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NTT Information Sharing Platform Laboratories
NTT 情報流通プラットフォーム研究所

Towards the New Era of Inter-Cloud Computing
- ICT architecture in the age of uncertainty -

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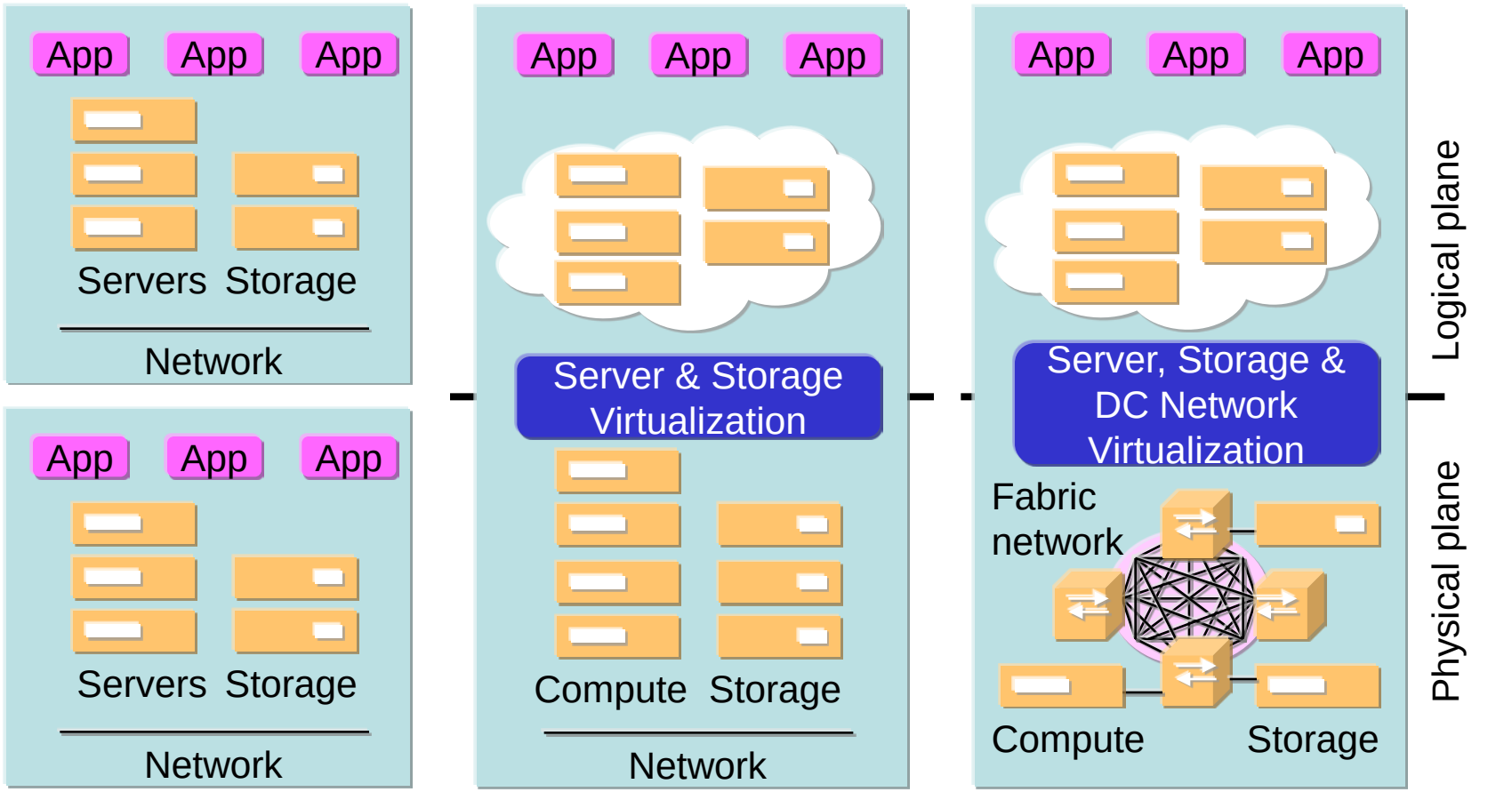
ICT and changing business environment

- Diversity of business, speed of change, and cost
- Uncertainty
  - Increasing complexity of systems and system operations
  - Wide diversity of terminals; impossible to predict winners
  - Changes in traffic, eg., migration from conventional Web, mail, P2P traffic to SNS, and video, then to HTML5, short video…
- Globalization, scale

- Running successful business in an unpredictable world
- Ensuring business continuity, no matter what happens
  - Economic unrest, natural disasters, pandemics, political instability, etc.

Changes in data centers and cloud computing



Conventional data center (Dedicated resources)

Server and storage virtualization

Network switch virtualization (flat NW topology, distributed protocol)

Challenges for mega datacenters

Implementation of server virtualization technologies poses new challenges for DC network architecture.

[Background]

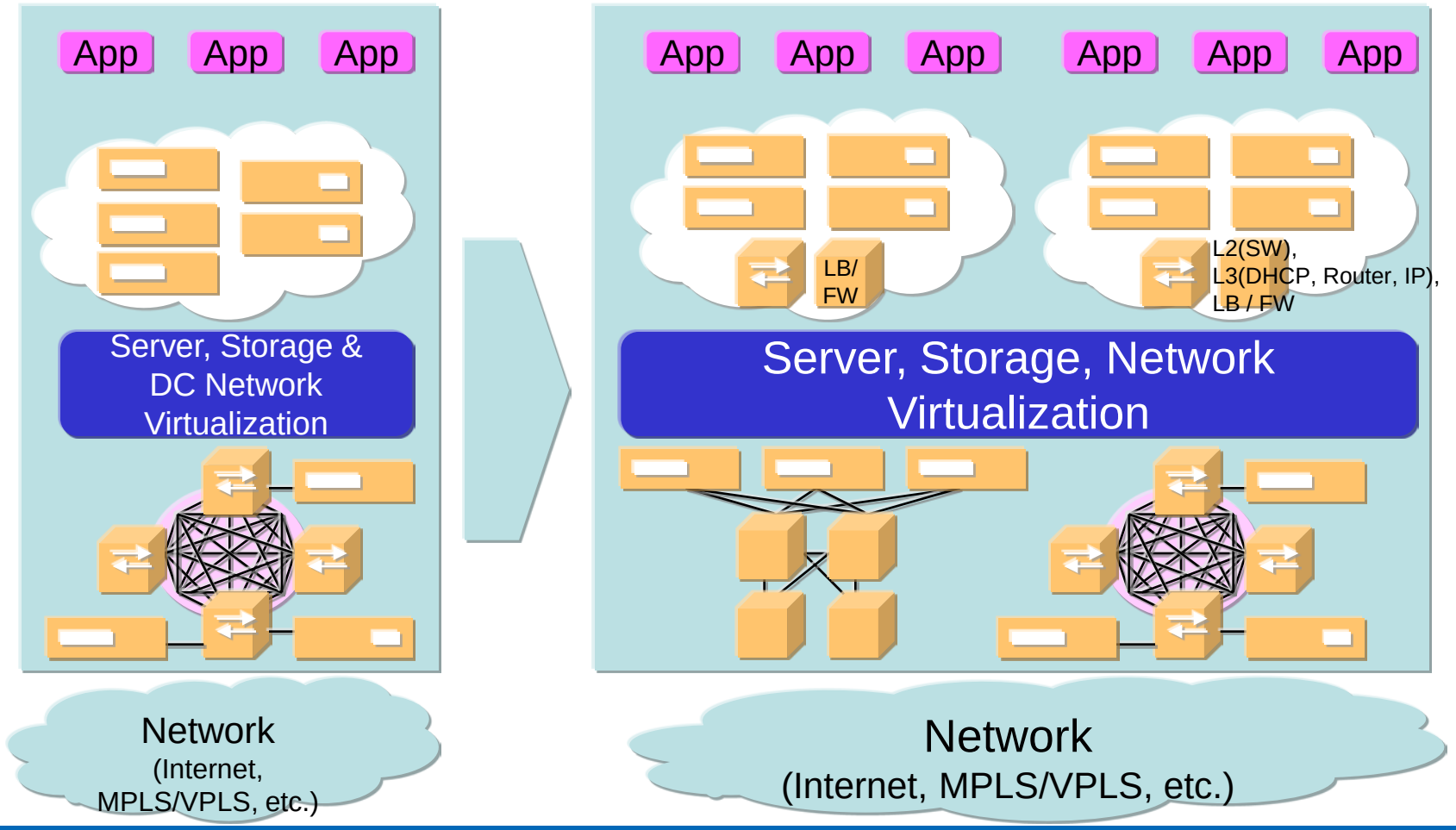
- High density, multi-tenant, migration, unbalanced traffic between tenants, inter-datacenter network, and new services (eg., NaaS)

[Challenges]

- **Big L2 network**
  - Difficulties in handling physical network appliances, the limitation of the number of VLANs, ARP flooding, scalability limitations of physical network (eg., the number of VLANs, the number of MAC learning table entries, duration of ARP learning, bandwidth of core switch's backplane, etc.) unbalanced traffic between tenants.
- **Network migration**: Network configurations (including routing information) can not be migrated, though virtual servers can be migrated easily.
- **Monitoring in logical network**: Logical network can't be monitored easily (logical – physical mapping management).
- **On-demand and programmable network**: Logical network needs to be configured by end-users (self-provisioning)

Hypervisors for networks

- Network hypervisor constructs multiple networks implemented in software on group of network devices (physical NW provides routing & forwarding functions)
- Multi-tenant (isolation, QoS policy, ACLs, etc.), programmable, on-demand, mobility



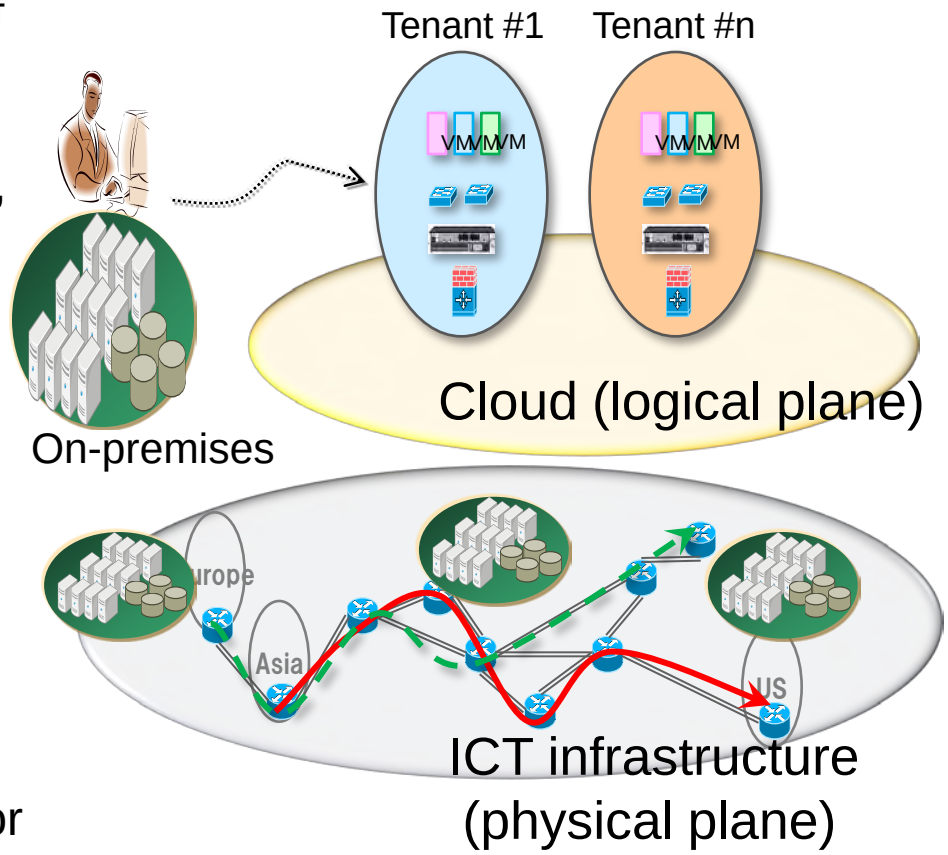
Requirements in the cloud eco-system

[Requirements from customers and cloud services providers' perspective]

- Migration from on-premises to cloud, self on-demand ICT facility control (self portal)
- Auto-scaling to suit demand, automated control/restoration of service during failure, auto-migration
- Solve problems of mega-data centers (see 'Challenges' on slide 4)

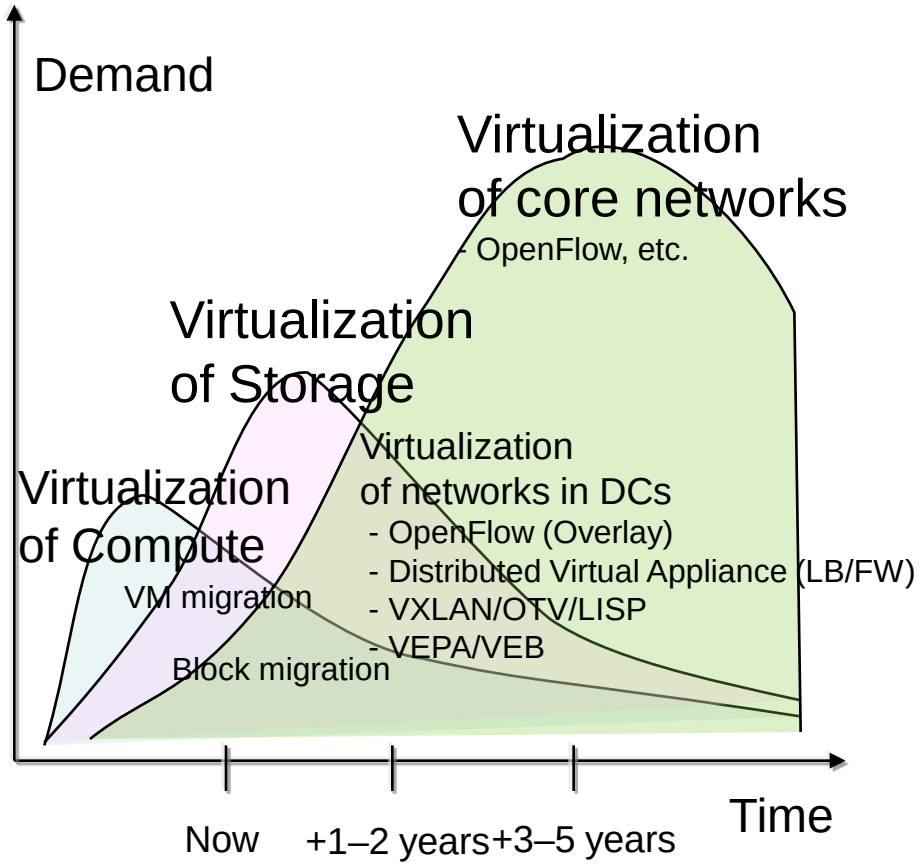
[Requirements from Carriers' perspective]

- Free path control of physical network for each service
- Programmable network control; network can be flexibly adapted to different media
- Ensuring continuity of service is unaffected by equipment renewal at EOL or EOS
- Carrier-grade performance, reliability, etc.



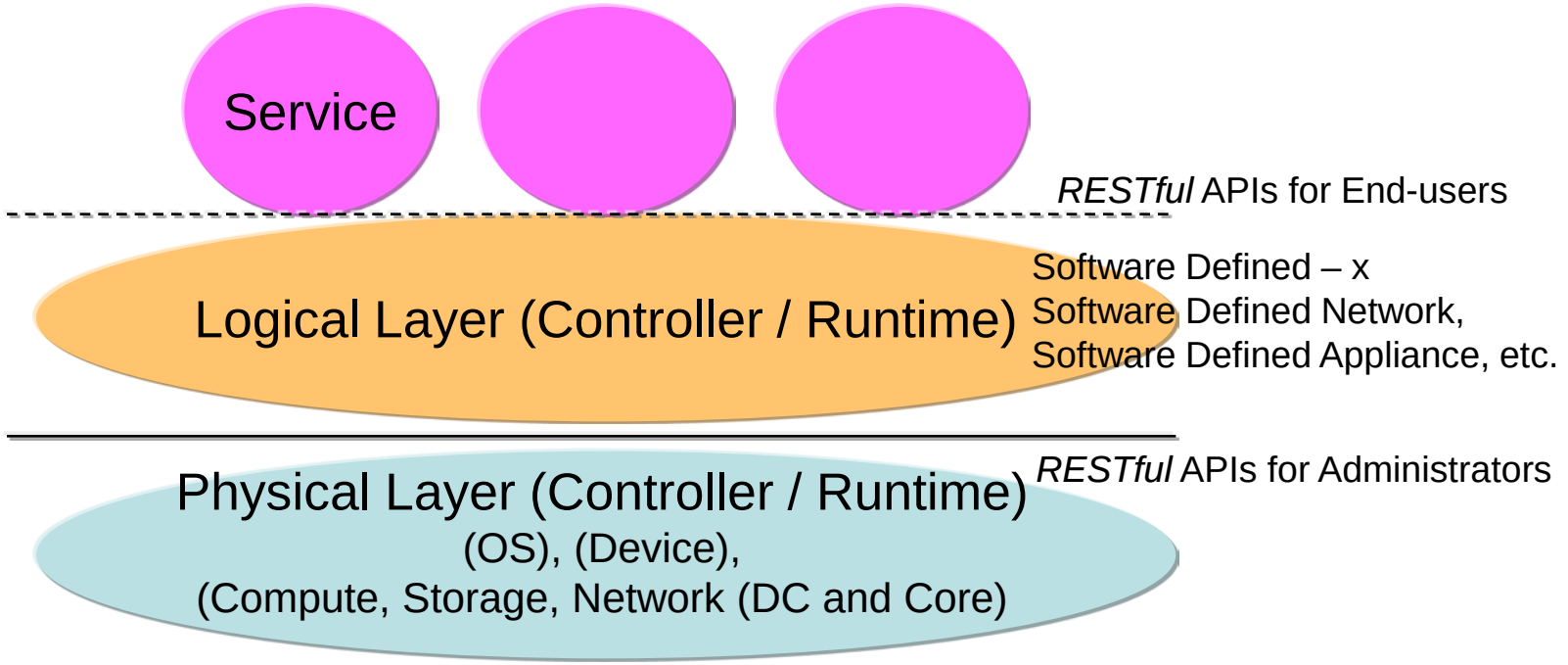
Evolution of virtualization technologies

- Advances in cloud technology, increase scope of virtualization
- On-demand (service velocity), programmable (software-controllable, operational efficiency), scale (can be migrated and extended freely)
- Computer virtualization has reached maturity, while use of storage virtualization has started (mobility has yet to be addressed)
- Cloud network virtualization is finally starting to be used (although issues still remain with regard to application range, scalability, etc.)



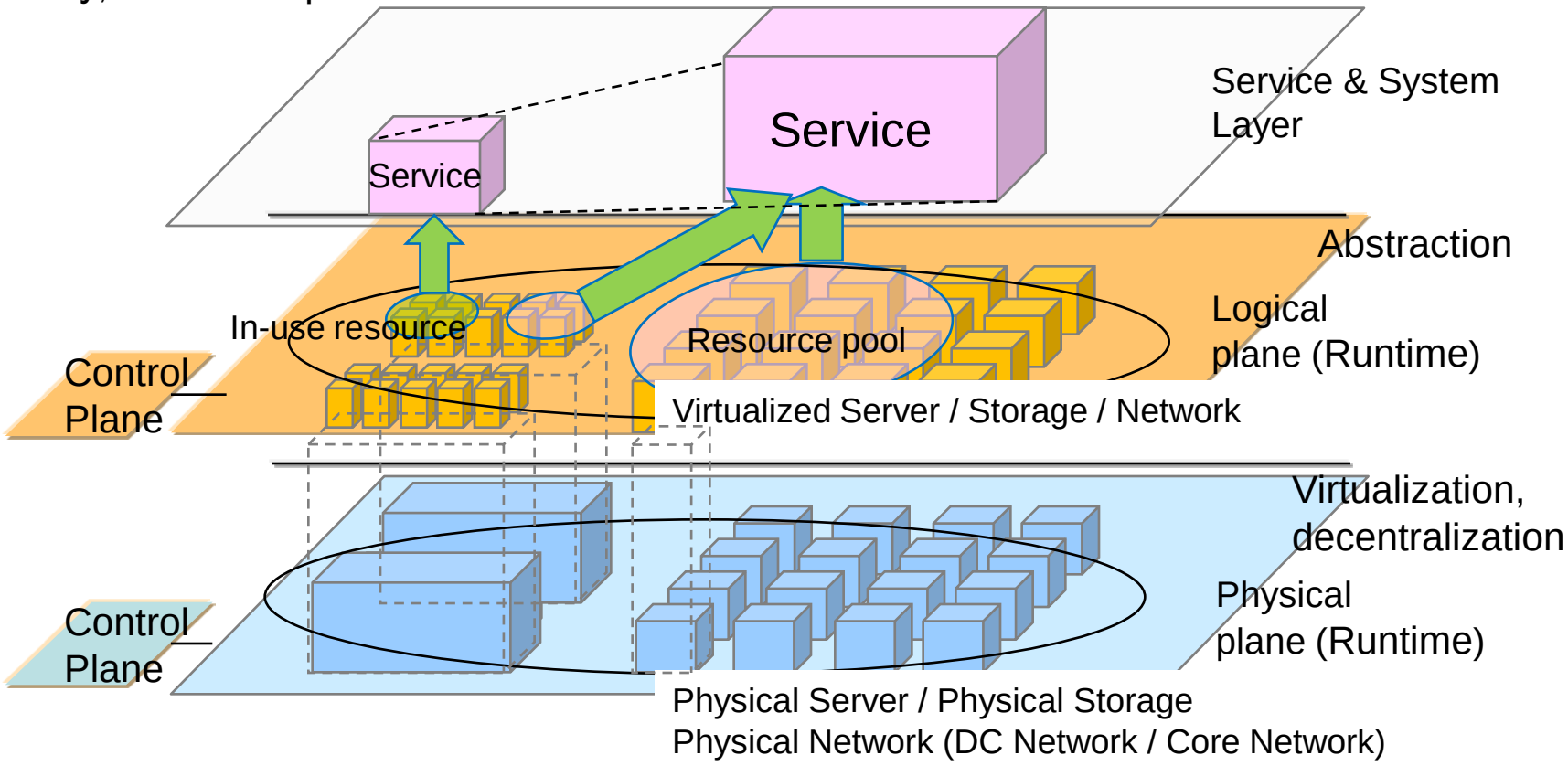
Complete layer separation

- Complete separation of physical and logical layers (Device Free / OS Free / VM Free / Network Free / …)
- ***"Adaptive x-Free Virtualized ICT Infrastructure"***



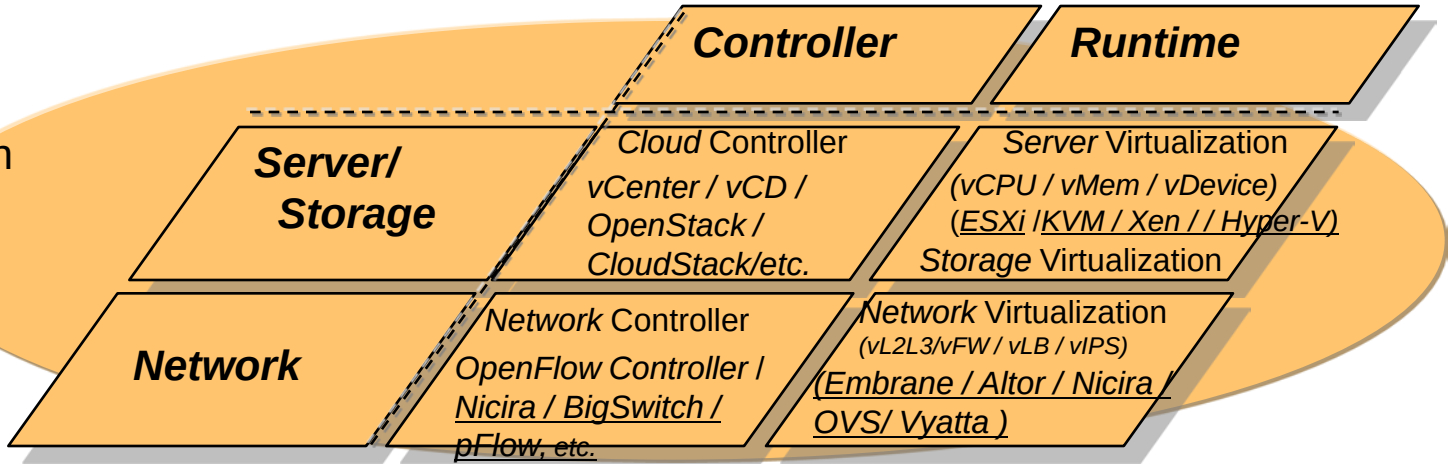
Ensuring business velocity and efficient operations

Dynamic resource management
−Cloud burst management
−Robust management
Speedy, efficient operation

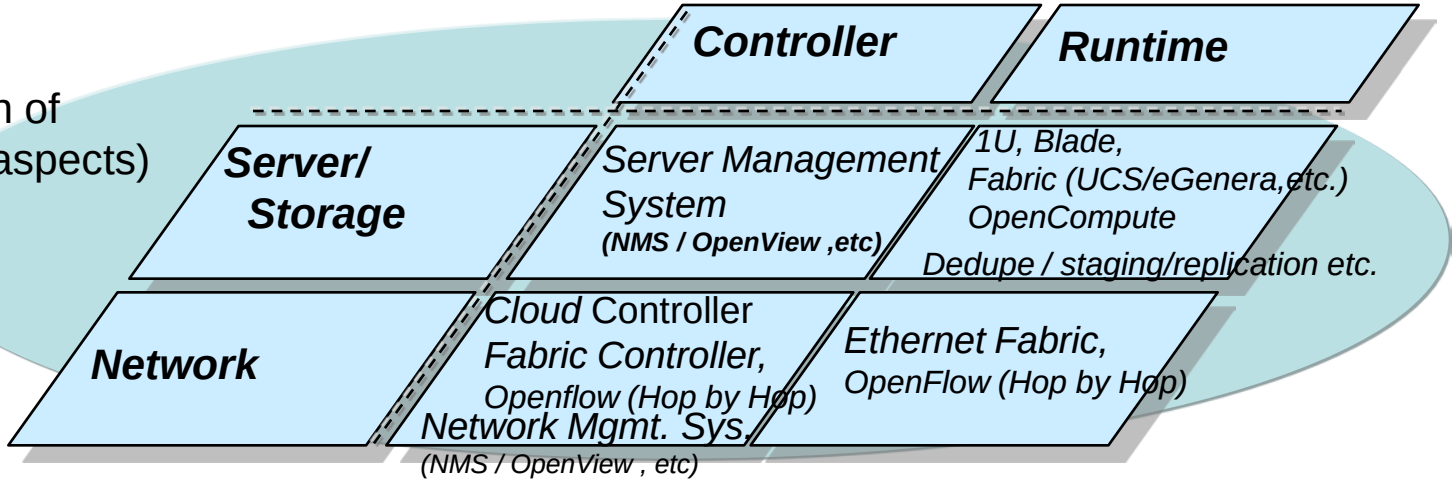


Categorization of logical and physical layer technologies

Logical layer
(implementation
of functionality)



Physical layer
(implementation of
non-functional aspects)
-Availability
-Scalability
-Performance
-Reliability

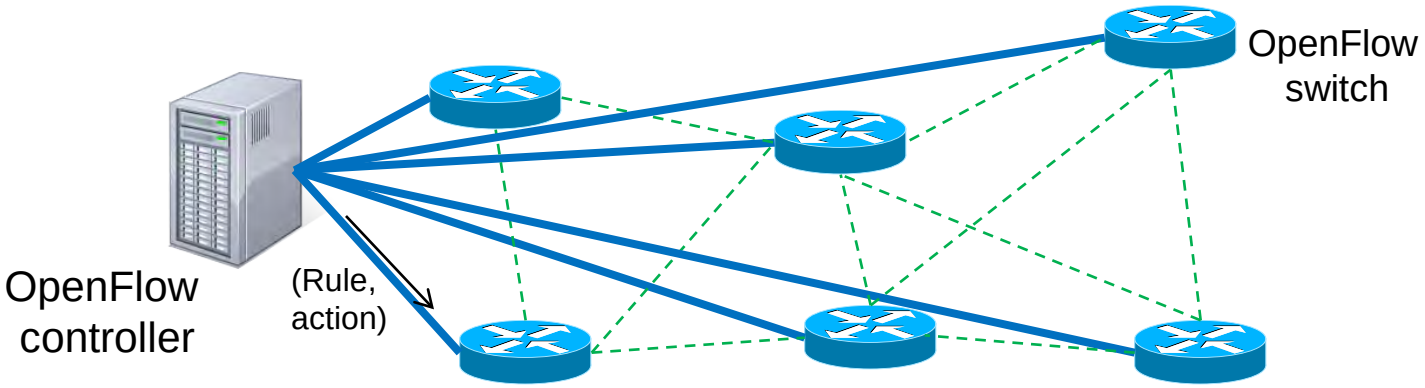


Key Technologies

- Software-Defined Networks
  - Data / control isolation, logical / physical, programmability
- Integrated Environment
  - Cloud controller – Network controller integration
- Inter-cloud Computing

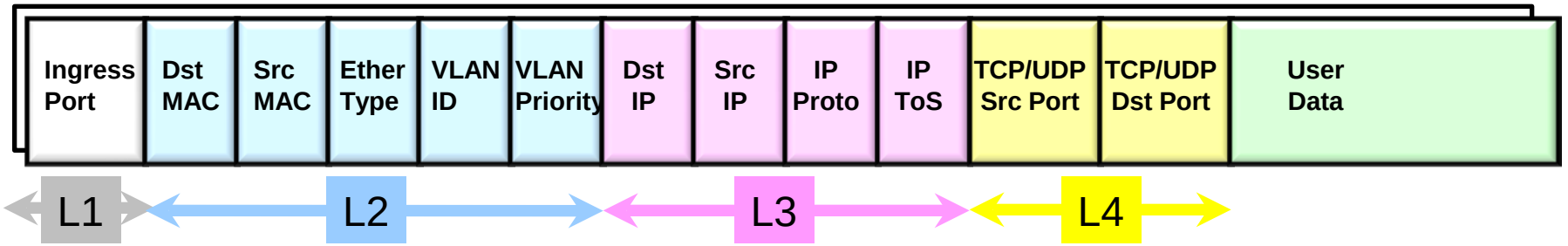
Software-Defined Network - OpenFlow

- Separation of control and data transfer
- Vendor-specific functions were hitherto implemented in hardware, but by injecting programs to generic switches, it is possible for vendors to implement their own functions on a software basis



Example rule: “If MAC address is XX, then transfer to port #○”

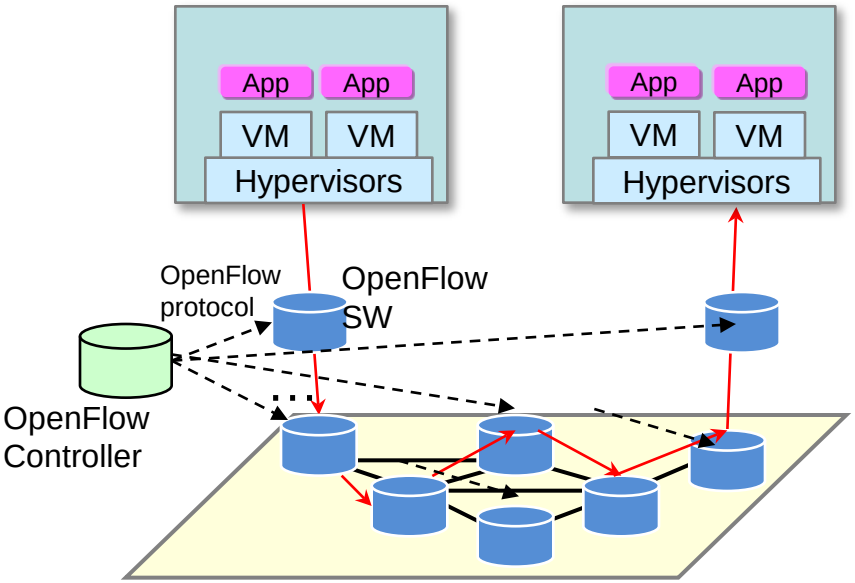
→ Routing can be performed based on MAC addresses

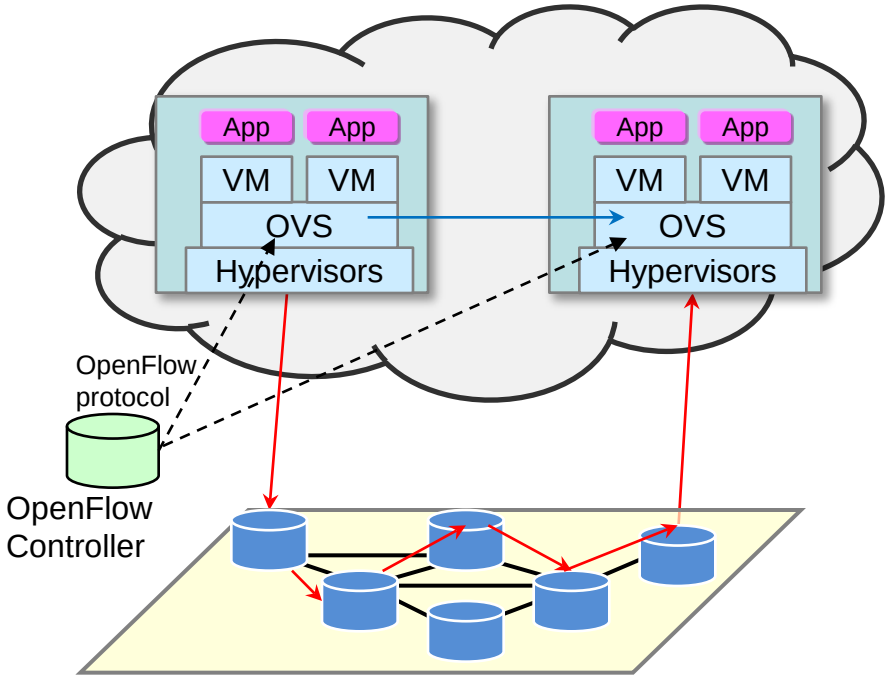


Typical uses of OpenFlow - Hop by Hop and Overlay

[Hop by Hop]
Technique to control communication flow at each node on network path.
Geared towards flexibility. Controllers can control all switches on communication path. Water bucket relay.

[Overlay]: Edge Networking for Cloud
Technique to control communication flow only at edge of network. (both ends of comm. path).
Geared towards scalability. Tunneling technologies are used to separate logical and physical layers.

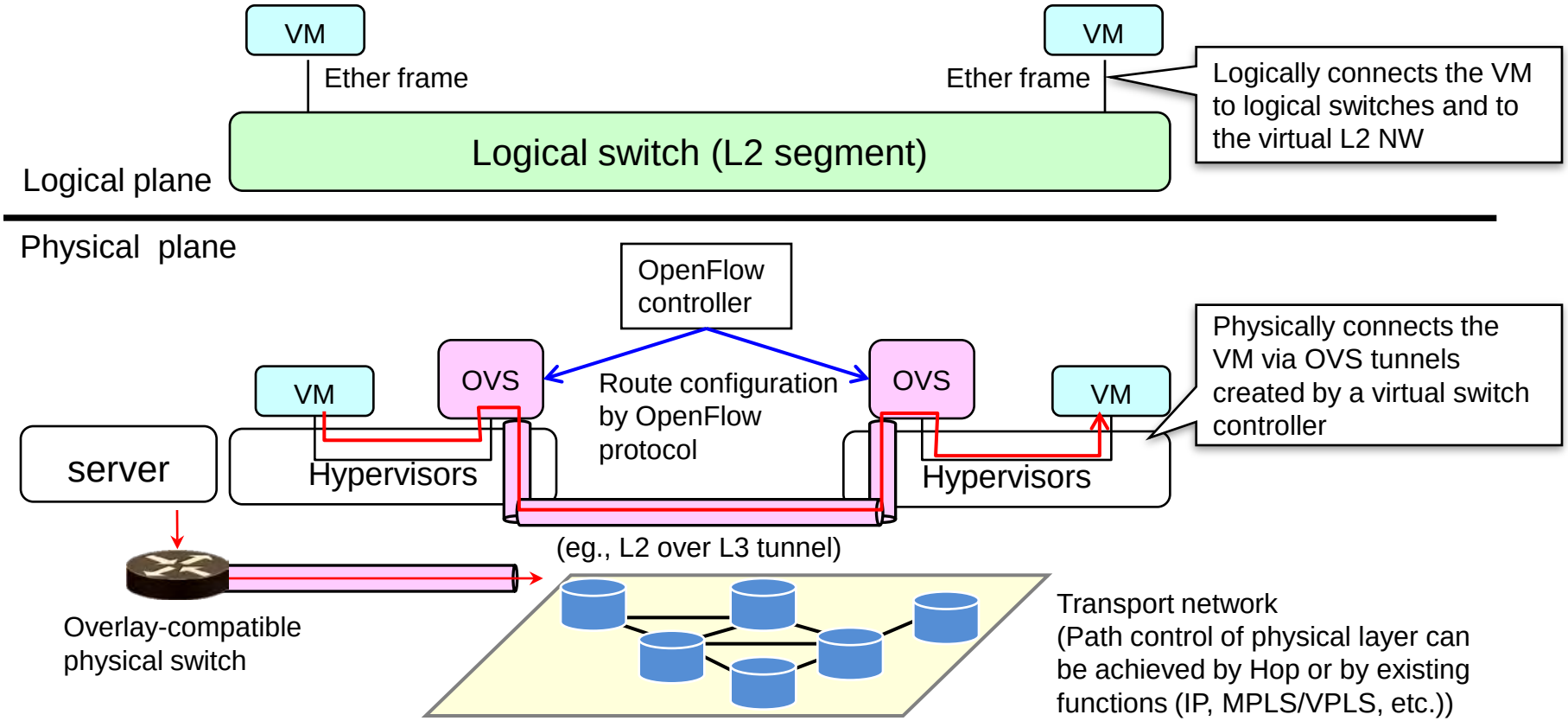




Path control of physical layer can be achieved by Hop or by existing functions (IP, MPLS/VPLS, etc.)

(Ref.) Principles of OpenFlow overlay

- Construct a logical L2 network independent from physical NWs
- The OpenFlow controller creates tunnels between virtual switches by controlling OpenFlow switches using OpenFlow protocol.
- OpenvSwitches running on hypervisors can be used as Overlay-compatible software switches. Overlay-compatible physical switches (pSwitch) can also be used.



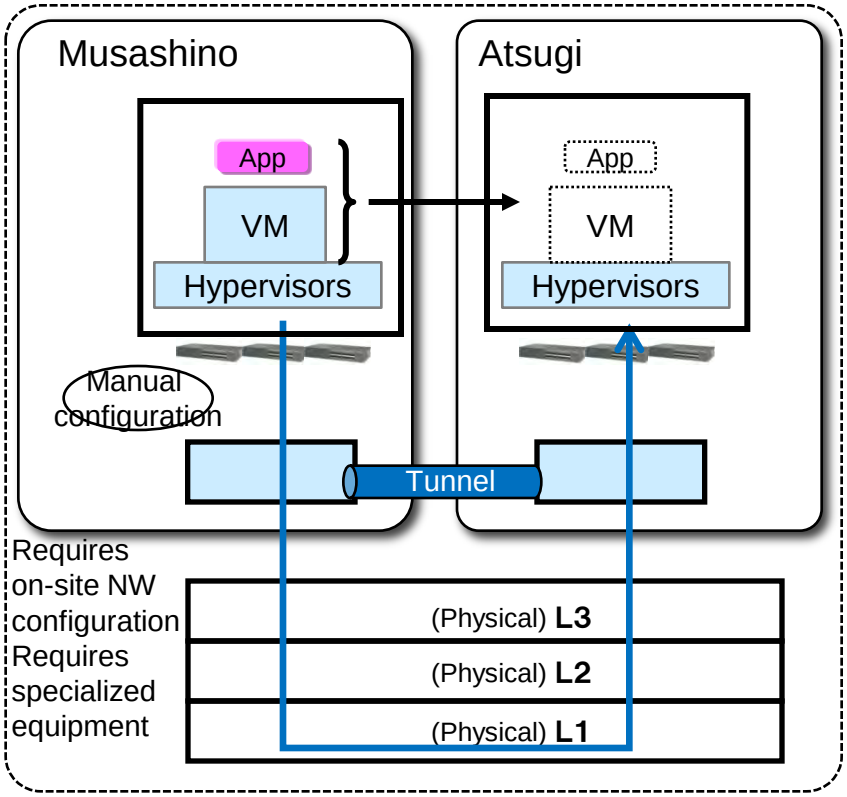
OpenFlow overlay use cases: Live migration between DCs

(Ref.) NTT PF Labs. live migration test between Musashino and Atsugi (2 August 2011)

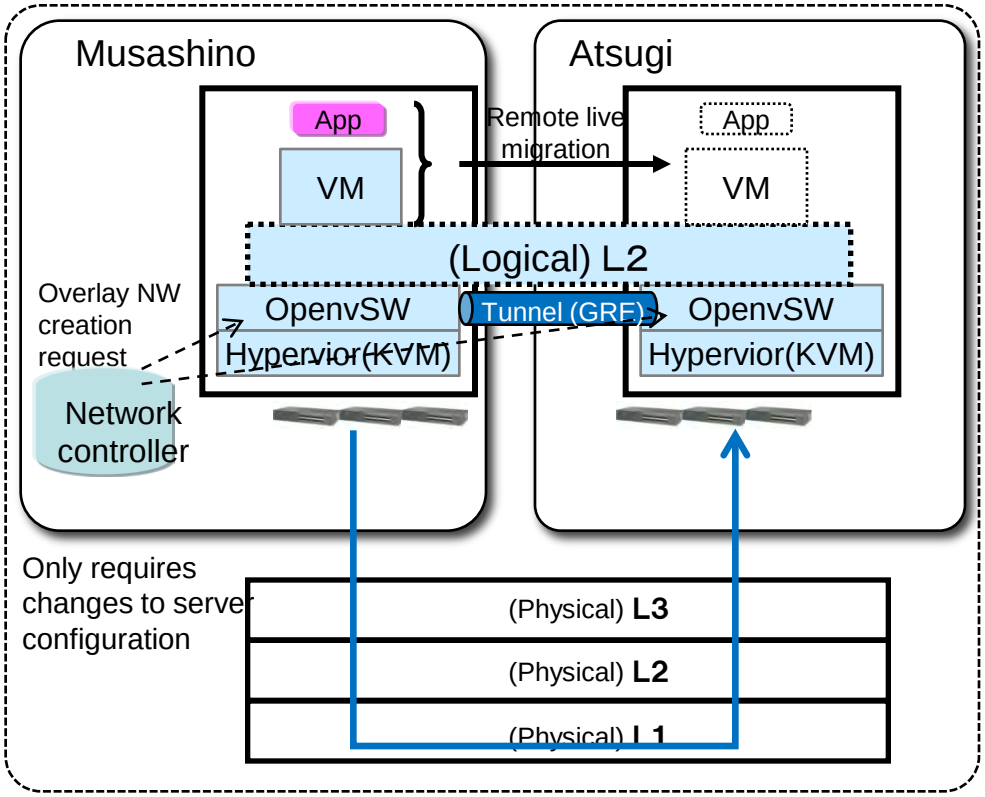
■Overlay method is not dependent on the physical network and can construct a logical network by L2 over L3 tunneling; thus can absorb differences in physical network configuration between DCs, and differences between networks of each DC.

■It can also automatically take over roles such as switch configuration on logical networks.

[Conventional remote live migration]

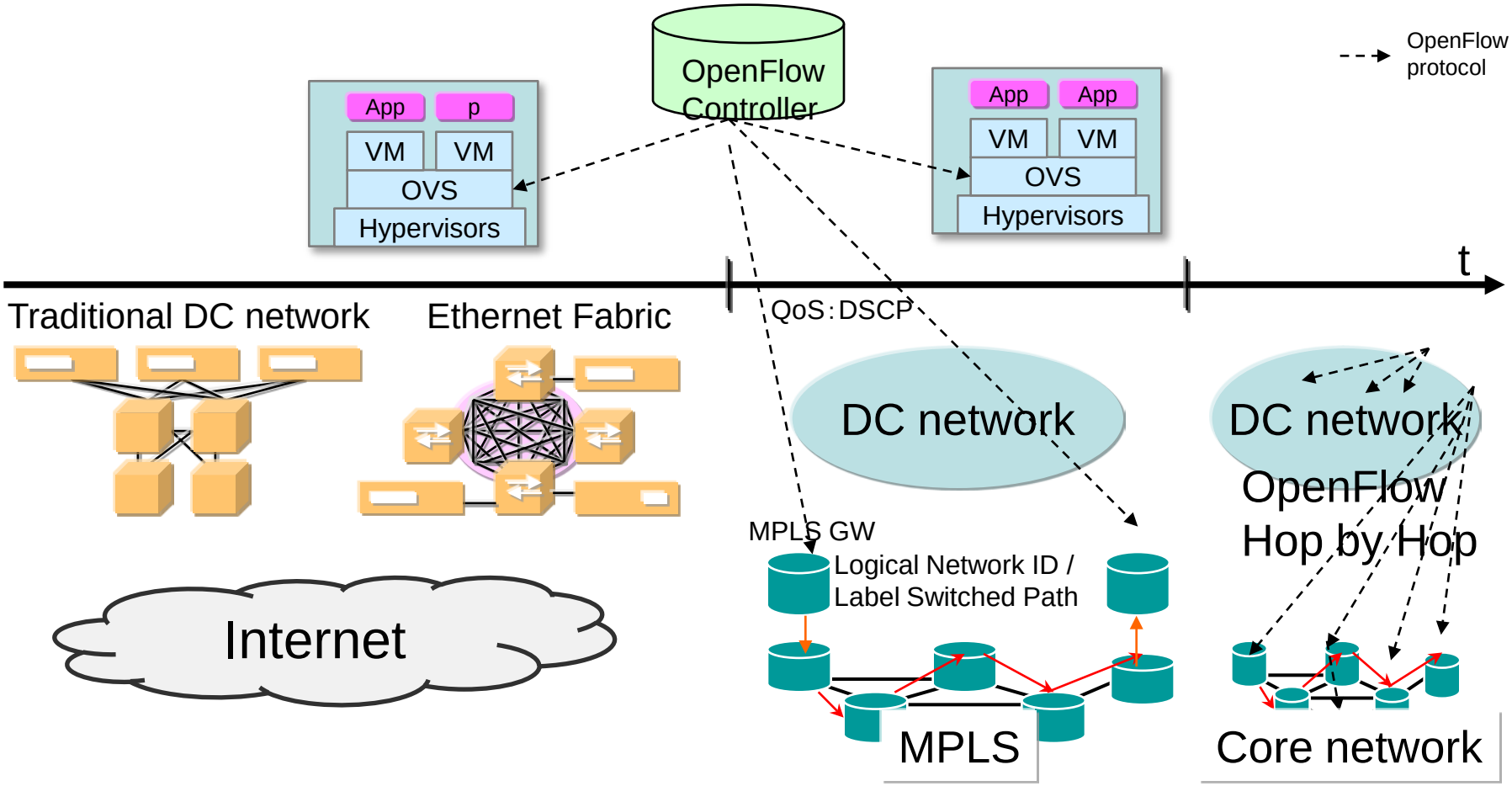


[Remote live migration based on virtual network technology]



Decoupling for the transformation
- OpenFlow overlay over core networks -

- OpenFlow Overlay over MPLS/VPLS enables QoS-guaranteed cloud access networks and DC-DC networks.



Key technologies

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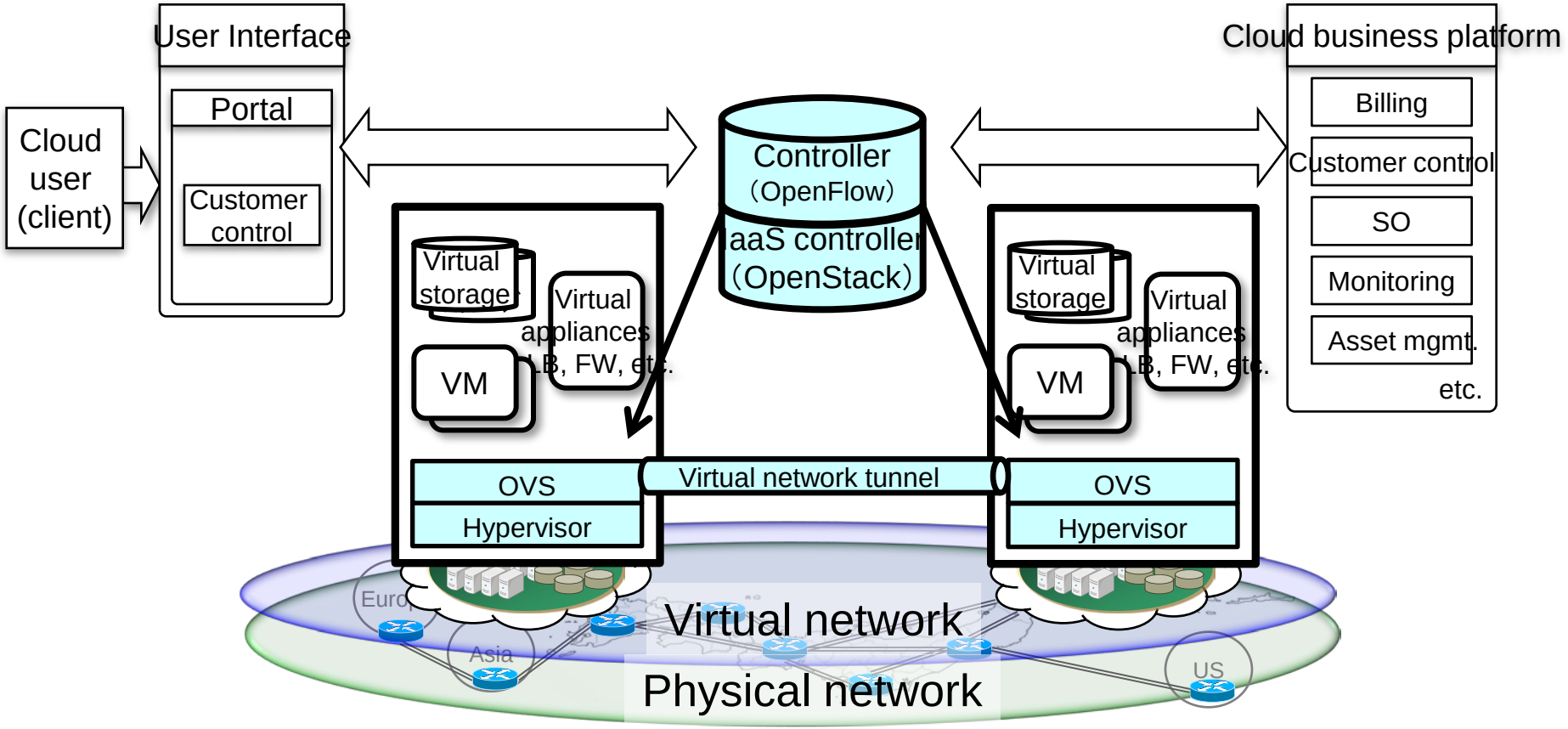
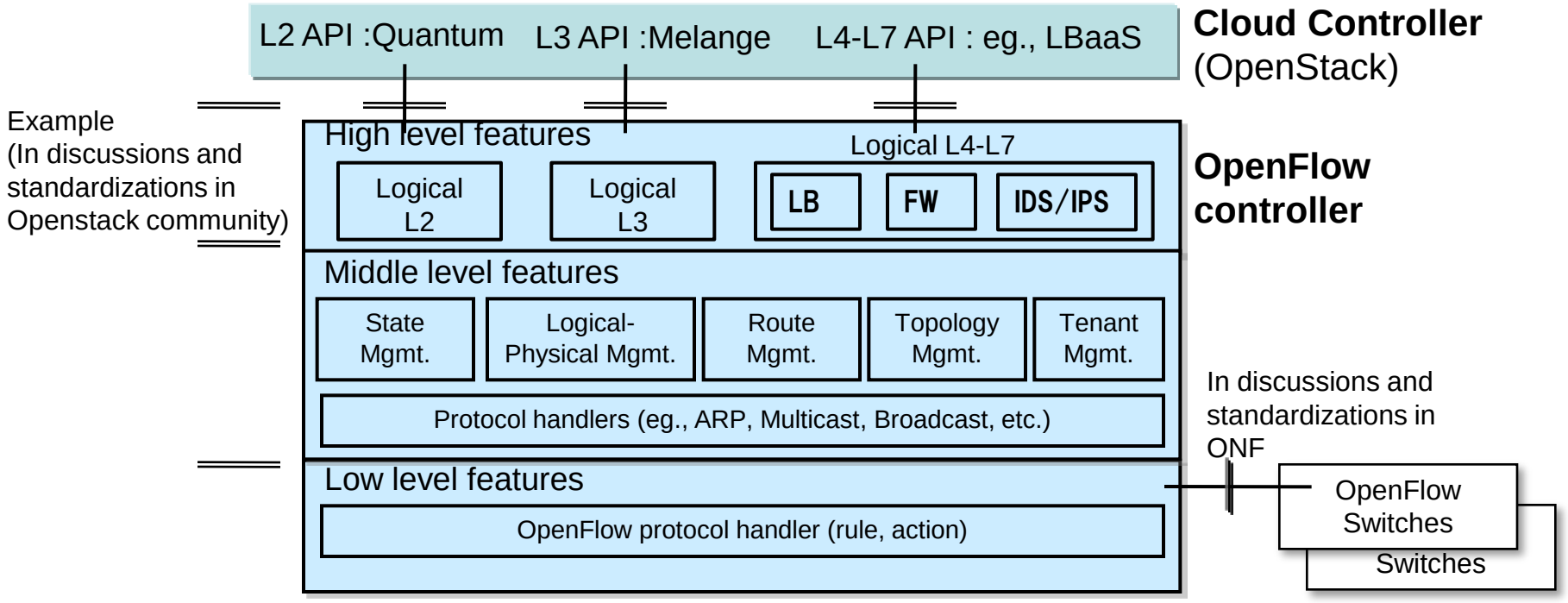
Integrated cloud-network control environment

Cloud controllers (e.g.: OpenStack) and virtual network controllers (OpenFlow (overlay type)) are integrated to cooperatively control both cloud and virtual network.



OpenFlow Controller APIs for Cloud Controller

- The APIs of OpenFlow controller can be classified into three groups.
  - Low level APIs: provide features to handle OpenFlow protocol directly
  - Middle level APIs: provide common libraries to create high level OpenFlow applications
  - High Level APIs: provide high level features to emulate existing physical appliances in the logical network such as L2 switch, routers, firewall and load balancers
- Example of OpenStack: The high level APIs are in discussion in OpenStack community. Quantum (L2) and Melange (L3) will be released as a stable version in the next Essex release in Apr. 2012.
- The controller APIs are currently vendor specific and have not been standardized yet.



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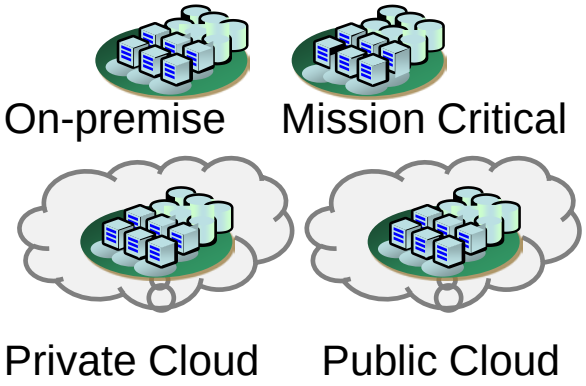
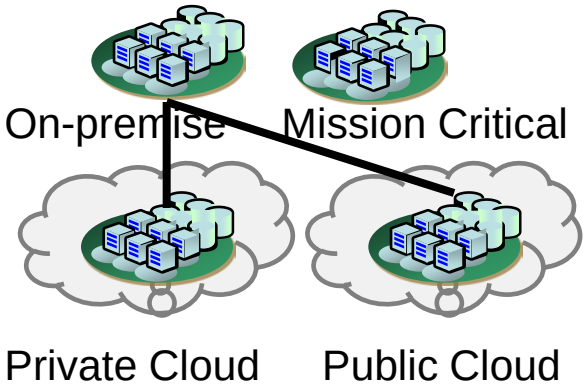
Evolution of Cloud Computing

On-Premise /
Private Cloud /
Public Cloud



On-Premise /
Private / Public /
Hybrid Cloud



On-Premise /
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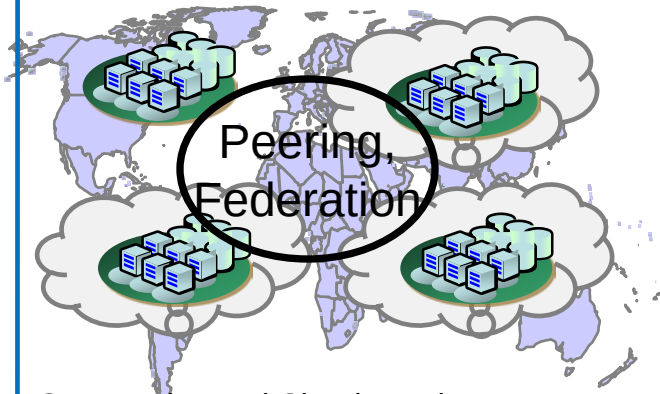

On-Premise and Cloud Peering,
Domain Orchestration(NaaS/IaaS/Paas),
Cloud Peering (Public / Private), federation,
etc.(some scenarios)

Compute / Storage / NW virtualization

Orchestration

Inter-cloud

Recent activities on inter-cloud computing

- ITU-T
  - Studying use cases, functional requirements, three types of scenarios (peering, federation, service broker) and reference architecture for inter-cloud computing at the Focus Group Cloud Computing (2010.6～2011.12).
  - SG13 established new WP and 3 Questions on cloud computing. Inter-cloud computing is one study item of this WP.
  - **GICTF** is actively contributing to Focus Group and SG13.
- IETF
  - Studying requirements, architecture and protocols for interoperability among cloud service providers.
  - Service Orchestration Protocol (SOP): Service independent protocol for service discovery, provisioning and life-cycle management.
  - Service Description Framework (SDF): Descriptions for service dependent information exchanged between clouds. Naming service, syntax / semantics, task and workflow is defined.
- IEEE
  - P.2302: Standard for Inter-cloud Interoperability and Federation (SIIF)
    - Studying inter-cloud topology, functional requirements, governance, and protocols.
  - Inter-cloud test bed
  - Inter-cloud security considerations

Summary

- Diversity of business, speed of change, globalization, and cost
- Uncertainty
  - Increasing complexity of systems and system operations
  - Wide diversity of terminals; impossible to predict winners
  - Changes in traffic
    - Migration from conventional Web, mail, P2P traffic to SNS and video, then to HTML5, short video…
- Complete layer separation (L/P, D/C, SDN, Adaptive x-Free…)
- Integrated environment (cloud controller – network controller integration)
- Inter-cloud computing, standardization (ITU-T, IETF, etc.)

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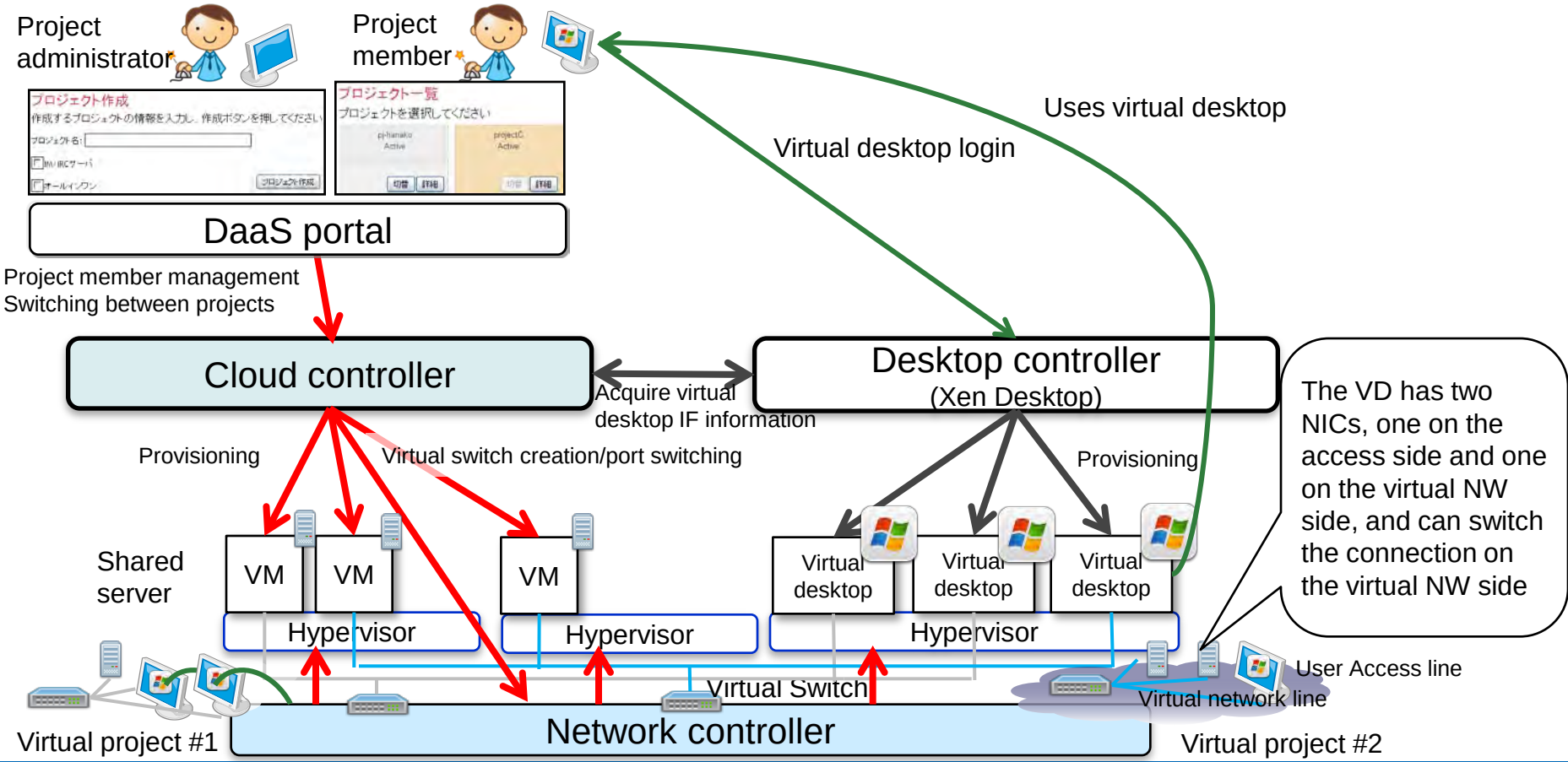
appendix

OpenFlow overlay use cases(2): DaaS with network virtualization

Integration Desktop as a Service (DaaS) with Network as a Service (NaaS)

■ Not only is terminal supplied on demand for each project, but also server environment and network environment are also supplied

■ Cooperates with cloud network desktop controller



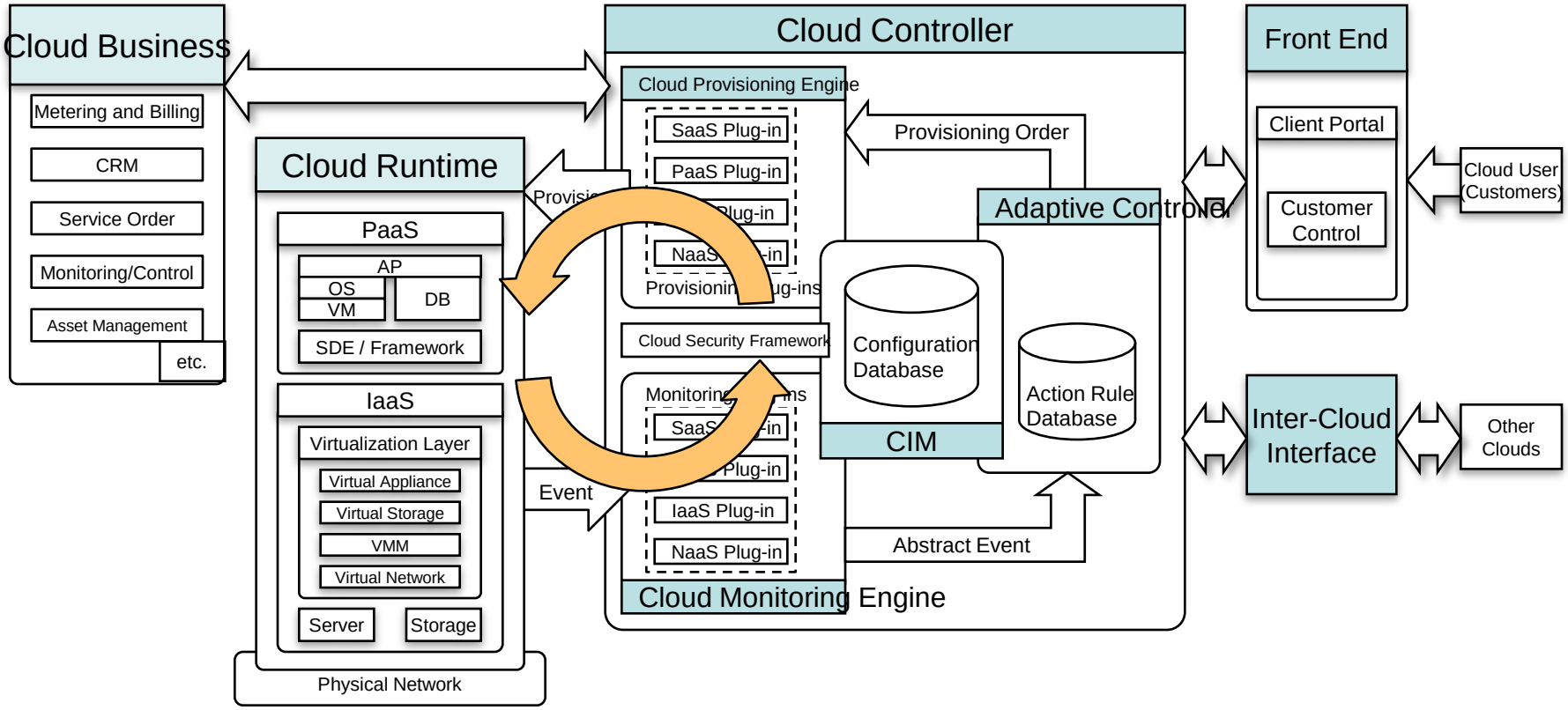
Cloud Architecture for "Adaptive x-Free Virtualized ICT Infrastructure "

Aims

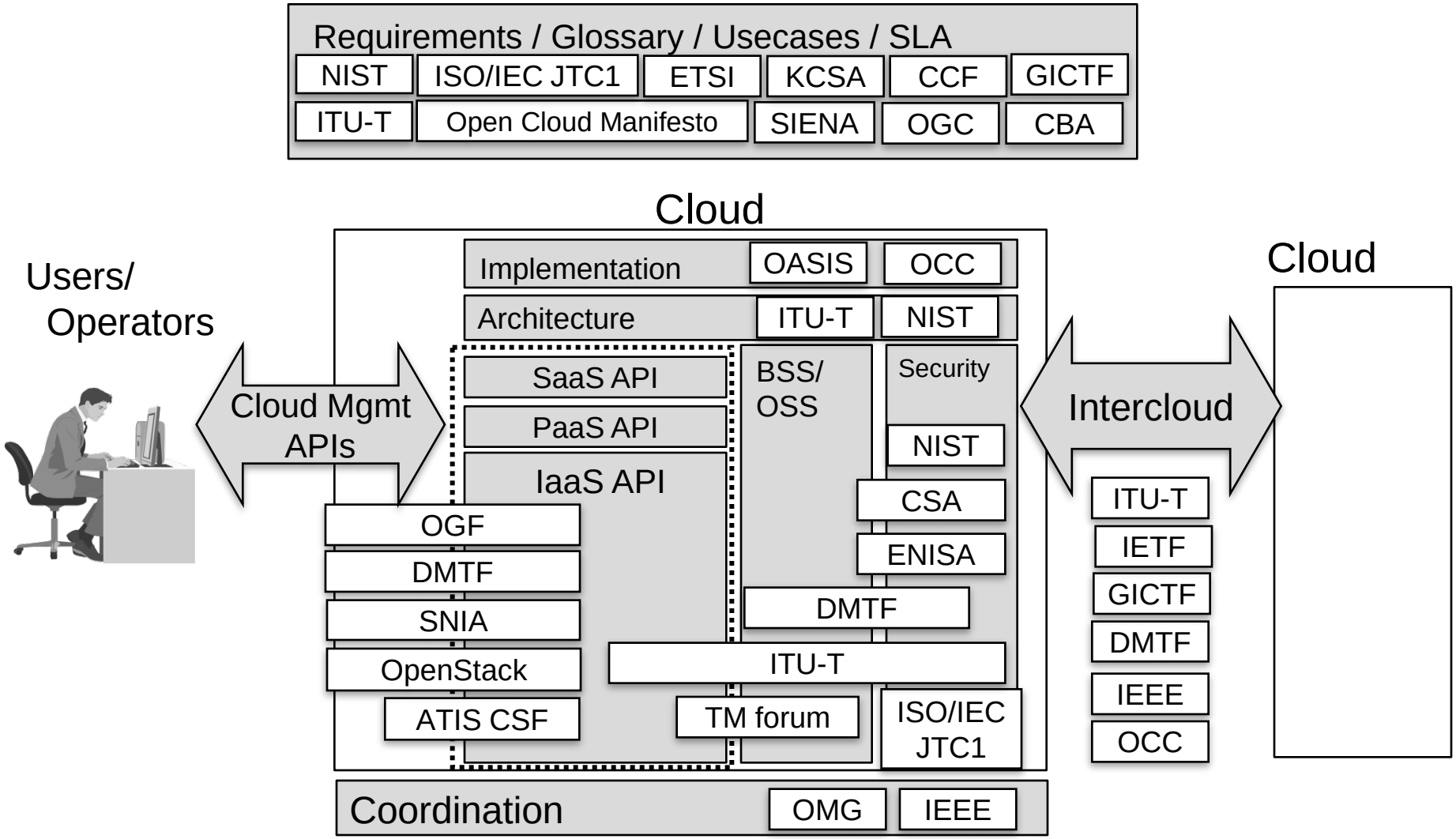
(1) To boost agility and velocity of cloud business

(2) More efficient operation (Orchestration and Auto-Scale)

(3) Unified cloud services with network



Standardization of cloud computing



Global Inter-Cloud Technology Forum

- Promote international standardization of “inter-cloud” interface through industry-academia-government collaboration and cooperation with standards bodies

GICTF

OGF DMTF distributed management task force, inc. SNIA siena Standards and Interoperability for eInfrastructure implemeNtation initiAtive

ITU IEEE openstack NIST

http://www.gictf.jp/index_e.html