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Network Computing

– a new paradigm for ICT

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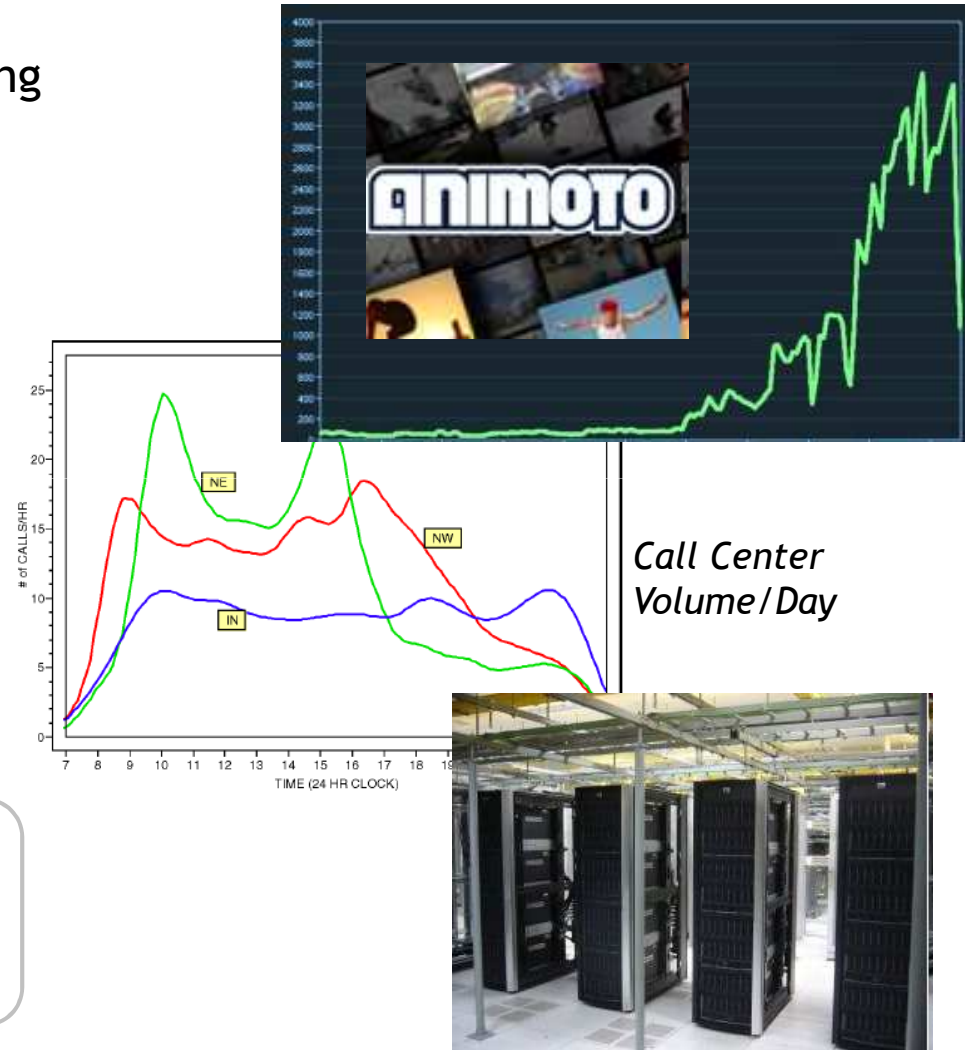
Real-Life Impact of Variations in *Processing* Demand

Motivation for (Network-Aware) Cloud Computing

Variations in user demand push dedicated assignment of computing resources to their limit.

- **Web Applications**,
e.g. 5,000 Animoto users a day spiked to 750,000 in three days.
- **TelCo Applications**,
e.g. call center volume during the day.
- **Enterprise Applications**,
e.g. business need variation over time.

Variations in user requests require on-demand assignment of computing resources.



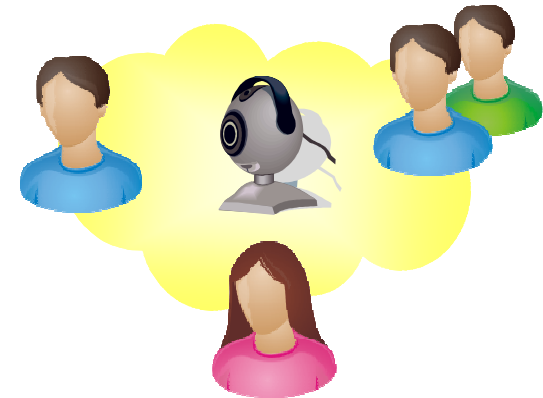
Handling Demand Variations through Cloud Computing?

Supporting *Real-Time Interactions* and *Secure Environments*

Today's Cloud Computing solutions are tailored towards consumer-focused, transaction oriented Web services.

But today's computing clouds give little support to:

- *Real-time interactions*, which are often session-oriented and rich-media,
- *Sensitive* (enterprise) applications, which have high security, reliability and privacy demands.



Such extensions require support from the network infrastructure.

- *Interactivity* requires network-awareness to ensure the needed user experience,
- *Secure Computing* requires trusted and secure on-demand connectivity between computing nodes.



Example: Dynamic Resource Assignment for Video Conferencing

Taking into Account Network and Server Resources



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Taking into Account Network and Server Resources



Beyond Cloud Computing – Towards NetComputing

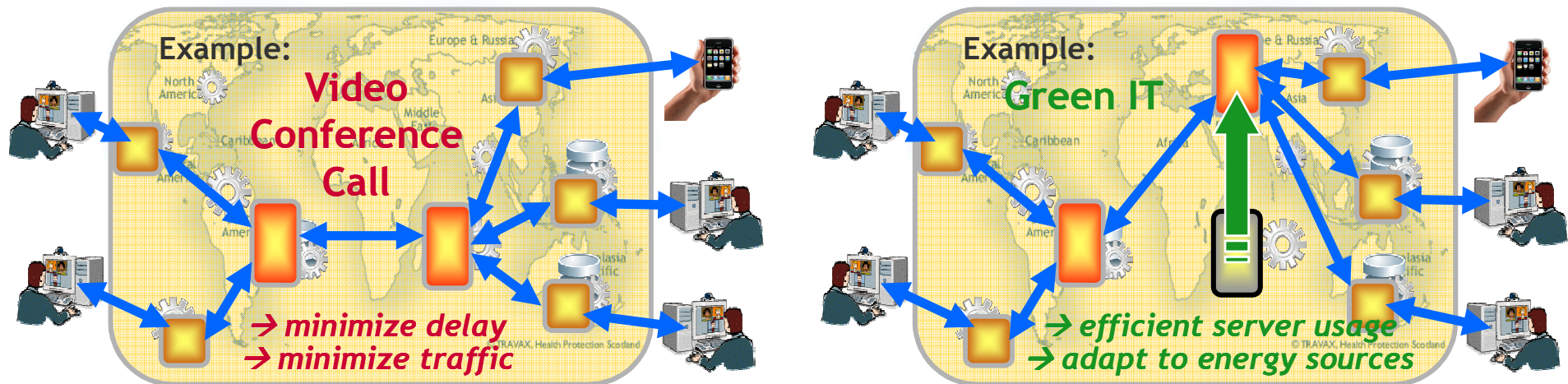
The Power of Dynamic, Network-Aware Resource Assignment

Bell Labs Approach: Enable real-time and secure cloud applications by creating a NetComputing infrastructure.

→ Provides dynamic, network-aware control of networked resources.

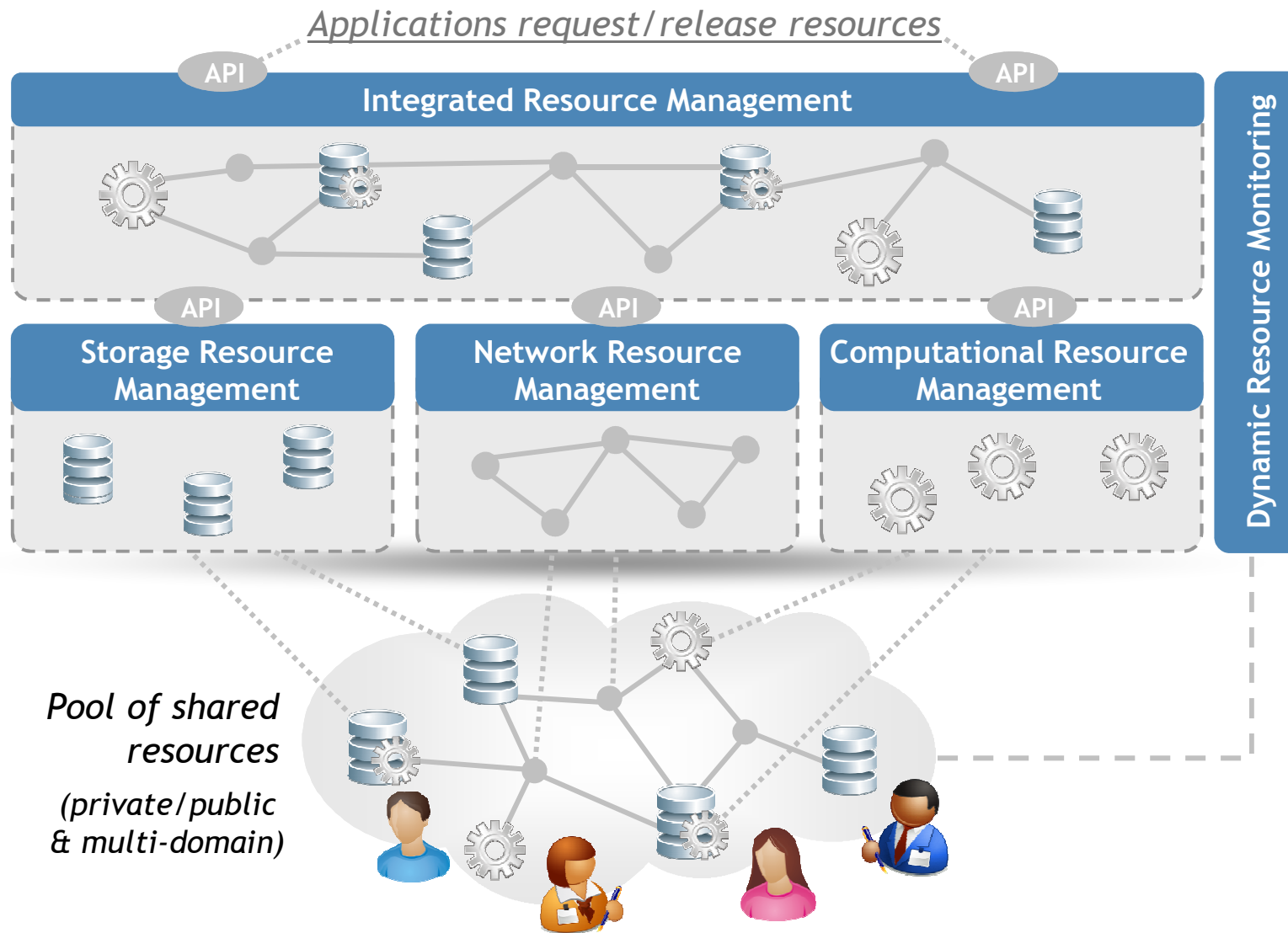
NetComputing benefits also include:

- More economical use of resources (e.g. media processors, energy),
- Improved user experience (e.g. real-time, interactive applications)
- Speedier application development (e.g. self-scaling, abstraction).



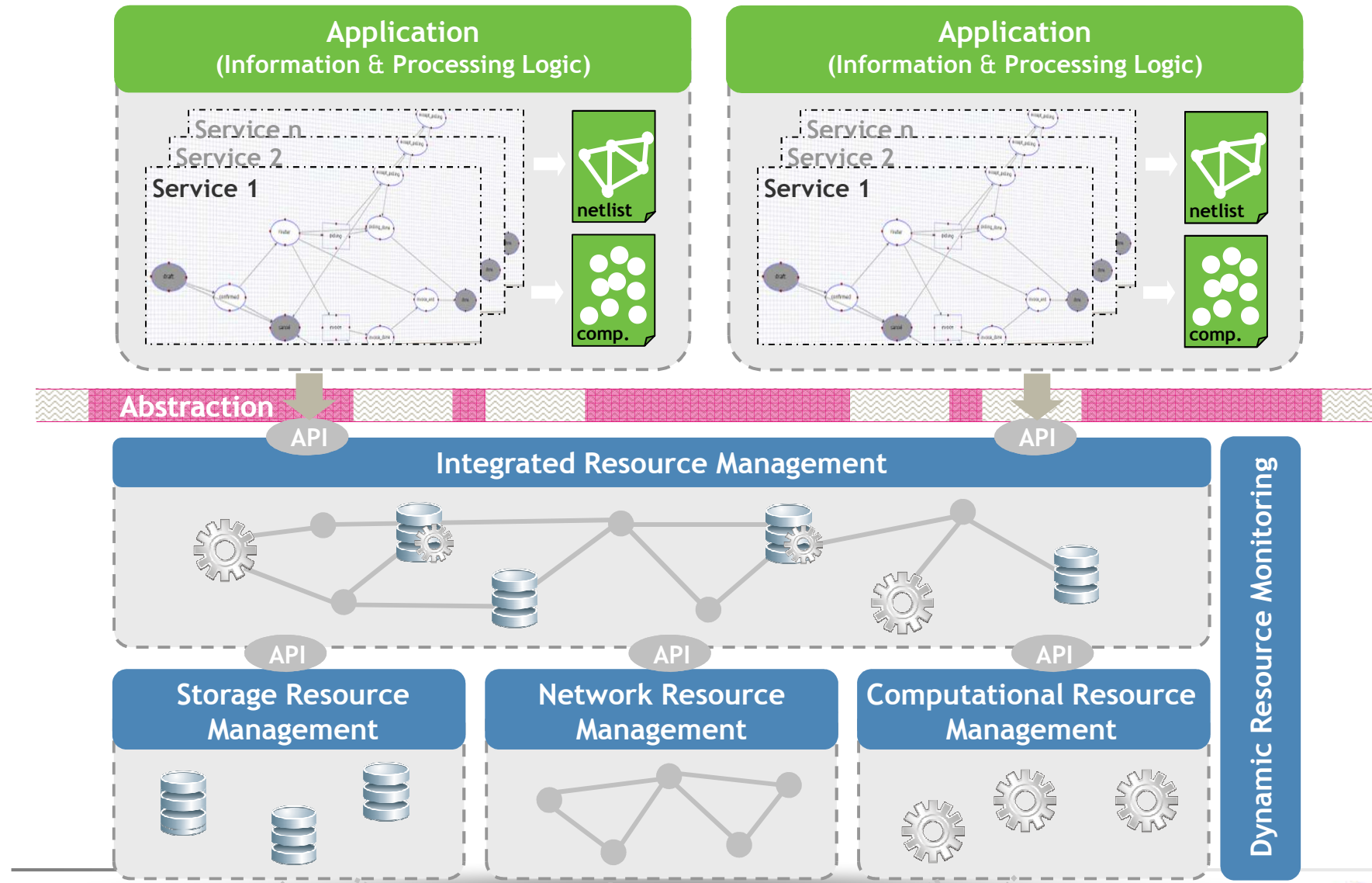
NetComputing – High Level Architecture

Integrated Resource Management



NetComputing - High Level Architecture

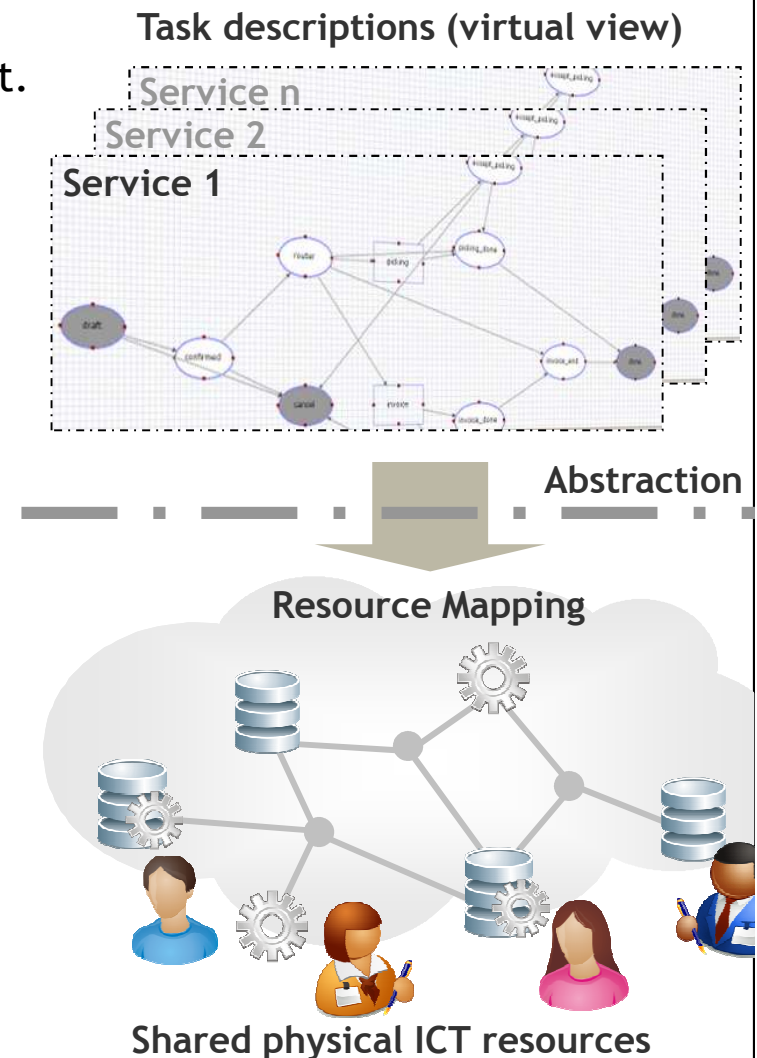
Consequent Abstraction of Application View and Physical Resources



NetComputing – In a Nutshell

How it works

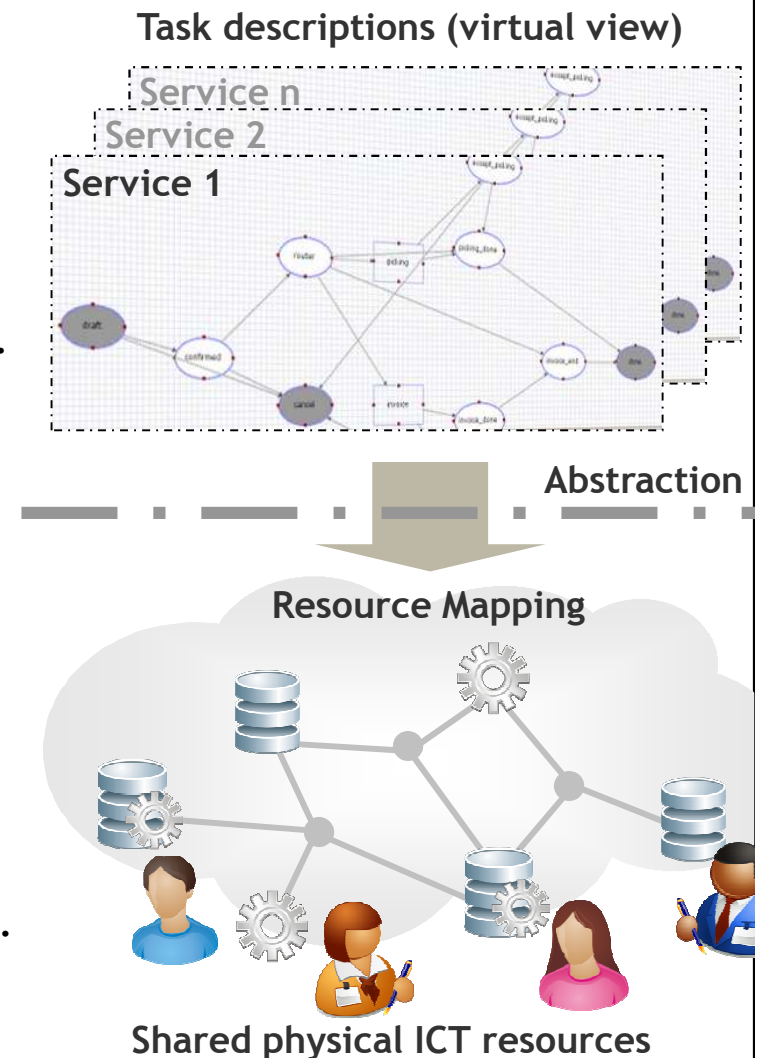
- 1. Describe the application,**
defining software components and how they interact.
- 2. Describe required resources:**
execution & communication requirements
as basis for allocation of resources.
- 3. Describe and discover available resources,**
across widely heterogeneous resource types,
without manual intervention (self-configuring).
- 4. Monitor available resources,**
in a scalable, timely, and economical manner.
- 5. Dynamically map tasks on resources,**
taking into account application requirements,
network status, resource capabilities & load,
location, energy consumption,...
- 6. Create execution environment**
to run the applications in a secure manner,
support on-demand scaling,
migrate components during runtime as needed
without disrupting the application.



NetComputing – In a Nutshell

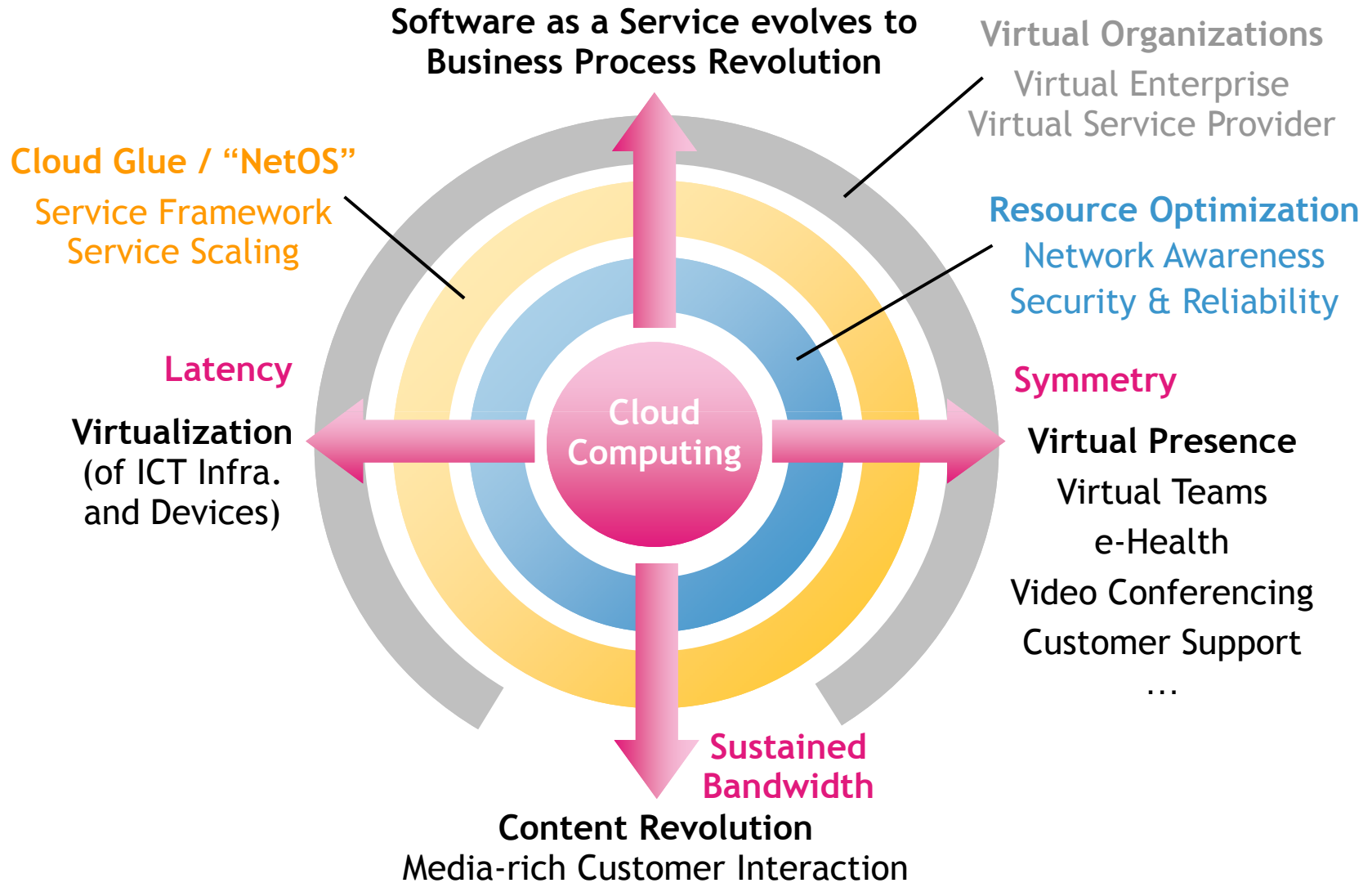
Key Innovations

- ❖ **Inherently scalable** applications, applications dynamically reconfigure without disruption.
 - ➔ Software development/execution environment for dynamic task assignment to virtual resources.
- ❖ **Reliable execution** on a collection of unreliable resources.
 - ➔ Algorithms to configure, assign, re-assign tasks/resources.
- ❖ **Timely response** to changing demands, assemble required resources in real-time.
 - ➔ Algorithms to monitor tasks, resource work loads.



Evolution Axes of Cloud / Net-Computing

Our Objectives



NetComputing

... Summary

Network aware cloud computing
providing reliable access to distributed processing and storage resources
as an infrastructure service or as an application platform.



Create technology to extend network agnostic grid and cloud computing
to real-time multimedia communication:

Grid & Cloud Computing exploit IT resource pools and provide elasticity
by means of **IT virtualization / grid middleware**

+ **Network knowledge**,
i.e. control of location and connectivity resources

= **NetComputing**

Pioneers a paradigm shift in ICT,
by for the first time considering IT and C capabilities in a holistic view.

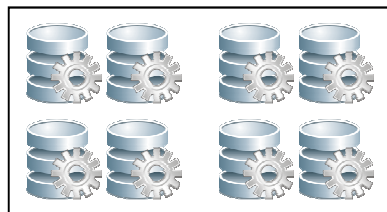
**Bell Labs:
Innovations for a
Changing World**

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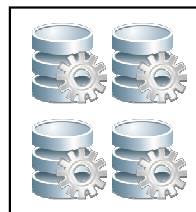
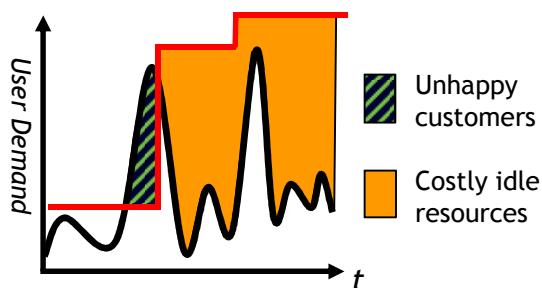


The Potential of On-Demand Resources

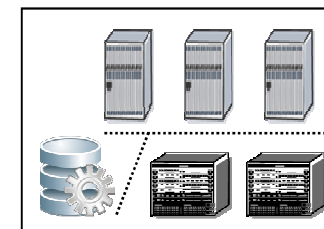
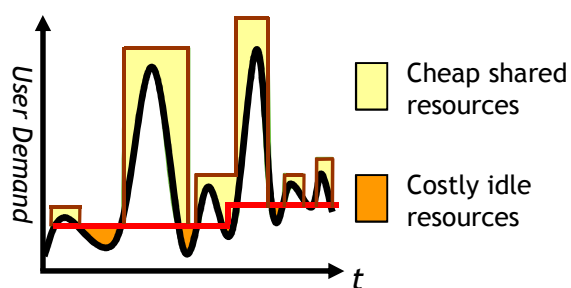
Providing Economical, Timely Response to Changing Demands



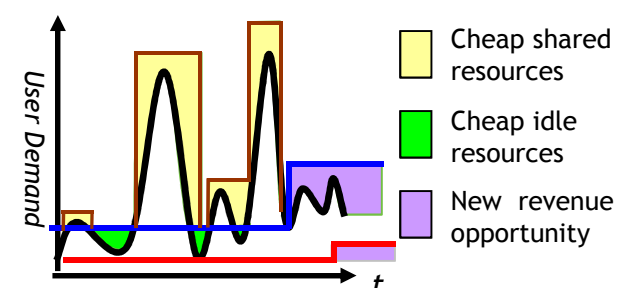
Today's Approach – Primarily dedicated, specialized resources.



Cloud Approach – Add shared computers to dedicated, specialized resources.



Hybrid Approach – Primarily shared and commodity; limited dedicated, specialized resources.



Key disruptions of resource sharing:

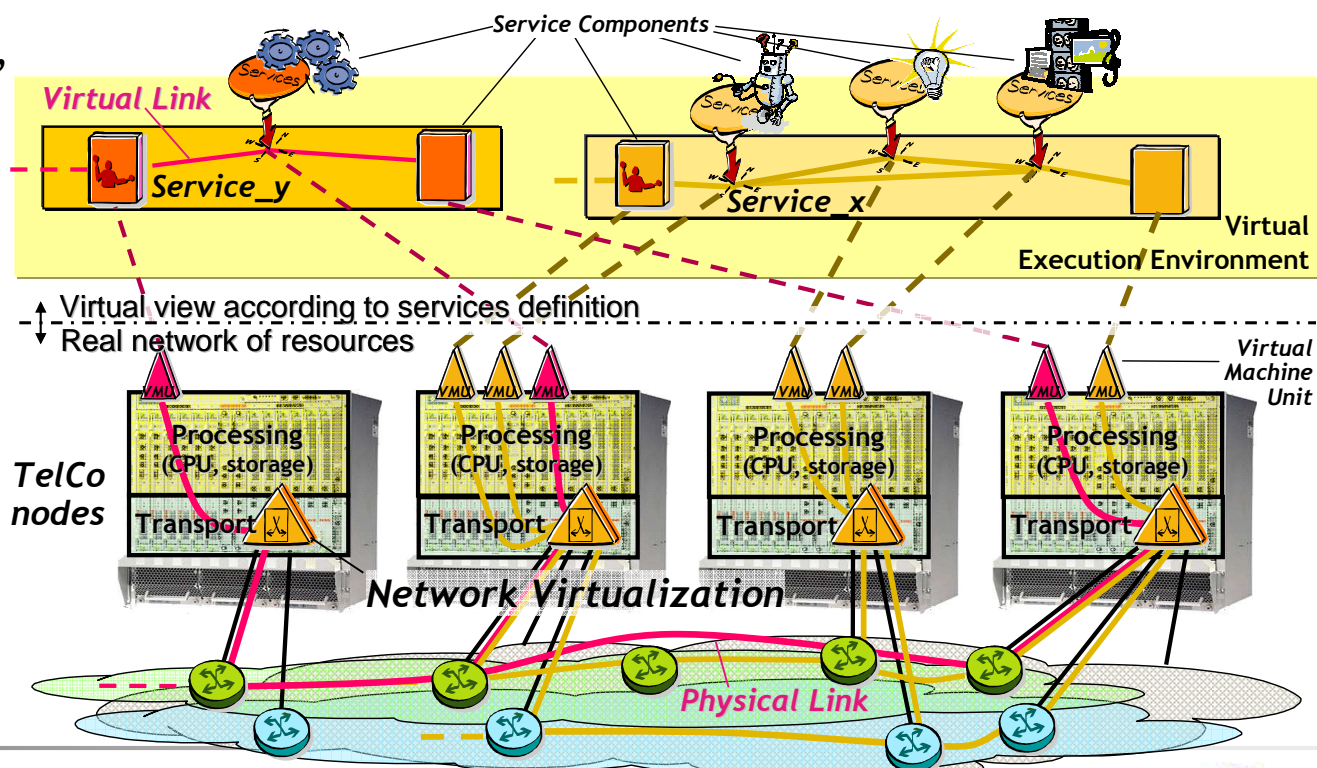
- Infrastructure investment diversifies – buy more shared services and fewer dedicated resources, focused deployment of specialized hardware.
- New market landscape – holders of specialized and/or shared resources compete with traditional equipment vendors; classical service provider's role divided/reduced.
- Applications are developed with/for new supporting technologies.

Initial Focus: TelCo 2.0 Infrastructure

The TelCo Cloud Concept

Utilize network aware cloud computing techniques to dramatically reduce costs and rapidly introduce new elastic services:

- Single generic operator infrastructure for true network convergence.
- Self-adapting cluster operating system across various nodes and products.
- Multi-dimensional optimization of overall network infrastructures:
 - flexible and adaptive resource provisioning,
 - efficient usage,
 - cost (CAPEX, OPEX),
 - eco-sustainable.



Initial Focus: Augmenting Enterprise Resources with Application Clouds

The Hybrid Cloud Concept

Enterprise may occasionally need to augment internal resources.

- A *Hybrid Cloud* provides resources on-demand to an enterprise in a way that those resources appear to be internal to the enterprise.

Key properties:

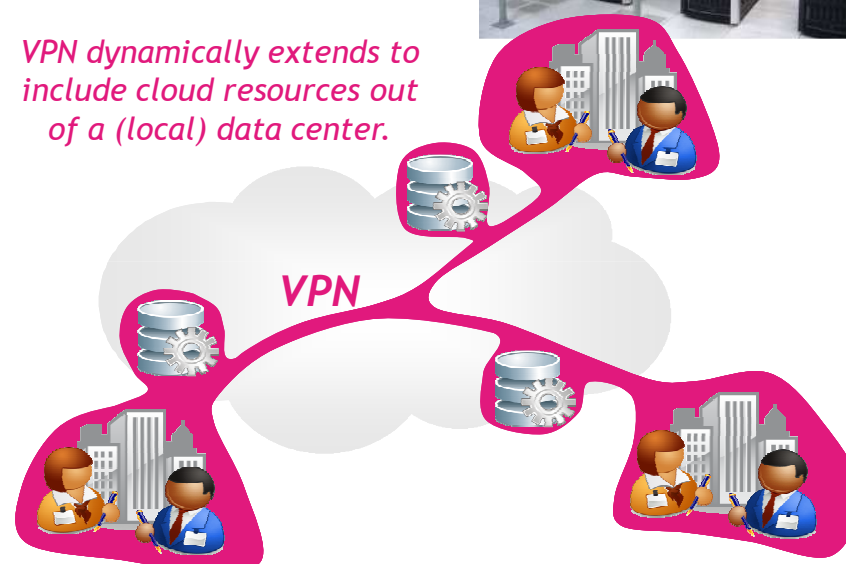
- Consistent (private) address space,
- Security as cloud resources appear internal,
- Seamless growth and shrink.

Benefits to the enterprise:

- Enterprises need to acquire internal resources only to satisfy average demand, rather than peak demand,
- Public facing resources can be completely implemented in the cloud to take advantage of the managed cloud features.

Network provider:

- Hybrid cloud functions offered as an *integrated feature with their VPN offer.*



Objectives of Bell Labs in NetComputing

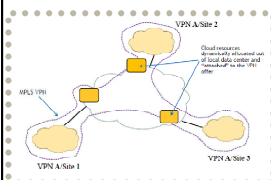
Much more to expect...

NetComputing for Application Enablement



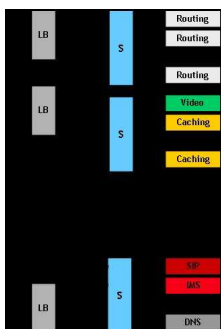
- Empower advanced Internet/web-based social and video communications applications.
- Media framework for (soft) real-time applications to run on heterogeneous resources providing seamless scalability, topology aware deployment and execution, security, etc.
- Virtualization of home and mobile devices that enable applications with highly graphical content in real time on low cost thin clients.

NetComputing for Business users



- Provide a way for enterprises to augment their internal resources by tapping into the cloud in a dynamic and transparent way such that the cloud resources appear local.
- Explore the implementation of managed security services for enterprises using a cloud computing approach.

NetComputing for the Service Provider infrastructure



- Allow service providers to leverage their network and offer NetComputing-as-a-service or (telecom) applications on a NetComputing platform.
- Bring elasticity, reliability and provisioning techniques from cloud computing into telecom infrastructure/services to reduce costs and rapidly introduce new elastic services.
- Develop a global “distributed computer” that allows the quick instantiation, expansion or downsizing of services, taking the network characteristics into account.
- Develop technology that allows TelCos to offer their own excess cloud capacity to the market in a way that does not compromise internal or third-party services running on the cloud.