



University of Messina, Italy



**THE SKY LOOKS CLOUDY
BUT THERE IS A CLEAR CORNER**

II Cloud Computing Conference
Rome – Italy, September 26°, 2011

Prof. Massimo Villari
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Outline

- Introduction on Cloud
- The Cloudy SKY
- Federated Clouds, the meaning
- Cloud @ UniMe:
 - Seen from the Top
 - Seen from the Bottom
 - Seen in Practical
- Our middleware
- Use Cases
- Few Words on Standards to make clearness
- Conclusions



Cloud Computing at a glance

Definition of Ian Foster,

the father of Grid Computing

Reported on: *Cloud computing and grid computing 360-degree*

A large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet.

Why Cloud Computing?

back in 1961, computing pioneer Prof. John McCarthy predicted that “computation may someday be organized as a public utility”

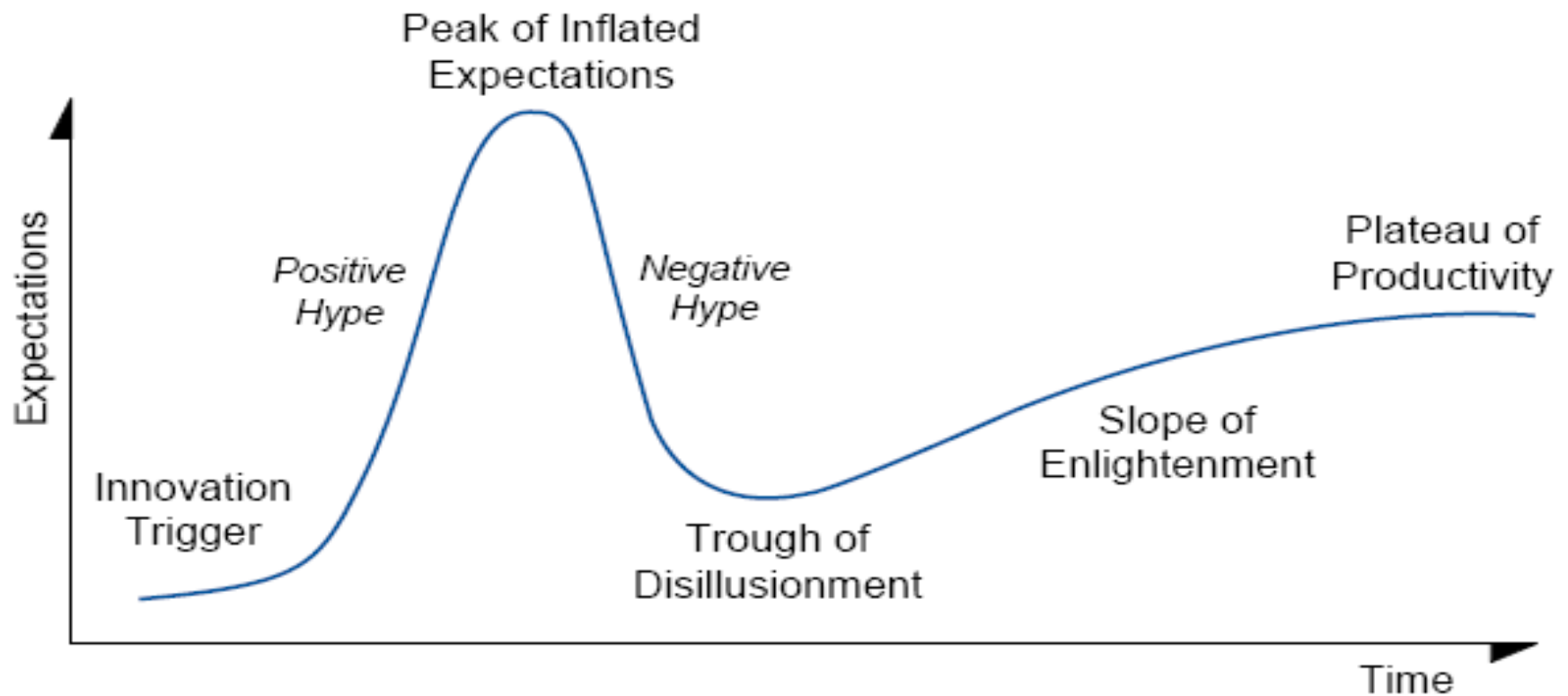
BUT.....

As “Cloud computing” seems to be “anything anywhere”, shouldn’t we focus more on “Cloud business” instead?

*“Technology vendors will deliver cloud infrastructure, but those details must be linked for us all, or 'the cloud' will just be nothing more than a buzz-word... We can't spend all of our time arguing about how to implement the cloud and almost no time talking about whether **our business** can fit the cloud model.”*

Daryl Plummer, Gartner Group Vice President, Gartner Fellow

Simple graphical approach to get a better understanding: *Gartner hype cycle*

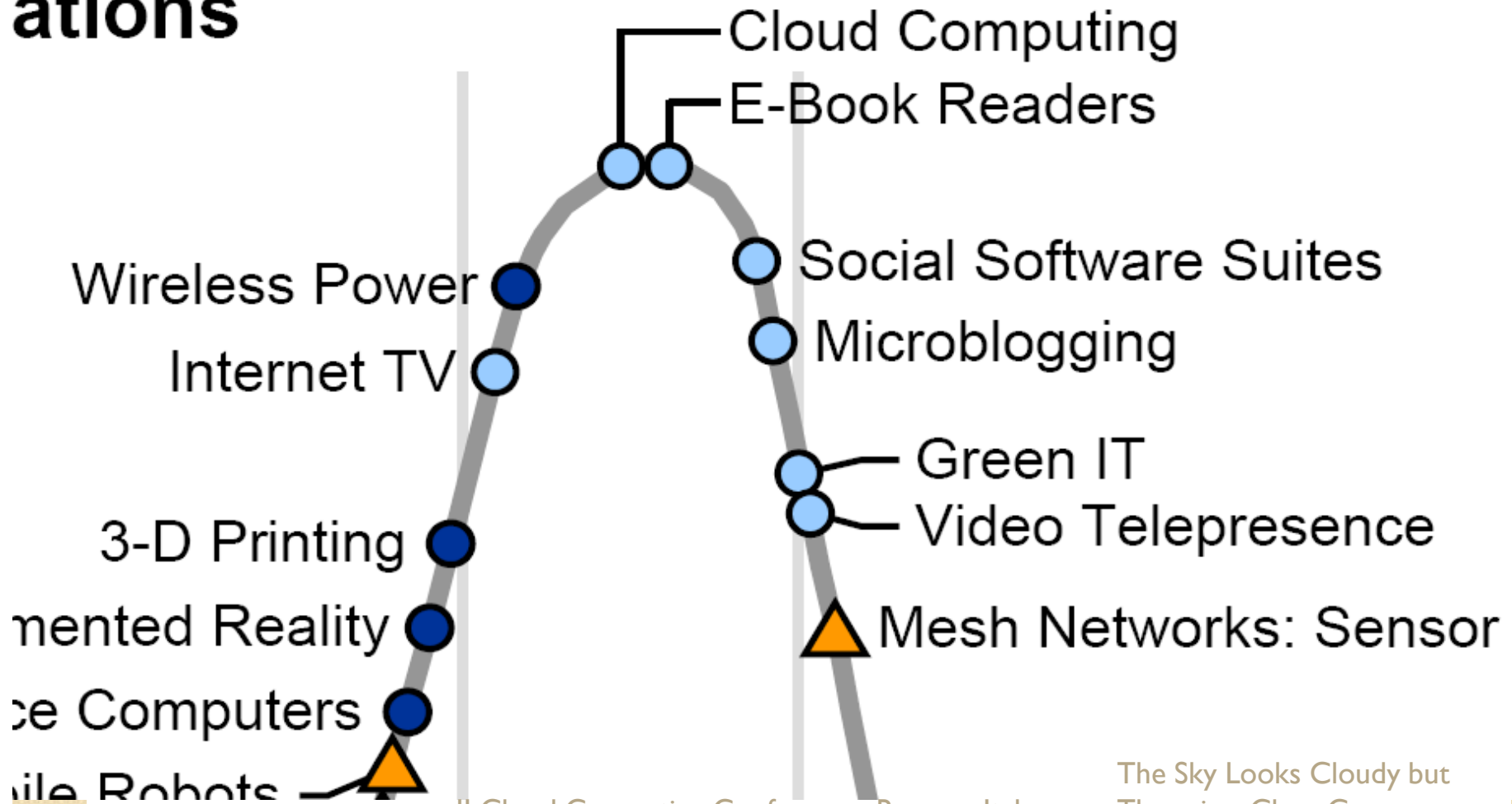


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Inside the Hype Cycle: What's Hot and What's Not in the Near Past

ations



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Gartner

....And NOW???



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The Cloudy SKY

- Ford Evos **cloud-connected** concept car unveiled at Frankfurt
- Could **Cloud Computing** Solutions Run Our Kitchen In The Future?

- IBM, Cisco, Microsoft Plan Green
Cloud Cities

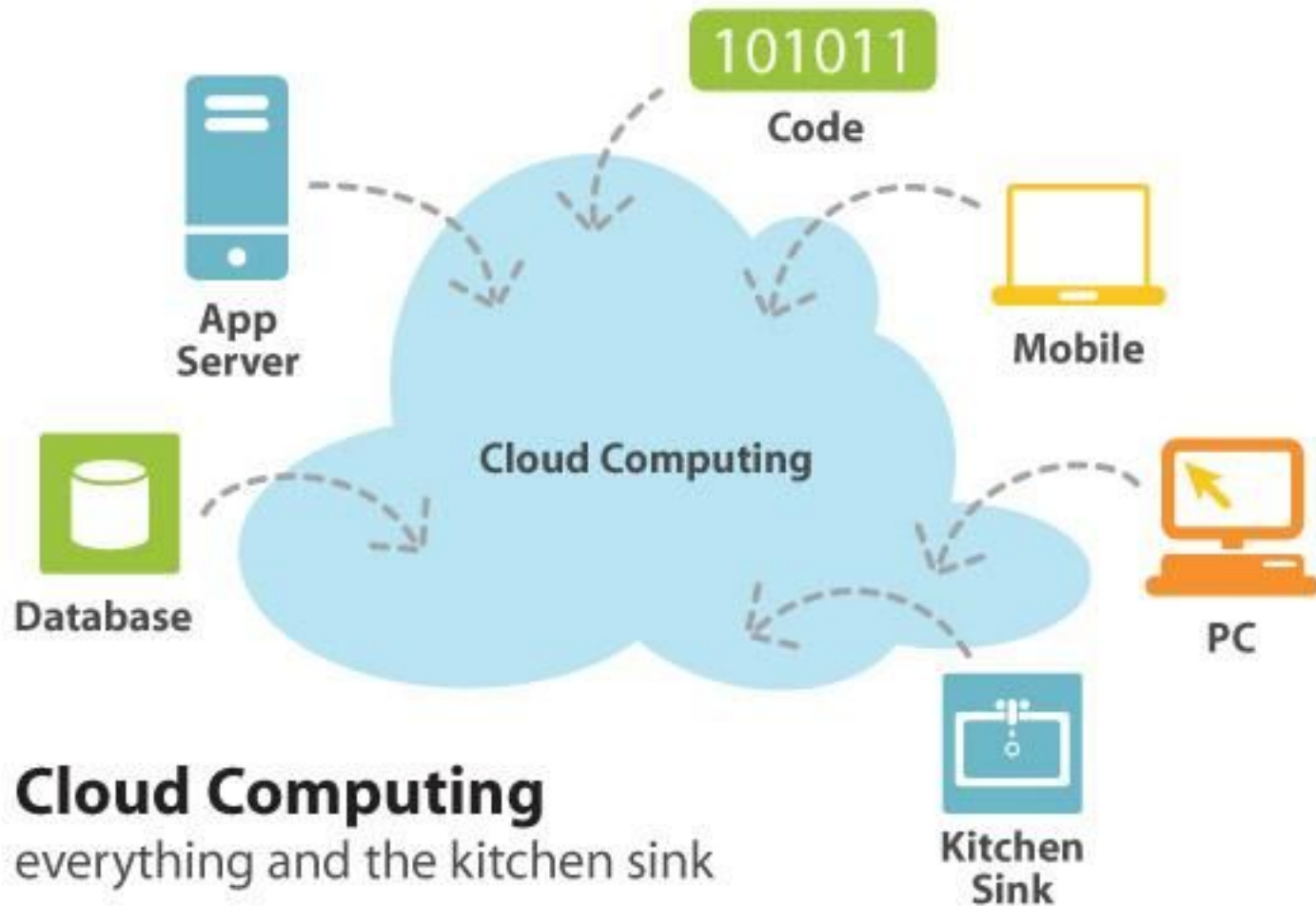
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What is Cloud Computing?



Cloud Computing
everything and the kitchen sink

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Cloud Computing: the meaning of classification

- SaaS
- PaaS
- IaaS
- But..... what's behind the corner? *aaS

• HaaS

- **Human as a Service**

• DaaS:

- **Database as a Service**

• FaaS

- **Facility as a Service**

• UaaS

- **Utility as a Service**

• EaaS

Everything as a Service



NIST Cloud Computing New Reference Architecture

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Fang Liu, Jin Tong, Jian
Mao, Robert Bohn, John
Messina, Lee Badger and
Dawn Leaf

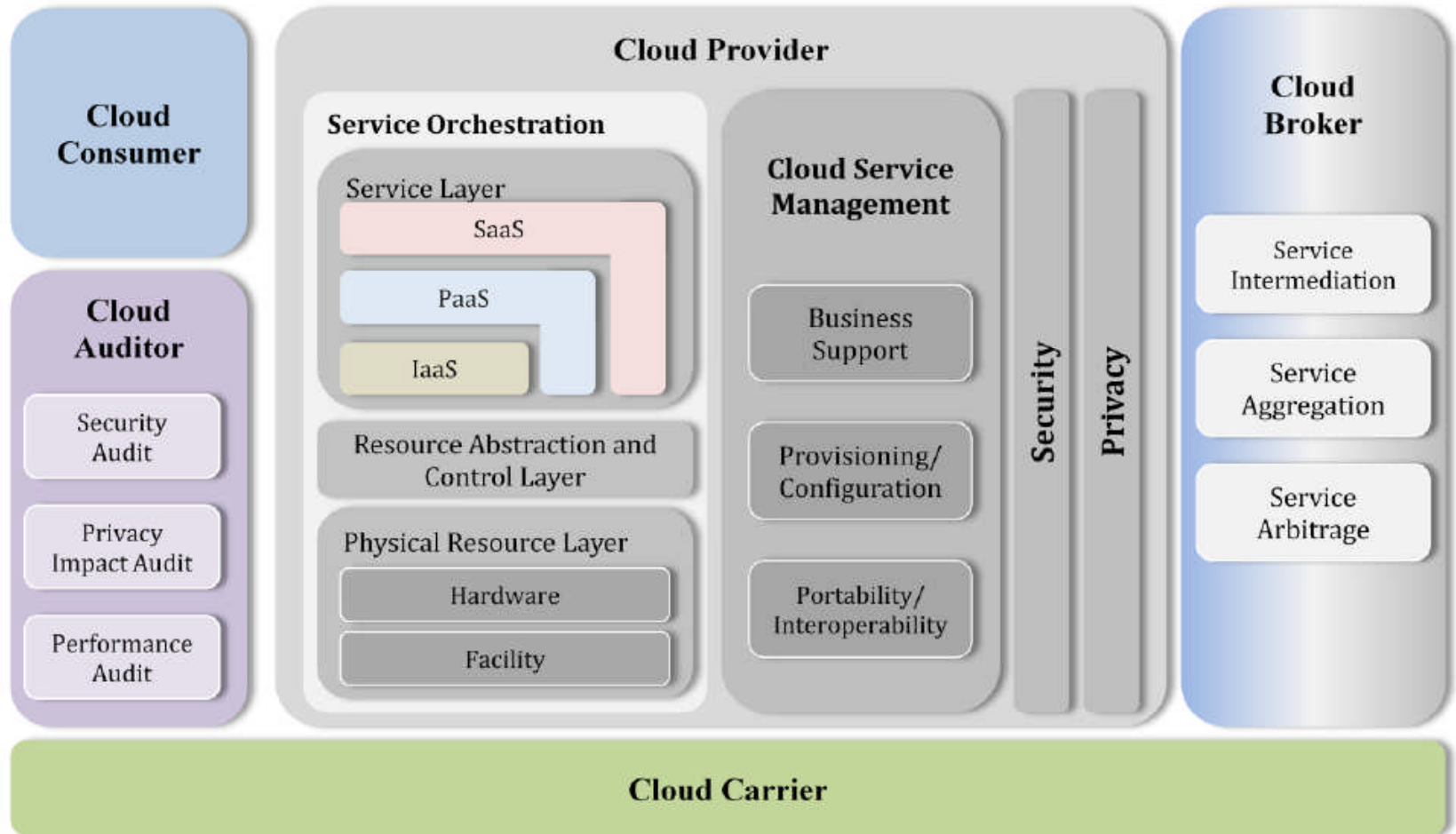
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NIST Cloud Computing New Reference Architecture



Cloud Computing providers

Organization	Service or tool	Description	Layer
Google	Google Docs	Online office suite	SaaS
	Google Maps API	The Google Maps API lets developers embed Google Maps in their own web pages with JavaScript.	SaaS > BAS
	OpenSocial	A common API for social applications across multiple websites.	SaaS > CAS
OpenID Foundation	OpenID	Distributed system to allow users to have a single digital identity across the Internet.	SaaS > BAS
Microsoft	Office Live	Online office suite	SaaS
Salesforce	Salesforce.com	Customer Relationship Management	SaaS

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 Tycoon Market-based system for managing compute resources in clusters
 IaaS > RS > VRS
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Different subsequent stages for Cloud Computing market

- 1) **Monolithic**: (now !!!!), cloud services are based on proprietary architectures - islands of cloud services delivered by megaproviders (this is what Amazon, Google, Salesforce and Microsoft look like today).
- 2) **Vertical Supply Chain**: some cloud providers will leverage cloud services from other providers. The clouds will be proprietary islands yet, but the ecosystem building will start.
- 3) **Horizontal Federation**: smaller, medium, and large providers will federate horizontally themselves to gain: economies of scale, an efficient use of their assets, and an enlargement of their capabilities.





Cloud Federation

- × Three types of Clouds

- + Open (free contribution)

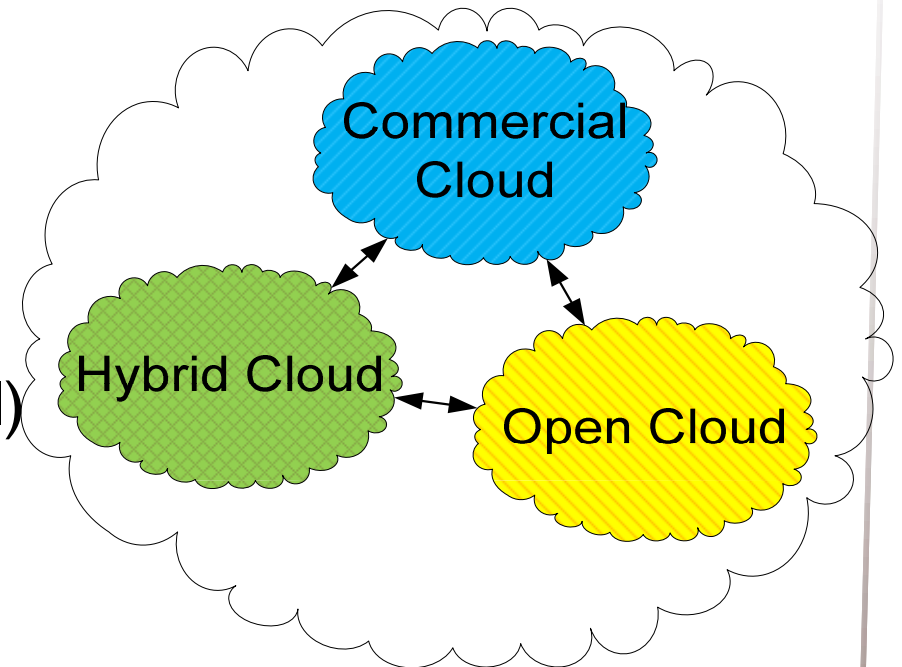
- + Commercial (by charge)

- + Hybrid (open/commercial)

- × The clouds can interoperate

- × A federation is composed of two or more Clouds that interoperate according to specific rules

- × A Cloud federation has different access points for users interaction





How SMBs Benefit From Cloud Computing

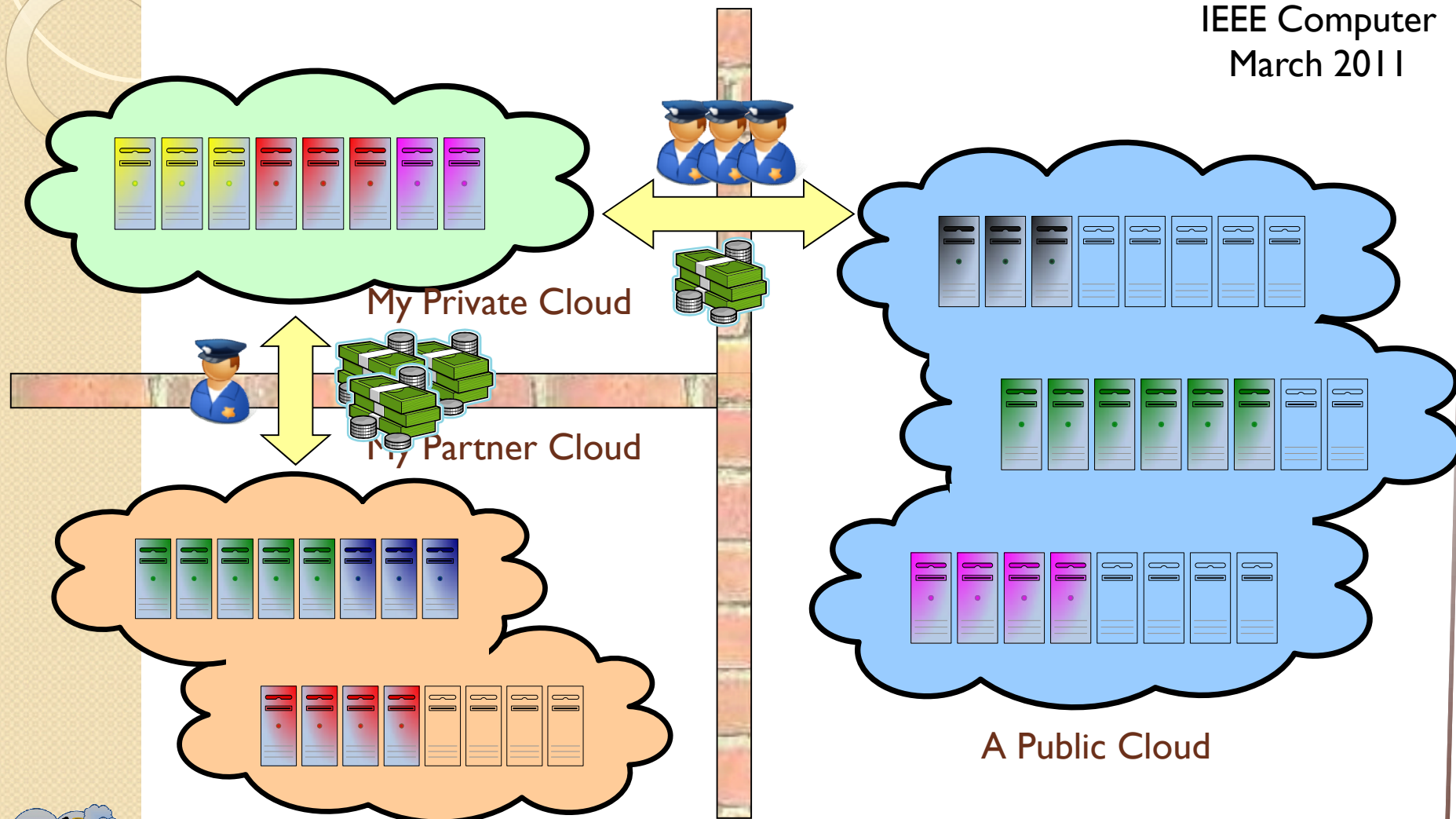
- SMB Cloud Spending To Approach \$100 Billion By 2014 (August 2010)
- Microsoft Survey Reveals 39 Percent of SMBs to Pay for Cloud Services Within Three Years: *Research suggests increasing opportunities for hosting service providers to benefit from selling cloud services.*
- Gartner Says By End of 2014 at Least 10 Percent of Enterprise Email Seats Will Be Based on a Cloud or Software-as-a-Service Model (September 20, 2011)
- Can the cloud become an SMB standard? *The “cloud”, as a technology entity, can easily lose the confidence of the SMB market, which is where the cloud can have the most benefit and do the most business. It’s going to be up to the vendors in this market to try to prevent this from happening. (By David Chernicoff | February 8, 2011)*





Cross Cloud Federation

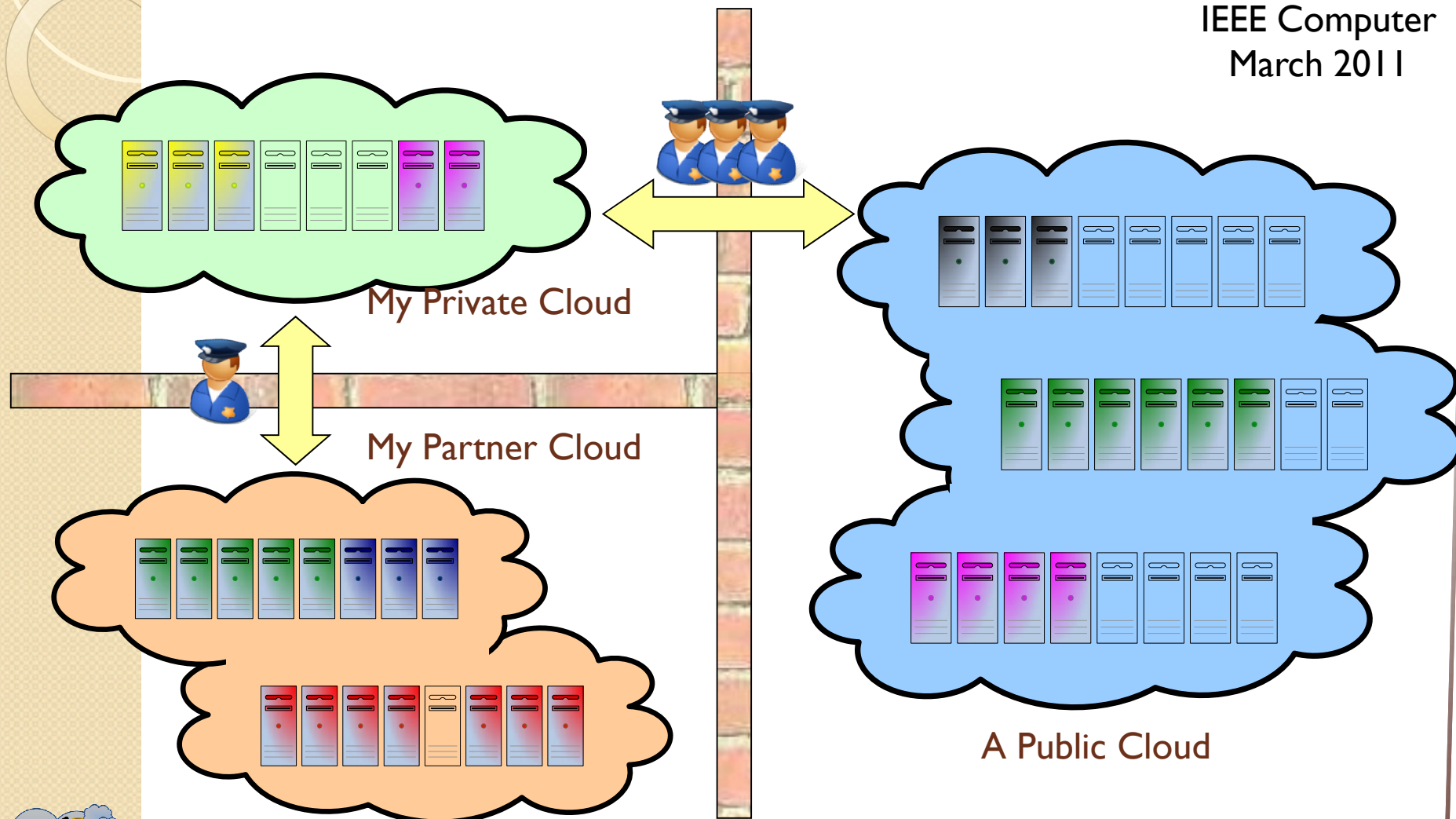
When One Cloud is
Not Enough
IEEE Computer
March 2011





Cross Cloud Federation

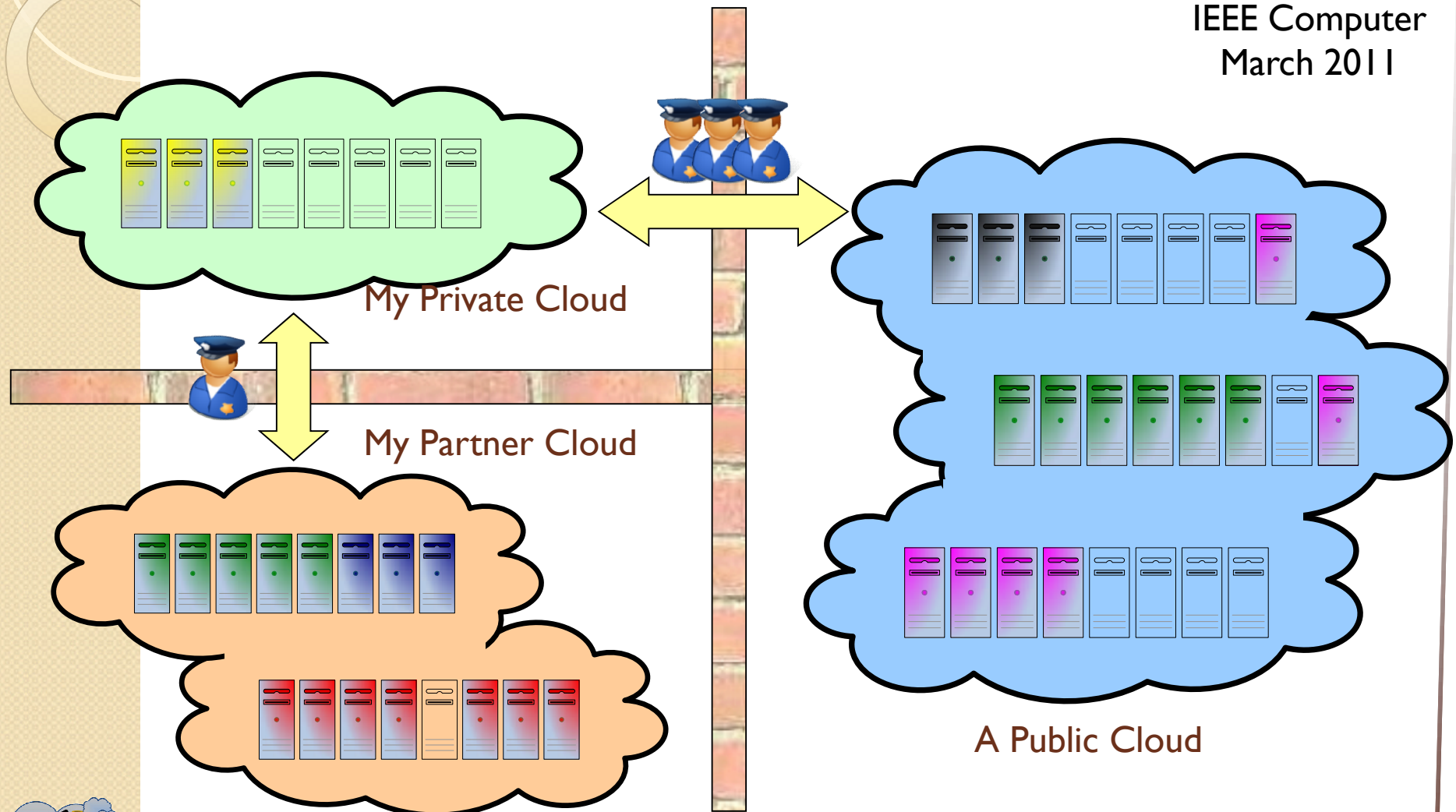
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Cross Cloud Federation

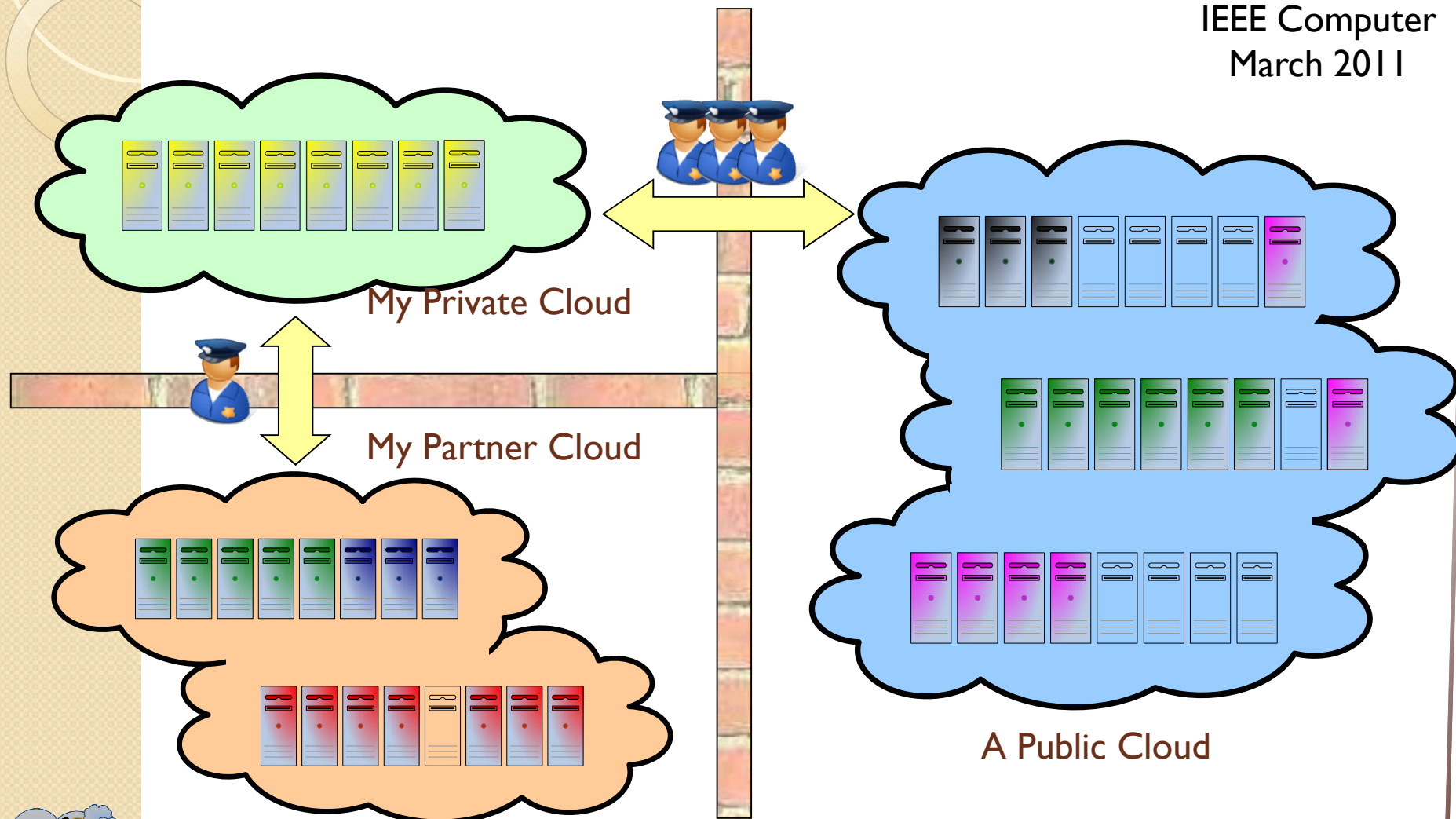
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Cross Cloud Federation

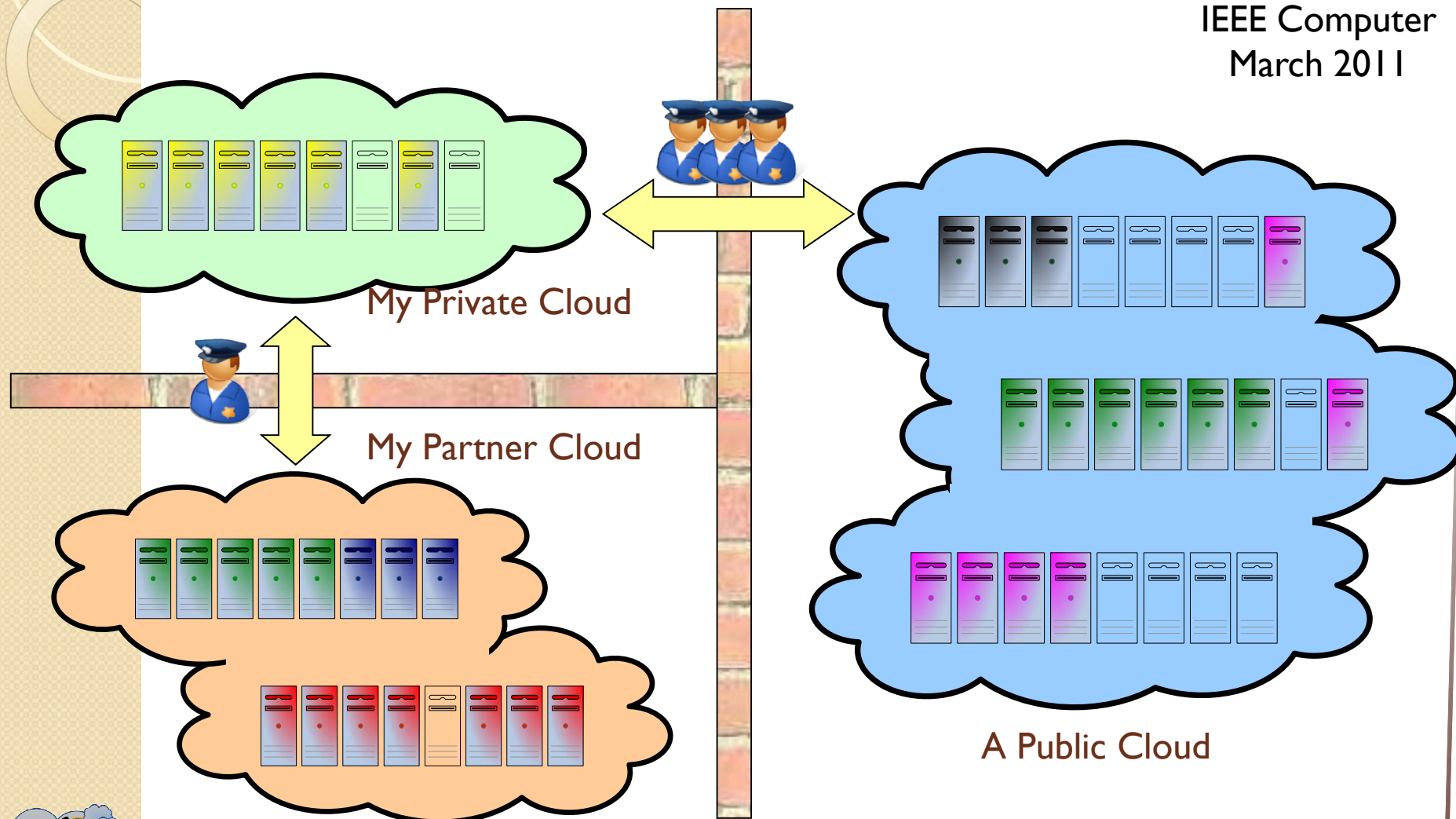
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Cross Cloud Federation

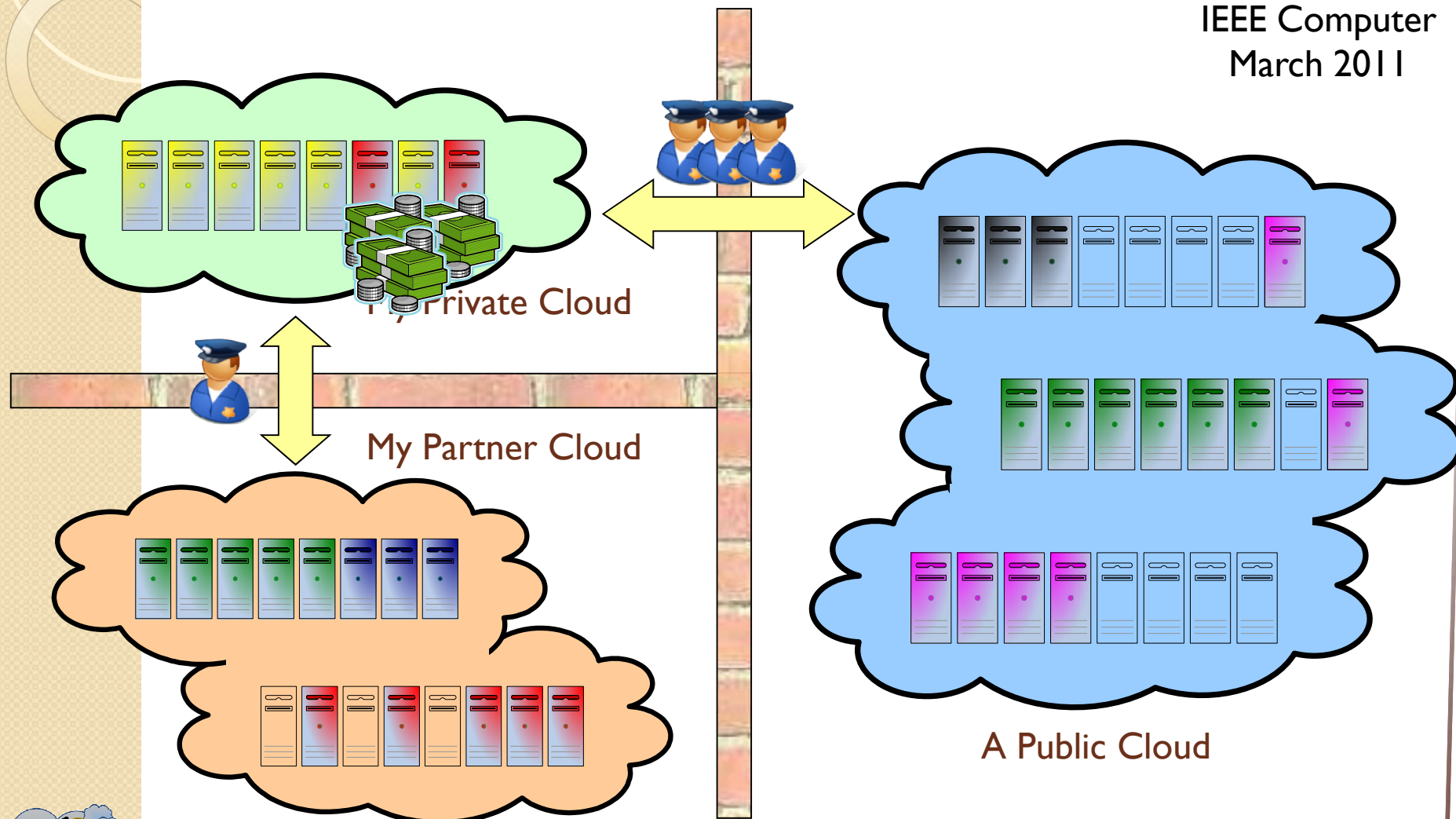
When One Cloud is
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IEEE Computer
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Cross Cloud Federation

When One Cloud is
Not Enough
IEEE Computer
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Do Federated Clouds make sense?

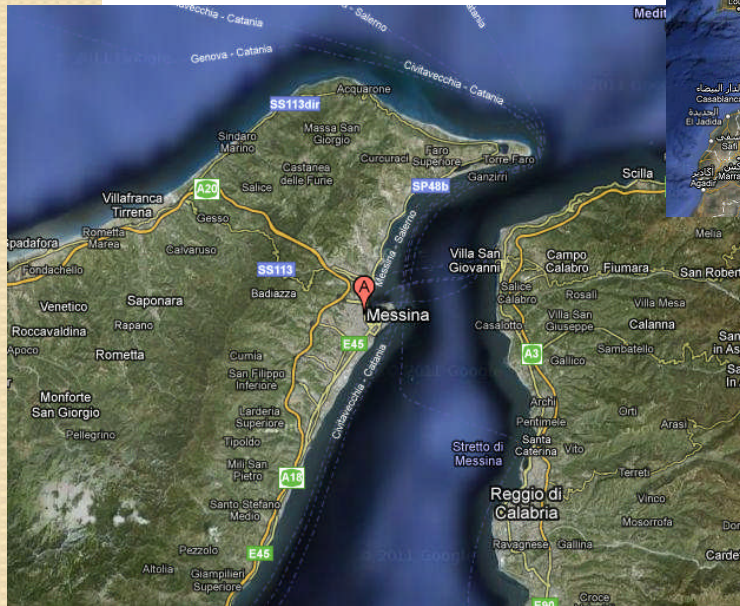
- OpenStack Initiatives: its goal is to allow any organization to create and offer cloud computing capabilities using open source software running on standard hardware. OpenStack Compute is software for automatically creating and managing large groups of virtual private servers.
- The IEEE standardization board has just launched a new initiative aimed at the definition of new standards for cloud interoperability.
- EGI: Federated Clouds Task Force is starting up
- Many other organisms of standardization (ITU, ETSI, ISO, etc.) are working in the same direction



RESERVOIR

7fp: cloud (2008-2011)

and In UNIME? (University of Messina)



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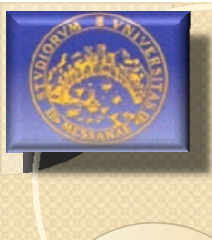


The pillars of CC for RESERVOIR

- **Separation**
 - Cloud computing providers lease resources on pay-per-use basis but do not expose infrastructure details to customers or partners
 - Cloud computing consumers use leased resources without exposing details of their applications to providers
- **Isolation**
 - Given the hosting nature of cloud computing providers, consumers need mechanisms and warranties that their application are isolated from others that are being hosted in the same infrastructure
- **Elasticity**
 - Cloud computing providers should automatically adjust the resources allocated to a particular application according to “elasticity rules” provided by cloud computing consumer
- **Federation**

To overcome the finite amount of resources available locally, cloud computing providers should be able to collaborate among themselves and share their resources





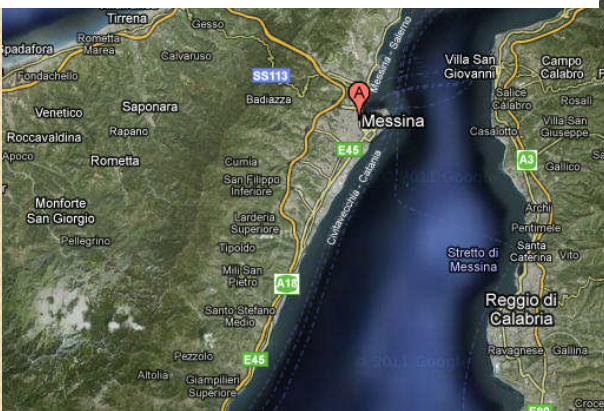
Why cloud In UNIME? (University of Messina)

VISION- CLOUD

7fp: cloud storage



Participant no. *	Participant organisation name	Part. short name	Country
1 (Coordinator)	IBM Israel - Science and Technology LTD	IBM	ISRAEL
2	SAP Research	SAP	Germany
3	Telefónica Investigación y Desarrollo	TID	Spain
4	Siemens AG	SAG	Germany
5	Engineering	ENG	Italy
6	National Technical University of Athens	ICCS/N TUA	Greece
7	Deutsche Welle	DW	Germany
8	RAI-Radiotelevisione italiana Spa	RAI	Italy
9	Umeå University	UMU	Sweden
10	SNIA Europe	SNIA	UK
11	Telenor	TN	Norway
12	France Telecom	FT	France
13	Swedish Institute of Computer Science	SICS	Sweden
14	University of Messina	UniMe	Italy
15	iTricity B.V.	iTricity	Netherlands



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VISION Cloud: Virtualized Storage Services Foundation for the Future Internet



- Goal
 - Architect and implement an infrastructure for the delivery of data-intensive storage services, facilitate media and telecommunications
- Innovations
 - **Raise Abstraction Level of Storage:** objects with user metadata
 - **Computational Storage:** technology for specifying close to storage
 - **Content-Centric Storage:** facilitate access to data relationships
 - **Advanced Capabilities for Cloud-based Storage:** store intensive services securely, at the desired QoS, at any location
 - **Data Mobility and Federation:** enable comprehensive interoperability across remote locations
- Facts:
 - A 3-year project, started Oct 2010
 - €15.709 M (total budget all partners)
 - www.visioncloud.eu



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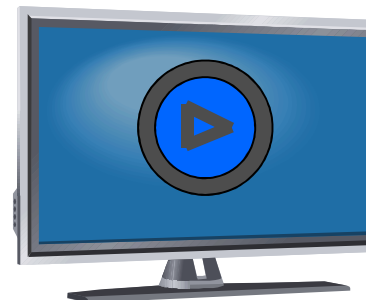
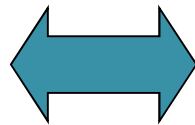




VISION Cloud: Raising the Abstraction Level of Storage



- Store video of the conference together with rich metadata



- What is new:
 - Metadata is an integral part of the storage
 - Rich metadata model describing both handling of an object and its content

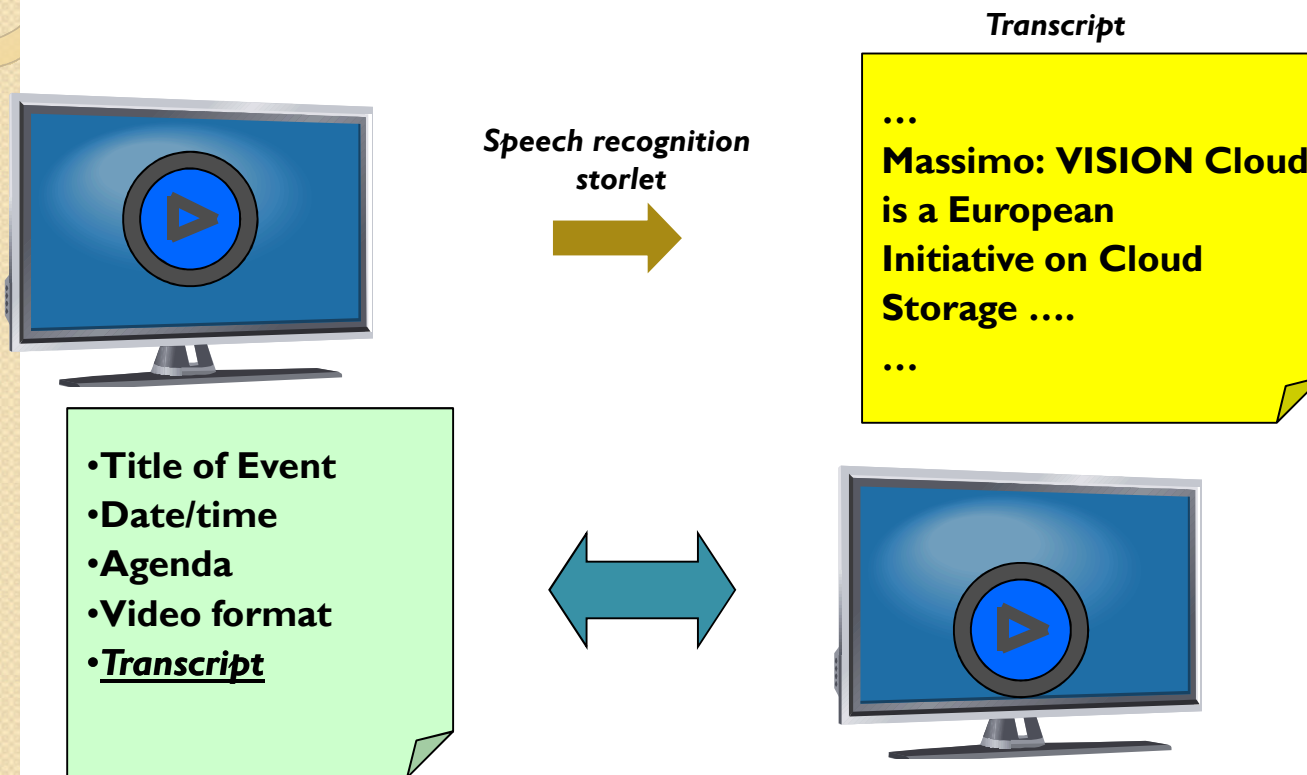




VISION Cloud: Computational Storage



- A **storlet** is triggered to automatically extract metadata



- **What is new:**

- Architected and safe way to run computations in the storage system

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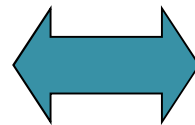


VISION Cloud: Content-Centric Storage



- Access data according to metadata values
- Build content networks

•Title of Event
 •Date/time
 •Agenda
 •Video format
 •Transcript



2nd IARIA Event Programme
 Monday, September 26th
 08:00-08:45 Registration
 08:45-09:00 Opening
 09:00-11:20 Session I:
 ...

...
Massimo: VISION Cloud is a European Initiative on Cloud Storage
 ...

▪ What is new:

- Storage leverages metadata and content networks to optimize itself

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VISION Cloud: Advanced Capabilities for Cloud Storage

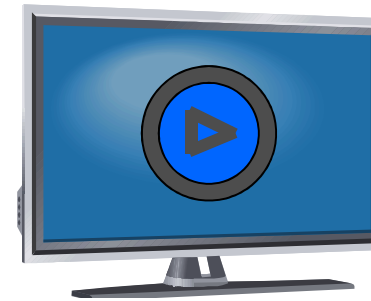
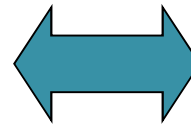


- **Delegate right to access an object to people that are not known by the storage system**

Petre



Delegate read access



2nd Cloud
Computing
participants

- **What is new:**

- Flexible yet secure access control

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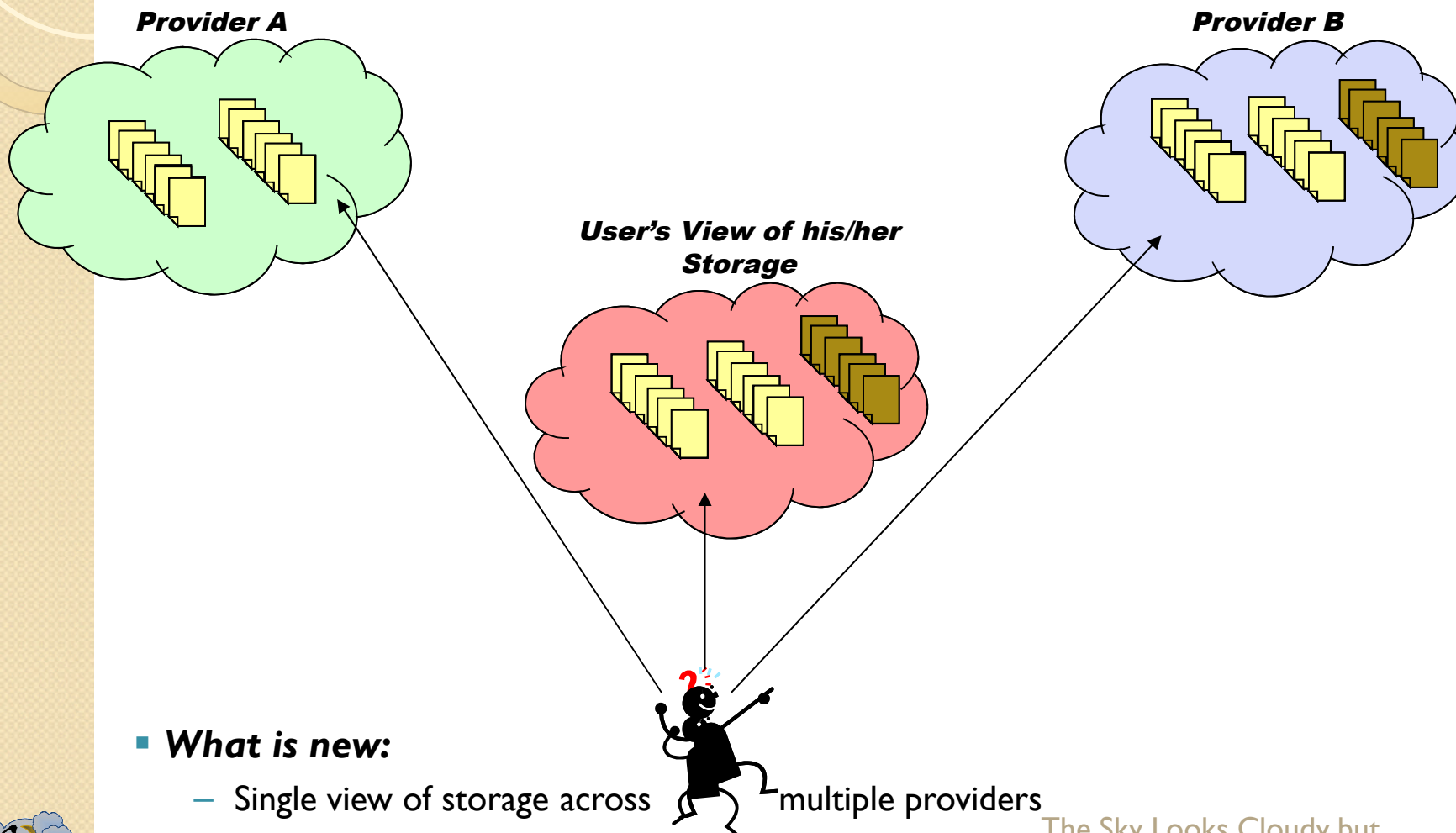
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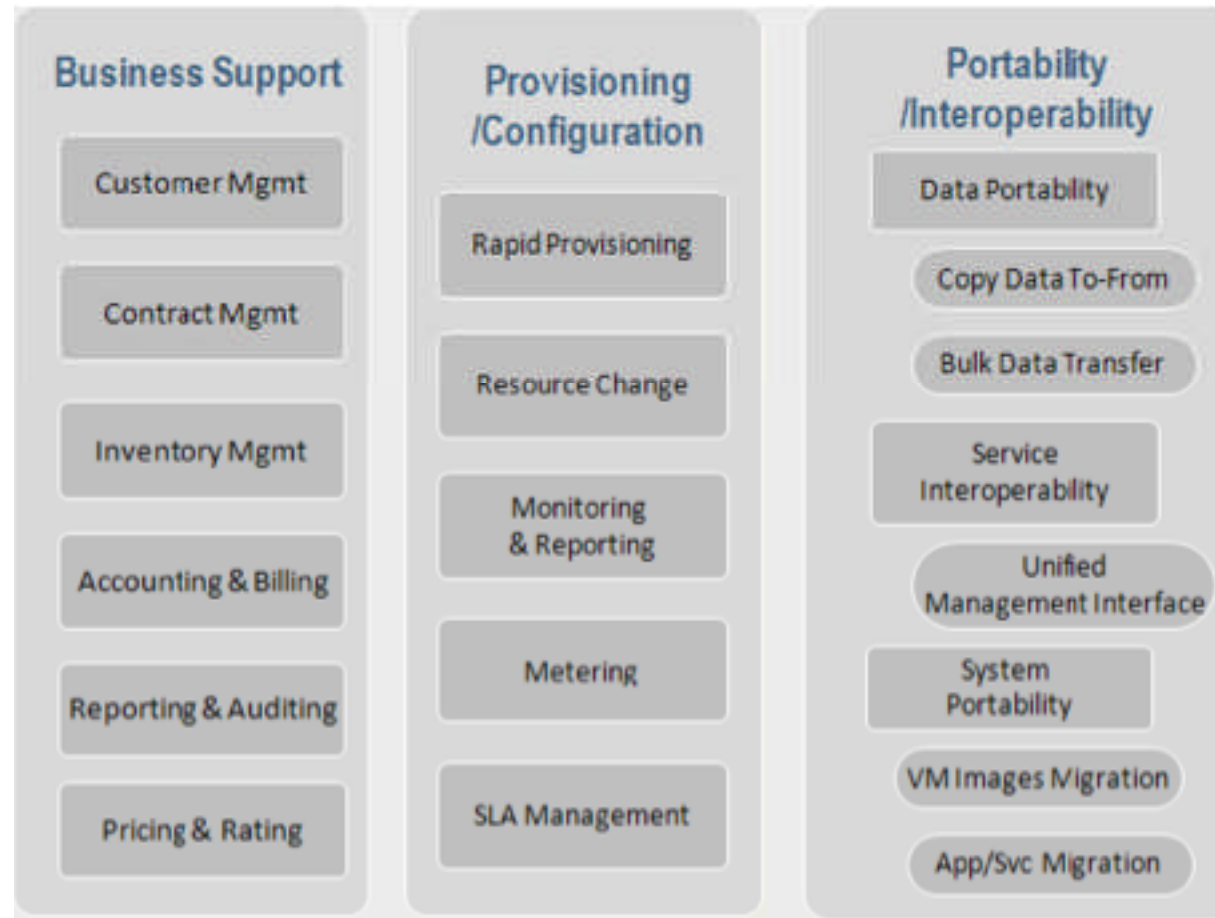
VISION Cloud: Federation and Interoperability

- Change storage providers without data lock-in





Cloud Service Management



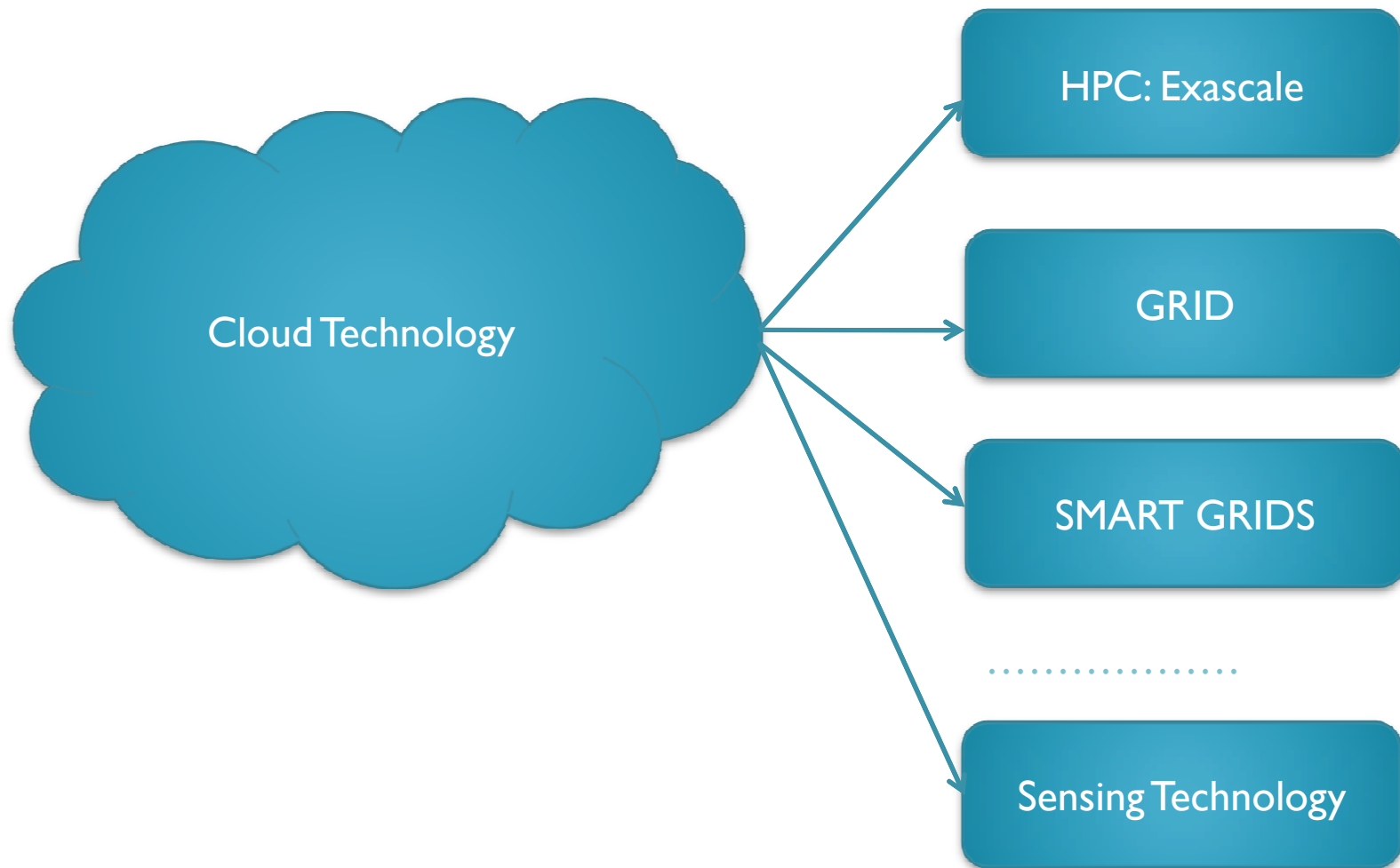
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Cloud Helpful Management for...



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Cloud @ UniMe:

- IaaS
 - Seen from the Top: Cloud Manager
 - Seen from the Bottom: Virtual Infrastructure Manager
 - Seen in Practical





A Cloud Middleware Model: the stack

Cloud Manager

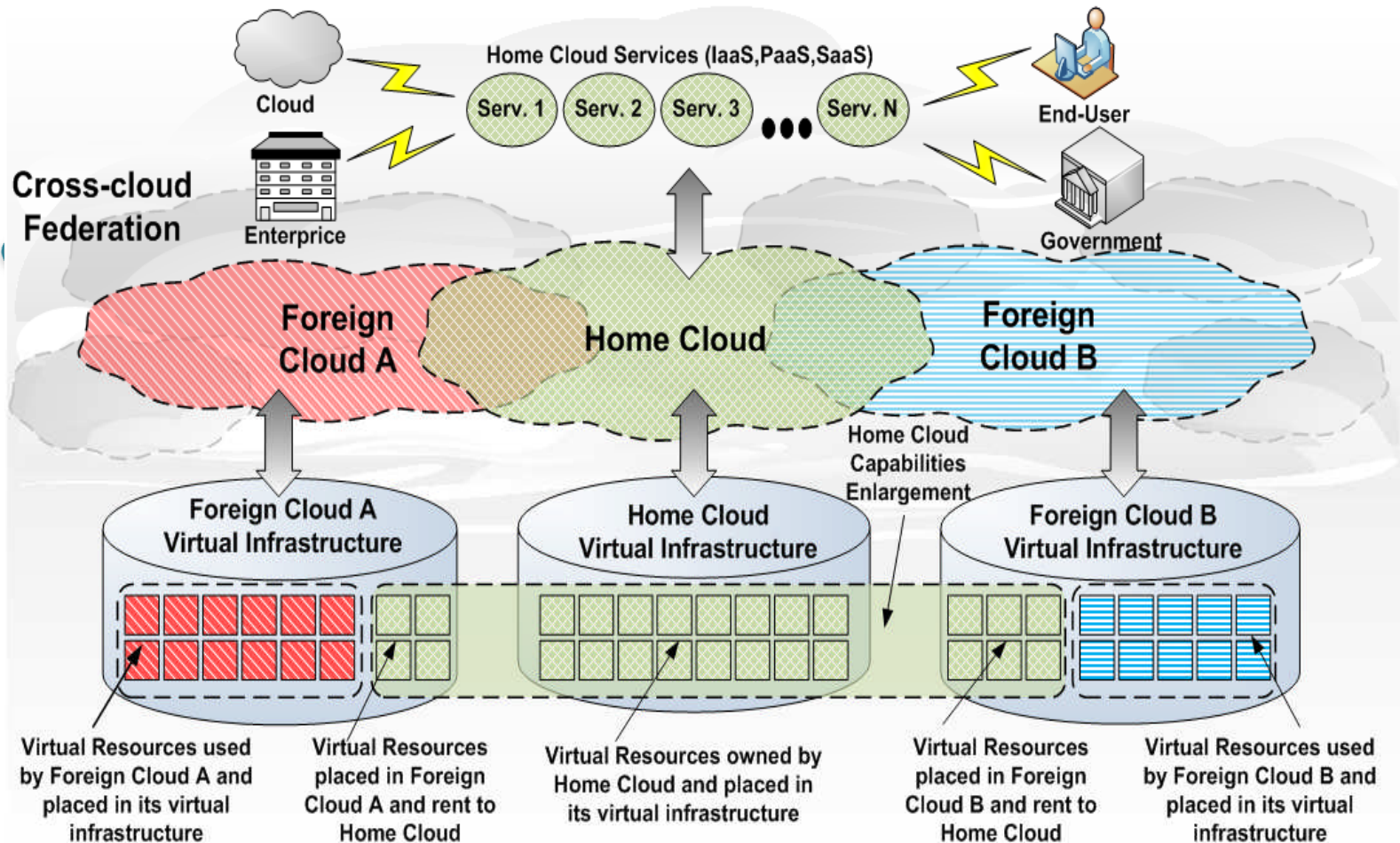
**Virtual Infrastructure
Manager**

**Virtual Machine
Manager**





Federated Cloud Scenario



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Three Phases Cross Cloud Federation Process:

- The Discovery
 - Peer-To-Peer (p2p) approach
 - Based conveniently on the **presence** concept
 - Concepts of “room”: i.e scalable monitoring, security enforcement...
 - Extensible Messaging and Presence **Protocol (XMPP)** based
- Match Making
 - Quantifiable and Unquantifiable parameters evaluation
 - Semantic and Syntactic approach
 - eXtensible Access Control Markup Language (**XACML**) based
- Authentication
 - Single Sign-On (SSO) authentication
 - Digital identities and third parties
 - Identity Provider model (IdP)
 - Security Assertion Markup Language (**SAML**)





Discovery XMPP based

```
<iq type='result '  
  from='foreigncloudA.net '  
  to='homecloud.org '  
  id='2g46s'>  
  <query xmlns='http://jabber.org/protocol/disco#info'>  
    <identity  
      category='cloud '  
      type='cross-cloud-federation-enabled '  
      name='foreign-cloud-A'/>  
    <identity  
      category='cloud '  
      type='european '  
      name='foreign-cloud-A'/>  
    <feature var='http://foreigncloudA.net/amount/cpu'/>  
    <feature var='http://foreigncloudA.net/amount/storage  
      '/>  
    <feature var='http://foreigncloudA.net/amount/memory'/>  
    <feature var='http://foreigncloudA.net/availability/  
      time'/>  
    <feature var='http://foreigncloudA.net/QoS'/>  
    <feature var='http://foreigncloudA.net/authentication/  
      IdP'/>  
    <feature var='http://foreigncloudA.net/cloud-black-list  
      '/>  
  </query>  
</iq>
```

Cloudy but

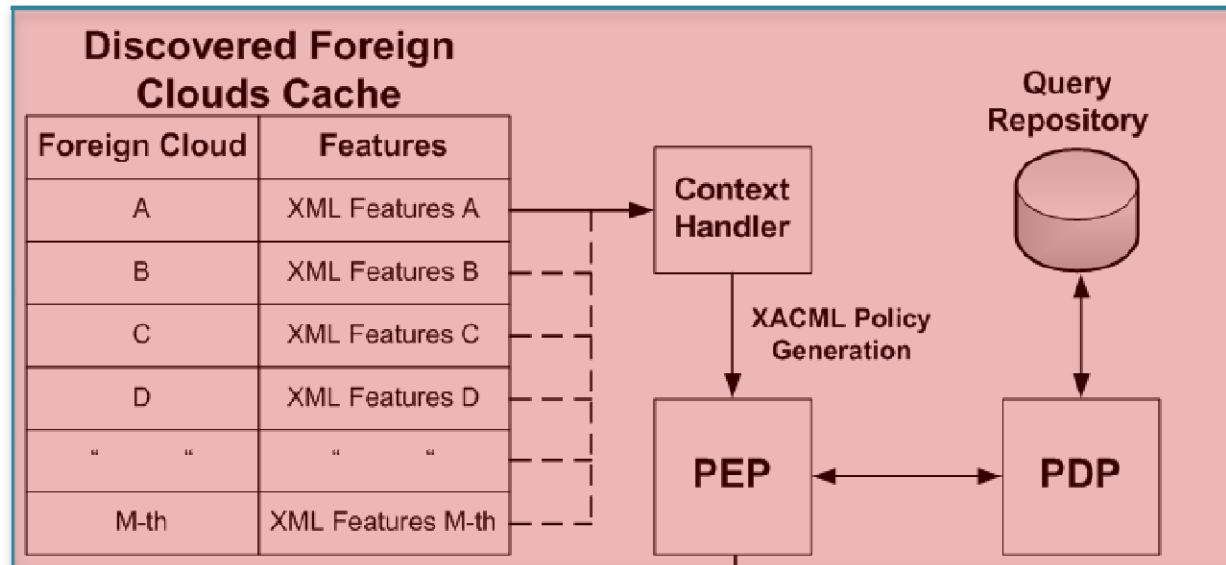
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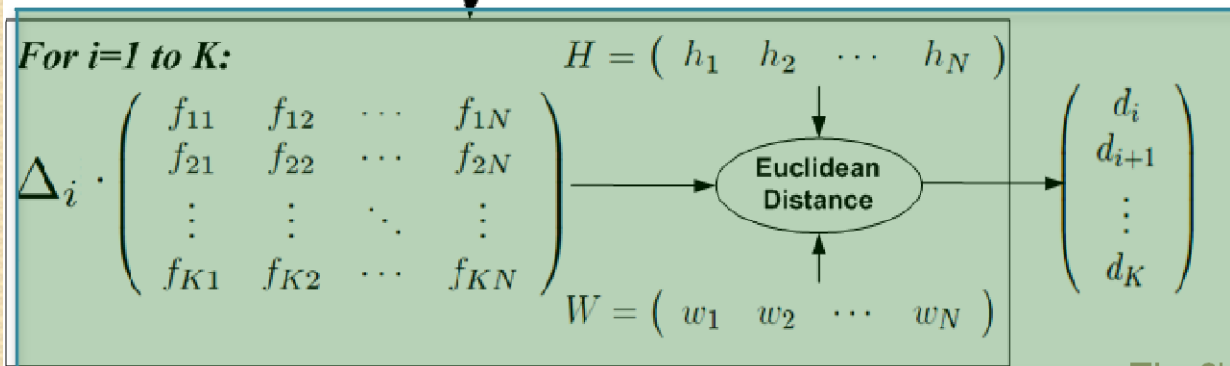


Match Making XACML based



Unquantifiable Parameters
 (e.g. the trusted IdP, the blacklisted clouds)

Quantifiable Parameters Extraction



Quantifiable Parameters
 (e.g. QoS metric greater than a threshold, resource availability from 10.00 AM to 5.00 PM, etc)





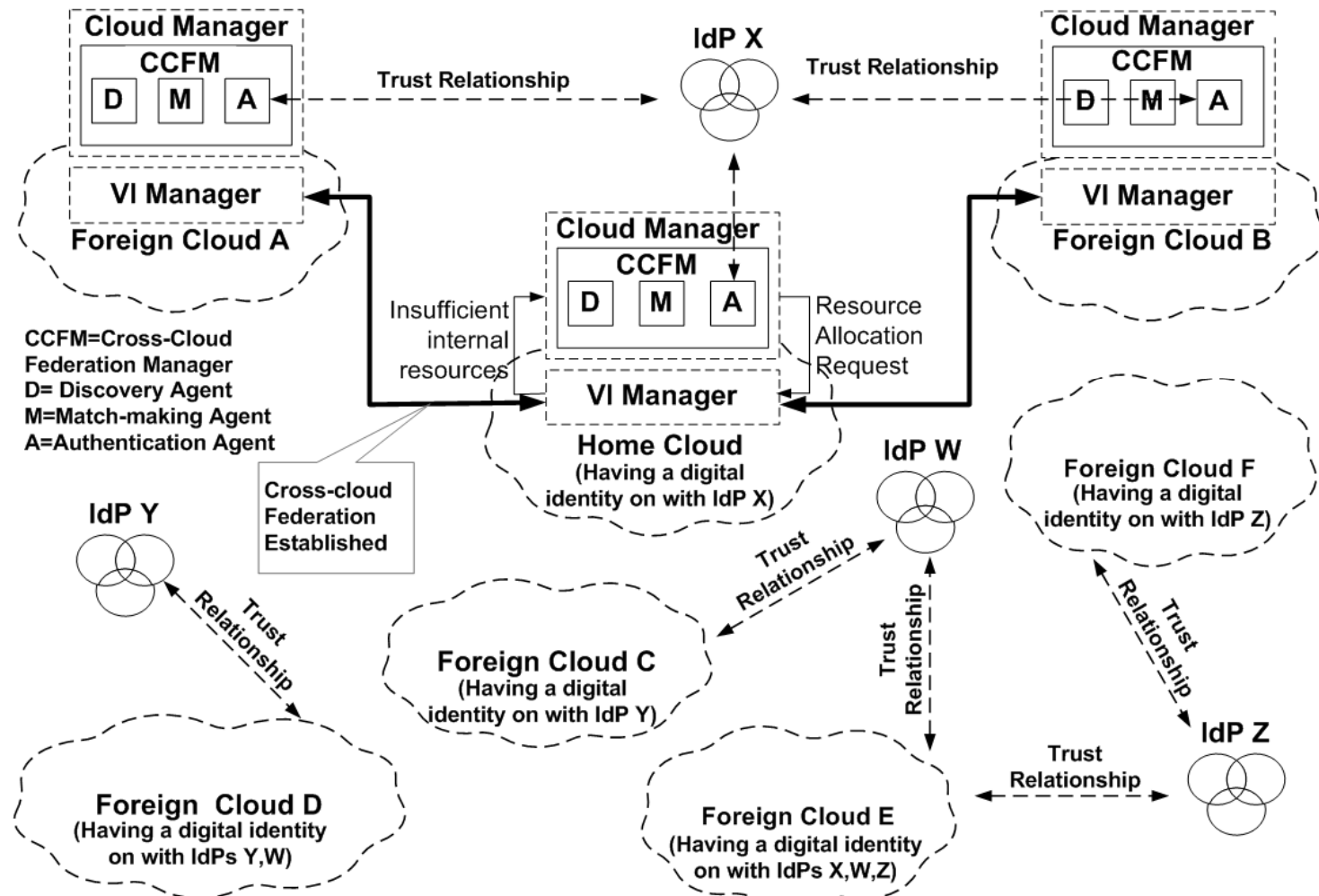
Authentication SAML based

```
<S:Body>
  <ns2:AA-ForeignCloud-A-ResReqResponse xmlns:ns2="http://webservices/">
    <return>
      <samlp:AuthnRequest xmlns:samlp="urn:oasis:names:tc:SAML:2.0:protocol" xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion" ID="dfa6" Version="2.0" IssueInstant="2010-01-12T18:34:42Z" AssertionConsumerServiceIndex="0">
        <saml:Issuer>https://cloudA.net/SAML2</saml:Issuer>
        <samlp:NameIDPolicy AllowCreate="true" Format="urn:oasis:names:tc:SAML:2.0:nameid-format:transient"/>
      </samlp:AuthnRequest>
    </return>
  </ns2:AA-ForeignCloud-A-ResReqResponse>
</S:Body>
```





Federation Establishment: IDCloud





Un

Cloud Name Space and its Motivations

- A cloud environment includes many concrete and abstracted entities which need to be identified, whose states can frequently change
- e.g. A “virtual machine”
 - It can be allocated, deallocated or migrated from a cloud to another.
 - A migration could trigger an identity alteration: a virtual resource being part of a virtual cloud service could later become part of another cloud service.
- Cloud entities could have one or more names, identifiers, and representations in various cloud contexts

Naming Issues

- Clouds are heterogeneous: each cloud may have its own naming system (e.g. DNS, URI-based, P2P, ...)
 - These naming systems, considered alone, are not enough.
 - The management and integration of Independent Cloud Name Spaces can be difficult.

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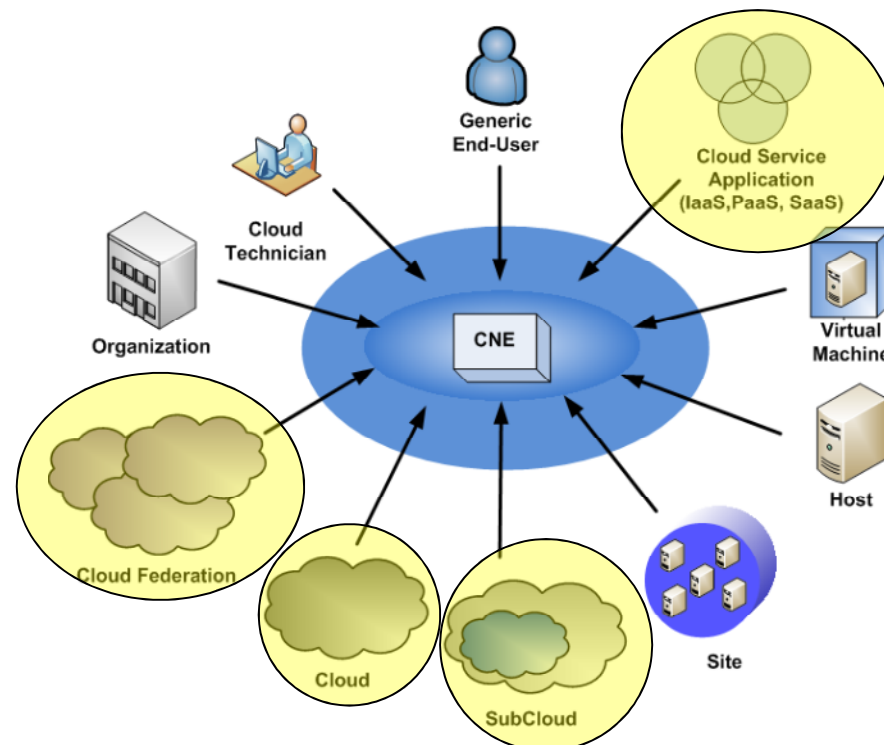
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Our Cloud Name Space Analysis

- Which are the entities involved in cloud computing?
- **Cloud Named Entity Class (CNEC)**
- **Cloud Named Entity (CNE).**
 - A generic entity indicated by one or more names, which may refer both to real/abstracted and simple/structured entities.



Abstracted and Structured

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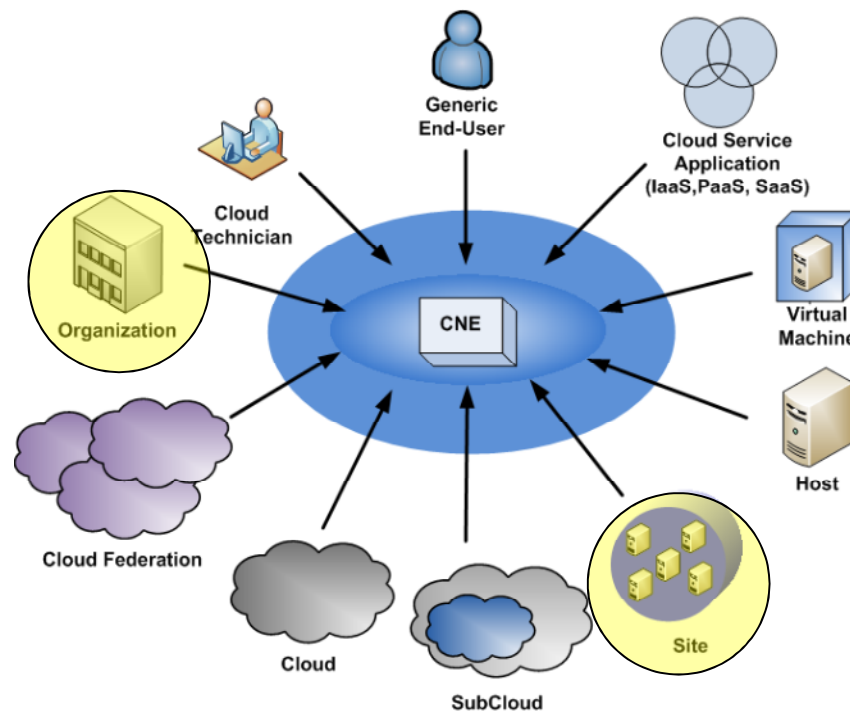
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Real and Structured

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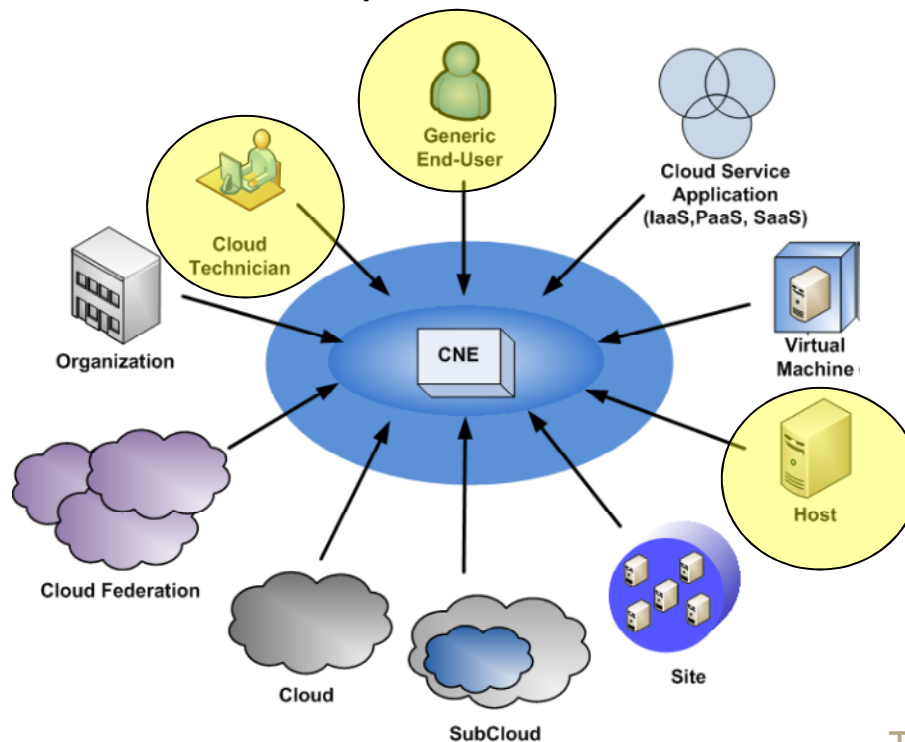
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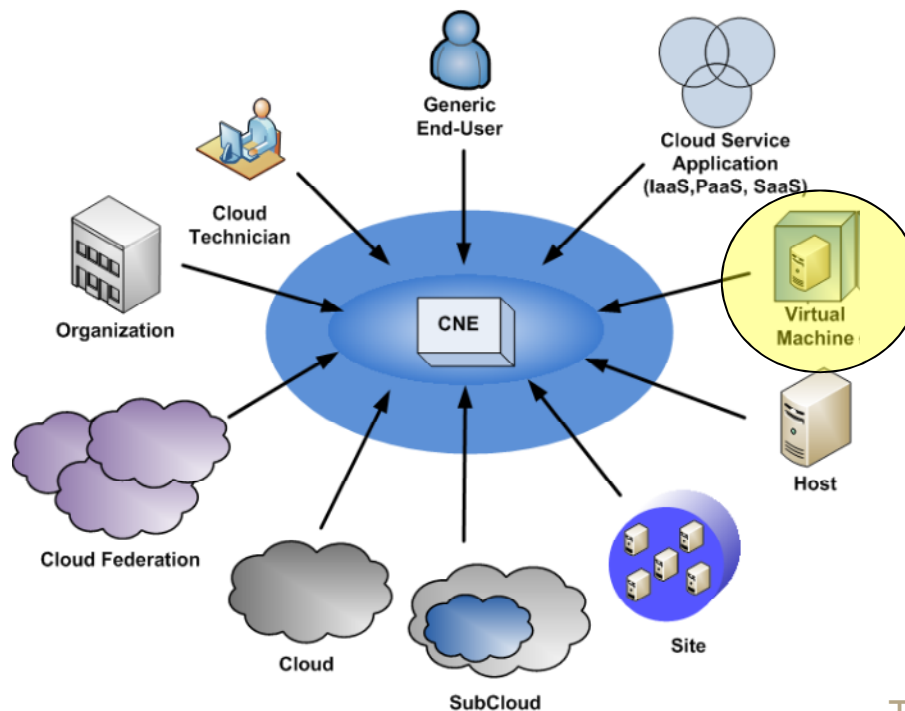
Real and Simple





Our Cloud Name Space Analysis

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Abstracted and Simple

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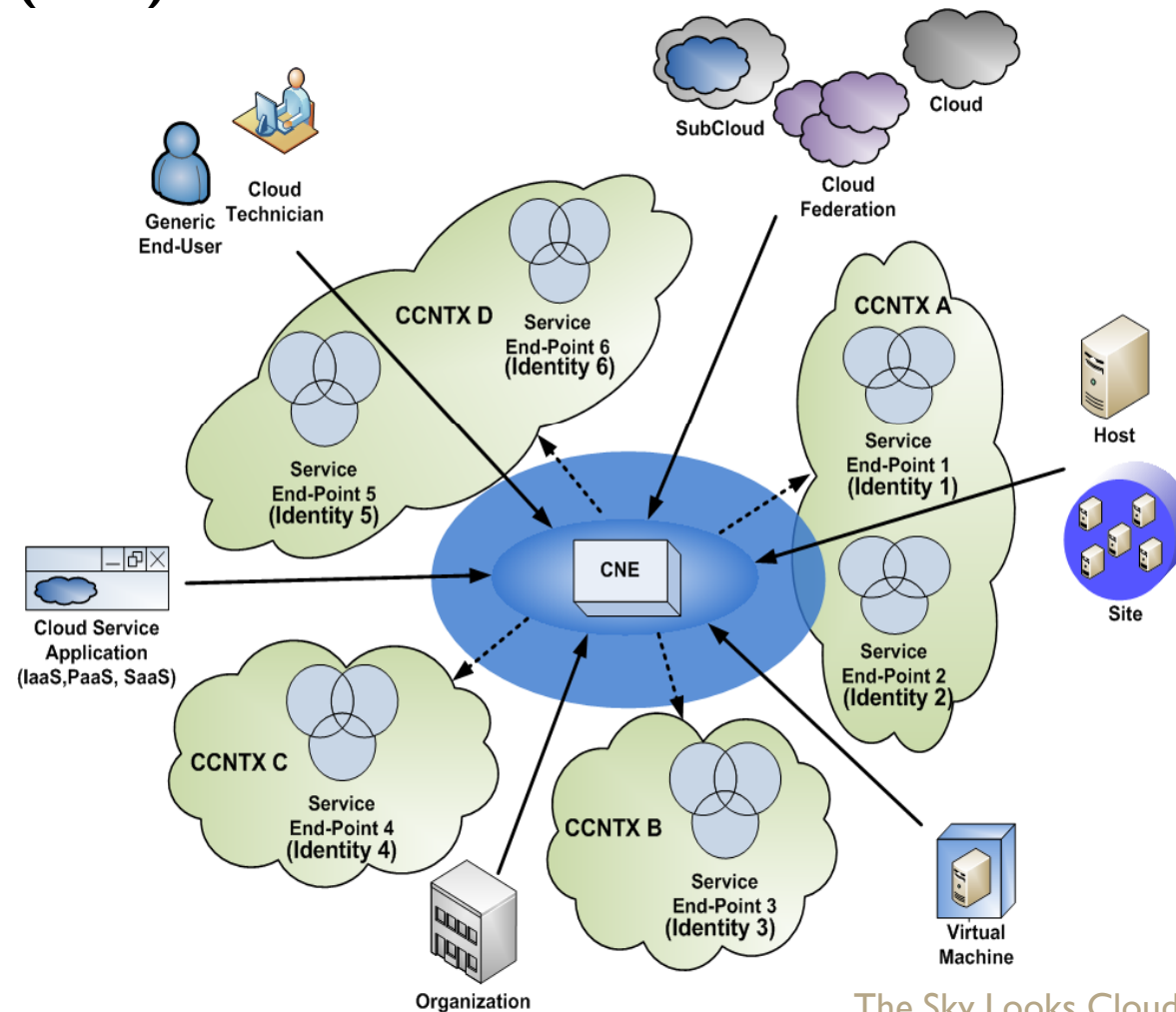
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Cloud Context (CCNTX)

An environment where a CNE may be resolved by means one or more **Service End-Points (SEPs)**.



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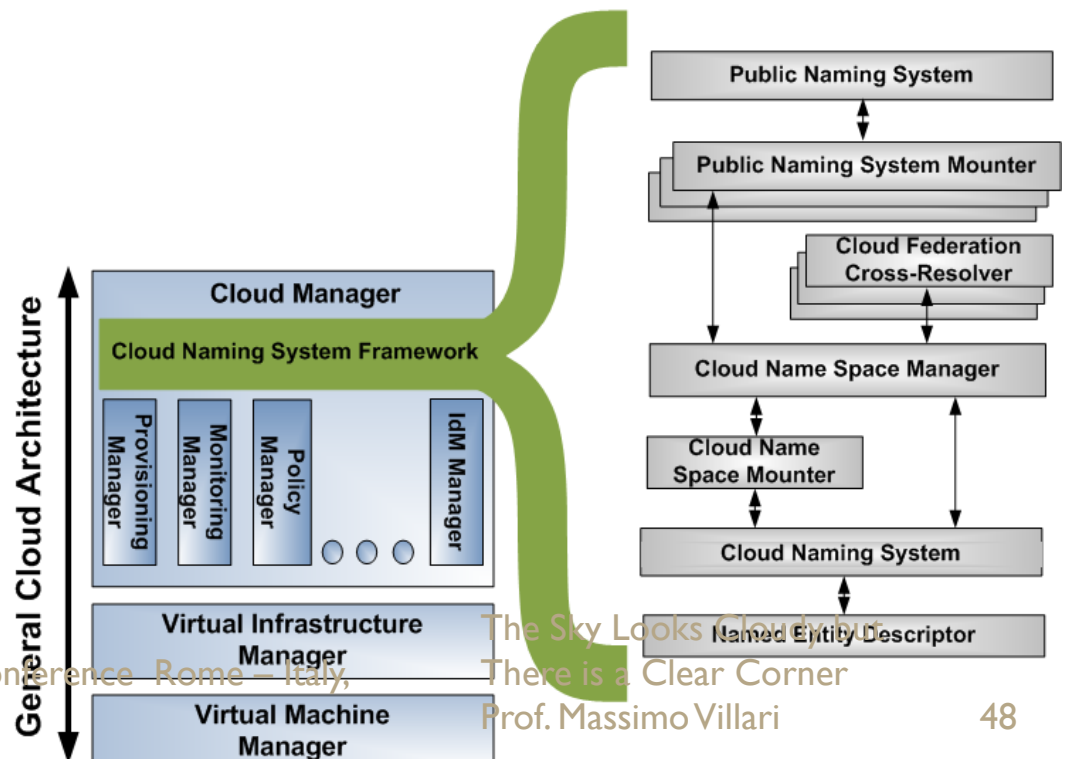
Our Solution

Cloud Naming System Framework able to

- Manage name spaces
- Mapping one or more names associated to a CNE, with the corresponding service representing the target CNE in a given CCNTX.
- Help “Cloud Manager Layer” tasks: each of such tasks requires to name and resolve appropriately the involved CNEs inside CCNTXs.

Requirements:

- *Compatibility*
- *Scalability*
- *Extensibility*
- *Entity description*
- *Name recycling*
- *Non-correlation*
- *Name space integration*



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Adoped Tecnologies in Our Practice Implementation

XRI Protocol

- Cloud Name Space Manager
- Cloud Name Space Mounter
- Cloud Naming System

HTTP Protocol

- Resolution of XRI Name

XRDS

- Cloud Named Entity Descriptor

DNS

- Public Naming System

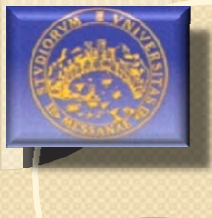




eXtensible Resource Identifier

- It provides a standard syntax for identifying entities, regardless any particular concrete representation.
- The protocol is built on URI (Uniform Resource Identifiers) and IRI (Internationalized Resource Identifiers)
- Since an URL is also an URI, the protocol provides a parsing mechanism from XRI to URL and other compatible URN domain.
- Global Context Symbols (GCS): “@”, “=”, “+”
- Persistent and reassignable identifiers: i-numbers (Canonical ID) and i-names (Local ID).
- E.g. **xri://@CLOUDA*lab2*host1*VM3**





eXtensible Resource Descriptor Document

```

<XRDS xmlns="xri://$xrd$" ref="xri://@CLOUDA*lab2*host1*VM3">
  <XRD xmlns="xri://$xrd*($v*2.0)" version="2.0">
    <Query>*VM3</Query>
    <Status code="100"/>
    <ServerStatus code="100"/>
    <Expires>2010-05-30T09:30:10Z</Expires>
    <ProviderID>xri://@CLOUDA*lab2*host1</ProviderID>
    <LocalID>*H2_VM3</LocalID>
    <EquivID>https://example.com/example/resource/</EquivID>
    <CanonicalID>xri://@CLOUDA*lab2*host1/!1234</CanonicalID>
    <CanonicalEquivID>xri://=1B822_d2f1_9a45_75bd</CanonicalEquivID>
    <Service>
      <ProviderID>xri://@CLOUDA*lab2*host1/!1234</ProviderID>
      <Type>xri://$res*cloudA*info</Type>
      <MediaType>application/xrds+xml</MediaType>
      <URI>http://resolve.example.com</URI>
    </Service>
    <Service>
      <ProviderID>xri://@CLOUDA*lab2*host1/!1234</ProviderID>
      <Type>xri://$res*auth*($v*2.0)</Type>
      <MediaType>application/xrds+xml;https=true</MediaType>
      <URI priority="10">http://resolve.example.com</URI>
      <URI priority="20">http://resolve2.example.com</URI>
    </Service>
    <Service>
      <ProviderID>xri://@CLOUDB*PlatformB/!9457</ProviderID>
      <Type>xri://$res*performance</Type>
      <MediaType>application/xrds+xml;https=true</MediaType>
      <URI priority="10">http://resolve.server1.net</URI>
      <URI priority="20">http://resolve.server2.net</URI>
    </Service>
  </XRD>
</XRDS>

```

The virtual machine name is mounted on the parent XRI Authority **xri://@CLOUDA*lab2*host1** with **xri://@CLOUDA*lab2*host1*VM3**

← **SEP Information**

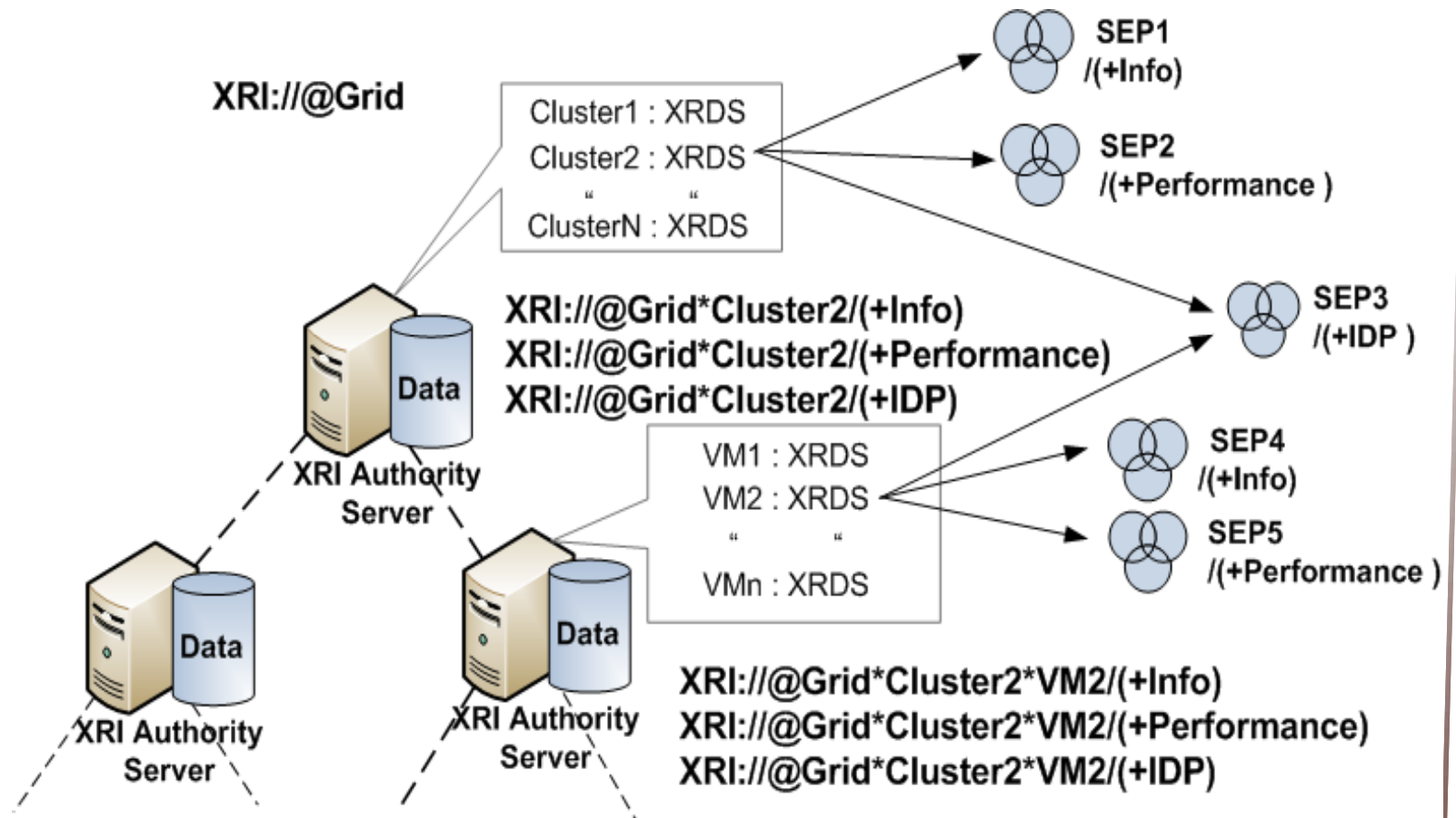
← **SEP Authentication**

← **SEP Performance**





XRI and the UTILITY COMPUTING (GRID)





A Cloud Middleware Model: the stack

Cloud Manager

**Virtual Infrastructure
Manager**

**Virtual Machine
Manager**





Design of a new VIM: CLEVER

A **C**loud-**E**nabled **V**irtual **E**nvi**R**onment:

- To simplify the access management of private/hybrid clouds
- To provide simple and easy accessible interfaces to interact with different “interconnected” clouds, deploy Virtual Machines and perform load balancing through migration.





Design of a new VIM: CLEVER

The pluggable design:

- integrating security,
- contextualization,
- VM disk image management
- *federation functionalities*
- It is able to grant:
 - high scalability,
 - modularity
 - flexibility in the middleware architecture,
 - fault tolerance requirements are also satisfied.





CLEVER architecture: the added values

- Inter host (inter cluster) Communication: p2p
- **Zero configuration: ZeroConf**
- Monitoring
- Security
- Fault Tolerance
- System Logs: Apache Log4j
- Distributed Database: Sedna (XML-based)
- Storage: Virtual Distributed Technology





CLEVER architecture: the added values

- Zero configuration: ZeroConf
 - Wizard Installation: common steps
 - Minimal requirements: S.O. and environment (Java)
 - All in a JAR file.
 - XMPP InBand Self Registration:
 - User name
 - Email address
 - Certificates
 - Pluggable approach:
 - Module auto loading at bootstrap phase
 - Runt-time module loading
 - Inter process communication: JMS, D-BUS





VIM: Summary comparison

FAULT TOLERANCE	●				●
SCALABILITY	●				
MODULARITY	●				●
CLUSTER INTERCONNECTION	●				
REMOTE INTERFACES	●	●	●	●	
HYBRID CLOUD SUPPORT	●		●	●	
MONITORING	●				●

Features / Cloud Middleware

CLEVER *Eucalyptus* *Nimbus* **ONE** *OpenQRM*

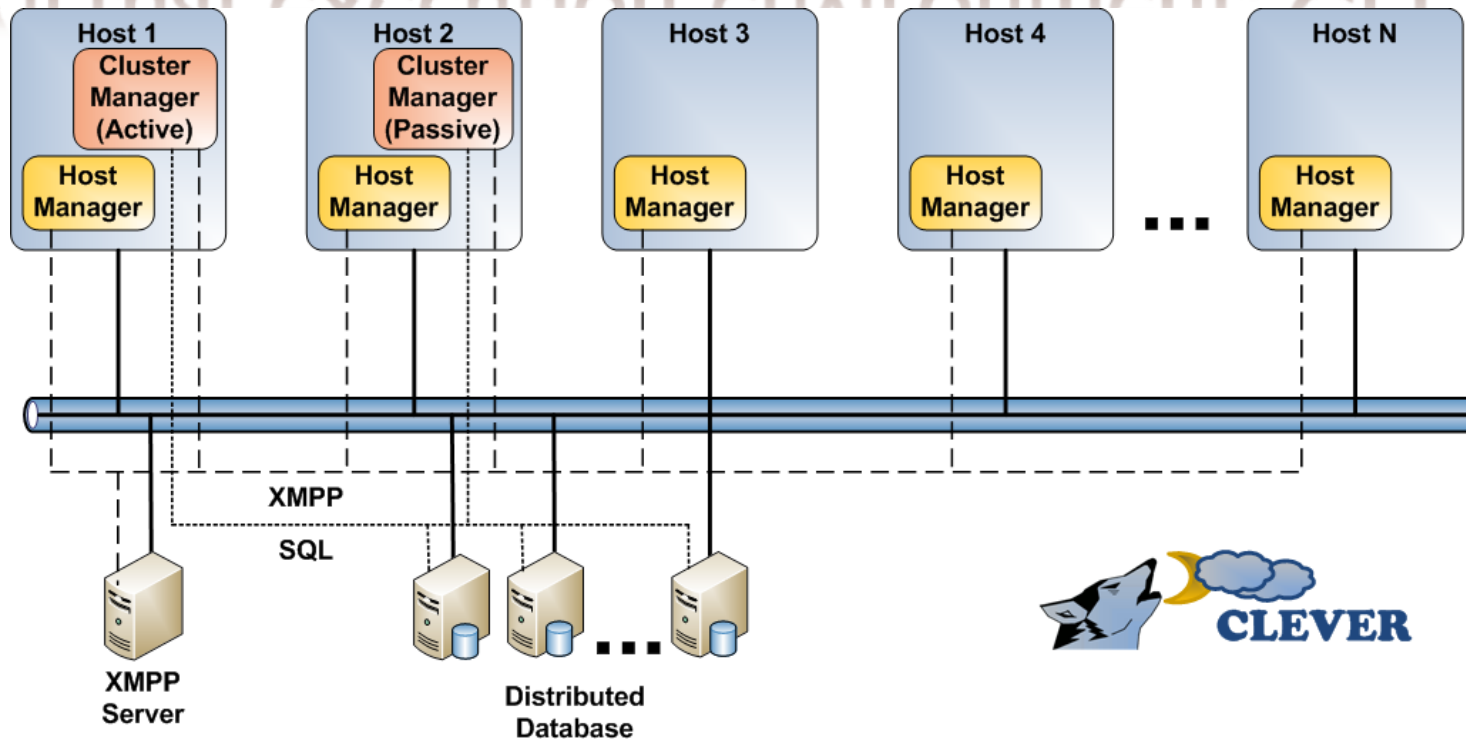
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Virtual execution environment: CLEVER



- Host Management Layer: Host Manager
 - Performs physical resources monitoring and VEs allocation
- Cluster Management Layer: Cluster Manager
 - Monitoring the overall state of the cluster, “coordinates” HMs
- External components: XMPP Server and Distributed Database
- XMPP advantages: host presence, open standard
- Central failure point does not exist:
- fault tolerance
- mechanism with multiple CM instances



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XMPP

XMPP

The base protocol used for XMPP is **RFC 2779**

(Instant Messaging / Presence Protocol Requirements).

PRESENCE AND INSTANT MESSAGING

PRESENCE AND INSTANT MESSAGING

- **Presence** — Presence is a means for finding, retrieving, and subscribing to changes in the presence information (e.g. "online" or "offline") of other users.
- **Instant Messaging** — It is a means for sending small, simple messages that are delivered immediately to online users.





CLEVER: Web and development

Home
Overview
Download
People

CLEVER: Cloud-Enabled Virtual Environment

CLEVER is a innovative cloud middleware fully designed at the **Università degli Studi di Messina**.

CLEVER simplifies the access management of **private/hybrid clouds** and provides simple and easily accessible interfaces to interact with different interconnected, clouds, deploy Virtual Machines and perform load balancing through **migration**.

The concept of interface is also exploited for integrating **security**, contextualization, VM disk image management and **federation** functionalities made available from higher level software components.

Due to its pluggable design, CLEVER is able to grant high scalability, modularity and flexibility in the middleware architecture, while **fault tolerance** requirements are also satisfied.

A prototype version of CLEVER has been developed to implement and test its main features. The development process is currently in progress to implement all the desired features.

- Official CLEVER's web site <https://clever.unime.it>.
- It is an open source project distributed under **MIT license** and downloading instructions can be retrieved from the download section of the web site.
- The source code is hosted on Google Code web site. Users and developers can get the source code downloading it from the following web address <http://code.google.com/p/clevercloud/>.





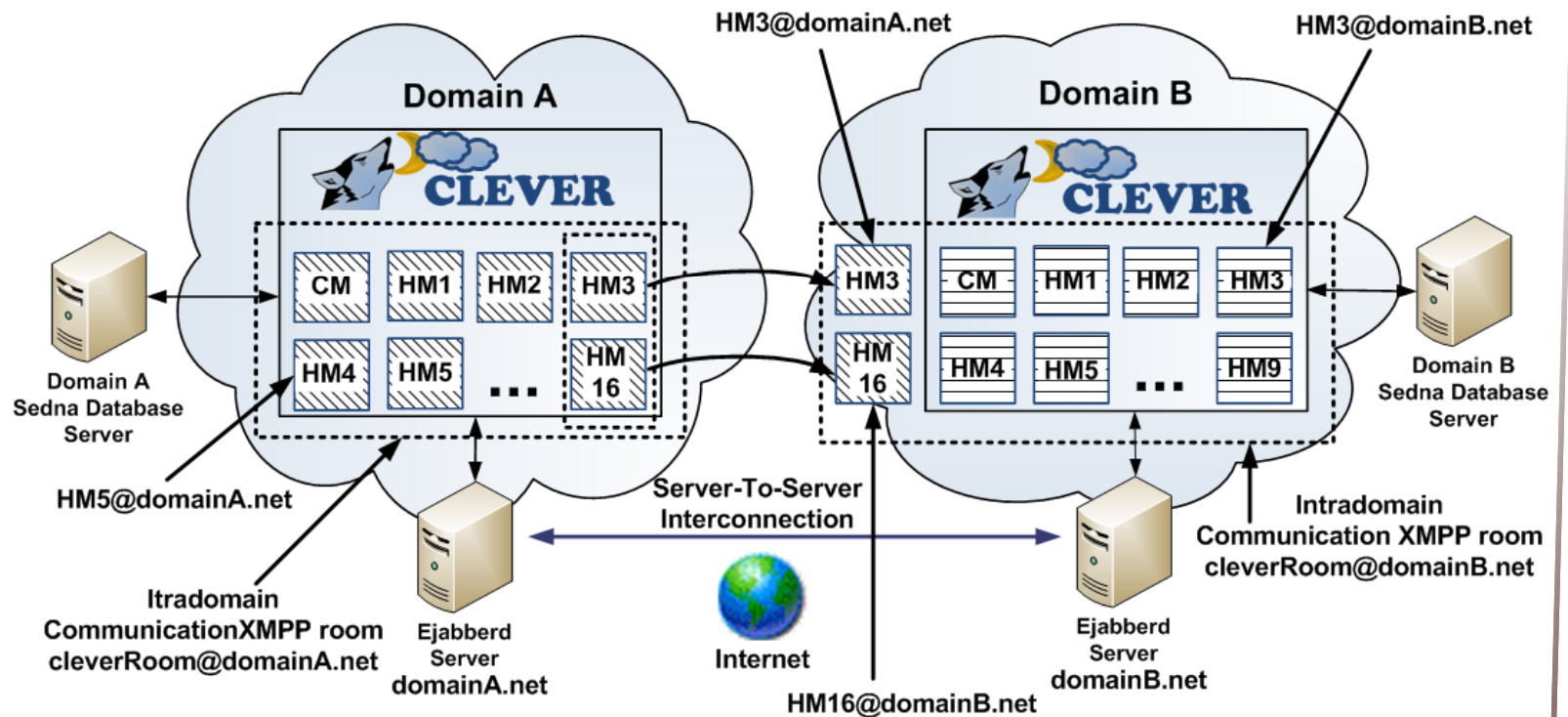
CLEVER in Horizontal Federation

- CLEVER has been designed with an eye toward horizontal federation:
 - Using XMPP for the CLEVER module communication (i.e., external communication XMPP room)
 - possibility to support in the future also interdomain communication between different CLEVER administrative domains.
- Federation allows to clouds to “lend” and “borrow” resources





CLEVER in Horizontal Federation

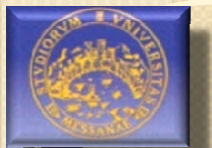




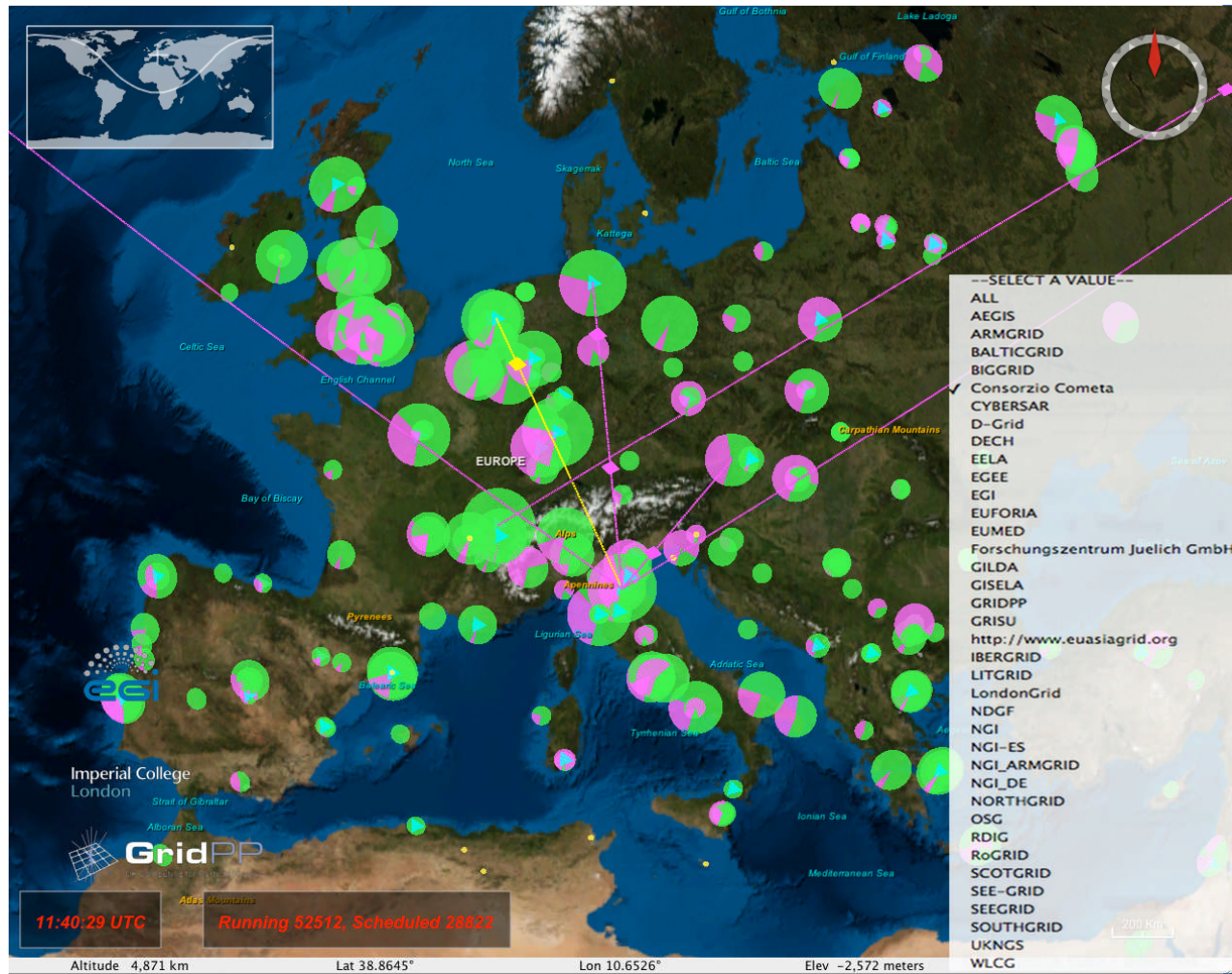
CLEVER on GRID: motivations

- Grid technology continues to dominate public sector and scientific computing environments.
- New interests have raised in deploying cloud technology on grid-enabled resources to improve the management and reliability of those resources via the virtualization layer.
- Integrating a Cloud in a Grid adopts the Cloud paradigm to strengthen its security with the robust federated identity and access management architecture of Grids.





EGI: European GRID Infrastructure



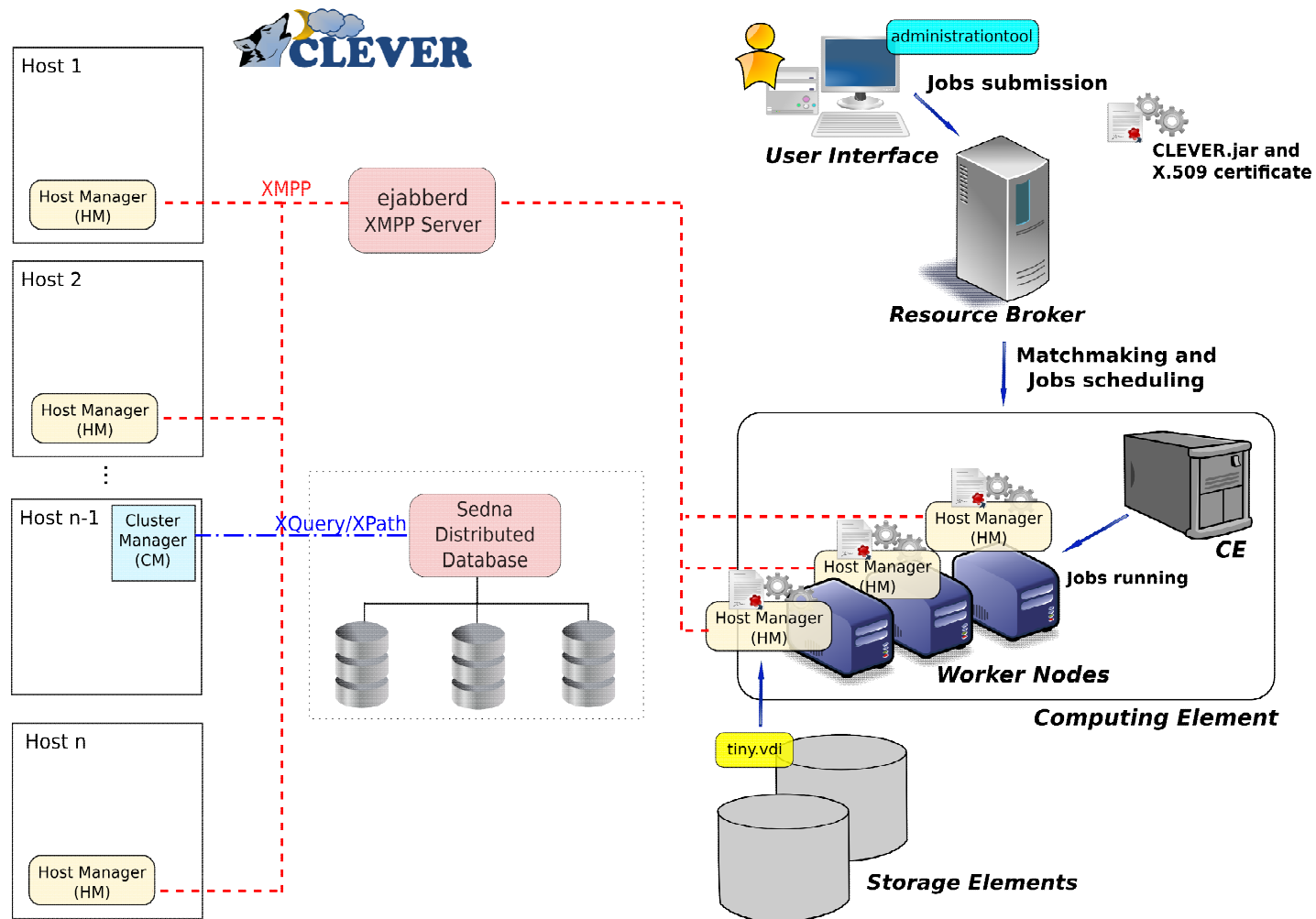
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CLEVER on GRID



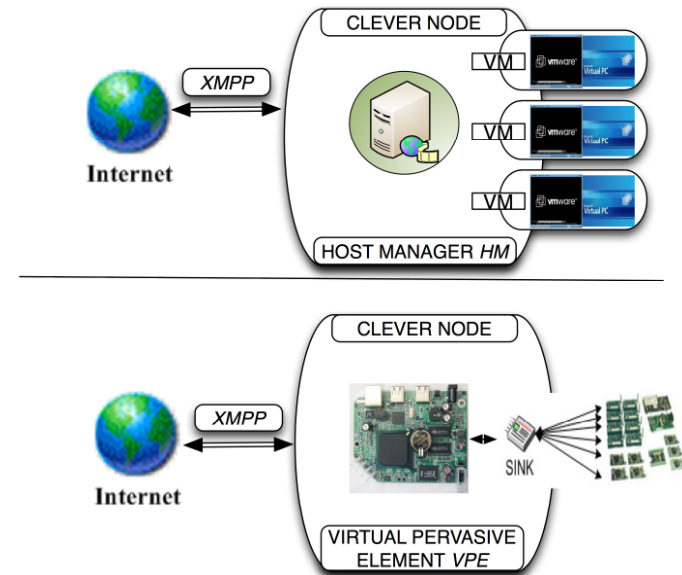
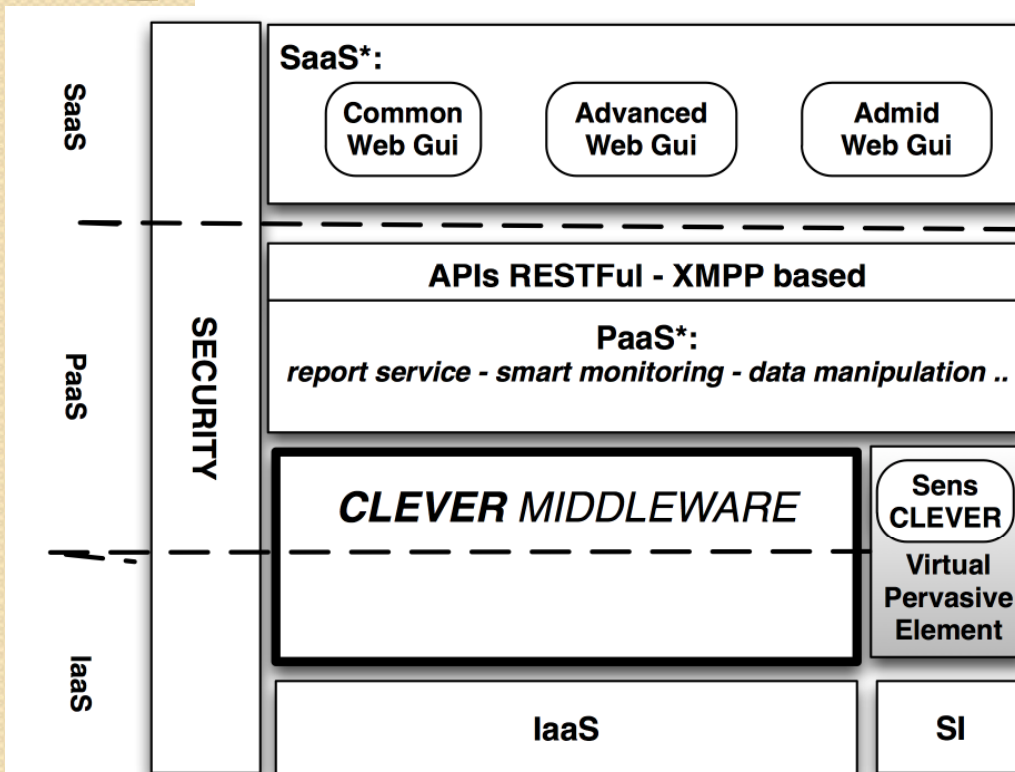
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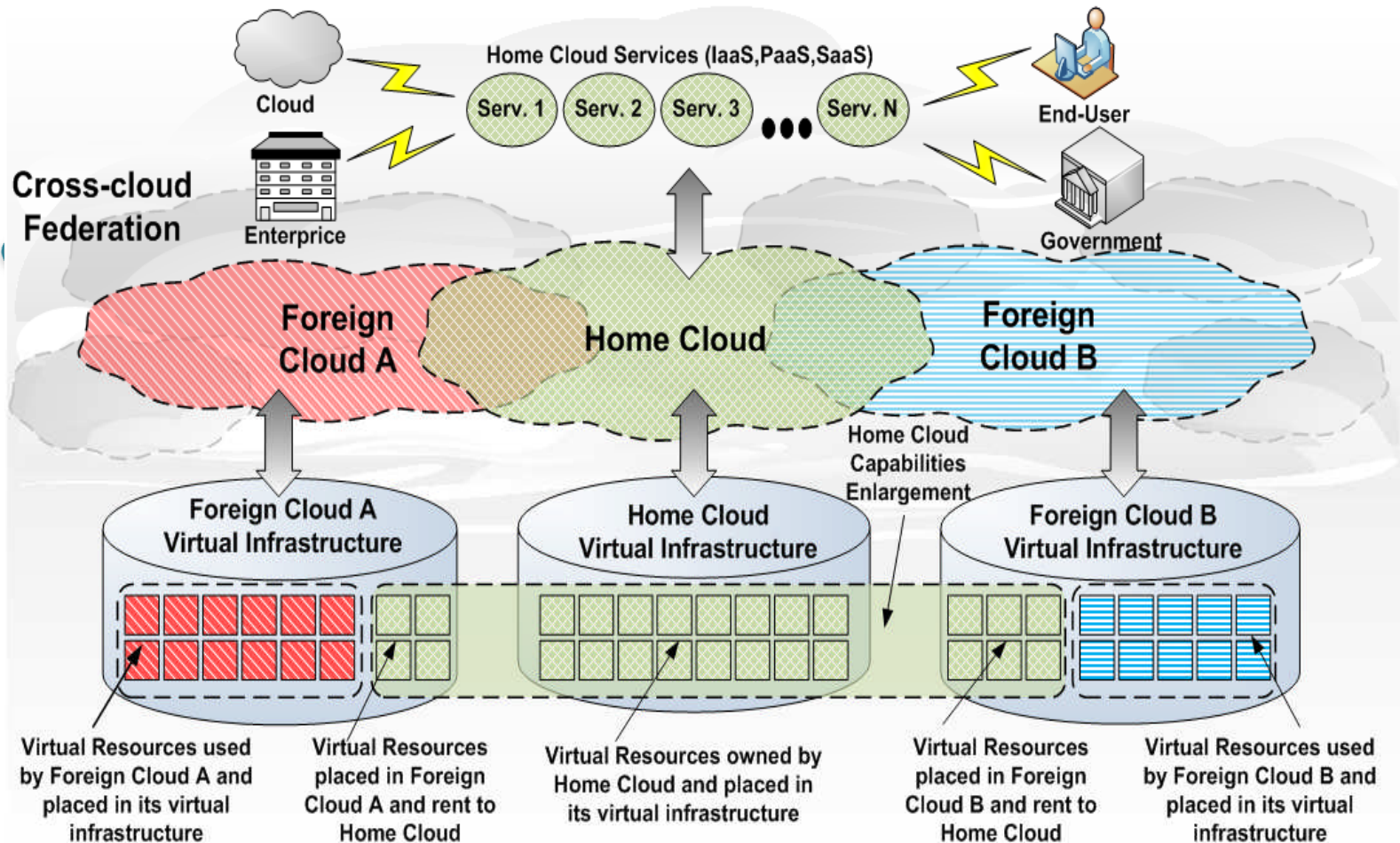


CLEVER and Sensing Technologies





Federated Cloud Scenario

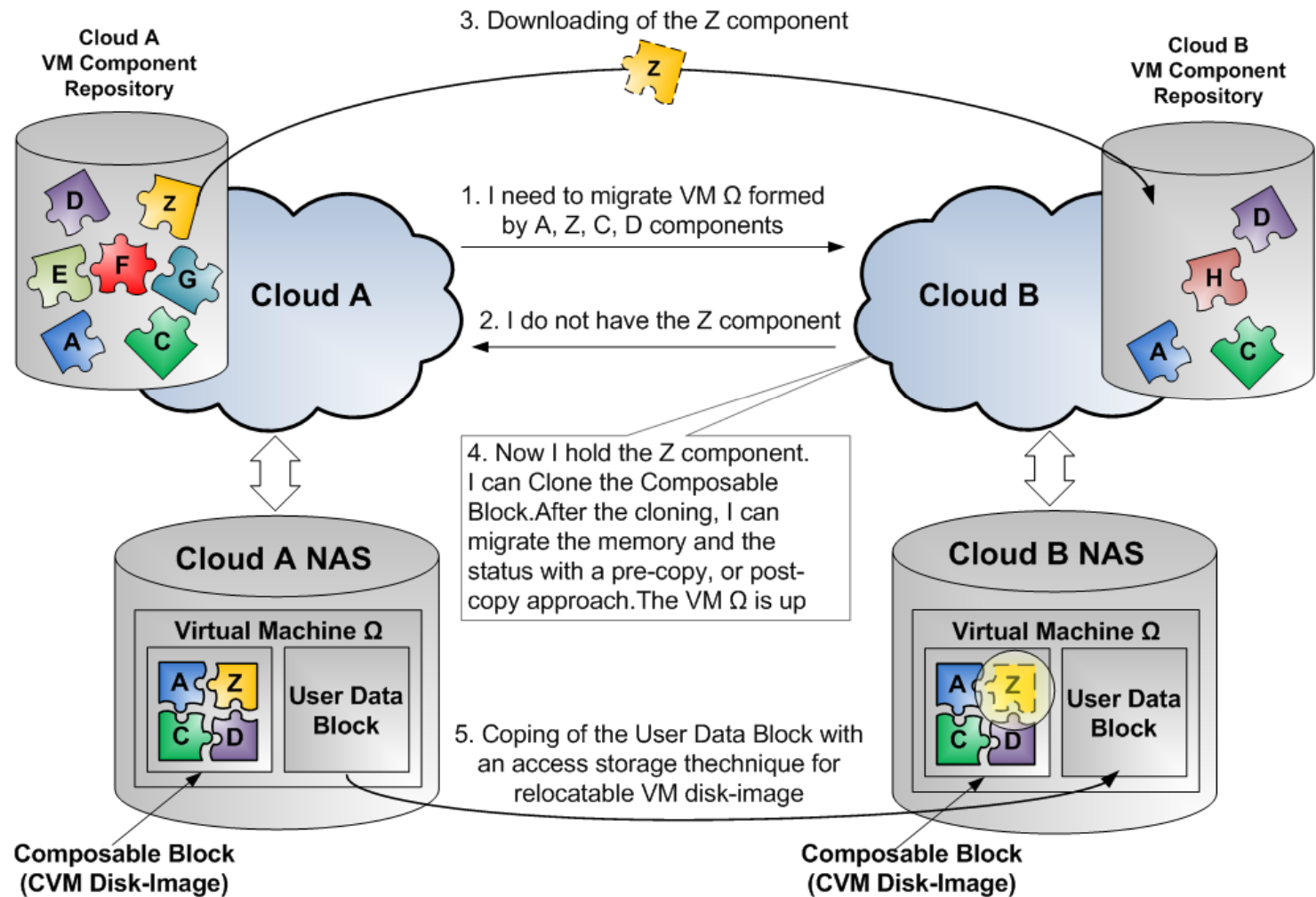


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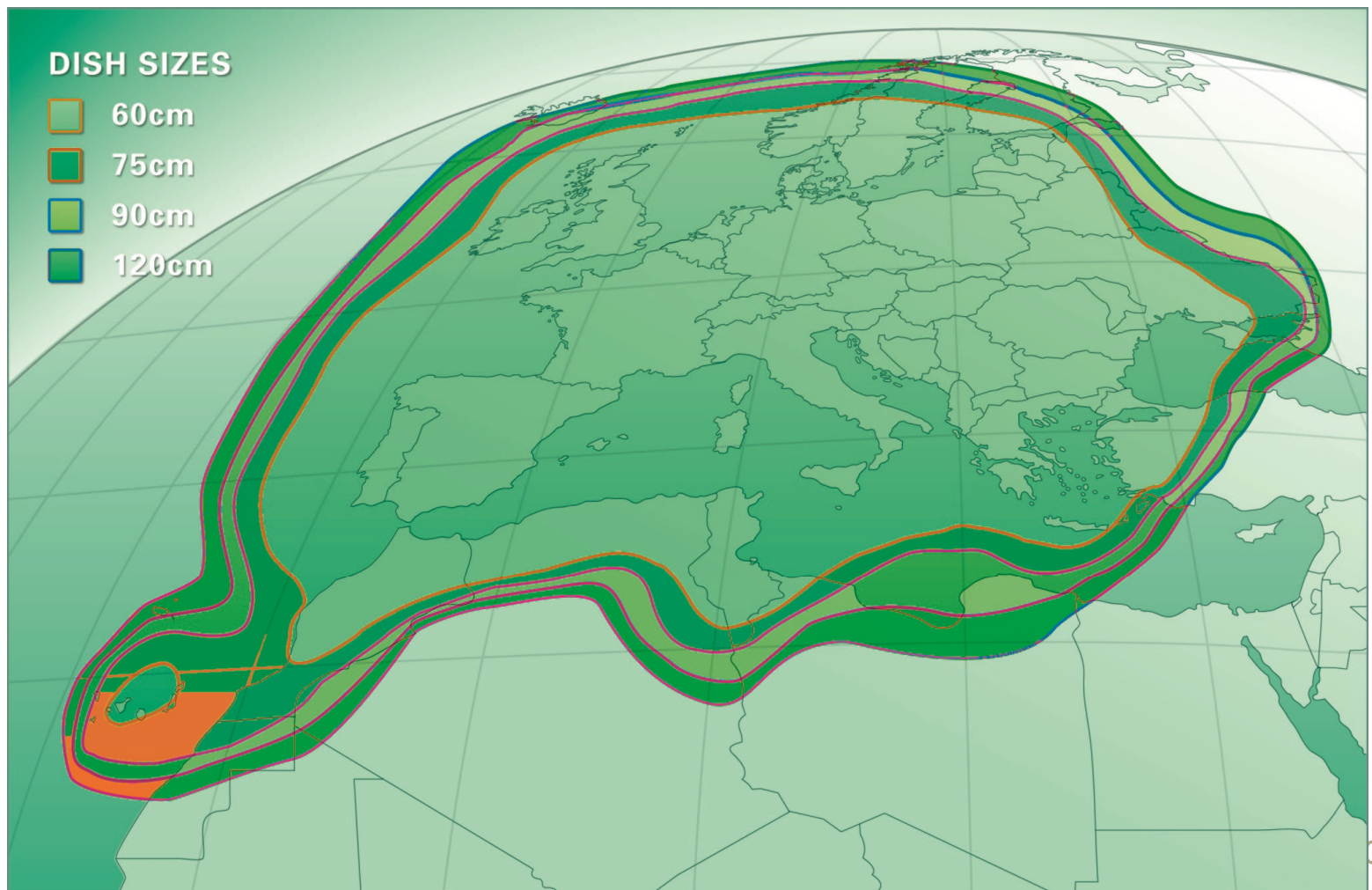
Tough Job: moving data





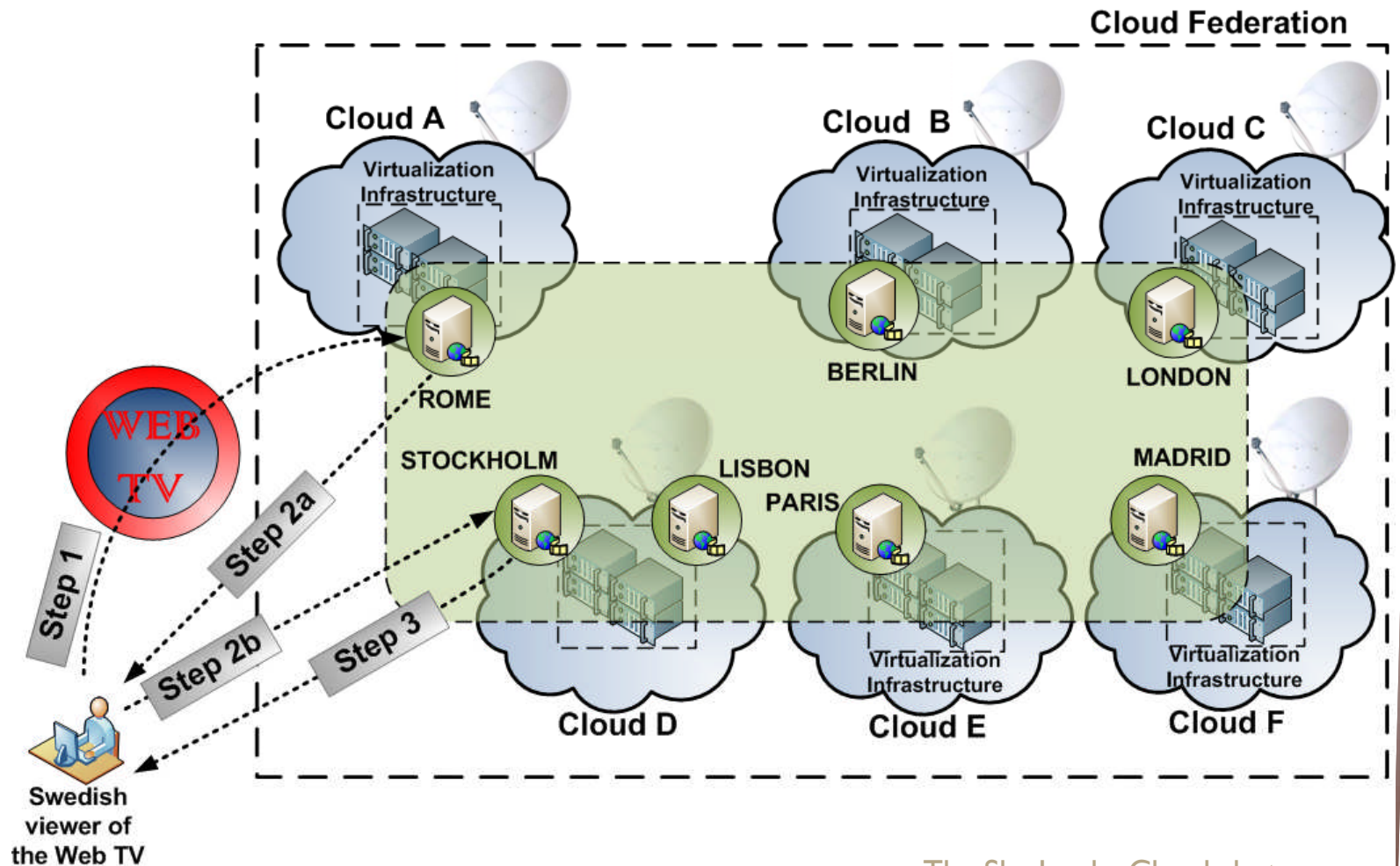
Tough Job: moving data

- VMs Satellite provisioning



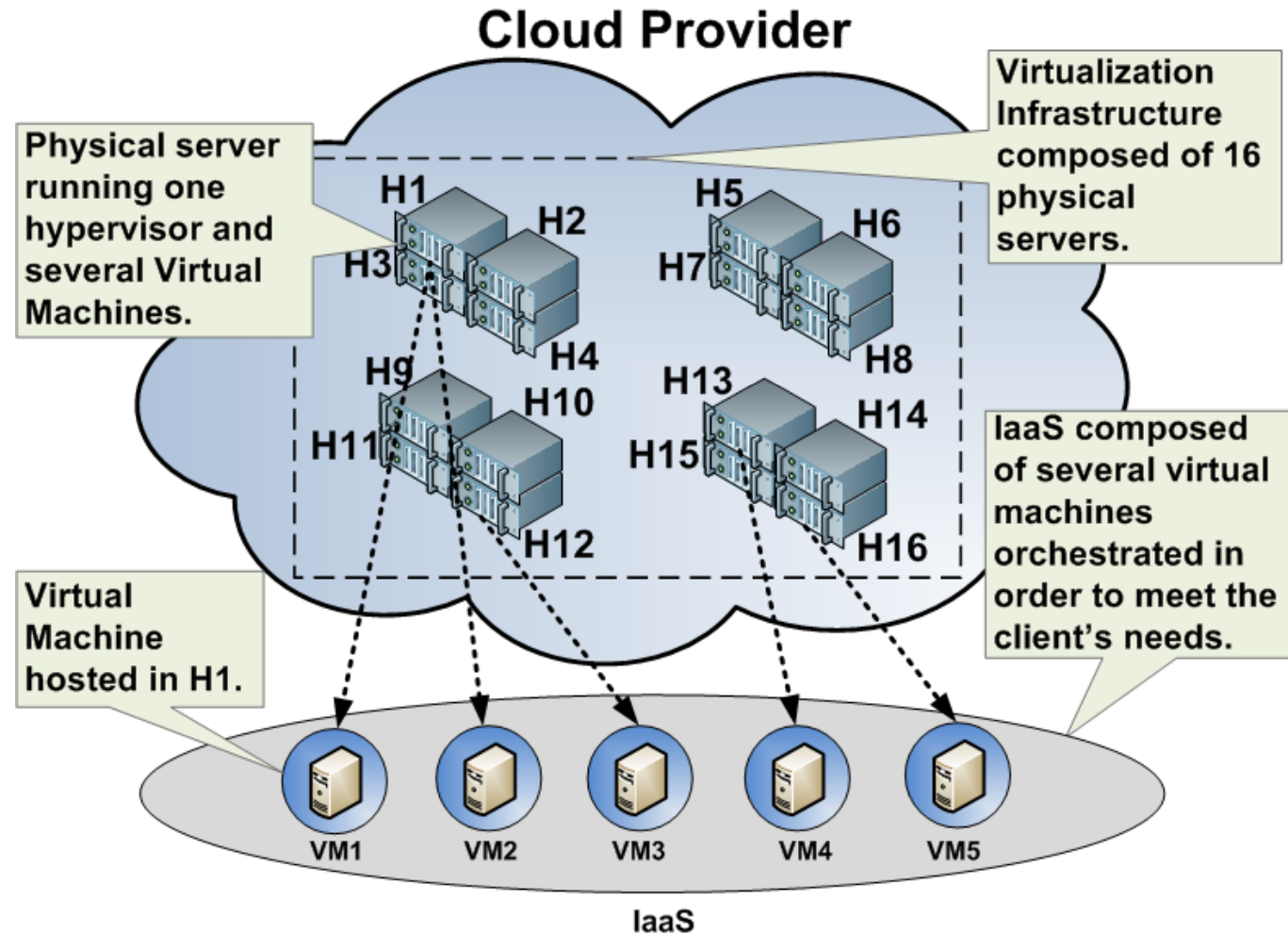


An example of Use Case: webtv and Clouds





An example of Use Case: webtv and Clouds





The Work done in Cloud

- Security in federated clouds:
 - Trusted Computing (TPM)
 - DDoS Threat Mitigation
 - Trustiness among Cloud Providers
 - Security profiles XACML based to meet Cloud Customer Security Requirements
 - New security capabilities in OpenNebula





Few Words in Standardization works

- A great fibrillation to make progress
- A way to differentiate businesses
- Many Std Boards to get the control





European Grid



Towards a sustainable grid infrastructure



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The METHAFOR: the painter and his paintings

Antonello da MESSINA in the Later Middle Age

Messina, 1429

Messina February 1479



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What are the issues in the standards?

CORBA
vs
HTTP
??

SOAP
vs
REST
??

CLOUD X
vs
CLOUDY
??



TIME (t)

TIME (t)

TIME (t)

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What is the possible solution, for IT markets?

The
CARROT
and
STICK



SOLUTIONS????
SELECT *GOOD* PAINTERS
AND
***ATTRACTIVE* BUSINESS**

possible
BUSINESS
and
Real
SECURITY
PRIVACY





Conclusions

- Highlights on Clouds
- Concepts of Federated Clouds
- Cloud @ UniME



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Book on Federated Clouds



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Achieving Federated and Self-Manageable Cloud Infrastructures: Theory and Practice



Editors:

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Call for Chapters:

Proposals Submission Deadline: May 15, 2011
 Full Chapters Due: July 15, 2011
 Submission Date: November 15, 2011

Introduction

Cloud Computing presents a promising approach for implementing scalable ICT systems for private and public, individual-, community- and business-use. Resources are pooled and offered on-demand with ubiquitous network access to rapidly configurable and elastic IT capabilities. Resources are delivered following three basic delivery models: provisioning of remote applications (SaaS), provisioning of remote platforms to create applications (PaaS), and provisioning of remote infrastructures for processing, storing, and networking (IaaS). The key benefits of providing computing power using Clouds are (a) avoidance of expensive computer systems configured to cope with peak performance; (b) pay-as-you-go solutions for computing cycles requested on-demand; and (c) avoidance of idle computing resources, resulting in novel business models.

Gartner, Inc. has identified Cloud Computing as the most important strategic technology for the year 2010. Looking toward the near future, T. Bittman has hypothesized that it will evolve in three subsequent stages (Gartner Blog Network):

- Stage 1 "Monolithic" (now), where cloud services are based on independent proprietary architectures - islands of Cloud services delivered by mega-providers (this is what Amazon

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- Authors/Editors
- Distributors
- Instructors

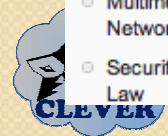
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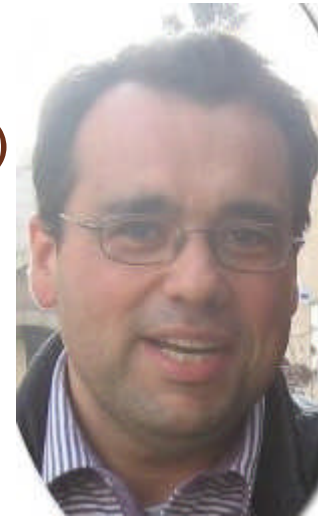
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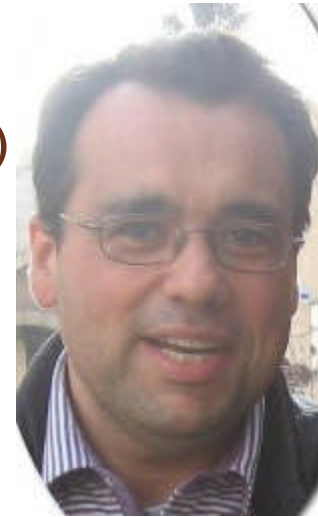
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THANK YOU

?
AND....

Prof. Massimo Villari (mvillari@unime.it)
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THE LAST THOUGHT

**A RESEARCHER IS SOMEBODY WHO
PERFORMS RESEARCH, THE SEARCH
FOR KNOWLEDGE OR IN GENERAL
ANY SYSTEMATIC INVESTIGATION TO
ESTABLISH FACTS**

<http://en.wikipedia.org/wiki/Researcher>



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