and offices across the country.”*

Referred to as utility computing or, recently (since 2007), as cloud computing:

- users access services based on their requirements without regard to where the services are hosted
- denotes the infrastructure as a “cloud” from which businesses and users can access applications as services from anywhere in the world and on demand
- cloud computing can be classified as a new paradigm for the dynamic provisioning of computing services supported by state-of-the-art data centers employing virtualization technologies for consolidation and effective utilization of resources.

# What is Cloud Computing /1

- Diverse kinds of computing needs
  - Scientific (high-performance) computing
    - Massive, application-specific, often brute-force
    - Compute-power hungry
  - Data centers
    - Focus on large-scale data processing, performing data-parallel computations on large volumes of data objects,
      - Mining billions of web pages, classifying data ...
  - Web-based computing and service computing
    - Turning the Internet into a rich application and service delivery platform

# What is Cloud Computing /2

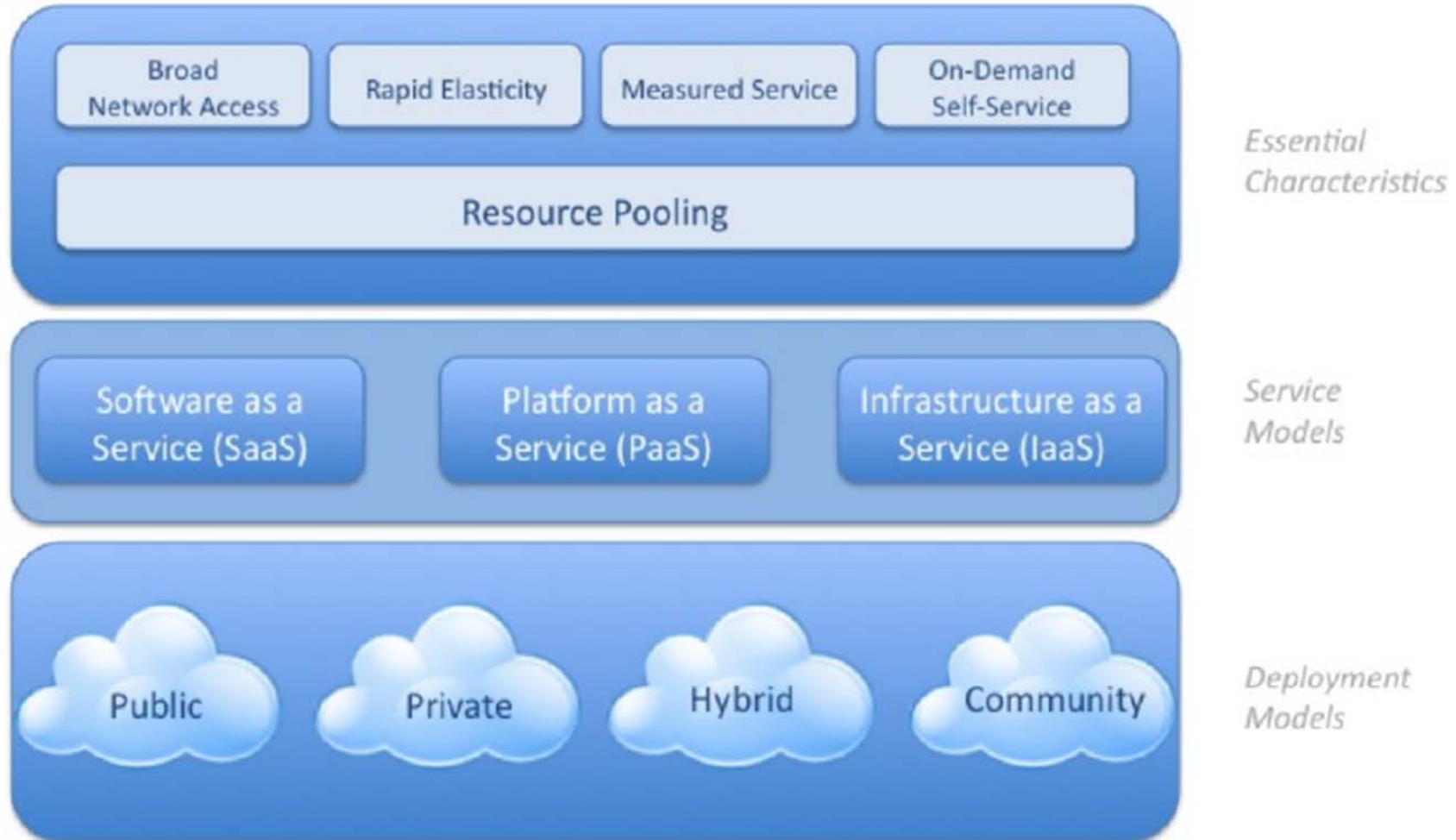
- The Guardian, Sept. 29, 2008
  - Richard Stallman, Founder, Free Software Foundation
  - “It’s worse than stupidity: it’s marketing hype. Somebody is saying this is inevitable - and whenever you hear that, it’s very likely to be a set of businesses campaigning to make it true.”
- Wall Street Journal, Sept. 26, 2008
  - Larry Ellison, CEO, Oracle
  - “...we’ve redefined Cloud Computing to include everything that we already do... I don’t understand what we would do differently ... other than change the wording of some of our ads.”

# What is Cloud Computing /3

- National Institute of Standards and Technology, US
  - Cloud computing is a model for enabling **[1] convenient on-demand**, **[2] pay-per-use**, **[3] network access** to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be **[4] rapidly provisioned** and released with **[5] minimal** management effort or service provider interaction (**self-service**)
  - This model promotes availability and is composed of the five essential characteristics listed above, three service models (**SaaS, PaaS, IaaS**), and four deployment models (private, community, public, hybrid)

<http://www.nist.gov/itl/cloud/upload/cloud-def-v15.pdf>

# What is Cloud Computing /4



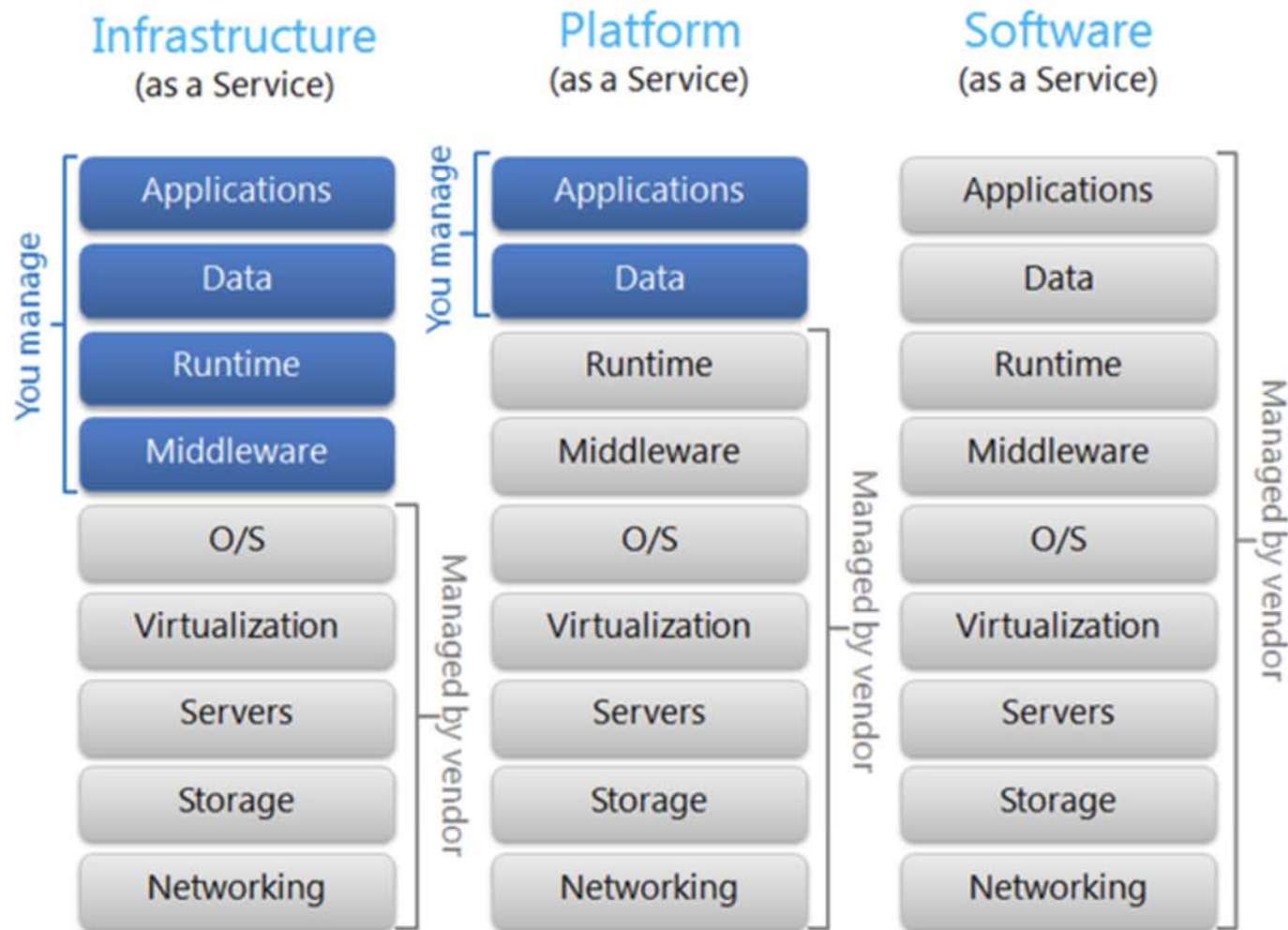
# What is Cloud Computing /5

- Over-the-Internet provisioning of dynamically scalable, virtualized resources
  - Computing, storage and network resources; computing platform and middleware; services (**IaaS**, **PaaS**, **SaaS**)
- Users do not need expertise in (computing) resource management
  - Hardware maintenance, system configurations, software upgrades, information updates, etc.
- Pay-per-use, like other utilities

*"I don't care where my servers are, who manages them, where my documents are stored, or where my applications are hosted. I just want them **always available** and access them from any device connected through Internet. And I am willing to **pay** for this service for **as a long as I need it.**"*



# Cloud Computing service models / 1

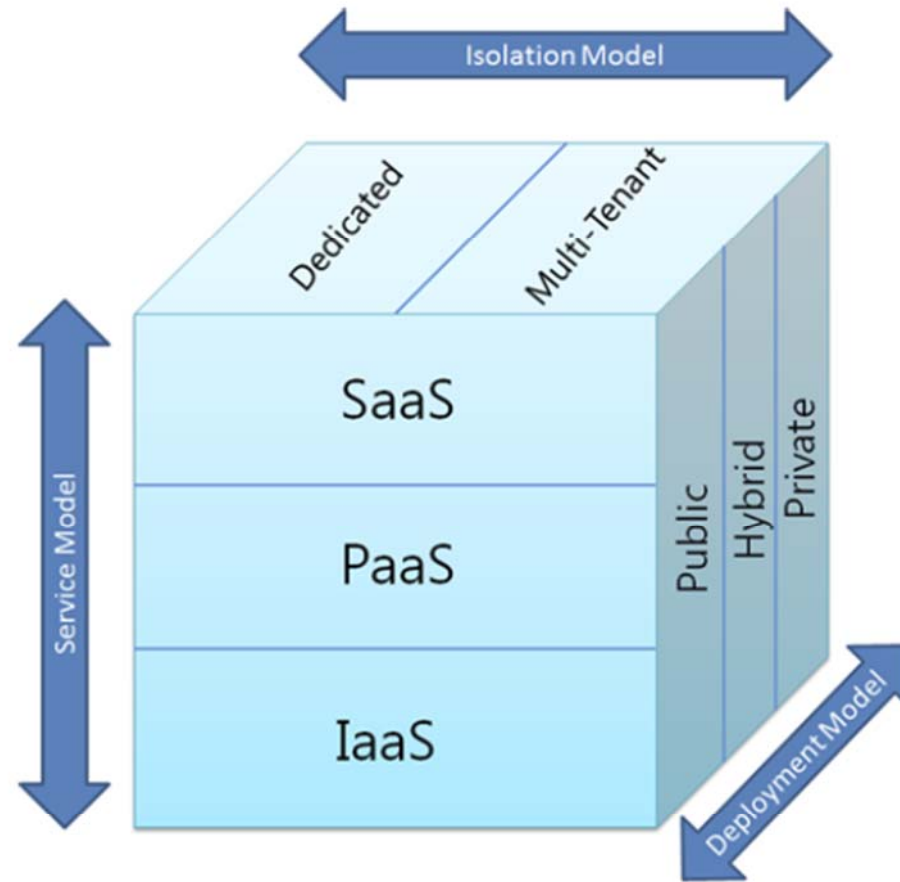


Fonte: <http://goo.gl/1jmkR>

# Cloud Computing service models /2

- **Infrastructure as a service**
  - Computing resources, such as storage and processing
    - You have your own program, but do not have the needed computing facility ⇒ use Amazon EC2
    - You have lots of data but insufficient local storage ⇒ use Amazon S3
- **Platform as a service**
  - Support layer to help users focus on their tasks, not on the hassles of resource provisioning
    - Ranges from handling applications (as you would in an application server) to realizing and deploying them
- **Software as a service**
  - Application delivery model where software and its associated data are hosted centrally and are accessed remotely via clients running on web browsers over the Internet

# Dimensions of Cloud Computing



Fonte: <http://goo.gl/1jmkR>

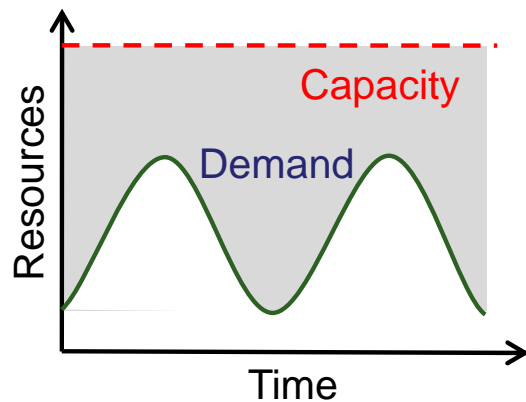
# IaaS requirements / 1

## ■ Scalability

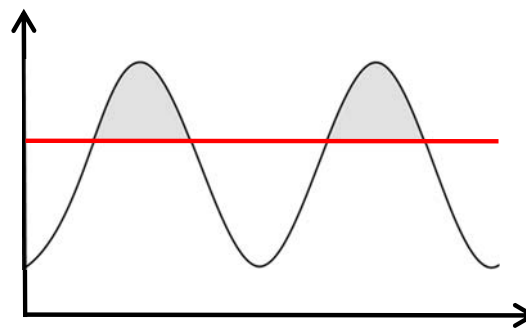
- System performance should remain by-and-large the same in small scale or large scale

## ■ Elasticity

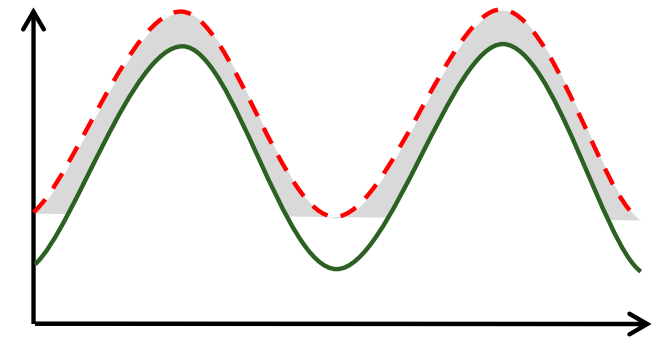
- Resource provisioning should be done only for as long as needed and strictly to the extent required



**Over-provisioning**



**Under-provisioning**



# IaaS requirements /2

## ■ **Availability & reliability**

- ❑ Clients should not worry about any failures at the provider side
  - Failures should be masked
- ❑ Data stored anywhere in the Cloud can be retrieved whenever needed
- ❑ Communication capability and capacity within the provider domain should be always available

# IaaS enabling technologies

## ■ Virtualization

- ❑ Cloud does not require virtualization, but ...
- ❑ Virtualization achieves efficient and secure sharing
  - VMs provide natural isolation
  - VMs can be easily handled, deployed, migrated and assigned resources

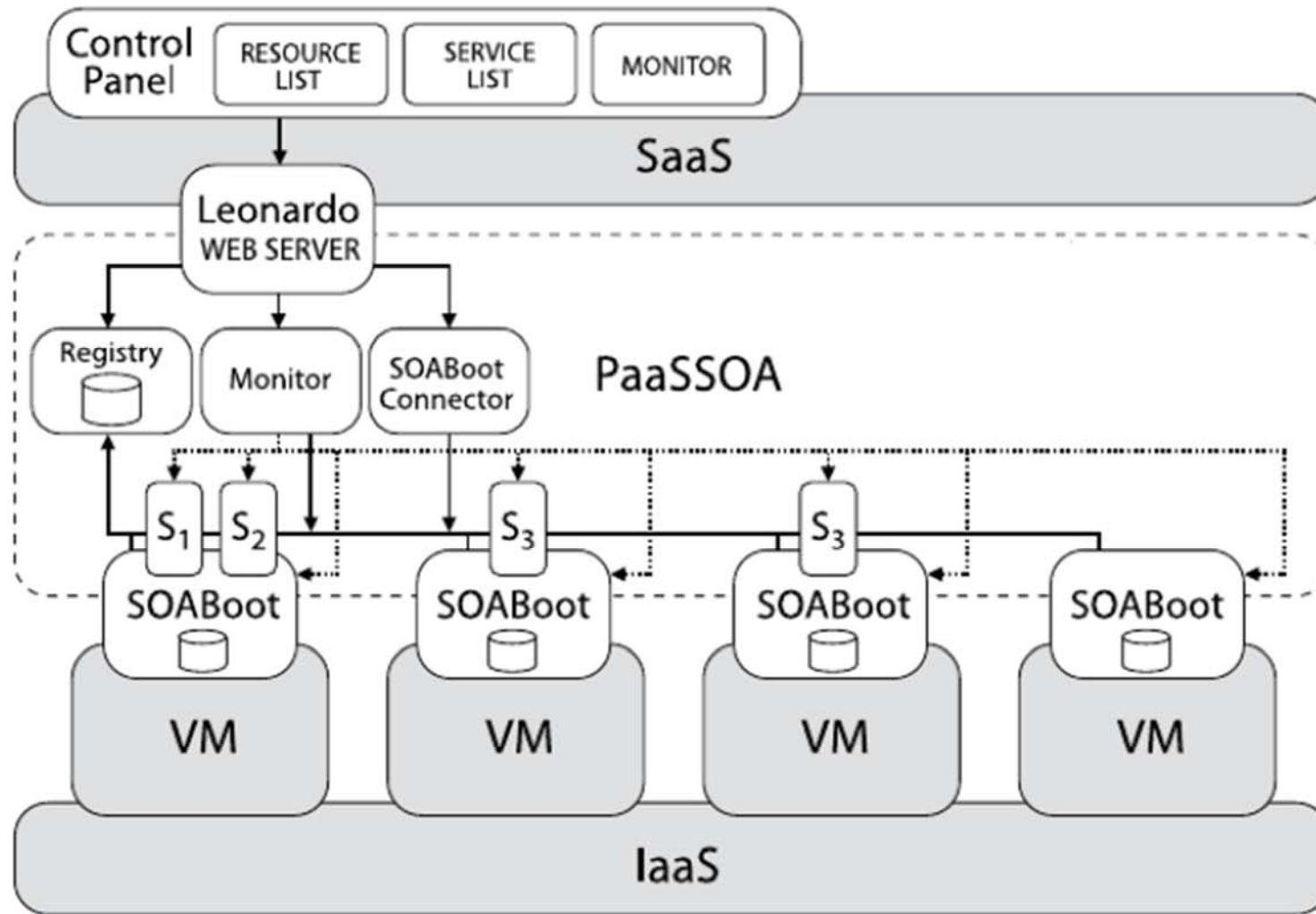
## ■ Storage

- ❑ File systems for a large number of users
  - GlusterFS (<https://www.gluster.org/>), Amazon S3
- ❑ Structured data storage in peta-scale
  - Big table, Distributed Hash Table solutions

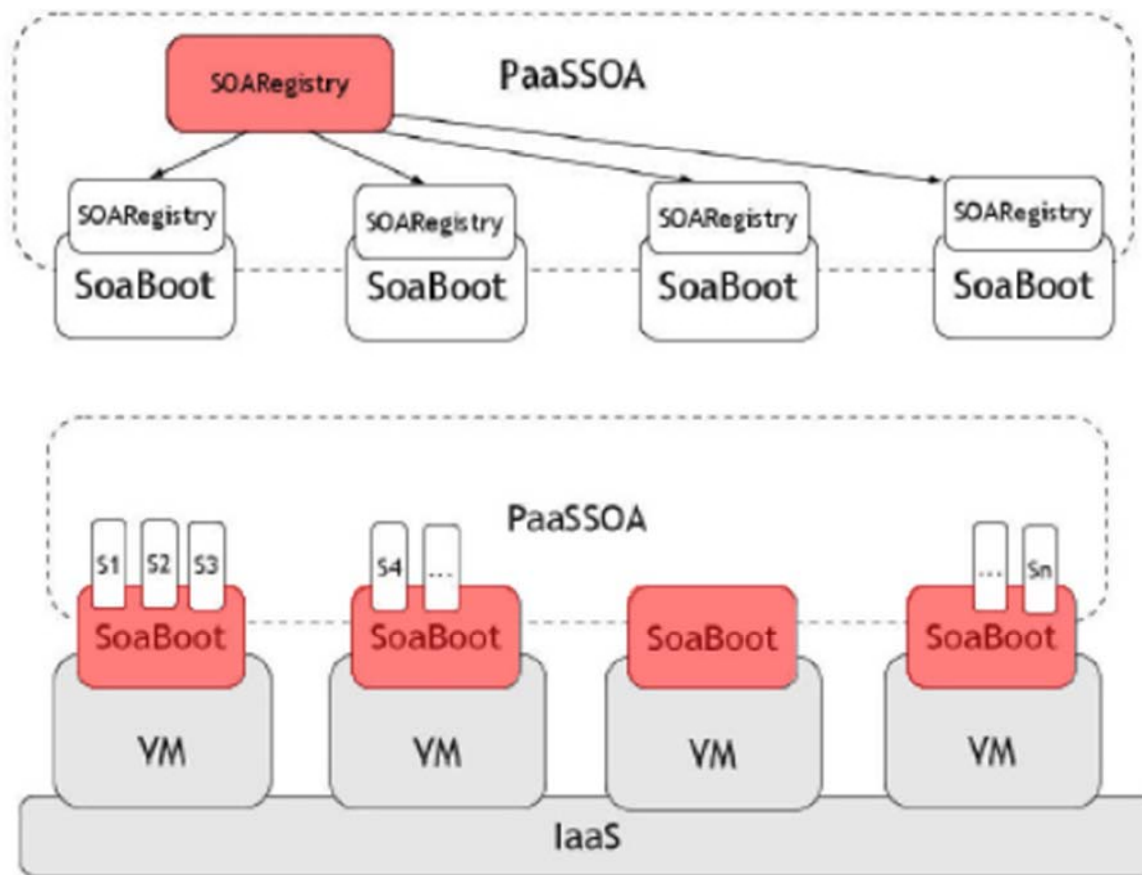
## ■ Monitoring, debugging, dynamic adaptation

- ❑ Performance analysis, fault isolation
- ❑ Event notification
- ❑ SLA negotiation and assurance

# Platform as-a-service (an instance of) / 1



# Platform as-a-service (an instance of) /2



- PaaS handles federated pool of resources
  - 1<sup>st</sup> level registry dispatches incoming requests
  - And resolves names to 2<sup>nd</sup> level
- SOABoot: service container assigned to VM hosts
  - Individual services can be queried, deployed, retired, started, stopped