Business Process Digitalization and Cloud Computing

15. Cloud Computing

Andrea Morichetta, Phd

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Computer Science Division

slides are based on Web Services, Service-Oriented Architectures, and Cloud Computing

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What is a Cloud?

- It's a cluster!
- It's a supercomputer!
- It's a datastore!
- It's Superman

- None of the above
- All of the above

What is a Cloud?

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- It's a supercomputer!
- It's a datastore!
- It's Superman

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- All of the above

CLOUD = Lots of storage + high speed computation

Introduction

Cloud Computing Definition

Definition:

- Cloud computing describes a new **integration, consumption and delivery of model for IT services based on internet**, and it typically involves the provision of dynamically **scalable** and often **virtualized** resources **as a service** over the Internet

Alternative definition:

- "Cloud computing is a buzzword"
  "The concept, quite simply, is that **vast computing resources will reside somewhere out there in the ether** (rather than in your computer room) **and we'll connect to them and use them as needed**"

  Jonathan Weber

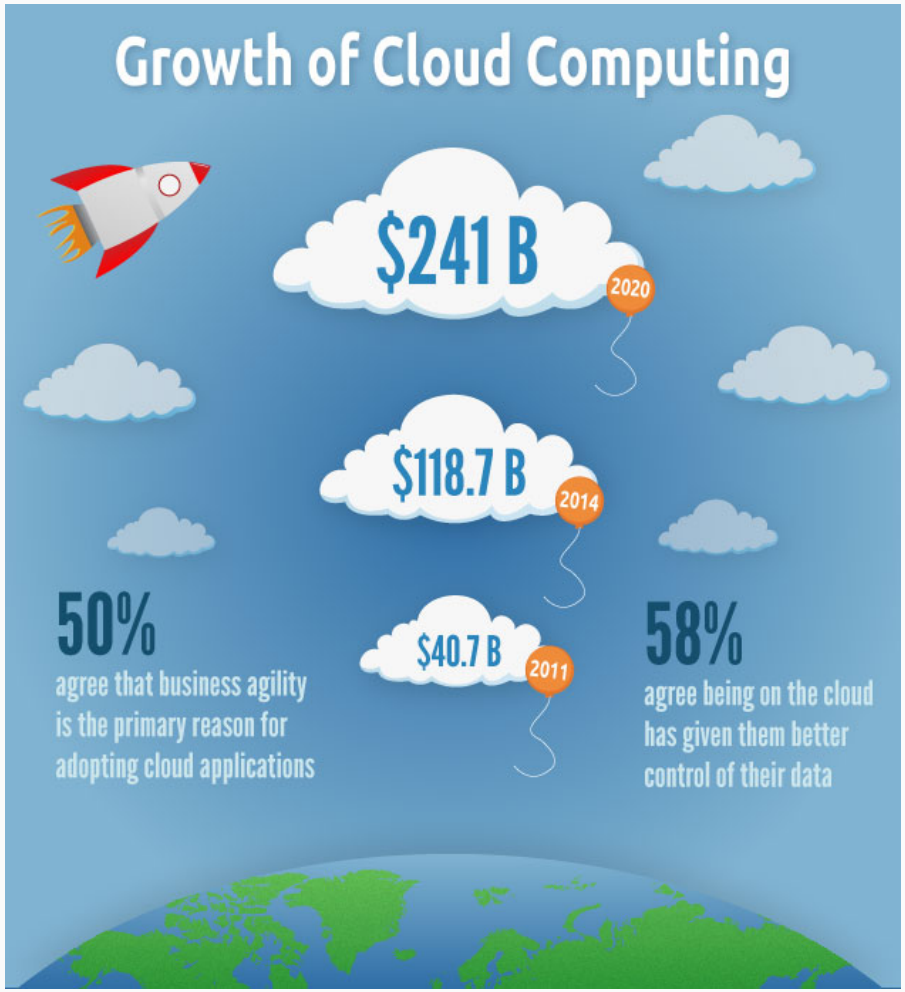
Cloud from vision to realization

- VISION
  "Computing may someday be organized as a public utility"
  [John McCarthy, MIT Centennial, 1961]
- REALIZATION
  "Let us use our spare resources for making profit by offering them as services to the public"
  [Jeff Bezos, CEO Amazon, 2006]

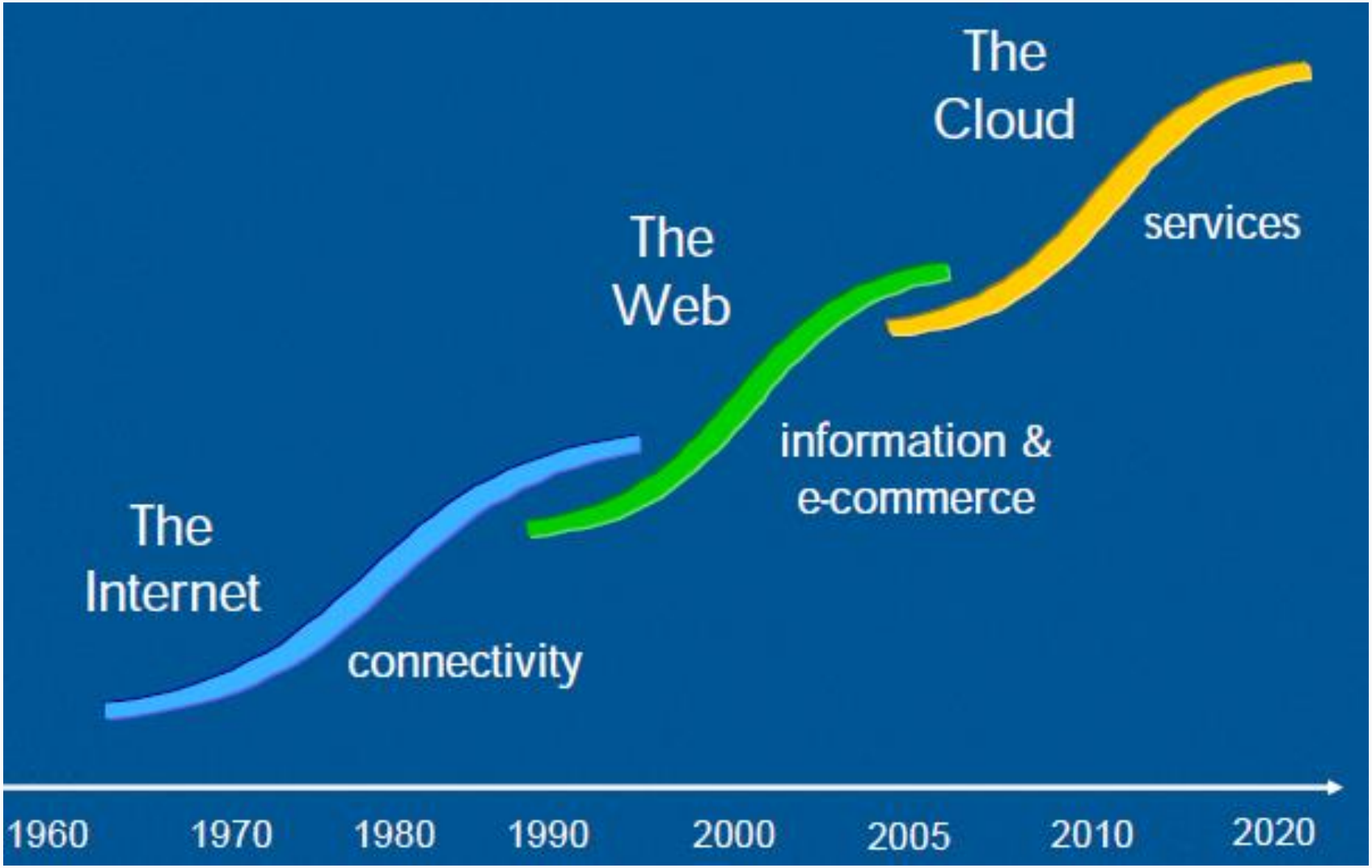
The CLOUD COMPUTING was born

Why Cloud Computing is so important?

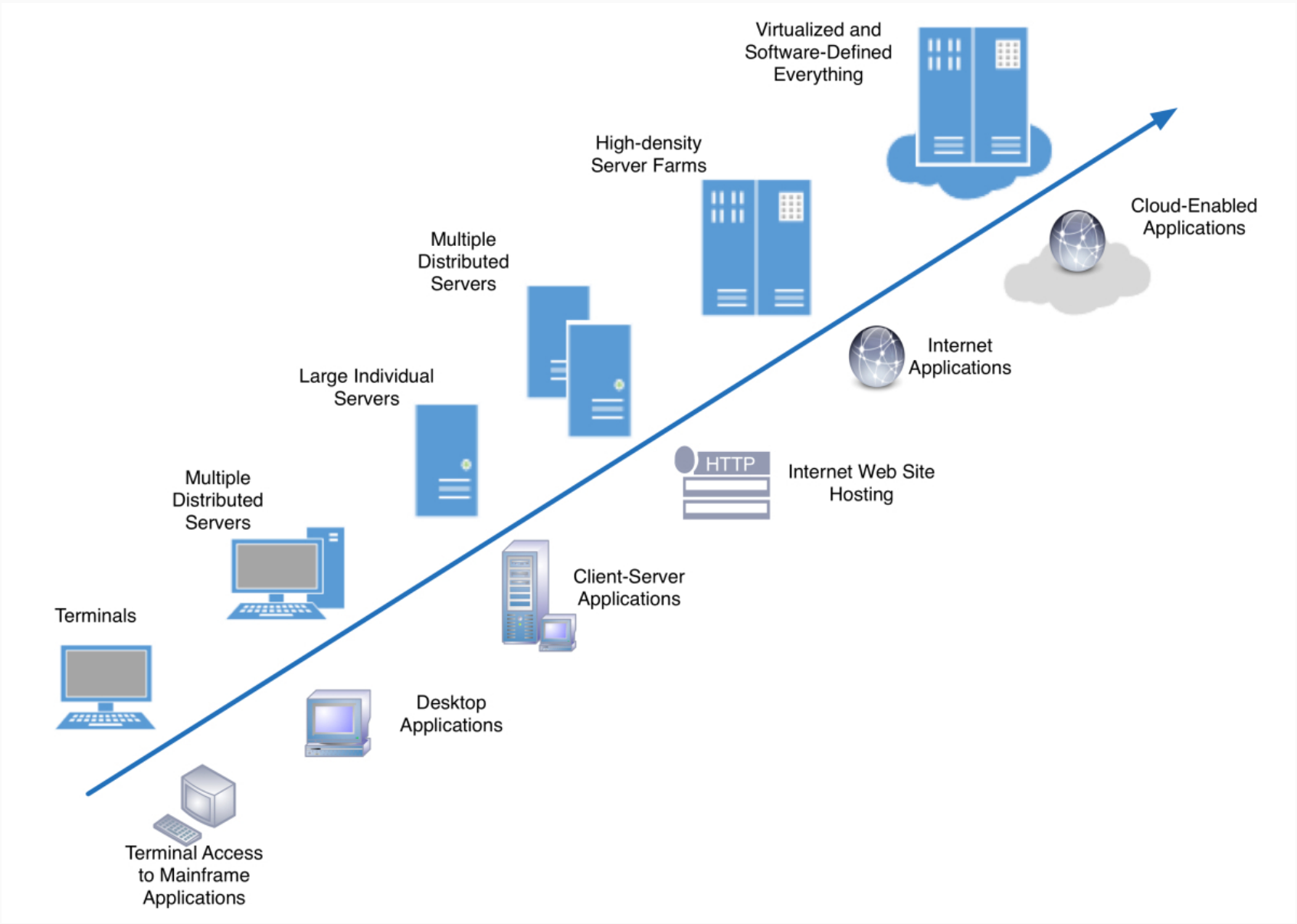
- **Acceleration in adoption of cloud computing** and cloud services
- It is **one of the top 5 technology trends in the next years**



Evolution of Cloud Computing

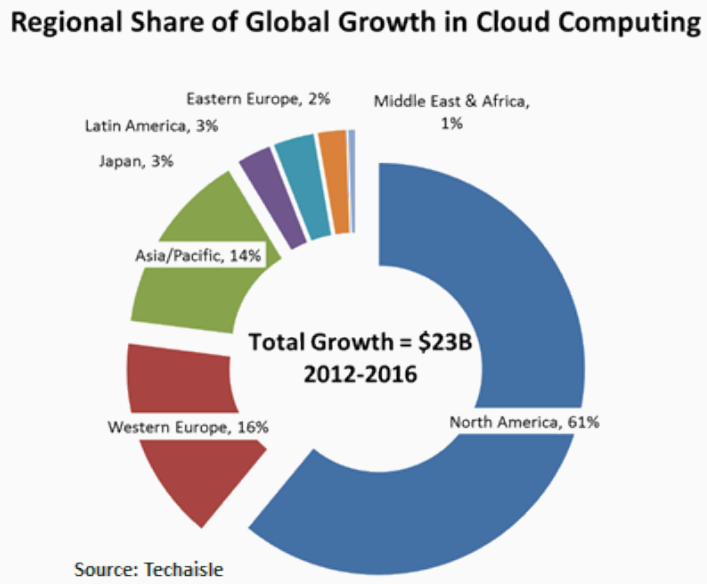


Evolution of Cloud Computing



What is Cloud Computing?

- **Services and Solutions that are delivered and consumed in real time over internet** are Cloud Services
  - When you store your photos online, use webmail or a social networking site, you are using a cloud computing service
- Cloud computing is a **delivery model of computing services over the Internet**
  - It enables real time development, deployment and delivery of broad range of products , services and solutions



Common Cloud Characteristics

- **On Demand** self-service
- Ubiquitous network Access: **Anywhere**, **Any time**, **Any Device**
- **Location independent** Resource Pooling
- **Rapid Elasticity**
- **Pay per use**
- **New Cloud Programming Paradigms** (MapReduce/Hadoop, NoSQL/Cassandra/MongoDB)
  - High in accessibility
  - Open source technologies

Supporting Factors for Cloud Computing

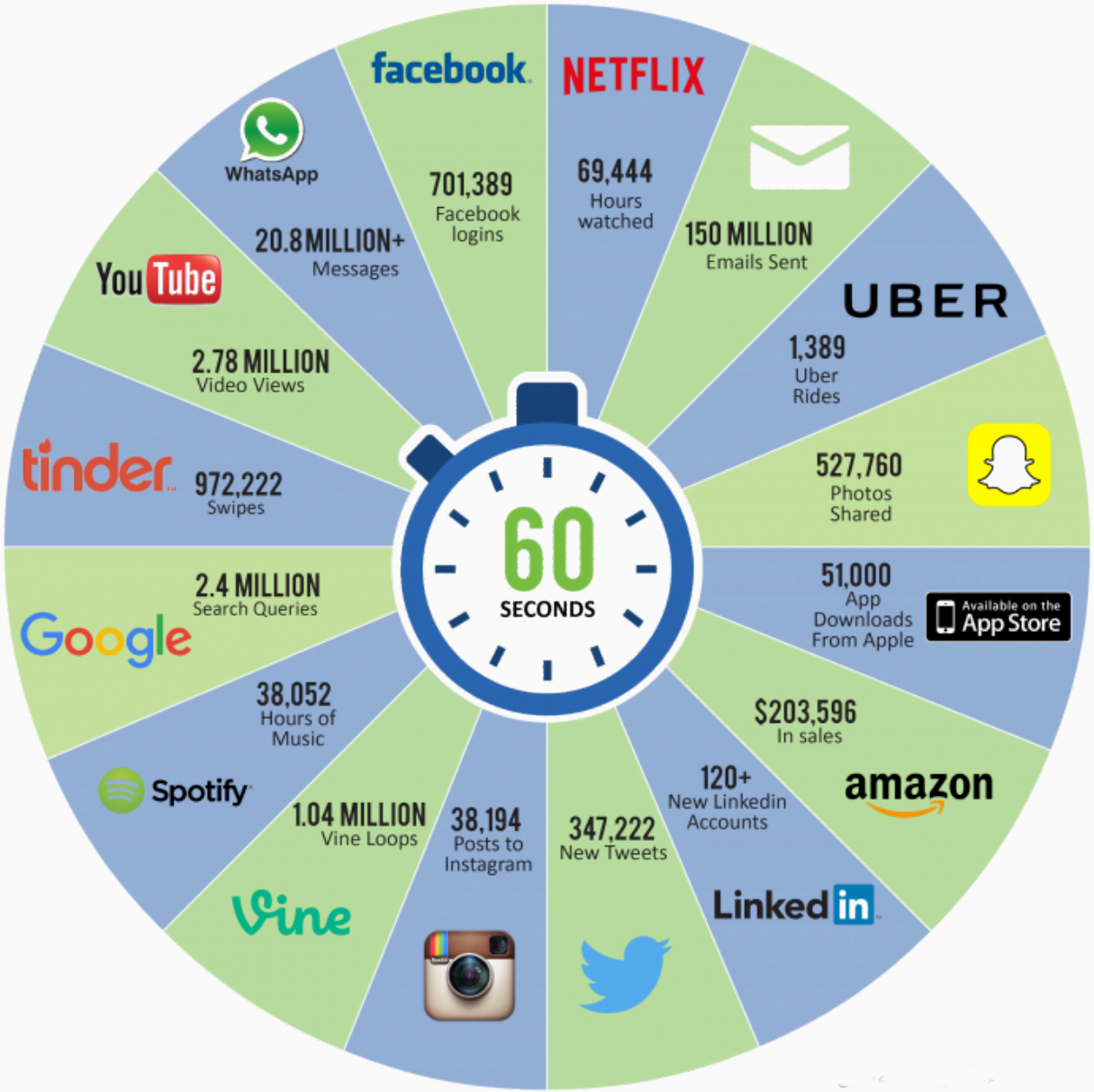
Combined effects of following factors have made Cloud Computing a compelling paradigm

- Advancement in **processors**
- **Virtualization** technology
- **Distributed Storage**
- **Automated Management**
- **Broadband** internet Access
- Fast and **Inexpensive Servers**

A taste of scale: Scenario 2013

- **7B+ mobile phones** (of which 3B+ are smartphones)
- **2,5B+ Internet users**
- **Facebook**: 1B+ users
- **iTunes**: 900K+ apps, 10B+ downloads, 47,000 per minute
- **YouTube**: 66+ hours of video uploaded every minute, 2B+ of video per day
- **Twitter**: 500M+ accounts, 200M+ tweets per day
- **Akamai**: 4TB/s delivery, from 15 to 30
- **Google**: 5B+ research per day
- **Saleforces**: 100K+ customers
- **Zynga**: 250M+ users
- **Amazon**: ti3,000$ (per minute!)

2016 What happens in an INTERNET MINUTE?



A taste of scale: Facebook Scenario 200ti

- 150 million **users** + about 250,000 **new users** per day
- 50,000 **transactions** per second
- 10,000+ **servers**
- **Data** are stored in thousands of database instances
- **Applications built on open source software**
  - Web and App tier: Apache, PHP, AJAX
  - Middleware tier: Memcached (Open source caching)
  - Data tier: MySQL (Open source DB)

A taste of scale: Facebook Scenario 2012

- 1B+ (150M in 200ti, 350M in 2009, 700M in 2011)
- 526 million **daily active users**
- 100M **new photos everyday**
- 125 billion **friend connections**
- 20 **comments per second**
- 70 **languages**
- Updates, comments, video, email, ecc.
- Total peak: 24 billions **operations per second**
- **Uptime** time equal to 99,9999% (the mytical 6 nine)

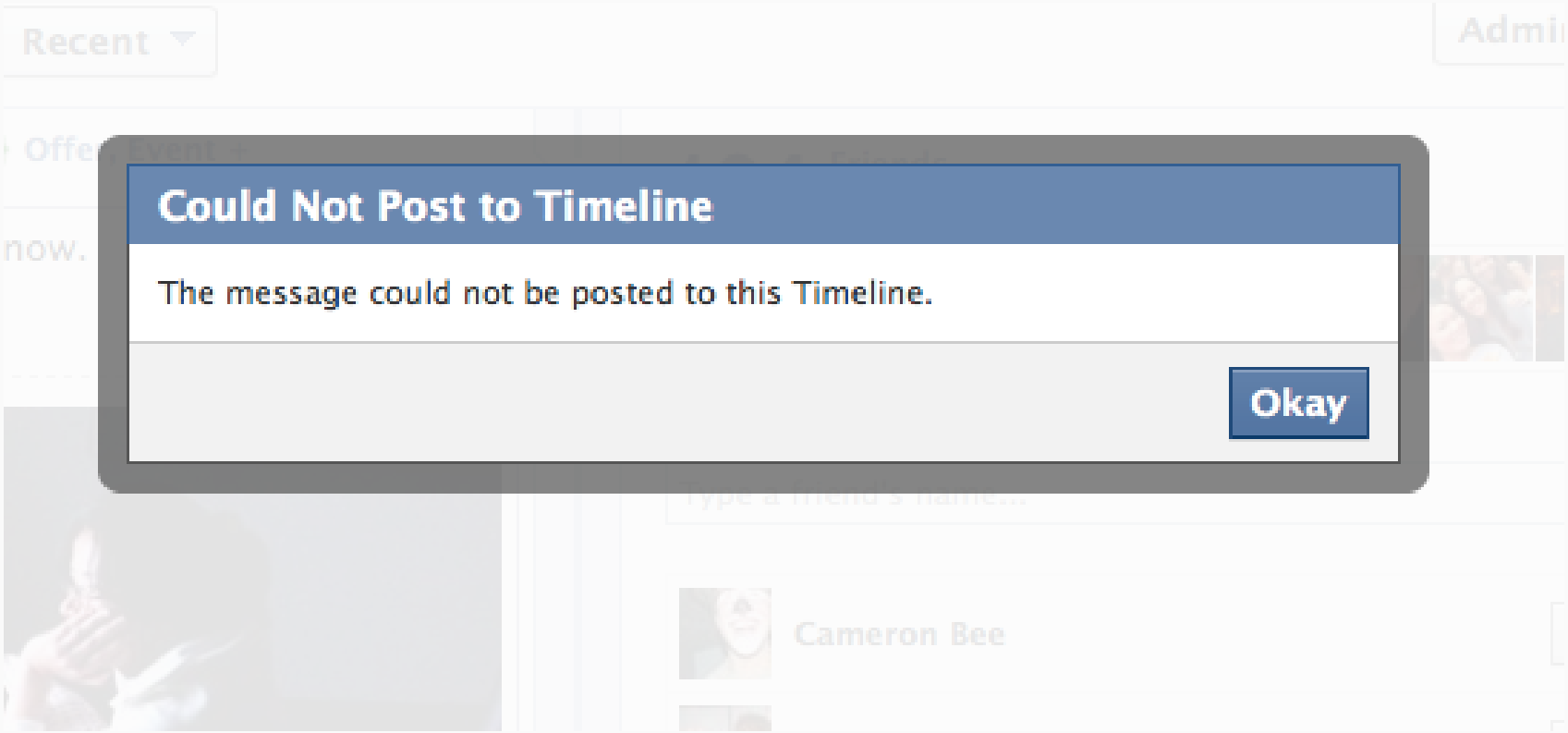
A taste of scale: Facebook Scenario 2016

- 1.71 billion monthly **active users**
- 1.0ti3 billion **daily active users**
- 350 million **photos per day**
- 500000 **new users** every day; 6 new profiles every second
- 4 million **likes every minute**
- 100 million **hours of daily video** watch time
- **Data warehouse**, with 300 petabytes of data
- ti0 **million people use Facebook Lite** (Mobile)

Althought..

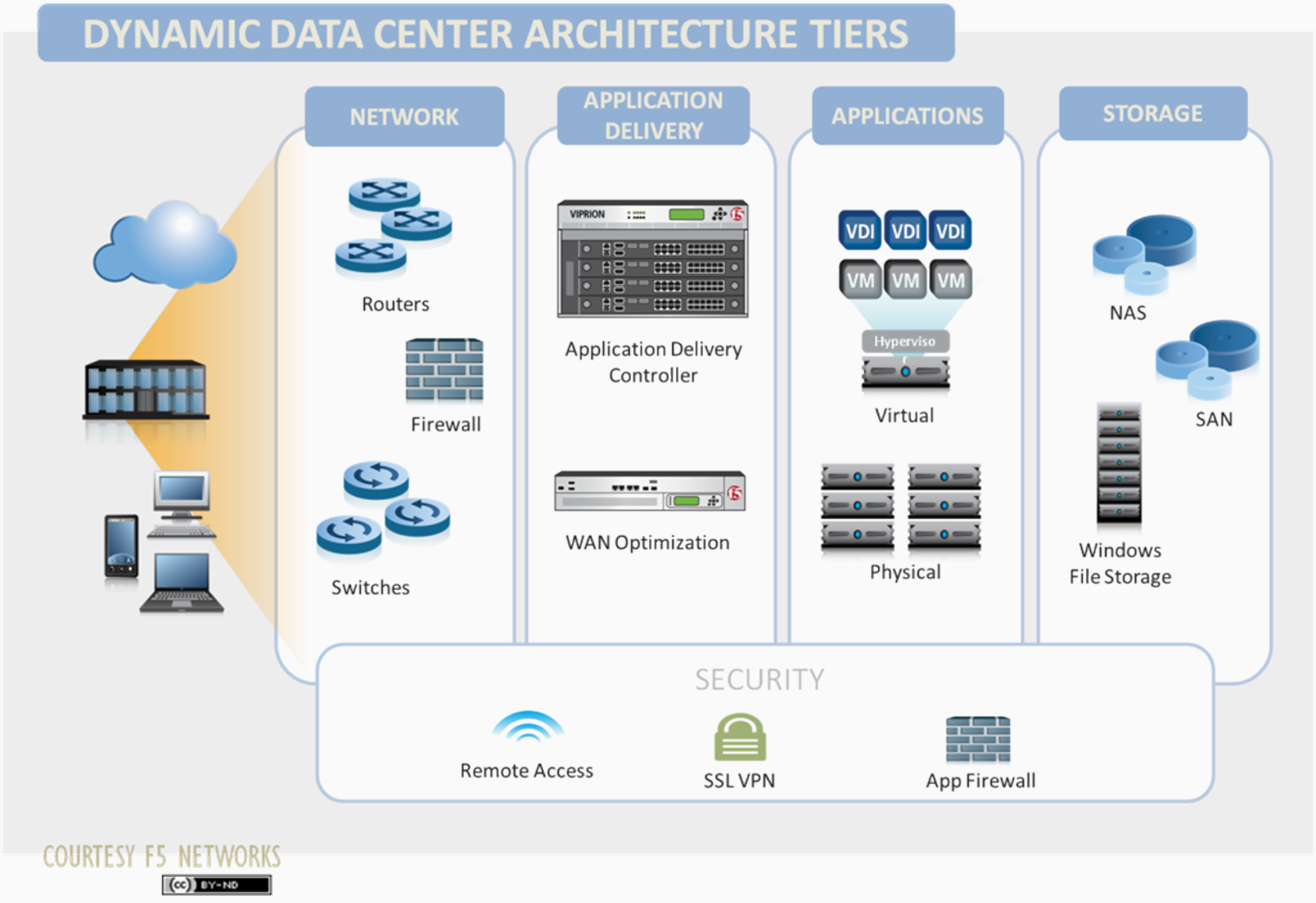
Uptime equal to 99,9999%, but..

October 21, 2013



https://uptime.is/advanced?sla=99.9999&dur=24&dur=24&dur=24&dur=24&dur=24&dur=24&dur=24

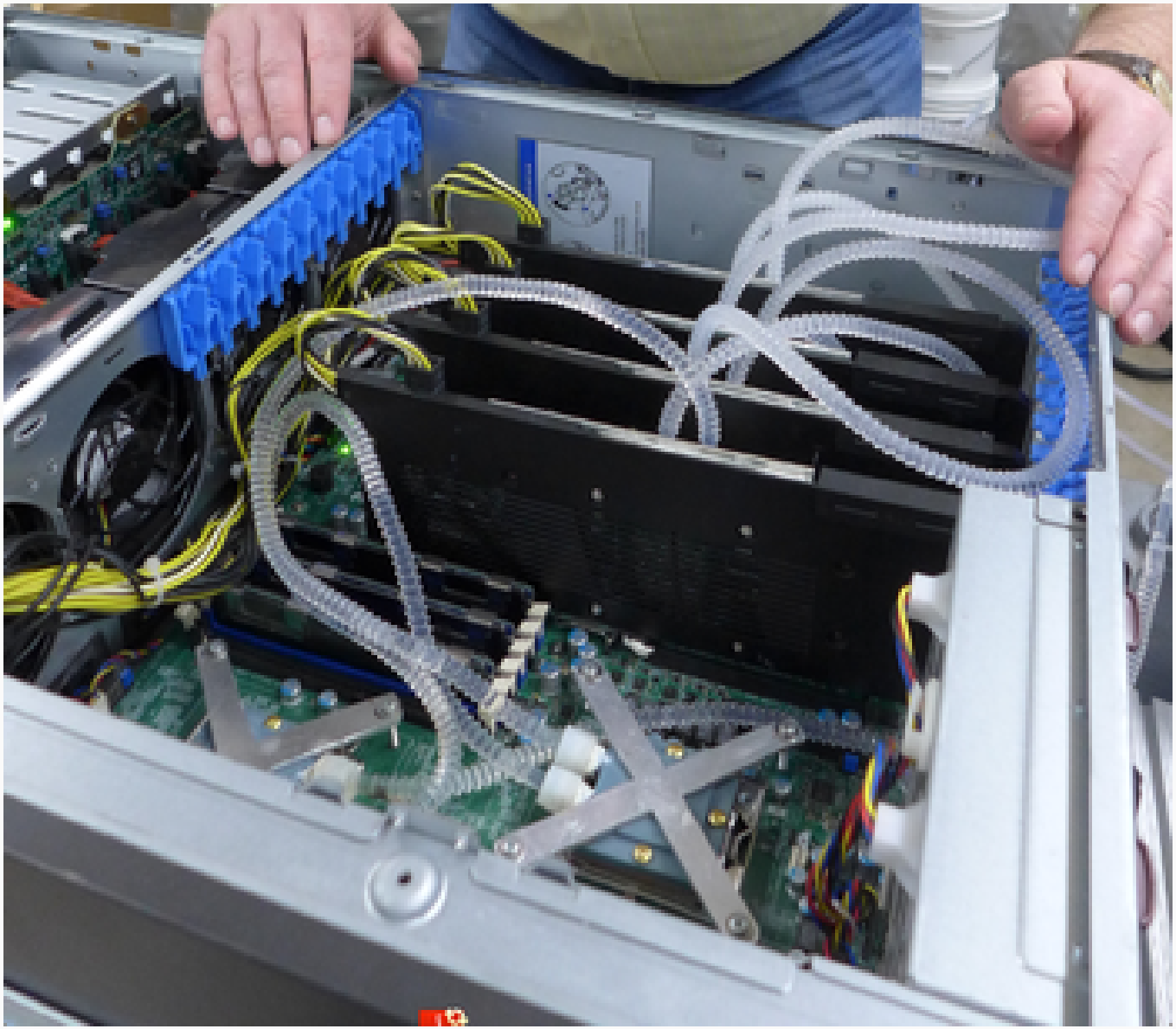
Data Center


DYNAMIC DATA CENTER ARCHITECTURE TIERS
NETWORK
APPLICATION DELIVERY
APPLICATIONS
STORAGE
Routers
Firewall
Switches
VIPRION
Application Delivery Controller
WAN Optimization
VDI
VM
Hyperviso
Virtual
Physical
NAS
SAN
Windows File Storage
SECURITY
Remote Access
SSL VPN
App Firewall
COURTESY F5 NETWORKS
BY-ND

Server (Front)

Server (Back)

Server (Inside)

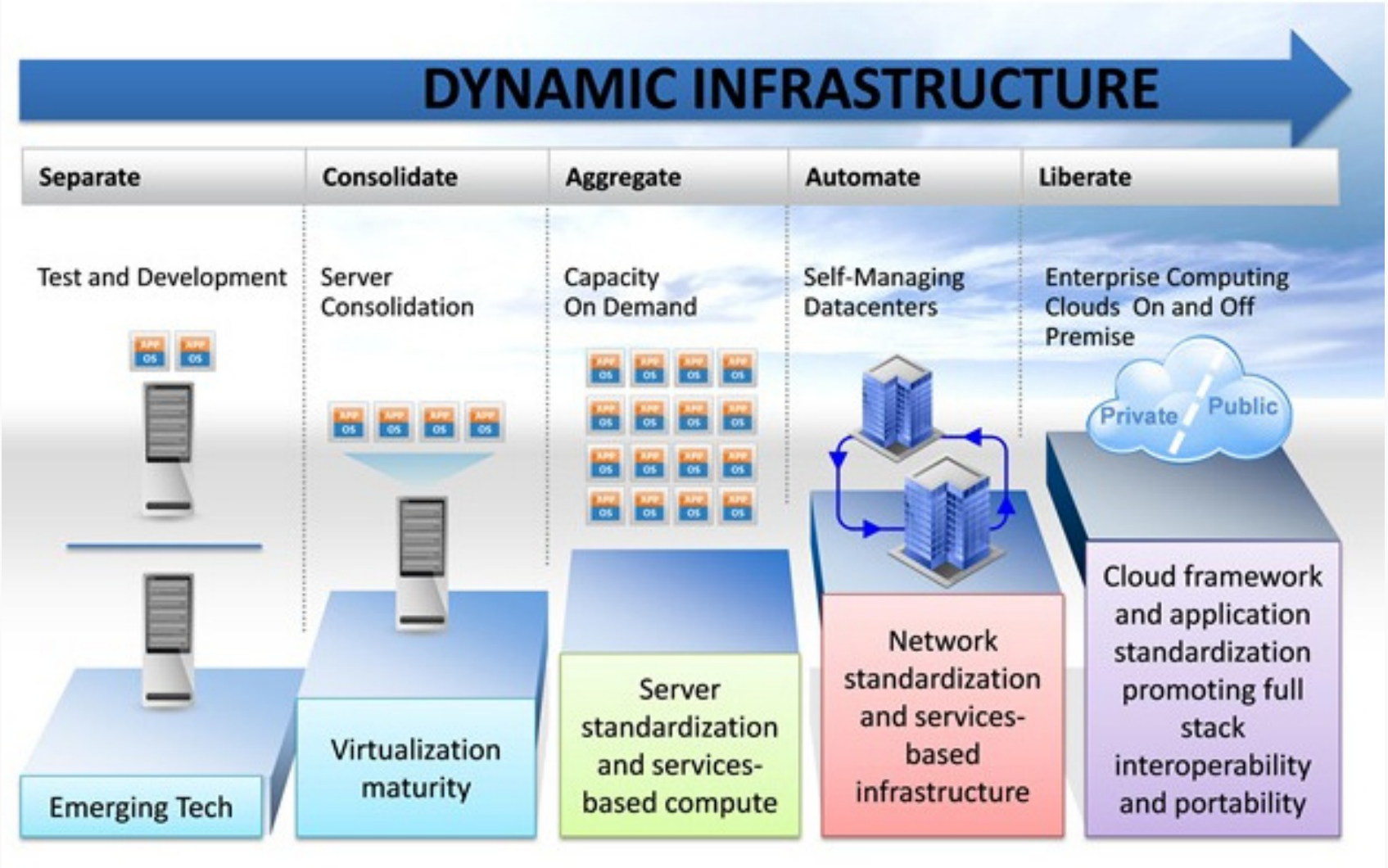


Server (Security)

Server (Temperature control)

- Purified cold air, through the system

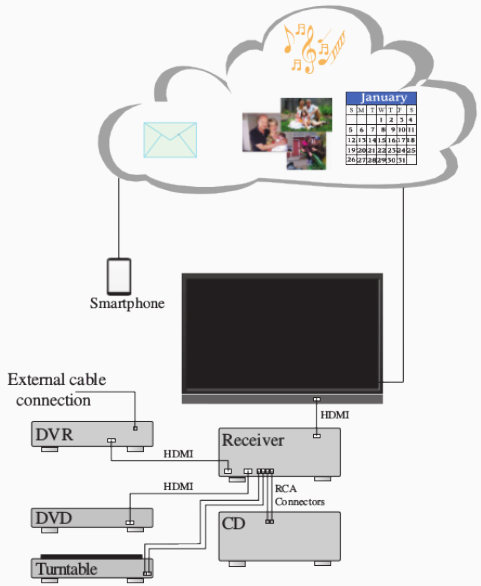
Cloud Infrastructure



Types of cloud

Cloud Computing and SOA

- A set of services **placed in a data center** and **connected** over the internet create the basis for the **cloud computing**.
- Why?
  - **Inexpensive hardware** (storage and servers)
  - **High speed internet connection**
- SOA can take advantages of cloud computing using internal and external service



Internal and External Service

External services:

- more **economic**
- more **functionality**

Organizations might find **cloud simpler than internal systems**

- It is possible to find **multiple service providers in the cloud of the same type** of the service.
- complete **features or innovations that are independent of the connections**
  - price
  - content
  - customizable interactions

Internal and External Service

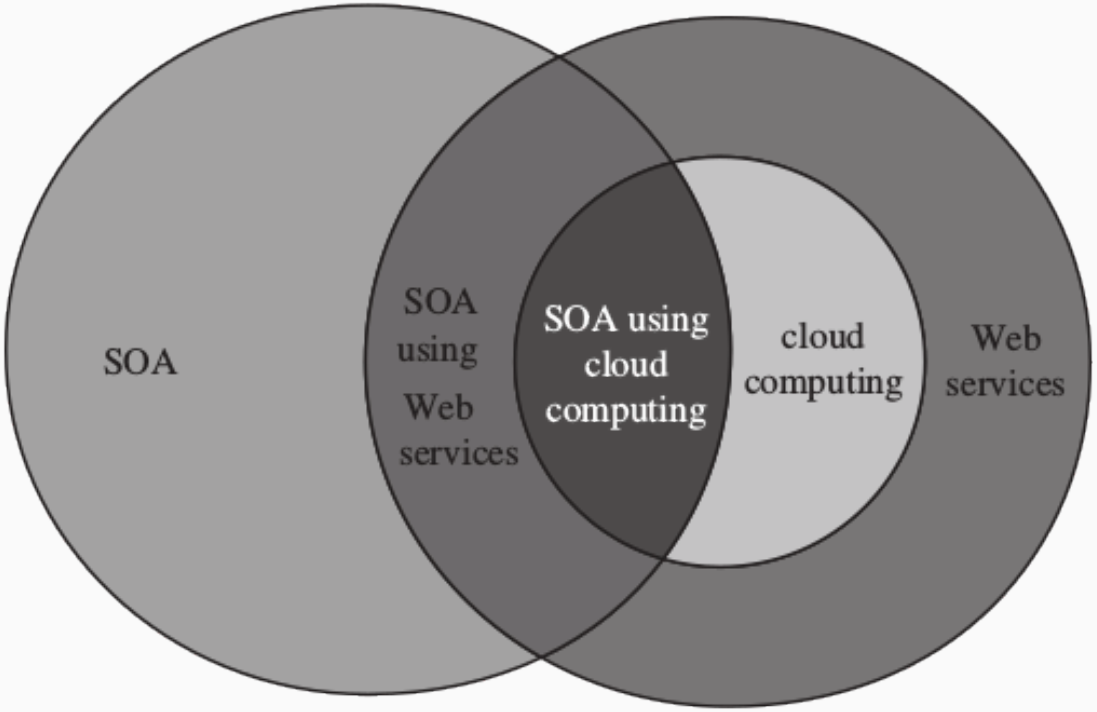
About Development effort:

- It is difficult for internal developer to **compete** with a cloud computing provider
- External providers can achieve **better product at lower cost**
- **Internal development:**
  - Might shift in less development
  - Put more effort in manage all connections work properly and **integrating new services**

The cloud

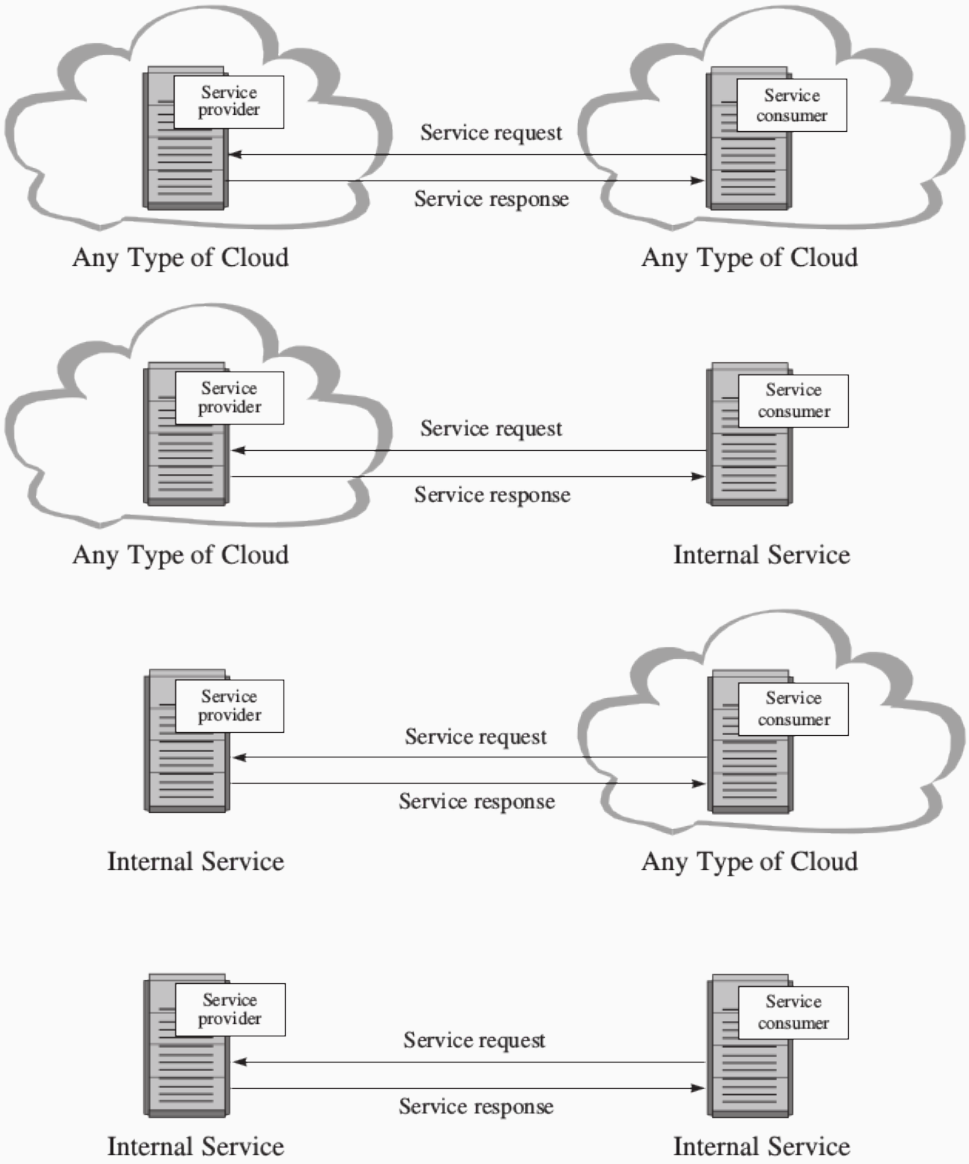
- **Provide software and hardware** resources via internet
- The **connections** are based on **API**
- API use **Web service** (SOAP, REST, JSON)
- The messages exchanged are usually **XML** or some **name-value** pairs

Relationship between Web Service, SOA and Cloud Computing



Our interest is in SOA using cloud computing

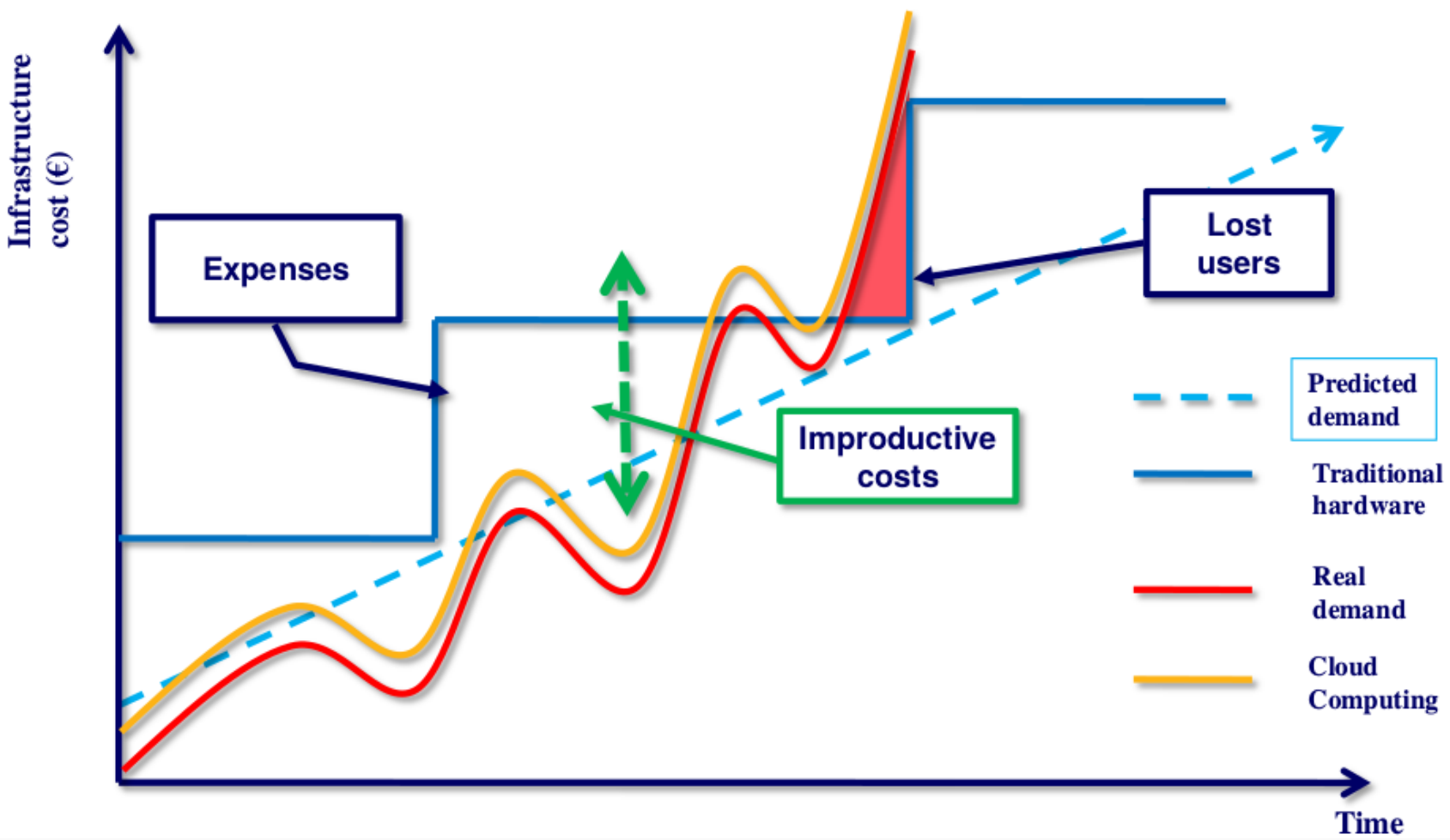
Various combination of Cloud Computing



Cloud Provider

- Usually cloud guarantee **high-availability** of its infrastructure
- Use **building blocks** to create services: software, tool, database, etc.
- **Suite of services**: CRM, document management
- Cloud define the price of usage according the **infrastructure** and the **demands**. (Pay per **transaction**, amount of **memory** used or for **peaks**)
- Cloud usually **avoid upfront costs** for temporal resource requirements
- **Issues**:
  - security
  - software tool and infrastructure,
  - privacy in shared environment

The capacity vs utilization urve



Types of Cloud

PUBLIC CLOUD:

- **Multitenancy**: allows multiple organizations to provide multiple types of services
- **Location independence**: dataceter could be anywhere in the world
- **Virtualization & device independence**:The underlying hardware is usually chosen by the cloud provider and not the users of the service
- **Management**: can be described as external cloud viewed from within a given organization

Types of Cloud

Community cloud:

- **Community**: More restricted than a public cloud (Industry segment, general interest, or other groups)
- **Tenancy**: Multi-tenanted
- **Location independence**: third party datacenter or by one member of the community

Private cloud:

- **Community**: Restricted to an organization
- **Tenancy**: Generally organization is single tenant, but if there is the necessity to cover various internal segment or unit is mul
- **Location independence**: third party datacenter or by one member of the community
- **Management**: Internal cloud, managed by the organization

Types of Cloud

Virtual Private Cloud:

- **Community**: Organization want to maintain an enterprise data warehouse in its datacenter located in a private cloud
- **Location independence**: allows the definition of the network that permit a database management system, business information, analytics systems, applicaiton server etc

Hybrid cloud:

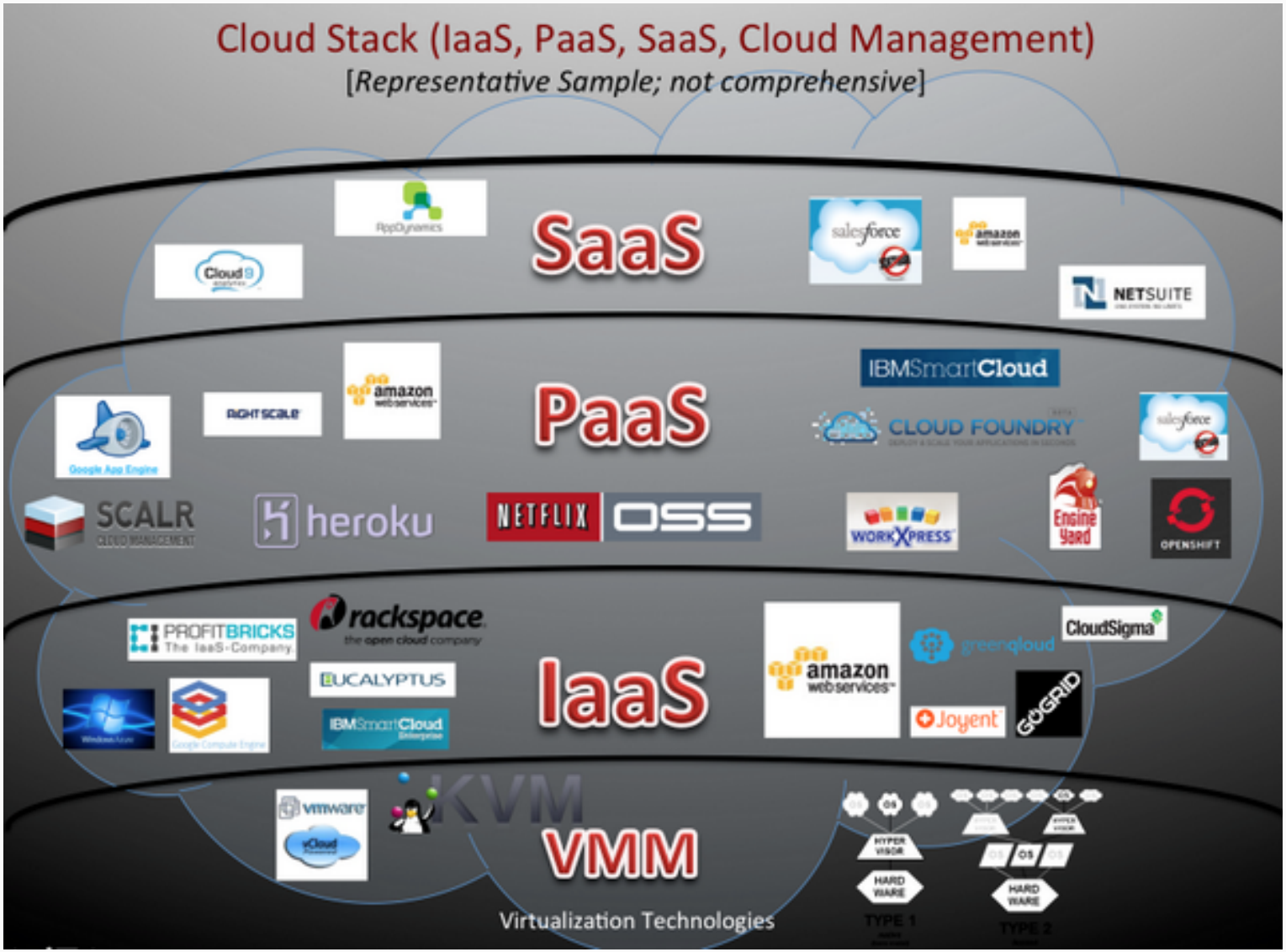
- **Community**: is the combination of any of the above.
- **Management**: may be private and public cloud combined together, could be ambiguous

Types of cloud

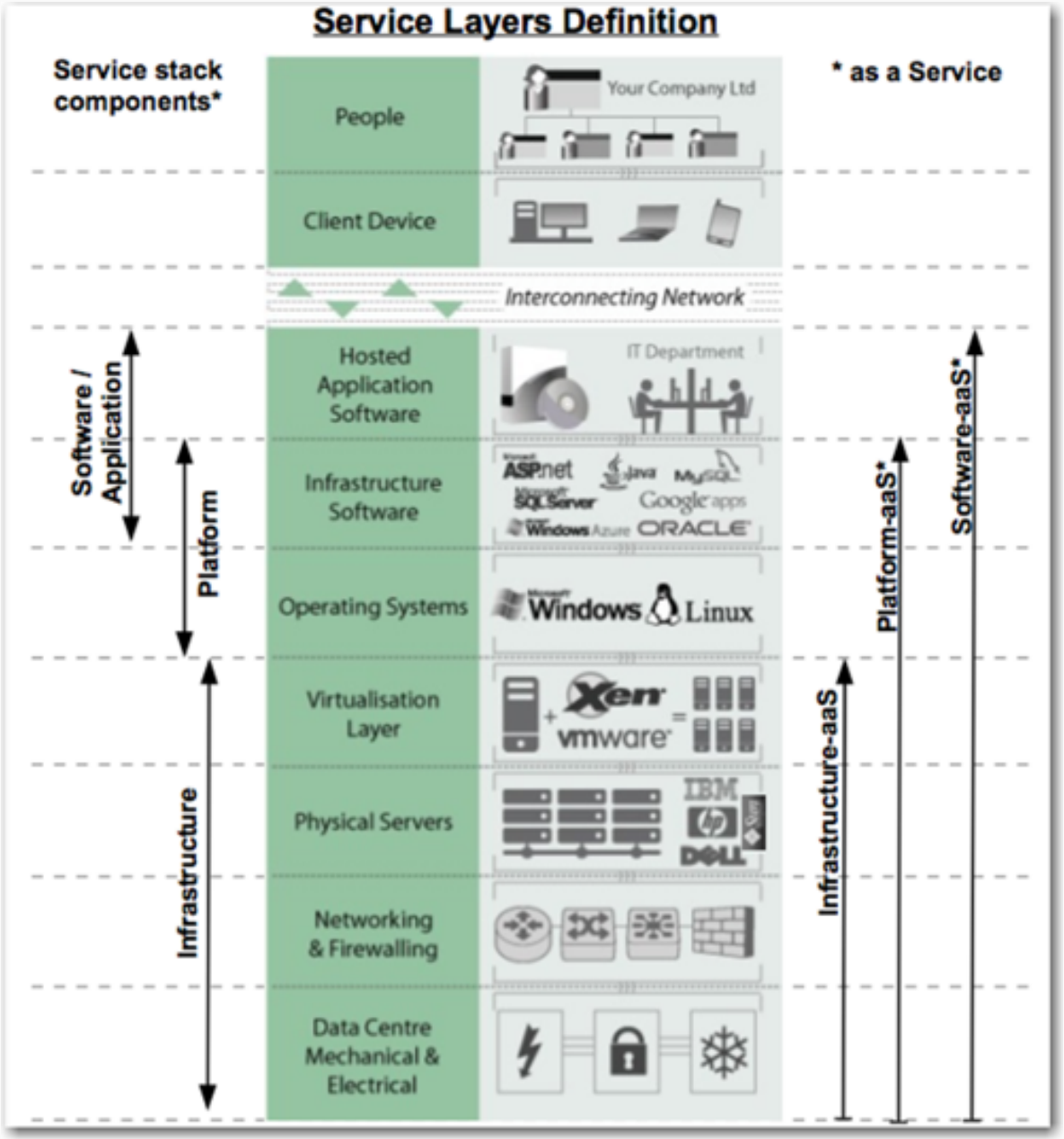
PUBLIC vs. PRIVATE vs. HYBRID CLOUD STORAGE

Characteristic	Public cloud storage	Private cloud storage	Hybrid cloud storage
Scalability	Very high	Limited	Very high
Security	Good, but depends on the security measures of the service provider	Most secure, as all storage is on-premise	Very secure; integration options add an additional layer of security
Performance	Low to medium	Very good	Good, as active content is cached on-premise
Reliability	Medium; depends on Internet connectivity and service provider availability	High, as all equipment is on premise	Medium to high, as cached content is kept on-premise, but also depends on connectivity and service provider availability
Cost	Very good; pay-as-you-go model and no need for on-premise storage infrastructure	Good, but requires on-premise resources, such as data center space, electricity and cooling	Improved, since it allows moving some storage resources to a pay-as-you-go model

Cloud Computing Stack



Cloud Computing Stack



Categories of Cloud Providers

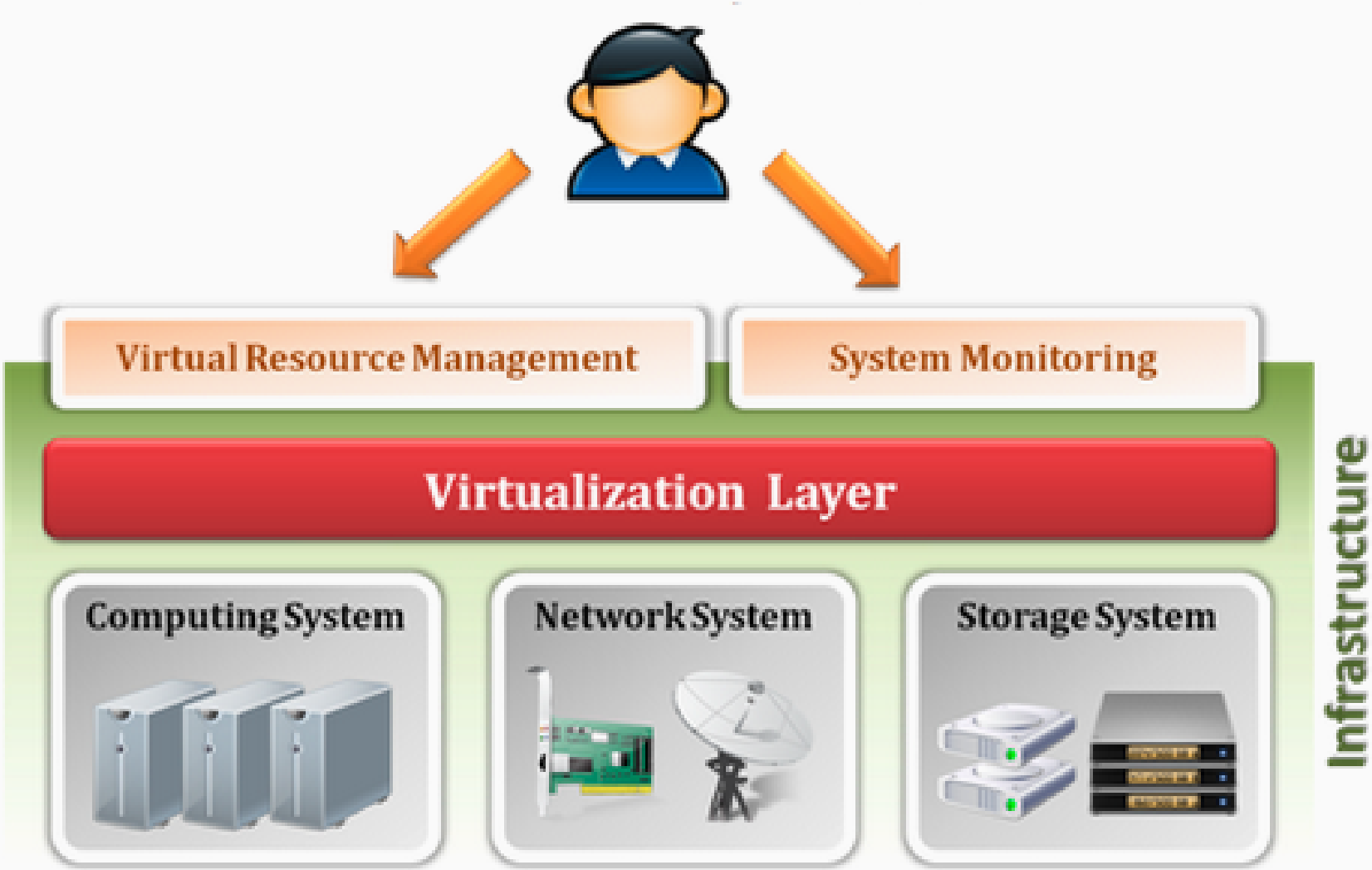
Infrastructure as a Service (IaaS):

- The capability provided to the consumer is to **provision processing, storage, networks, and other fundamental computing resources** where the **consumer is able to deploy and run arbitrary software,** which can include **operating systems and applications.**
- The consumer does not manage or control the underlying cloud infrastructure but **has control over operating systems, storage, deployed applications, and possibly limited control of select networking components** .

IaaS Benefit

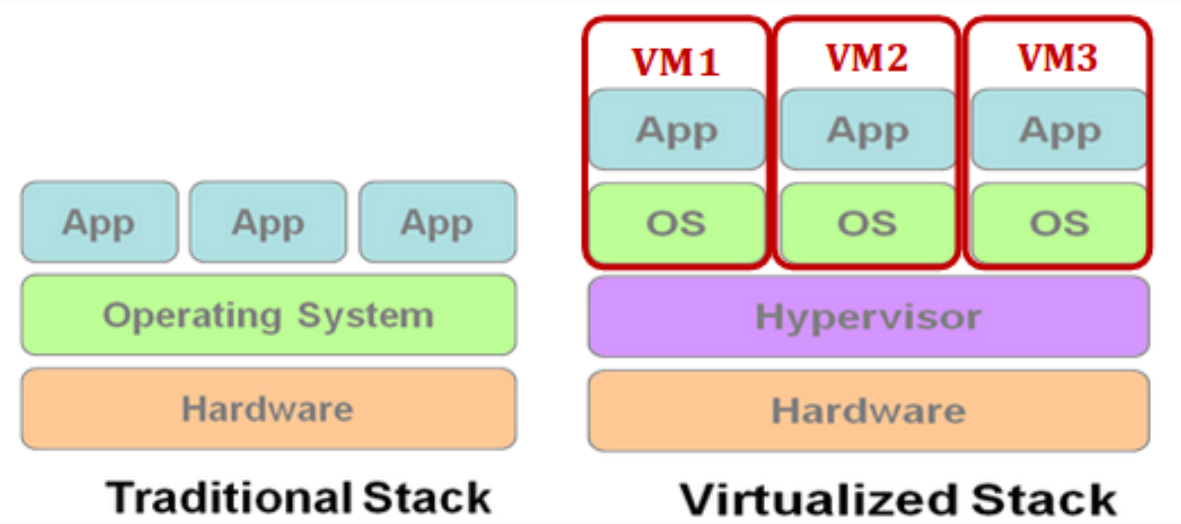
Recommended	No - Recommended
Demand is very volatile	Regulatory compliances for outsourcing of data storage and processing difficult
New organizations without capital to invest in hardware	
Organization is growing rapidly and scaling hardware would be problematic	
Internal pressure to limit capital expenditure and to move to operating expenditure	Where the highest performance required can be supported by the on premise or dedicated hosted infrastructure
Trials or temporary infrastructural needs	

Iaas System Architecture



IaaS

- **Virtualization**
  - Virtualization is an **abstraction of logical resources** away from underlying physical resources.
    - Virtualization technique **shift OS onto hypervisor**.
    - Multiple OS **share the physical hardware** and **provide different services**.
    - Improve **utilization, availability, security and convenience**.



IaaS

Properties supported by virtualization technique:

- Manageability and Interoperability
- Availability and Reliability
- Scalability and Elasticity

Resource Management Interface:

- Several types of virtualized resource :
  - **Virtual Machine** As an IaaS provider, we should be able to provide the basic virtual machine operations, such as creation, suspension, resumption and termination, ...etc.
  - **Virtual Storage**: As an IaaS provider, we should be able to provide the basic virtual storage operations, such as space allocation, space release, data writing and data reading, ...etc.
  - **Virtual Network**: As an IaaS provider, we should be able to provide the basic virtual network operations, such as IP address allocation, domain name register, connection establishment and bandwidth provision, ...etc.

System Monitoring Interface:

- Several types of monitoring metrics :
  - **Virtual Machine:** As an IaaS provider, we should be able to monitor some system states of each virtual machine, such as CPU loading, memory utilization, IO loading and internal network loading, ...etc.
  - **Virtual Storage:** As an IaaS provider, we should be able to monitor some storage states of each virtual storage, such as virtual space utilization, data duplication and storage device access bandwidth, ...etc.
  - **Virtual Network:** As an IaaS provider, we should be able to monitor some network states of each virtual network, such as virtual network bandwidth, network connectivity and network load balancing, ...etc.

Iaas Summary

- IaaS is the deployment platform that **abstract the infrastructure.**
- IaaS **enabling technique Virtualization**
  - Server Virtualization
  - Storage Virtualization
  - Network Virtualization
- IaaS **provided services**
  - Resource Management Interface
  - System Monitoring Interface

Categories of Cloud Providers

Platform as a Service (PaaS):

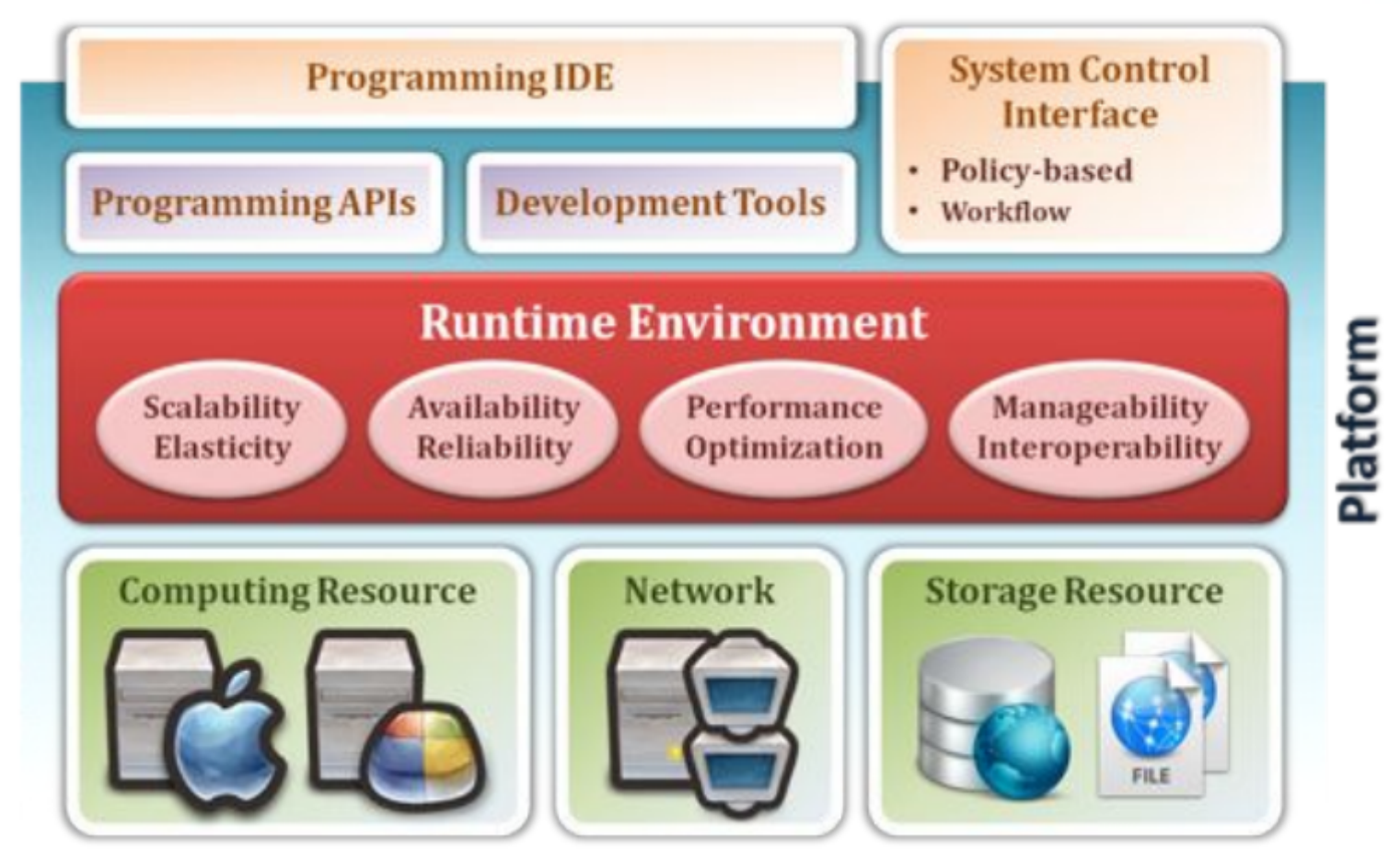
- The capability provided to the consumer is to **deploy onto the cloud infrastructure consumer created** or **acquired applications created using programming languages and tools supported by the provider.**
- The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but **has control over the deployed applications and possibly application hosting environment configurations.**

Categories of Cloud Providers

Platform as a Service (PaaS):

Recommended	No - Recommended
Multiple developers working on a development project or where external parties need to interact with the development process.	Where the applications need to be highly portable in terms on where it is hosted
	Where proprietary languages or approaches would impact the development process
	Where applications performance requires customization of the underlying hardware and software

System Architecture



PaaS

Runtime Environment Design:

- **Runtime environment:** refers to **collection of software services** available. Usually implemented by a collection of program libraries.
- **Common properties in Runtime Environment**:
  - Manageability and Interoperability
  - Performance and Optimization
  - Availability and Reliability
  - Scalability and Elasticity

PaaS

- **Programming IDE:**
  - Users make **use of programming IDE to develop their service** among PaaS.
    - This **IDE should integrate the full functionalities** which supported from the underling runtime environment.
    - This **IDE should also provide some development tools**, such as profiler, debugger and testing environment.
  - The **programming APIs** supported from runtime environment may be various between different cloud providers, but there are still some common operating functions.
    - Computation, storage and communication resource operation

PaaS

System Control Interface:

- **Police Based Control:**
  - Typically described as a **principle or rule to guide decisions** and achieve rational outcome(s)
  - Make the **decision according to some requirements**
- **Workflow Control:**
  - Describe the **flow of installation and configuration of resources**
  - Workflow processing daemon **delivers speedy and efficient construction and management of cloud resources**

PaaS Summary

- PaaS is the development platform that **abstract the infrastructure, OS, and middleware to drive developer productivity.**
- PaaS enabling technique
  - Runtime Environment
- **PaaS provide services**
  - Programming IDE
    - Programming APIs
    - Development tools
  - System Control Interface
    - Policy based approach
    - Workflow based approach

Categories of Cloud Providers

Software as a Service (SaaS):

- The capability provided to the consumer is to **use the providers applications running on a cloud infrastructure**. The **applications are accessible from various client devices through a thin client interface** such as a web browser (e.g., web-based email).
- The **consumer does not manage or control the underlying cloud infrastructure** including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of **limited user-specific application configuration settings.**

SaaS Infrastructure

Recommended	No - Recommended
No differentiated service	Required fast processing and real time data required
Significant interaction between the Organization and outside world	Legislation or regulations don't allow data to be hosted externally.
Need for web or mobile access	
Required only for short term	Existing on-premise solution fulfills all organization's needs.
User demands spikes significantly	

SaaS Infrastructure

SaaS

- **Web Service:**
  - **Web 2.0 is the trend** of using the full potential of the web
    - Viewing the Internet as a computing platform
    - Running interactive applications through a web browser
    - Leveraging interconnectivity and mobility of devices
    - Enhanced effectiveness with greater human participation
- **Properties provided by Internet** :
  - Accessibility and Portability

SaaS

- **Web-based Applications:**
  - Conventional applications should translate their access interface onto web-based platform.
  - **Applications in different domains**
    - General Applications: Applications which are designed for general propose, such as **office suit, multimedia and instant message**, ...etc.
    - Business Applications: Application which are designed for business puropose, such as **ERP, CRM and market trading system**, ...etc.
    - Scientific Applications: Application which are designed for scientific propose, such as **aerospace simulation and biochemistry simulation**, ...etc.
    - Government Applications Applications which are designed for government propose, such as **national medical system and public transportation system service**, ...etc.

SaaS

- **Web Portal:**
  - Apart from the standard search engine feature, web portals **offer other services such as e-mail, news, stock prices, information, databases and entertainment.**
  - Portals provide a way for enterprises to provide a consistent look and feel with access **control and procedures for multiple applications and databases, which otherwise would have been different entities altogether.**
  - Some examples: Google, Yahoo, ..etc.

SaaS Summary

- SaaS is the finished applications that you rent and customize.
- SaaS enabling technique
  - Web Service
- SaaS provide services
  - WebKbased Applications
    - General applica8ons
    - Business applications
    - Scientific applications
    - Government applications
- Web Portal

Forces Driving the Adoption of Web Services

Change in any organization

- can be challenging
- there is a technical aspect of changing that is the **Force field analysis**

In the following we analyze various **integration techniques** related to human aspect of changes that drive the adoption of web service, service-oriented architecture and cloud computing

Forces Driving the Adoption of Web Service

There are two aspects:

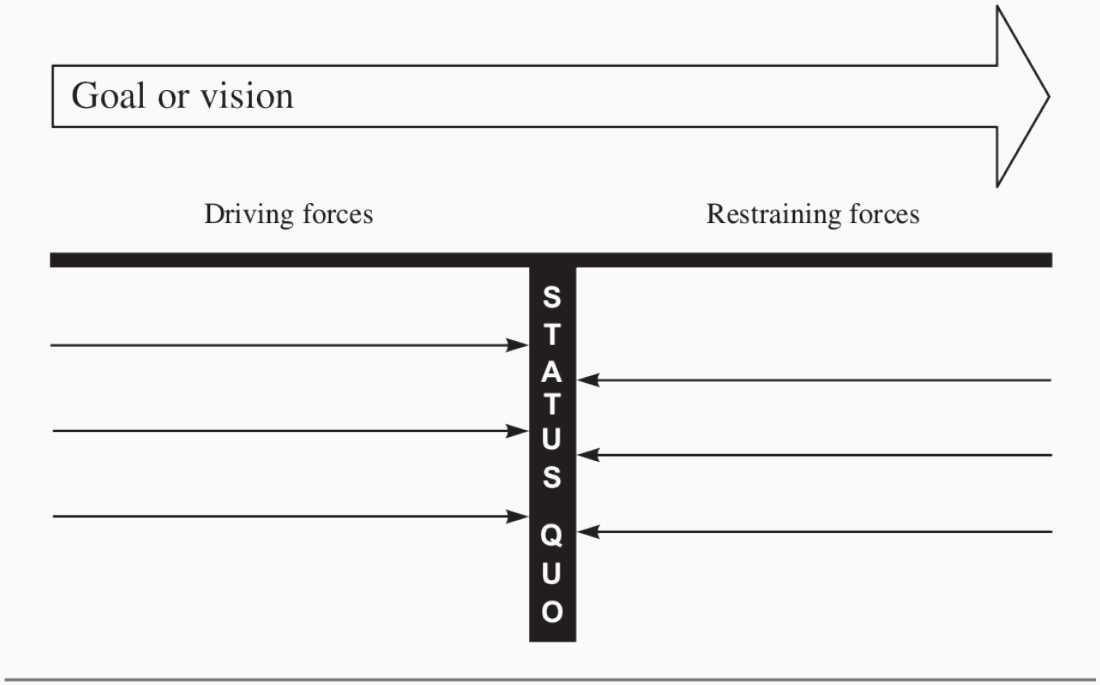
- The **vocabulary of the messages sent**
- The **communication protocol**

We analyze the force driving both aspects

Advances of technology and standards permit changes to occur

Force Field Analysis

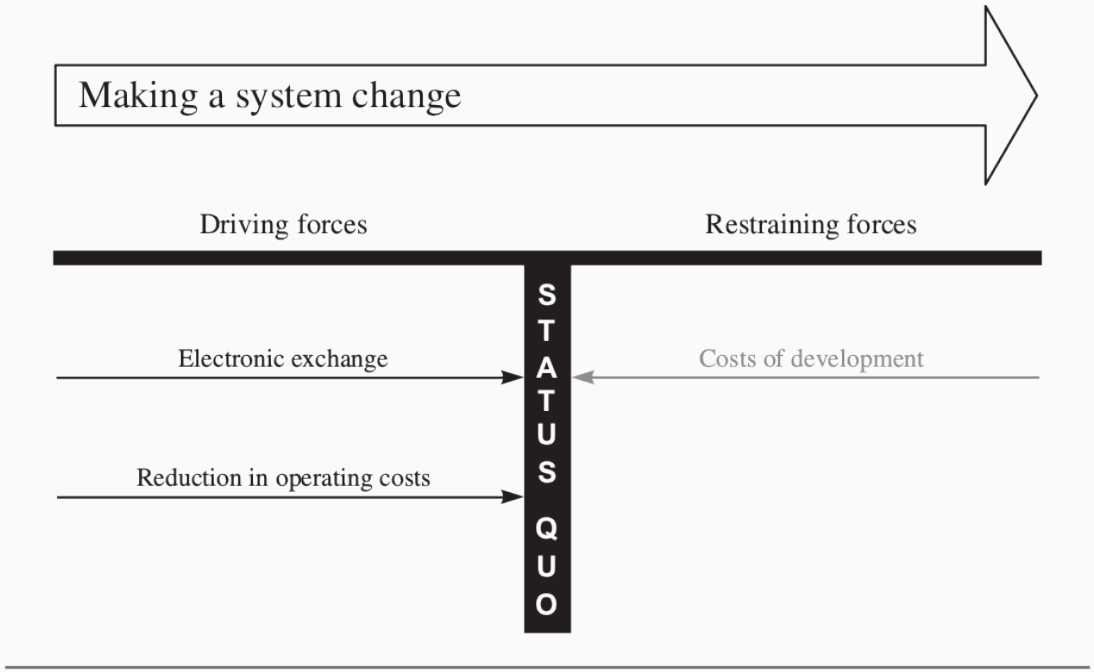
Provides a perspective of forces at work when trying to make changes in organizations



- **Goal or vision**
- **Driving forces**: help to achieve the goal
- **Restraining forces**: hinder goal achievement
- **Status quo**: is the equilibrium between the two forces

Force Field Analysis Example

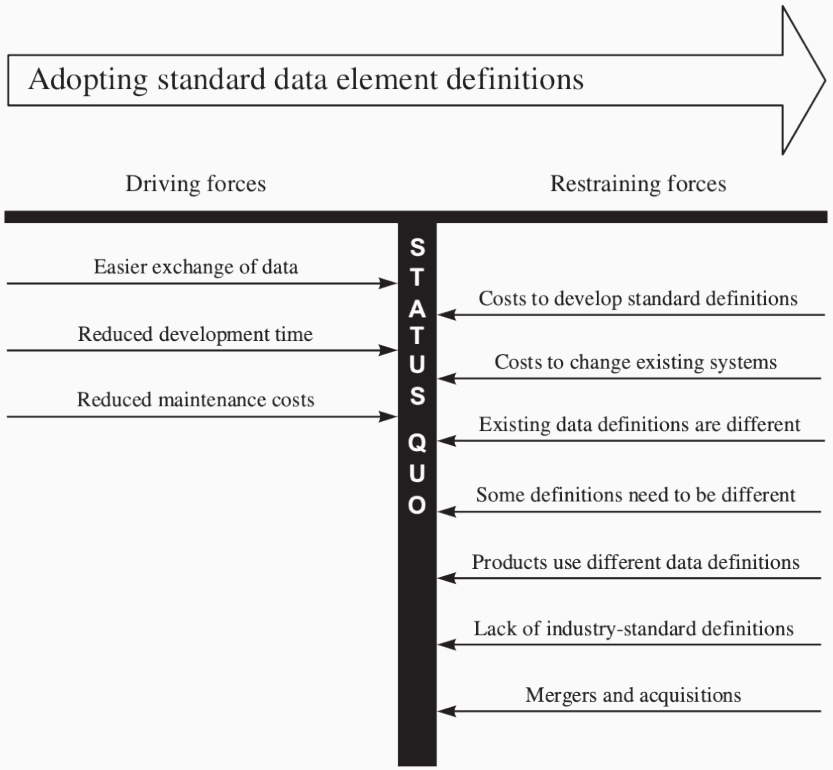
- Forces can be **internal or external** the organization
- The **model show the visible forces** in order to perform changes with the most available information
- For moving the equilibrium you need to **strength the driving forces or weaken the restraining forces** (best approach)



Adopting Standard Data Element

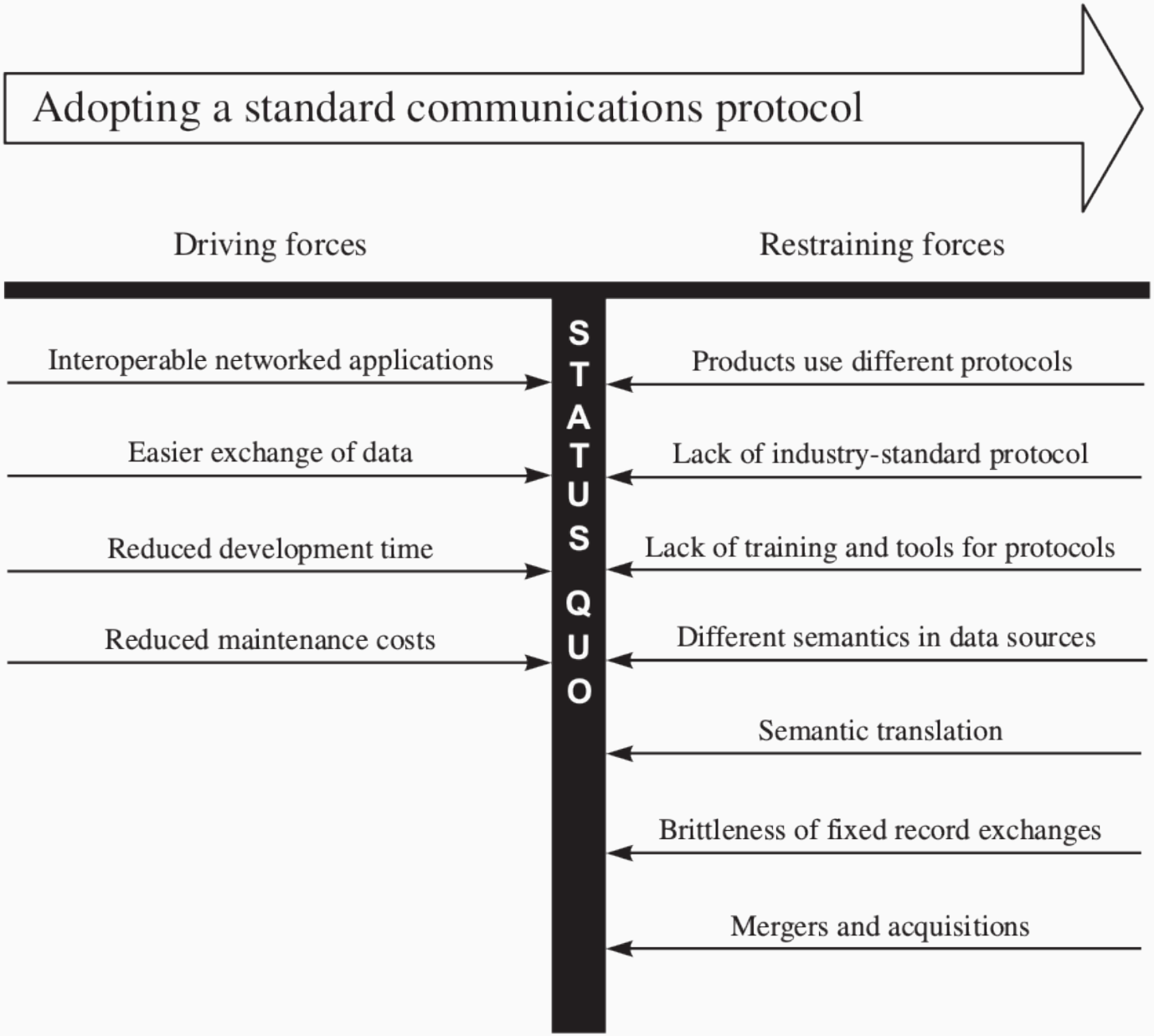
In 90ti's organizations were **running their custom software** (exchange data more easily, reduce development time, reduce maintenance cost)

With the need of **integration and standardization** we lead in:

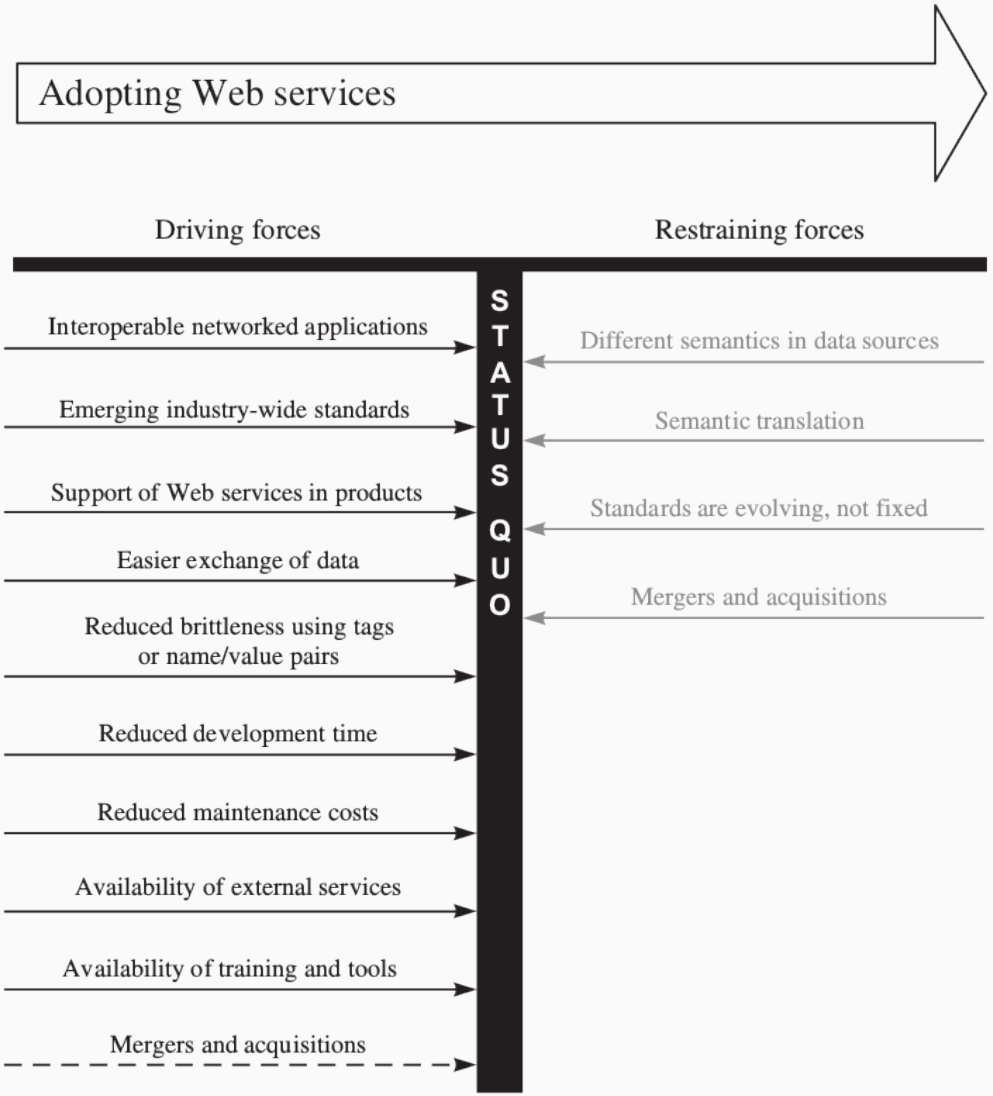


- **data can be easily interchanged** with standard definition
- element definition $\Rightarrow$ semantic vocabulary

Adopting Standard Communication Protocol



Adopting Web services

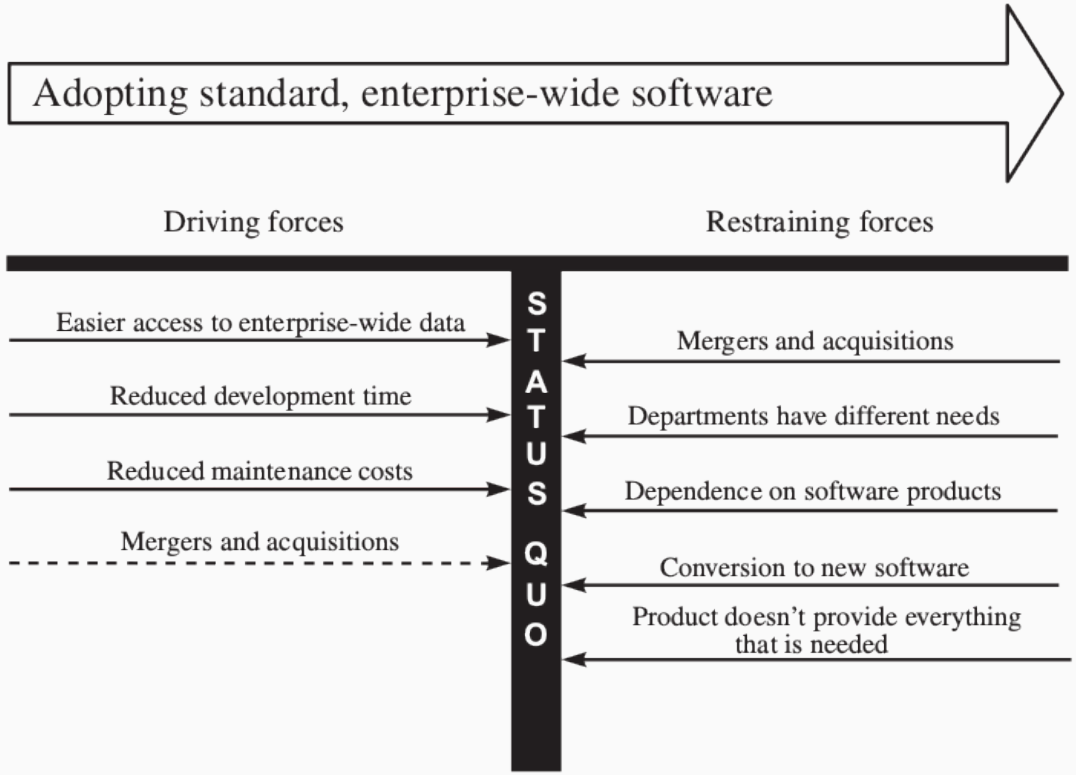


Web services makes **interoperation between systems much easier**. They use both **XML or name/value pairs for message formats** and HTTP with **TCP/IP on the Internet for a communications protocol**.

Forces Driving the Adoption of SOA

Adopting Standard,Enterprise Wide Software

- The appeal of **adopting standard software** is that **everyone use the same software**
- Entire organization uses the **same data definitions, semantics, and format for exchange data**
- Work best in small organizations



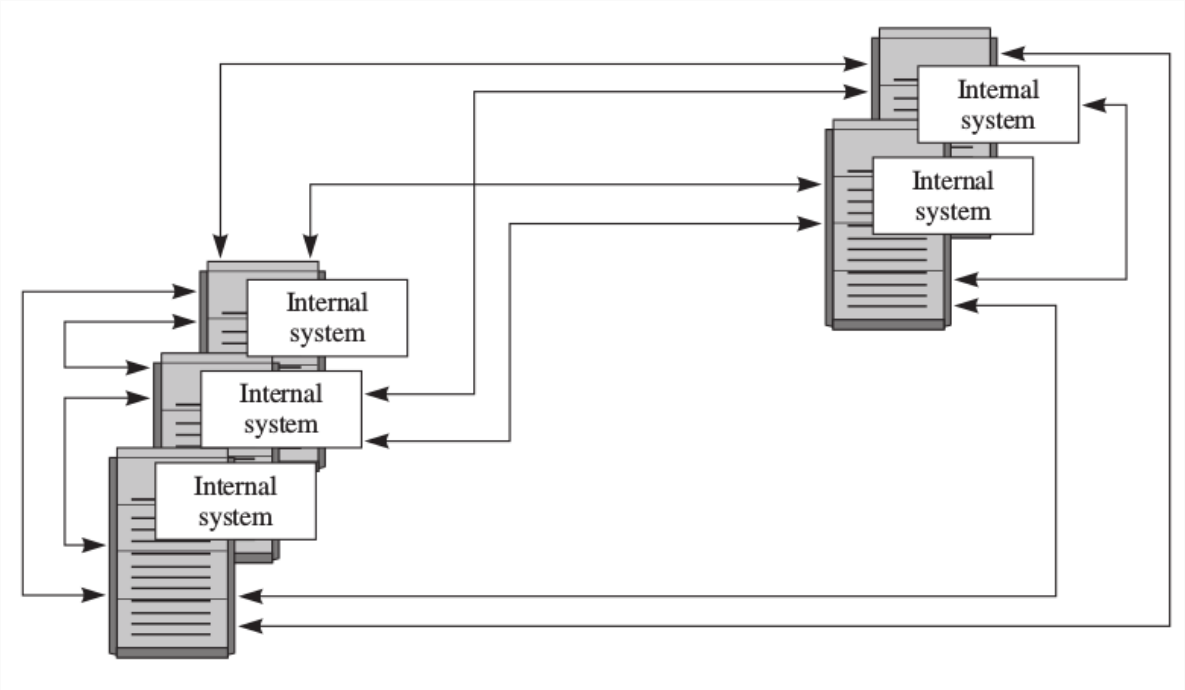
Adopting Standard,Enterprise Wide Software

Merges and Acquisitions:

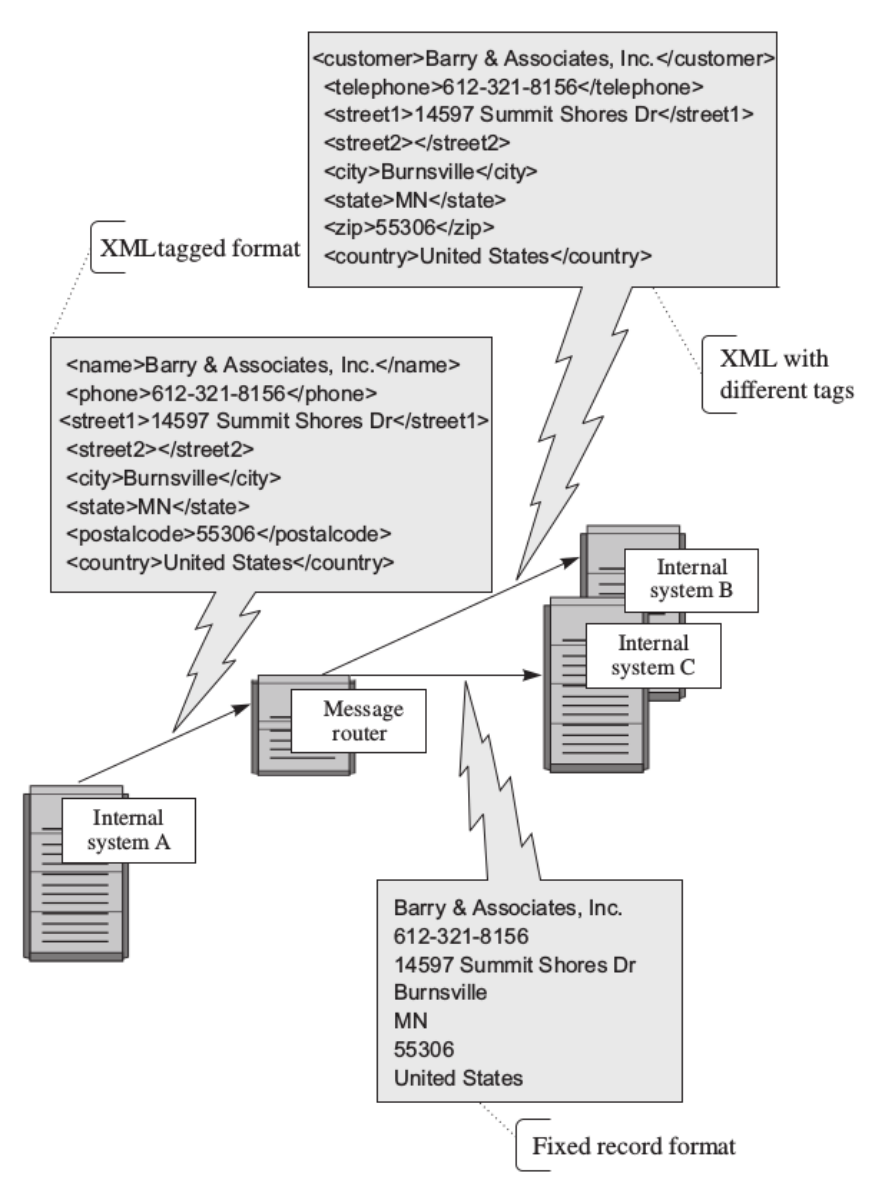
- Organizations or departments can use **different software needs.**
- Difficult to find **"one size fit all" software**
- Use a **single software suite** form one vendor **makes organization dependent**

Adopting Enterprise Service Bus

In system integration there is the need to propagate data among internal system.

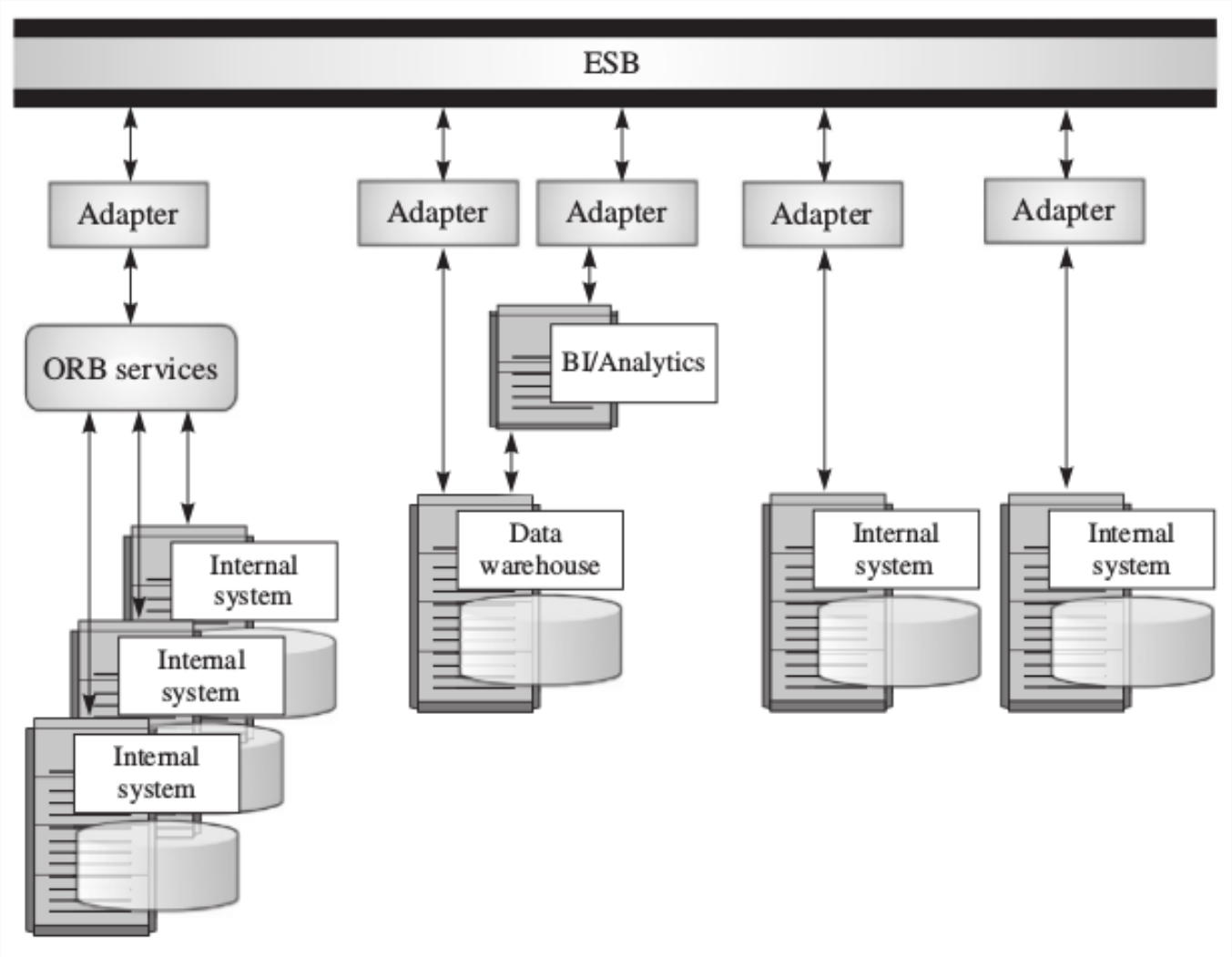


Message Router



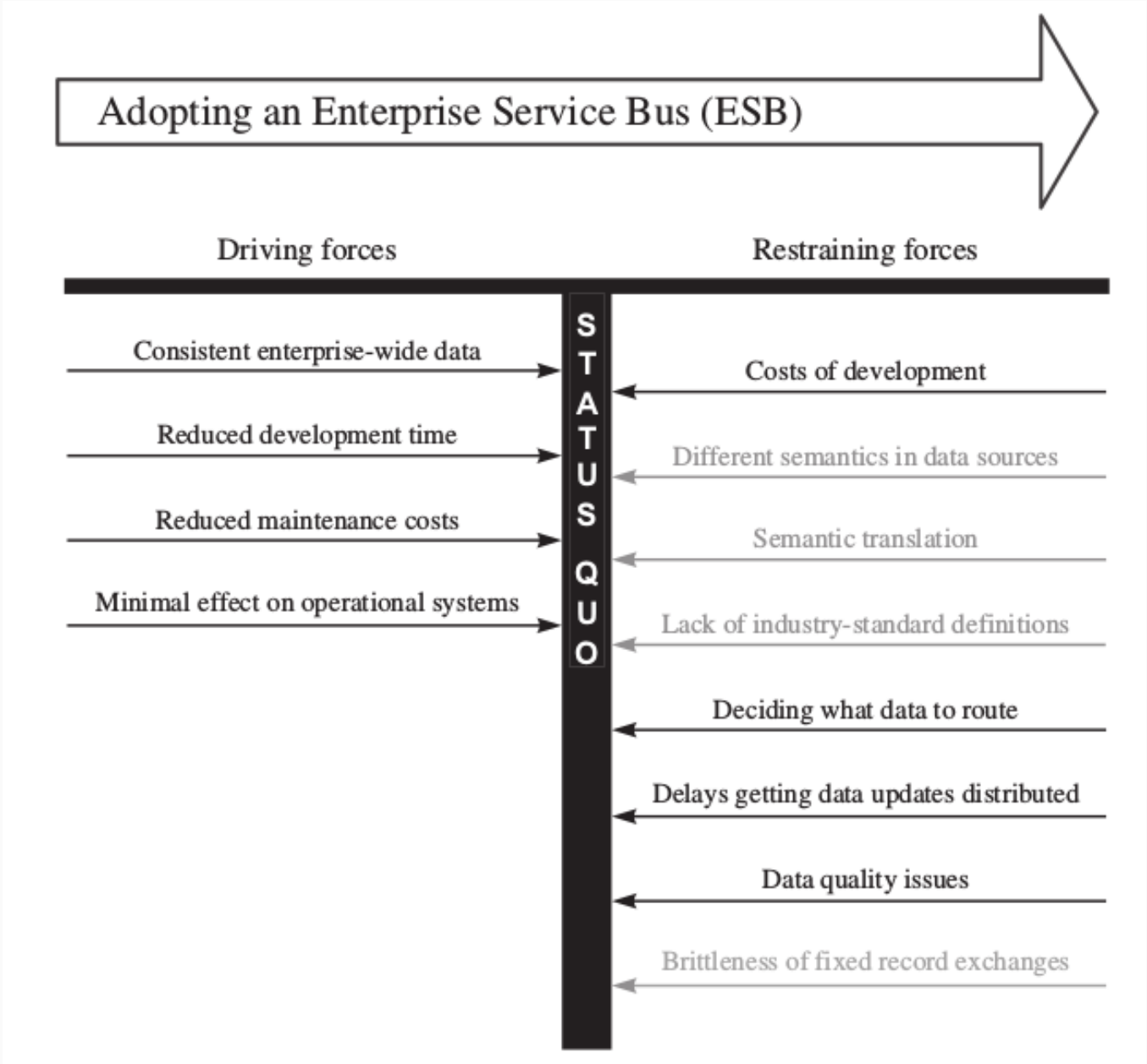
A message router need to transform data between sender and receiver

Enterprise Service Bus

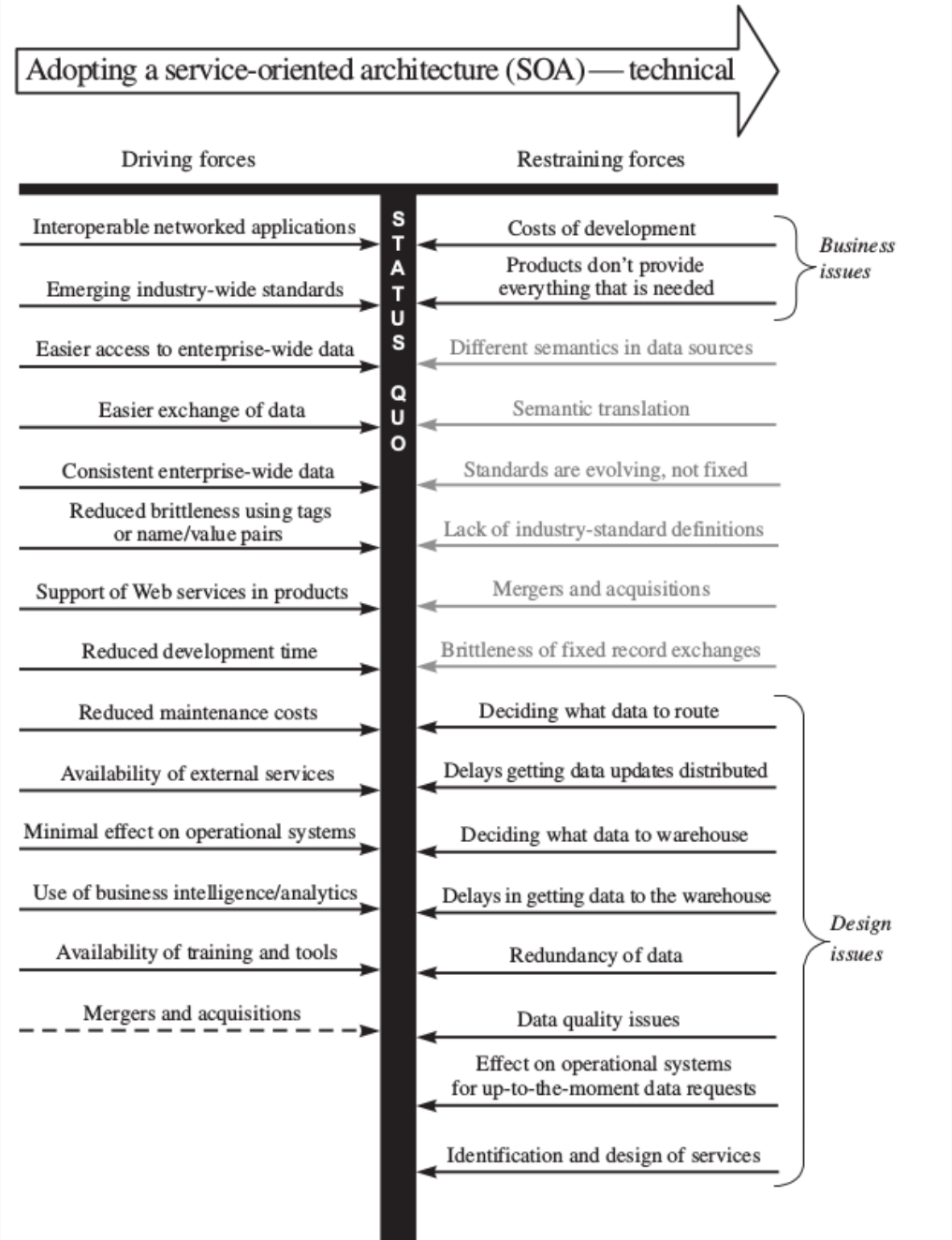


- monitors, logs, controls routing
- standard vocabulary semantics

Adopting Enterprise Service Bus

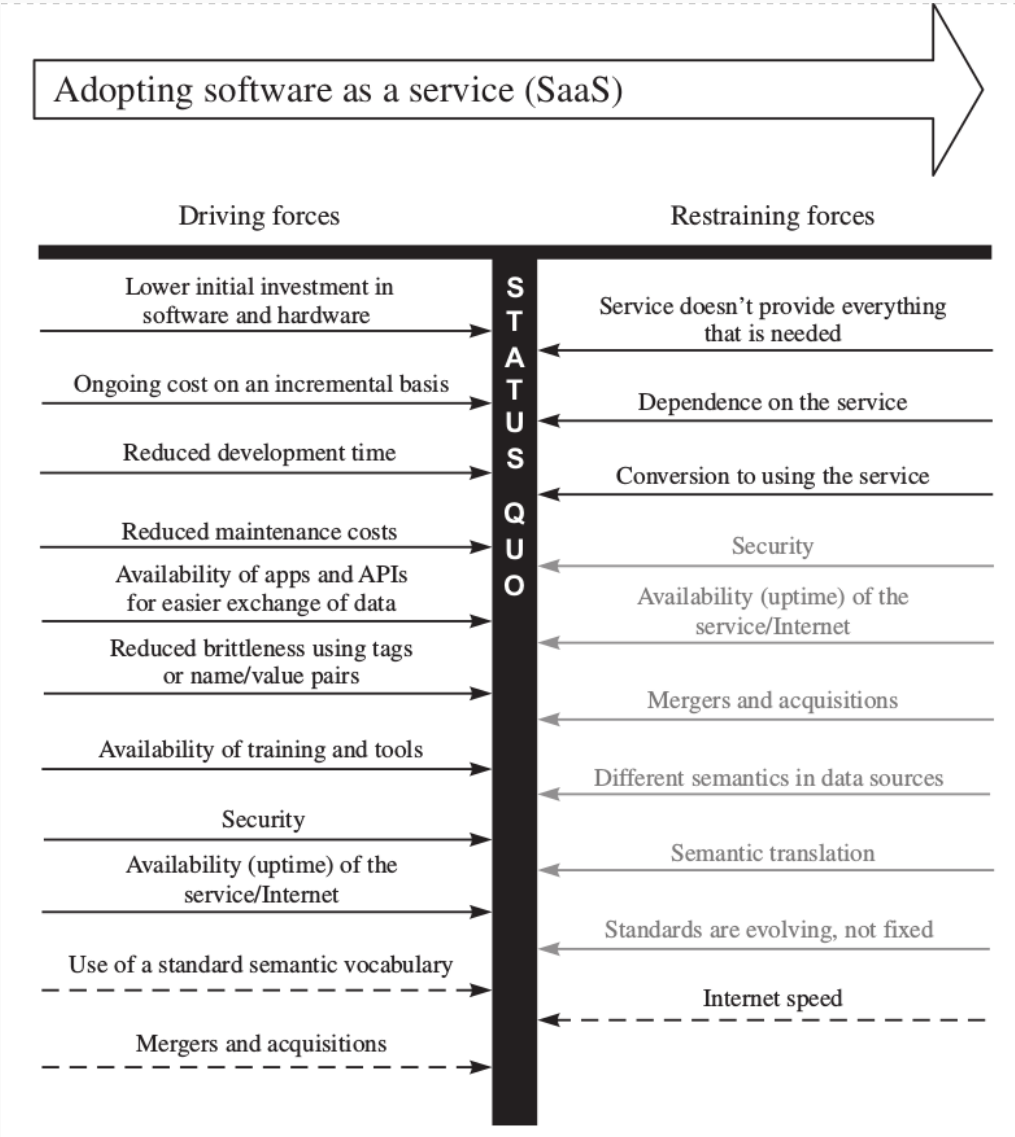


Adopting SOA

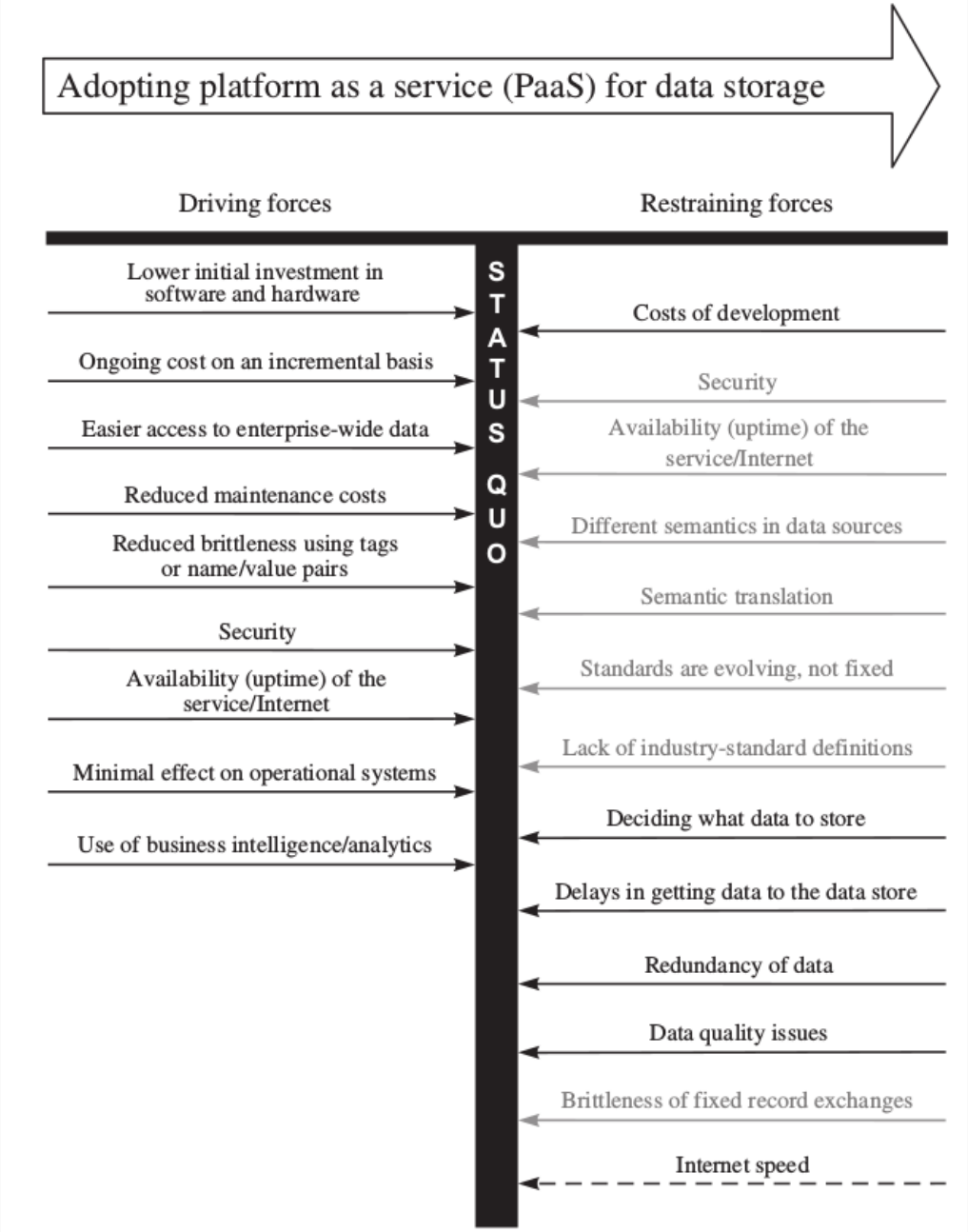


Forces Driving the Adoption of Cloud Computing

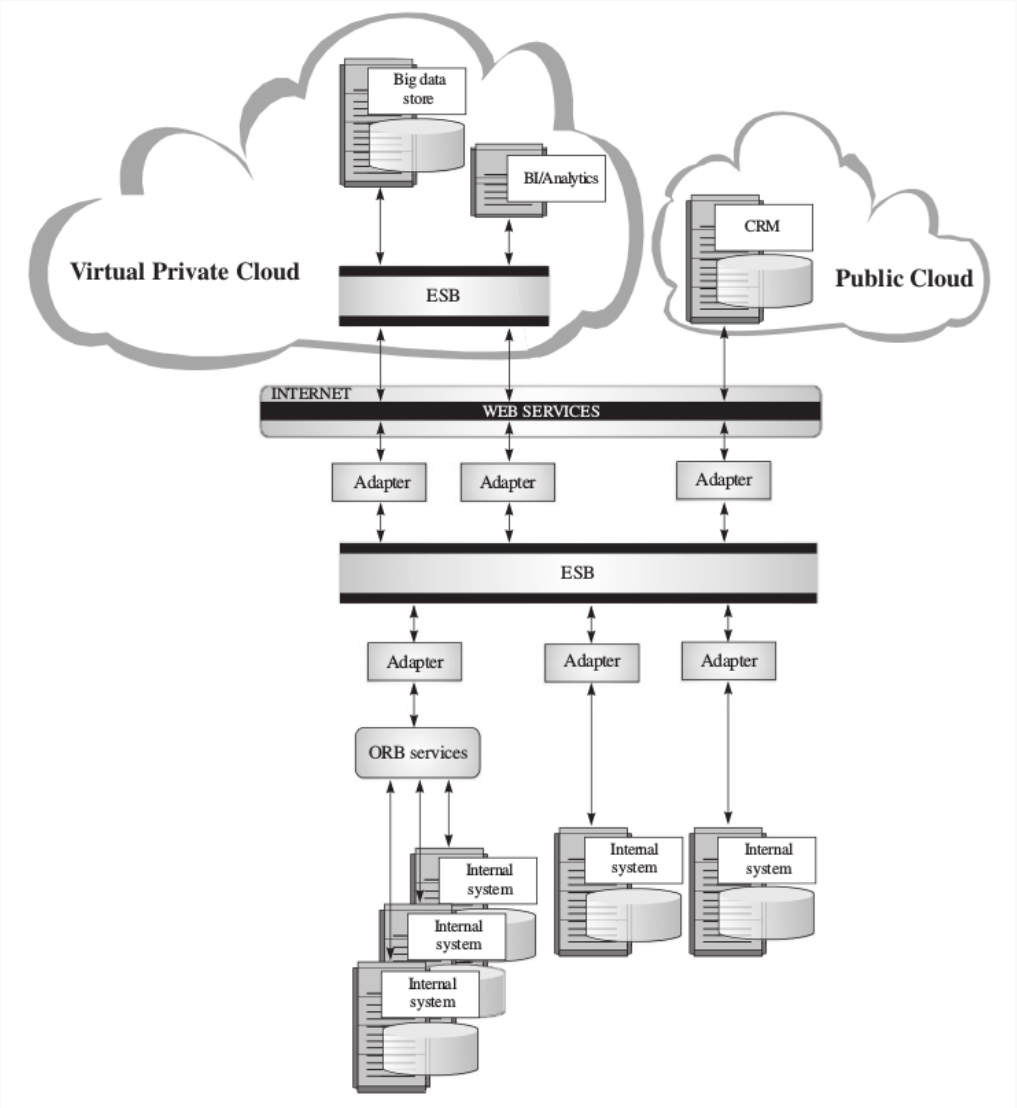
Adopting Cloud Computing



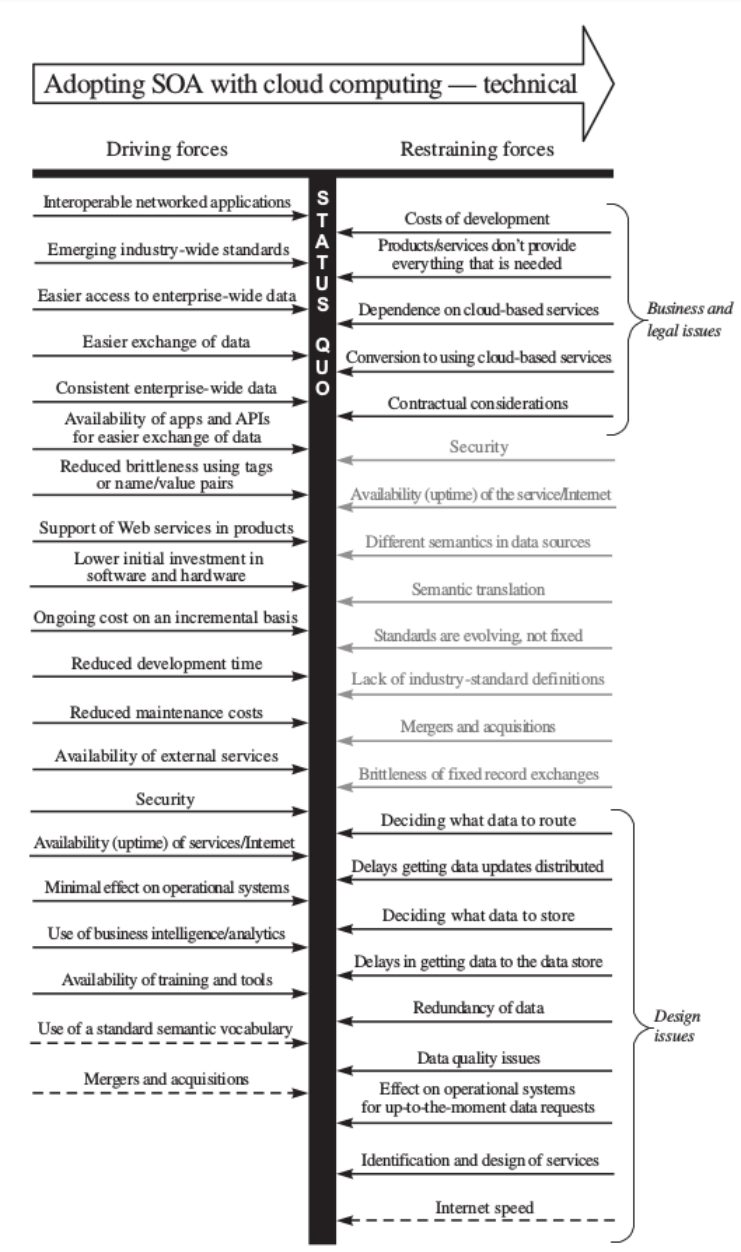
Adopting Cloud Computing



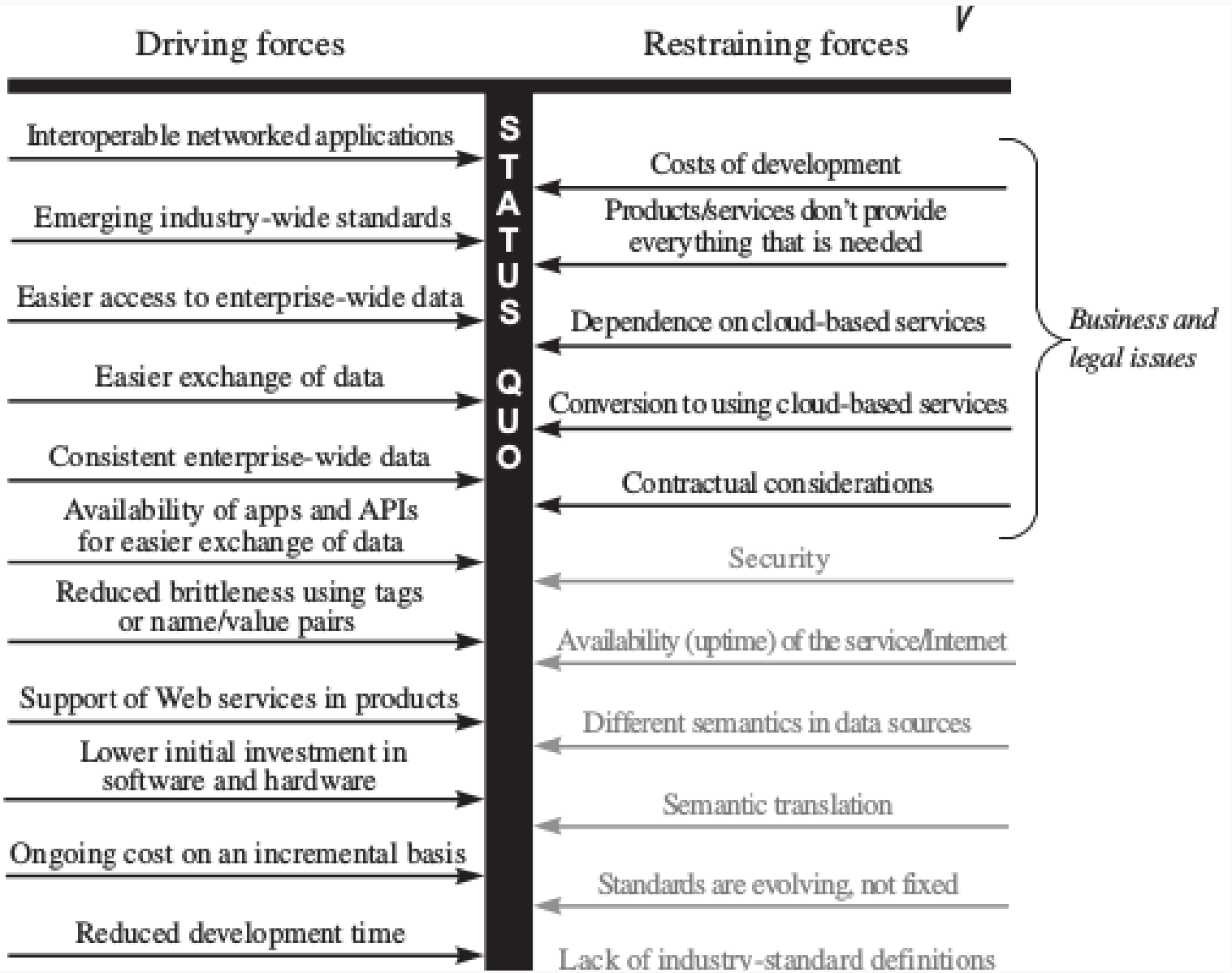
Adopting Cloud Computing



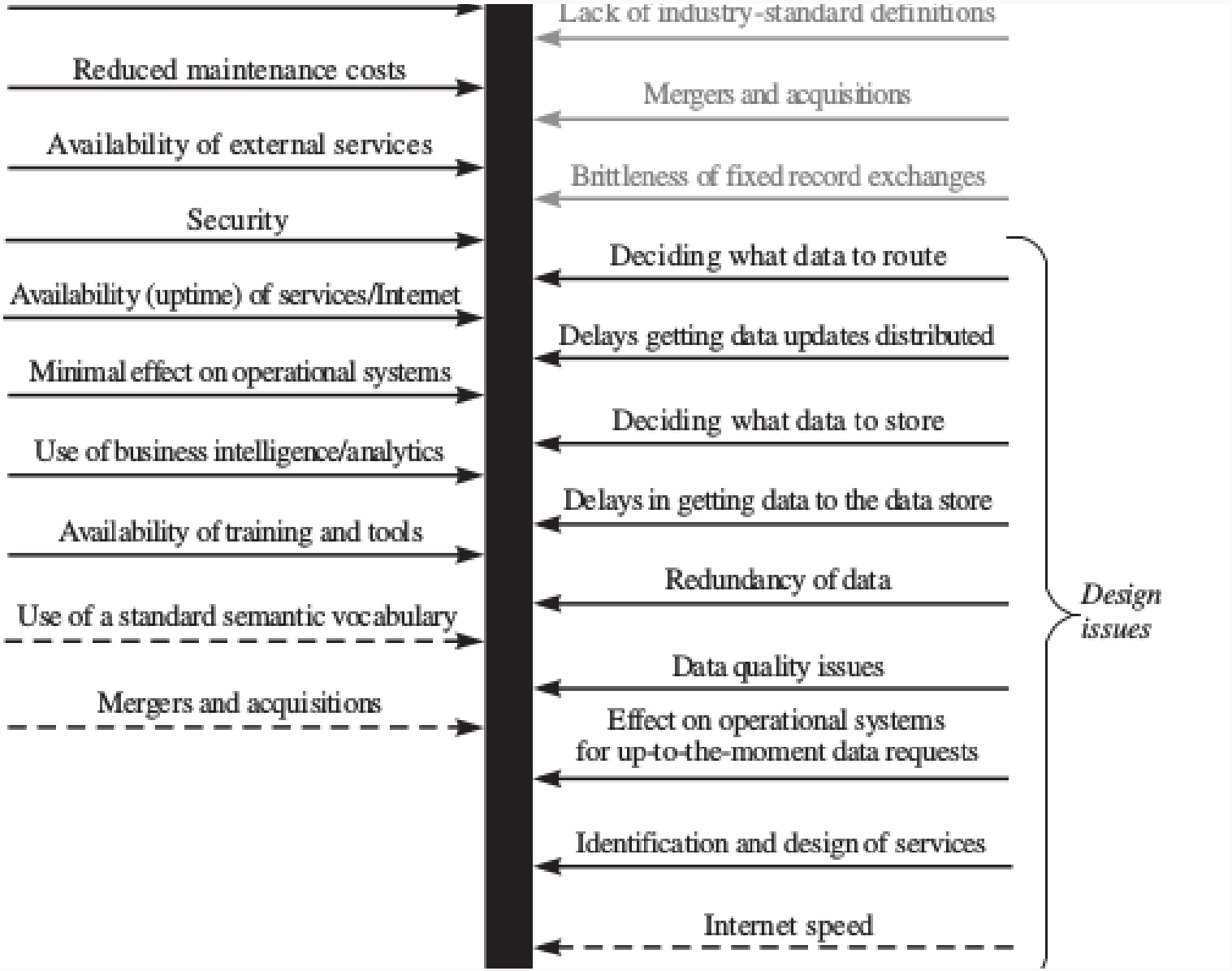
SOA with Cloud Computing



SOA with Cloud Computing



SOA with Cloud Computing



Questions?