Cloud and Datacenter Networking

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Laurea Magistrale in Ingegneria Informatica

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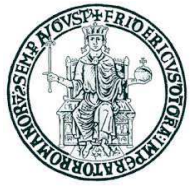
Cloud Computing introduction



Lesson outline

- Cloud Computing: characteristics, service and deployment models
- Cloud Computing and Utility Computing: benefits and risks
- IaaS, PaaS and SaaS solutions and commercial offerings

The Utility Computing vision

- “Computing may someday be organized as a public utility”
  - John McCarthy, MIT Centennial in 1961
- "As of now, computer networks are still in their infancy. But as they grow up and become more sophisticated, we will probably see the spread of ‘computer utilities' which, like present electric and telephone utilities, will service individual homes and offices across the country."
  - Leonard Kleinrock, 1969
- Huge computational and storage capabilities available from utilities
- Metered billing (pay for what you use)
- Simple to use interface to access the capability (e.g., plugging into an outlet)

NIST definition of Cloud Computing

- 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
- *This cloud model is composed of five essential characteristics, three service models, and four deployment models*
- http://www.nist.gov/itl/cloud/
- http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

National Institute of Standards and Technology

Computing as the fifth utility

- After
  - Water
  - Gas
  - Electricity
  - Telephone

Cloud computing: actors

- Cloud Provider
  - An organization that offers cloud services according to a “pay-per-use” model
  - Examples: Amazon, RackSpace, Salesforce, Google
- Service Provider
  - An organization that provides services to end users, possibly combining resources and services acquired by one or more Cloud Providers
- Cloud Subscriber
  - A person or organization that has been authenticated to a cloud and maintains a business relationship with a cloud
- End User
  - Cloud Subscriber and End User may be different entities or the same
- Many commercial services accessed through the Internet have been implemented by Service Providers that rely on resources (Virtual Servers, Storage, etc.) provided by Cloud Providers
  - Eg. Dropbox, Netflix, etc.
- A classification of cloud actors by NIST may be found at https://www.nist.gov/itl/important-actors-public-clouds

Five essential characteristics of Cloud Computing

NIST identified the following characteristics that every cloud service must have:

- **On-demand self services** - Cloud Computing services must be provided without requiring human interaction with any service provider
- **Broad network access** - Cloud capabilities are made available over the Internet and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms such as mobile phones, laptops and PDAs
- **Resource pooling and multi-tenancy** - The provider's computing resources are pooled together to serve multiple consumers using a multiple-tenant model, in which physical and virtual resources are dynamically assigned and reassigned according to consumer demand
  - Resources include storage, processing, memory, network bandwidth, virtual machines and application services
- **Rapid elasticity** - Cloud services must be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in; to the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time
- **Measured service** - Cloud computing resource usage can be measured, controlled, and reported providing transparency for both the provider and consumer of the utilised service. Cloud computing services use a metering capability which enables to control and optimise resource use. This implies that, just like traditional utilities, Cloud service are charged per usage metrics according to a ***pay per use pricing model***

Service Level Agreements (SLAs)

- Contract between customers and service providers
- An SLA determines the level of service to be provided
- Contains performance metrics (e.g., uptime, throughput, response time)
- Problem management details
- Documented security capabilities
- Contains penalties for non-performance (SLA violations)
- See http://www.sla-zone.co.uk

Foundational Elements of Cloud Computing

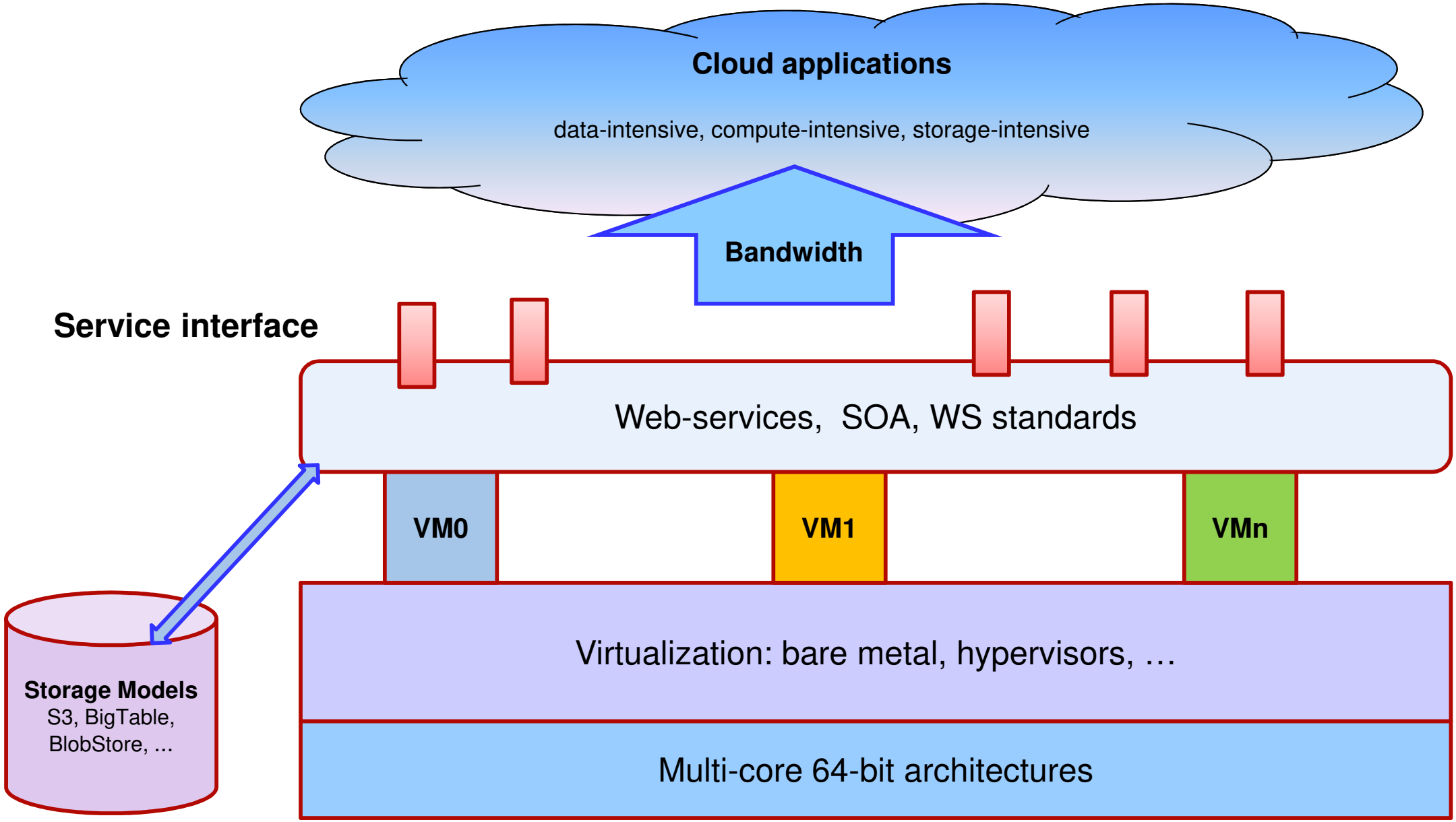
Primary Technologies

- Virtualization
- Grid technology
- Service Oriented Architectures
- Distributed Computing
- Broadband Networks
- Browser as a platform
- Free and Open Source Software

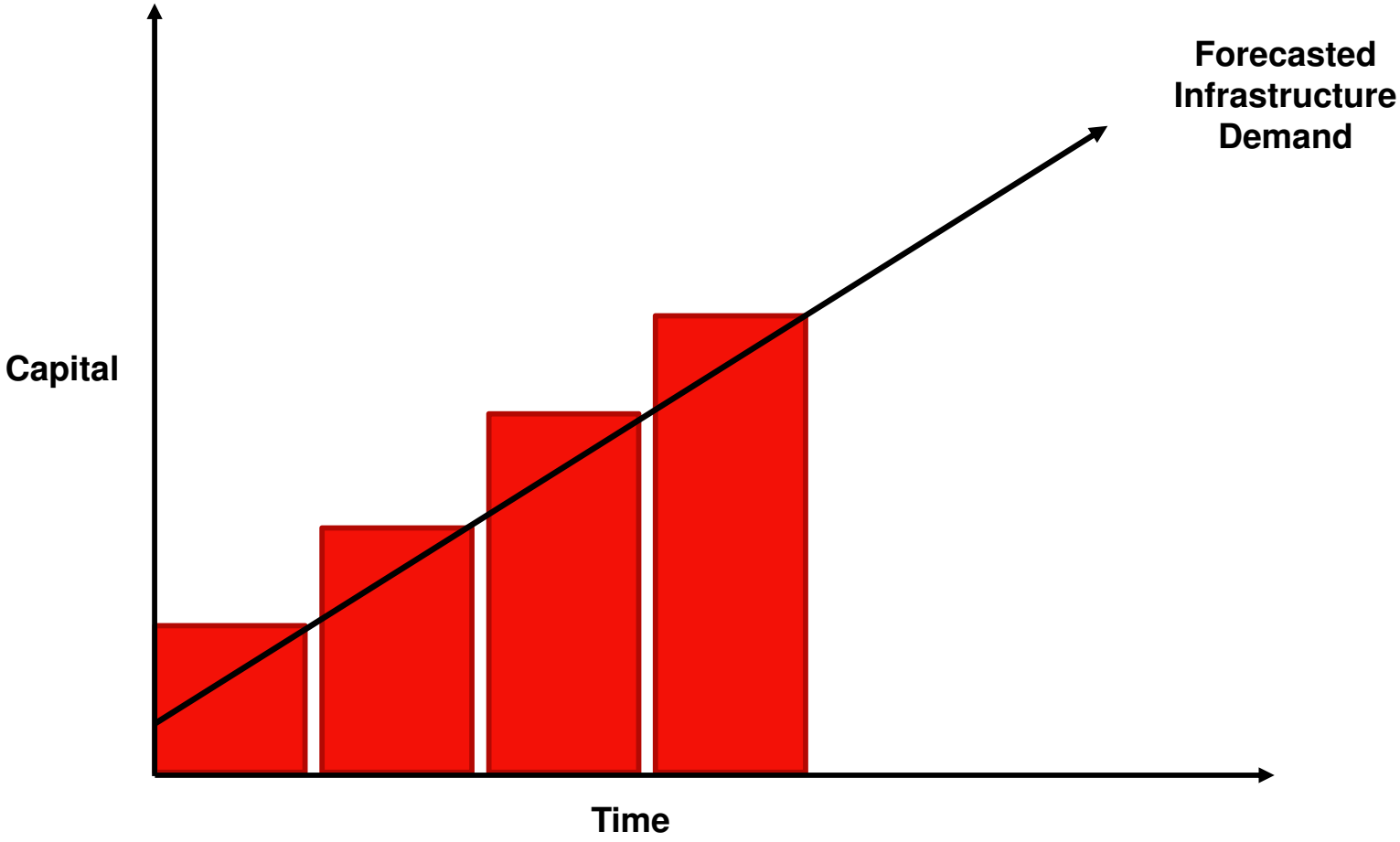
Other Technologies

- Autonomic Systems
- Web 2.0
- Web application frameworks
- Service Level Agreements

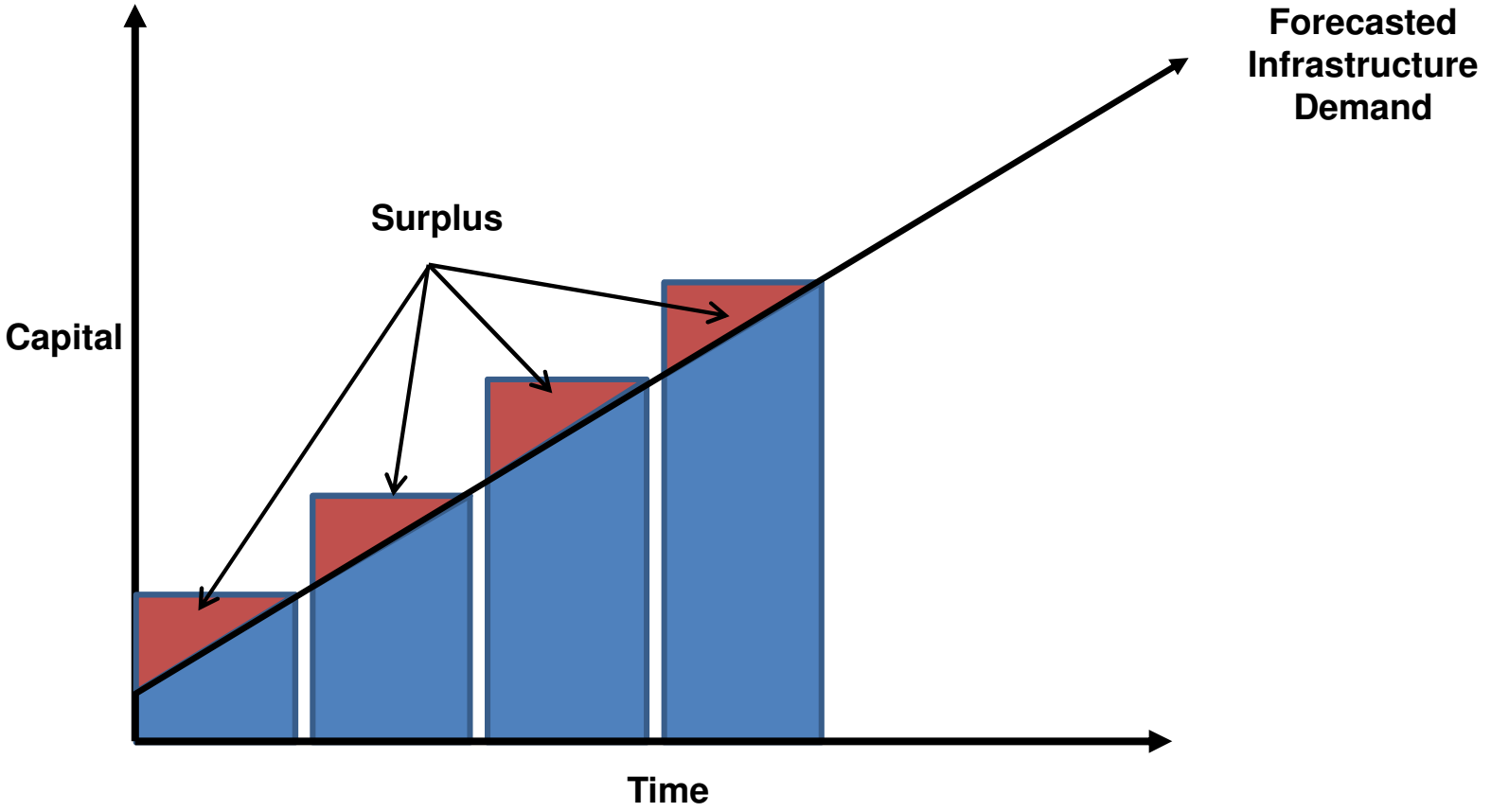
Cloud Computing: enabling technologies



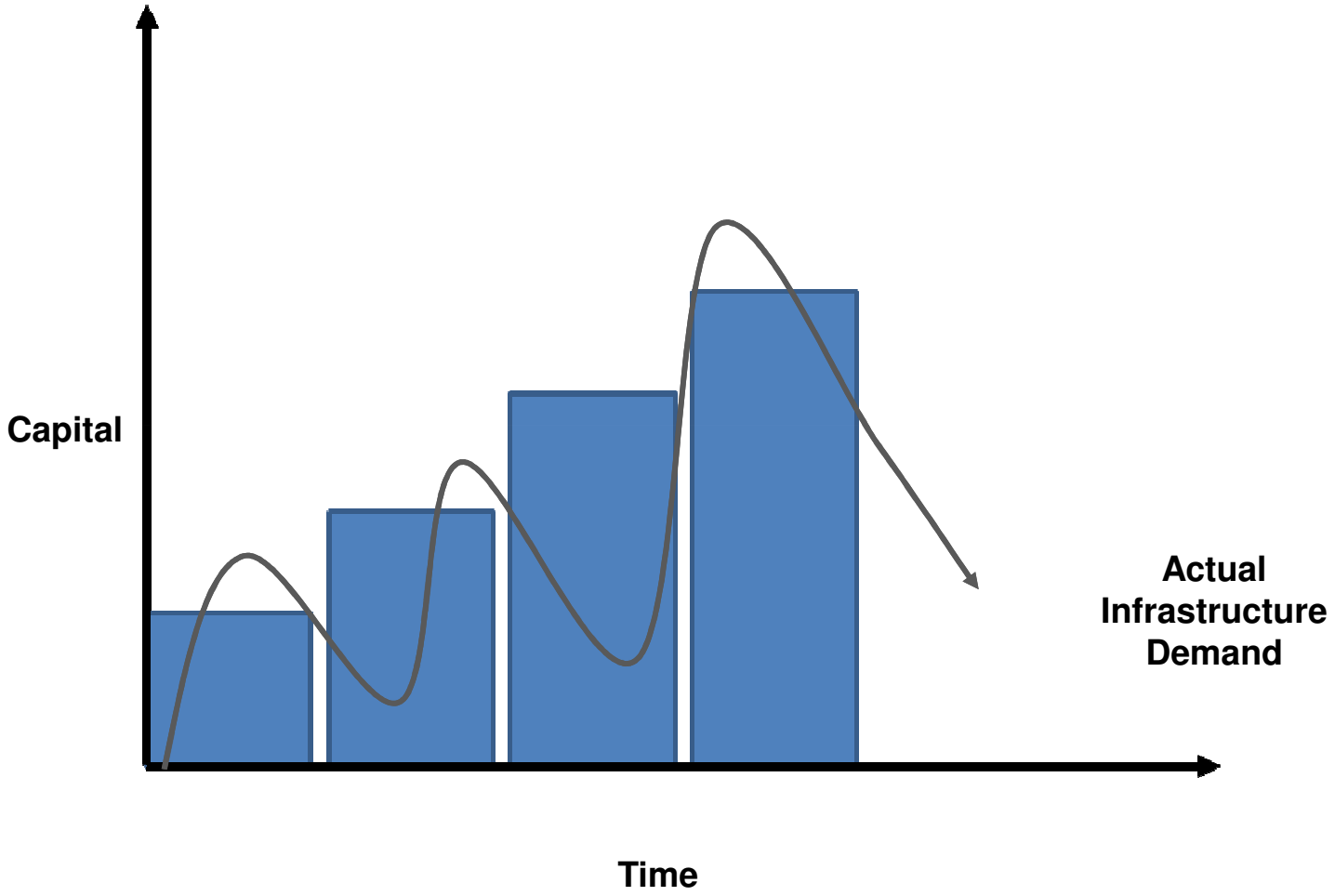
Traditional Infrastructure Dimensioning Model



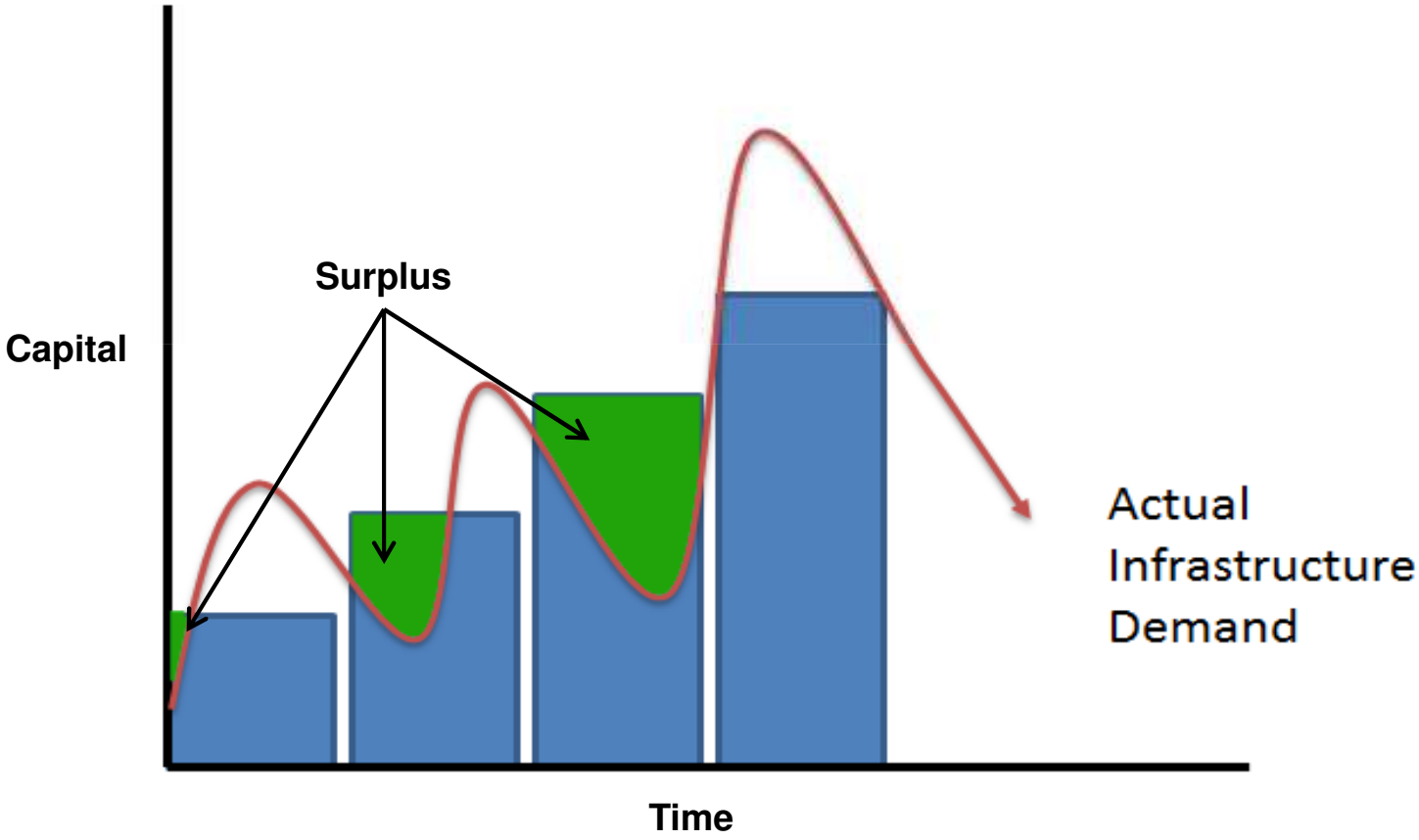
Acceptable Surplus



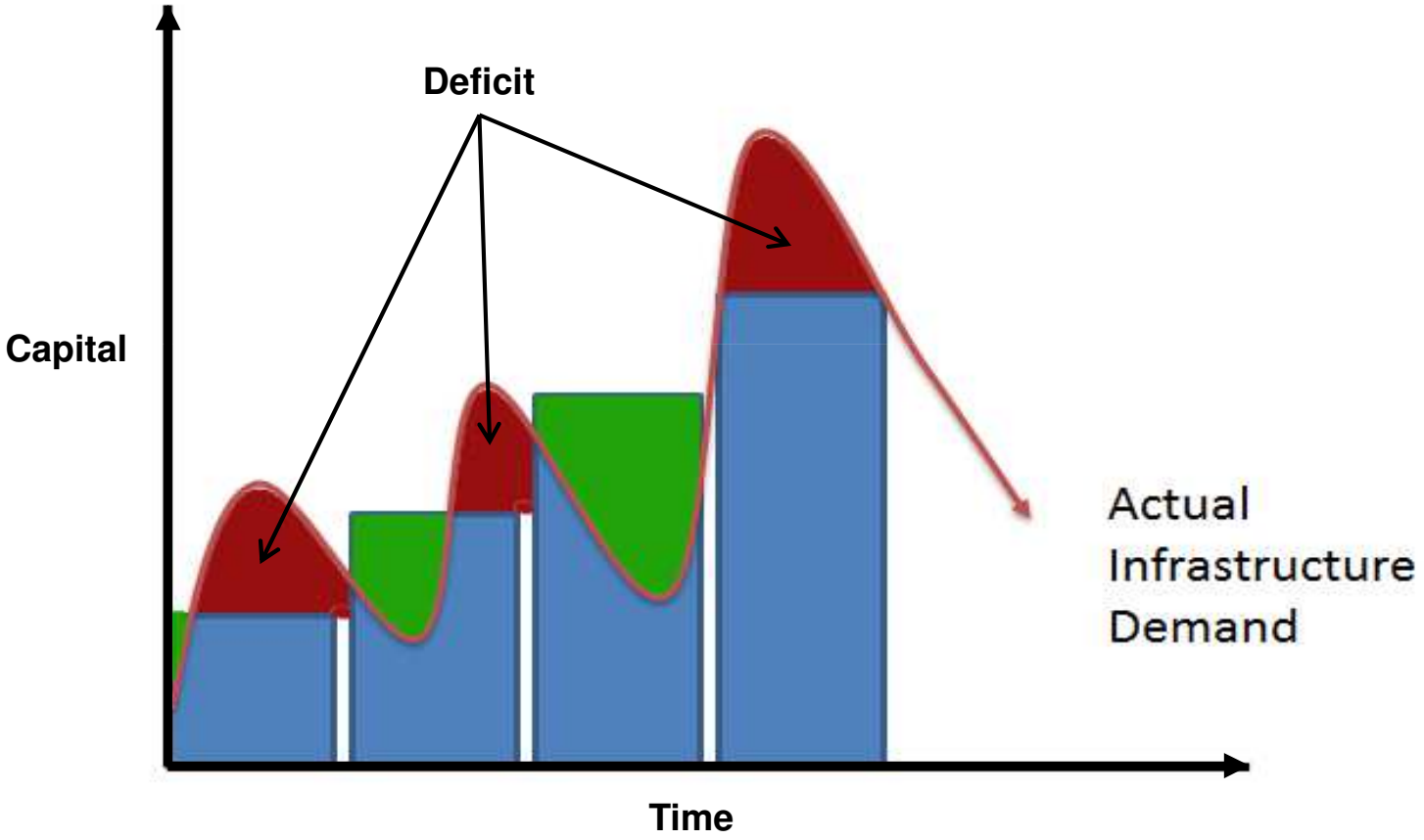
Traditional Dimensioning Model in the real world



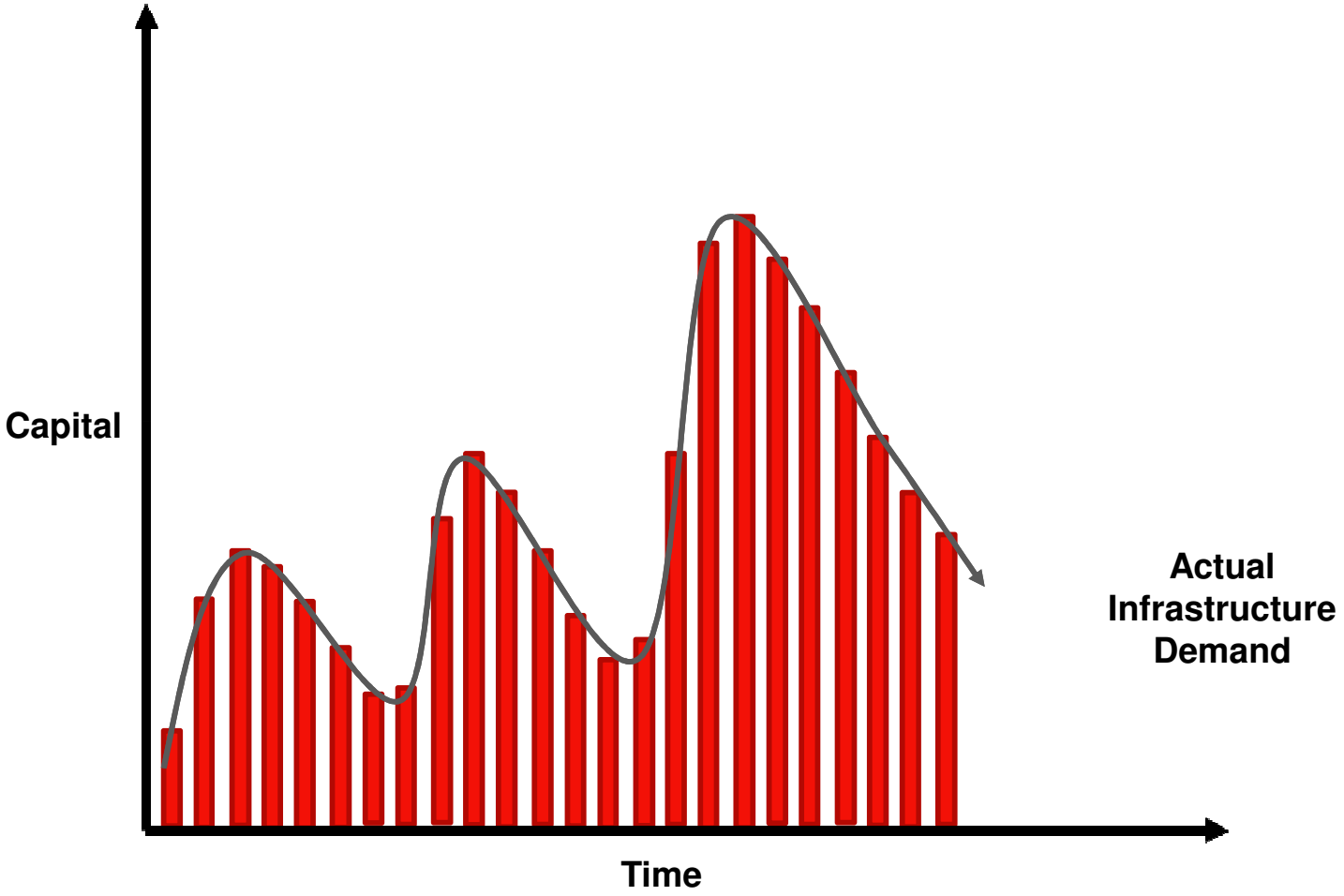
Unacceptable Surplus



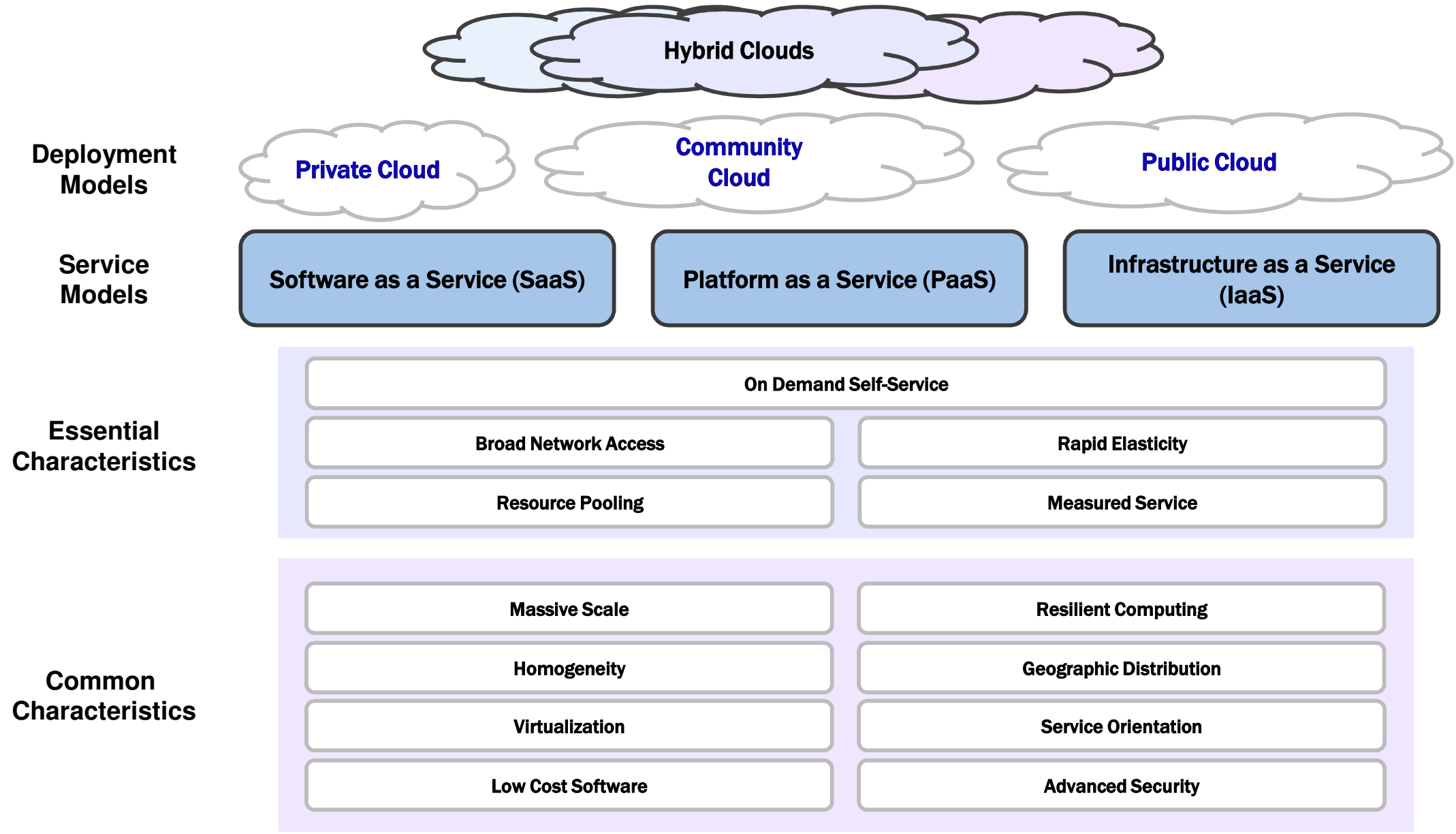
Unacceptable Deficit



Utility Infrastructure Model



The NIST Cloud Definition Framework



Deployment Models

- Public cloud
  - Public cloud (off-site and remote) describes cloud computing where resources are dynamically provisioned on an on-demand, self-service basis over the Internet, via web applications/web services, open API, from a third-party provider who bills on a utility computing basis
- Private cloud
  - A private cloud environment is often the first step for a corporation prior to adopting a public cloud initiative. Corporations have discovered the benefits of consolidating shared services on virtualized hardware deployed from a primary datacenter to serve local and remote users
- Hybrid cloud
  - A hybrid cloud environment consists of some portion of computing resources on-site (on premise) and off-site (public cloud). By integrating public cloud services, users can leverage cloud solutions for specific functions that are too costly to maintain on-premise such as virtual server disaster recovery, backups and test/development environments
- Community cloud
  - A community cloud is formed when several organizations with similar requirements share common infrastructure. Costs are spread over fewer users than a public cloud but more than a single tenant

Cloud Computing: service models

- IaaS – Infrastructure as a Service
- PaaS – Platform as a Service
- SaaS – Software as a Service
- DaaS – Desktop as a Service
- Sensor as a Service
- …
- XaaS - Everything as a Service

Infrastructure as a Service (IaaS)

- IaaS consists in delivering a technology infrastructure as an on demand scalable service
  - Usually billed based on usage
- IaaS is not managed hosting: traditional managed hosting is a form of web hosting where a user chooses to lease entire server(s) housed in an off-site data center
- IaaS providers rely on large-scale datacenters in which they gather large amounts of IT resources shared among customers (multi-tenancy)
  - Servers
  - Storage systems
  - Network devices
  - Specialized devices: IDS, VPN servers, firewalls, load balancers
- Use of virtualization at all levels (servers, storage, network) allows high levels of utilization of available resources
- Cloud datacenters need very good connectivity to the Internet
- Public IaaS providers have built several datacenters located in several countries all over the five continents for redundancy and to reduce access latencies

IaaS Examples

Platform as a Service (PaaS)

- PaaS provides all of the facilities required to support the complete life cycle of building and delivering web applications and services
- Three kinds of PaaS solutions:
  - Those which are coupled to a specific public IaaS platform
    - Many of these are directly provided by IaaS providers
  - Those which are compatible with several IaaS providers
    - Application developers may choose the IaaS provider
  - Those which are offered as a service that includes the acquisition of IaaS resources
    - The PaaS provider has its own resources or buys them from a 3rd party IaaS provider
    - The application developer does not directly buy IaaS services
- Characteristics of PaaS platforms:
  - Support for the creation of highly scalable and reliable multi-tier sw applications
  - Isolation guarantees in a multi-tenant environment
  - Support for several programming languages
  - Support for several operating systems to execute the hosted applications

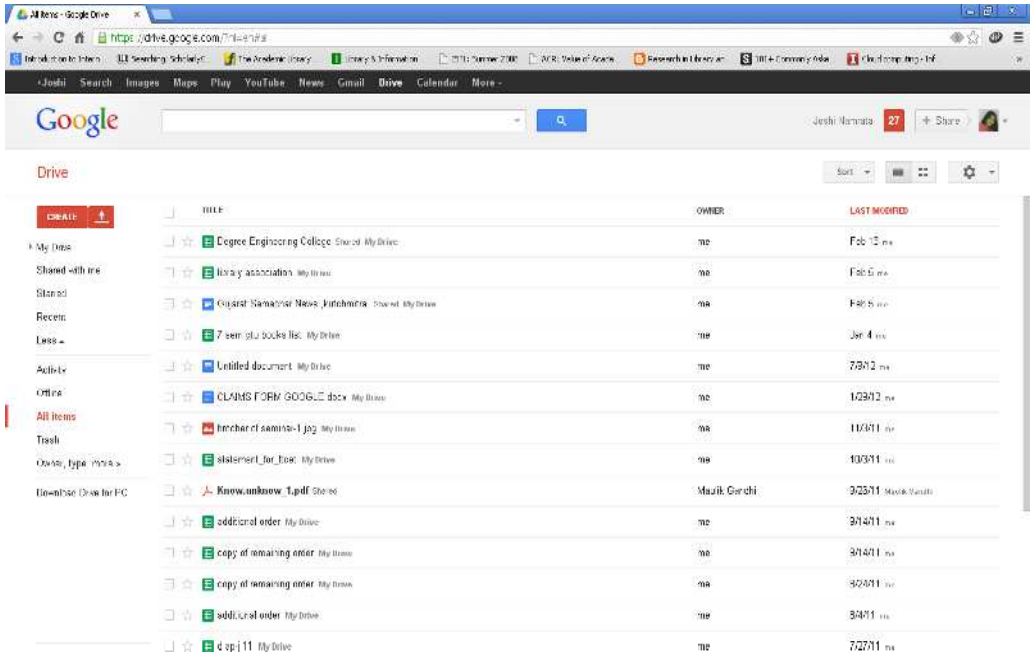
PaaS Examples

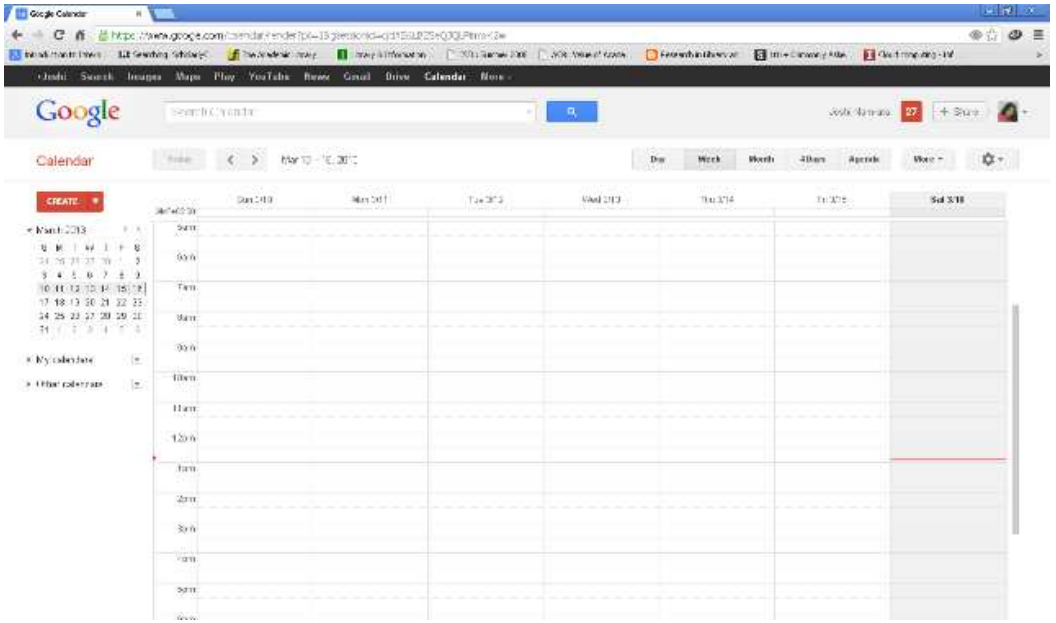
Software as a Service (SaaS)

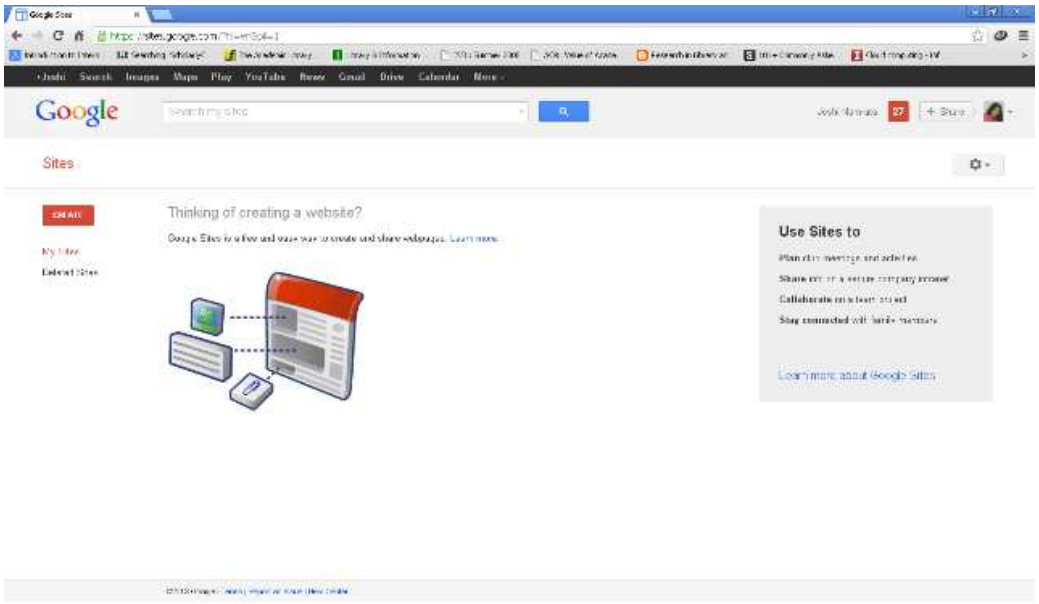
- SaaS is a software delivery methodology that provides licensed multi-tenant access to software and its functions remotely as a Web-based service
  - Usually billed based on usage
  - Usually multi tenant environment
  - Highly scalable architecture
- SaaS is not ASP 2.0 !
  - The old-days ASP model concentrated on providing an organization with the ability to move certain application processing duties to leased third-party managed servers
  - ASPs were not necessarily concerned about providing shared services to multiple tenants, but rather hosting a dedicated application on behalf of the customer

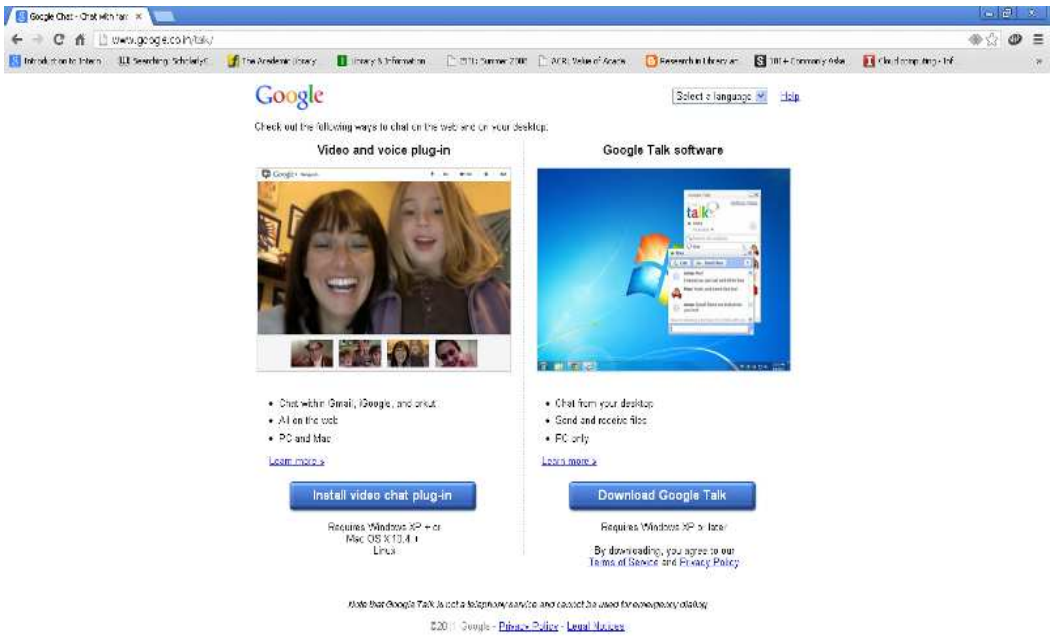
SaaS Examples

Software-as-a-Service: Google apps

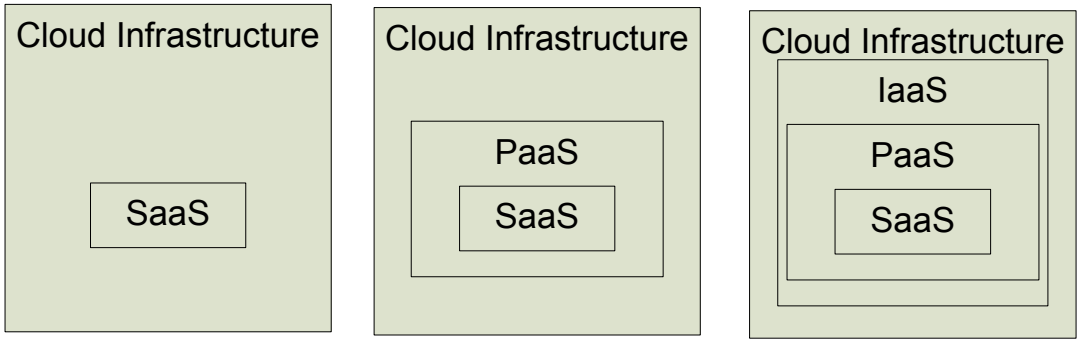




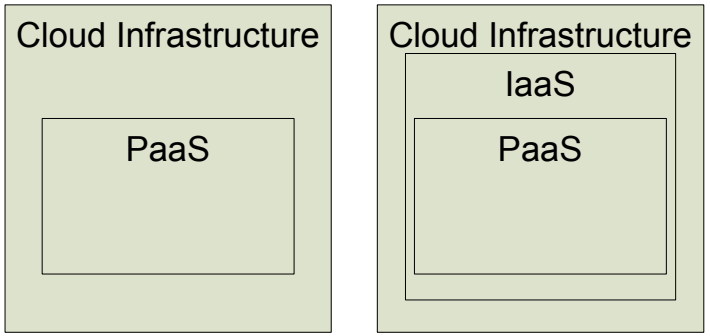




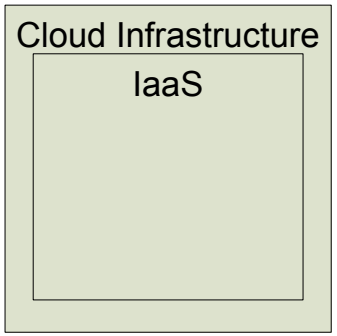
Service Model Architectures



Software as a Service (SaaS) Architectures



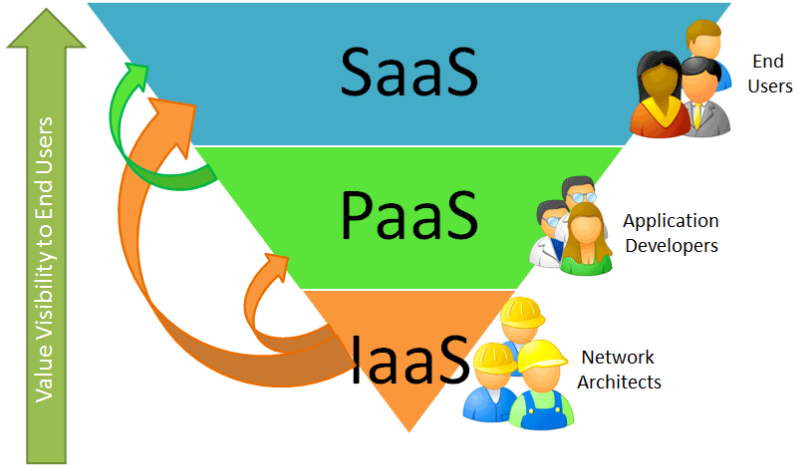
Platform as a Service (PaaS) Architectures



Infrastructure as a Service (IaaS) Architectures

Advantages of Cloud Computing services for end users

- Not necessary to invest in acquiring, maintaining and update IT infrastructures
- Cost of software licenses included in the service
- Customizability of services
- Cloud providers that have specialization in a particular area (such as e-mail) can bring advanced services that a single company might not be able to afford or develop
- Scalability, reliability, and efficiency



Private Cloud infrastructures

- Managing IT resources "as if they were in the Cloud" may bring the benefits of virtualization and consolidation within an organization's IT department
- Furthermore, this process paves the way for opening up to Public and Hybrid Cloud adoption
- VMware enriched its portfolio with a Private Cloud management suite
  - VMware vCloud Suite extends the VMware vSphere hypervisor
- In the last few years a few open-source projects have been established to develop software suites to manage IaaS services in Private Cloud environments
  - OpenStack
  - OpenNebula
  - Eucalyptus

- Hardware vendors are also pushing the Private Cloud market
  - HP Elion (HPE) supports both Eucalyptus and OpenStack
  - Dell Red Hat OpenStack cloud
  - Cisco Metapod Private Cloud Solution based on OpenStack
  - Ericsson-Mirantis partnership (OpenStack)