Overview of Y.3011: “Framework of network virtualization for Future Networks”

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Scope

- Scope of the Recommendation
  - Definition
  - Overview and motivation
  - Problem spaces
  - Design goals
  - Applicability of network virtualization
  - And use cases in Appendix

- Why network virtualization for FNs?
  - Key functional features for realizing FNs objective, Service awareness
  - Key technology for FNs design goals; service diversity, functional flexibility, virtualization of resources

Our problem statement:

Why network virtualization is necessary?

- The current network architecture is under serious reconsideration and people started thinking about alternatives
  - Redefining network architecture requires many challenges
  - Difficult to drastically change the basic architecture of large scale networks
    - Enormous amount of resources are required to build, operate, and maintain them
  - It is difficult to foresee all the user demands that may arise in the long term future
- It's necessary to support a variety of the new different architectures to accommodate the heterogeneity of future networks
  - Network architecture should be designed to flexibly adapt the continuous changing requirements about networks

What is common means?

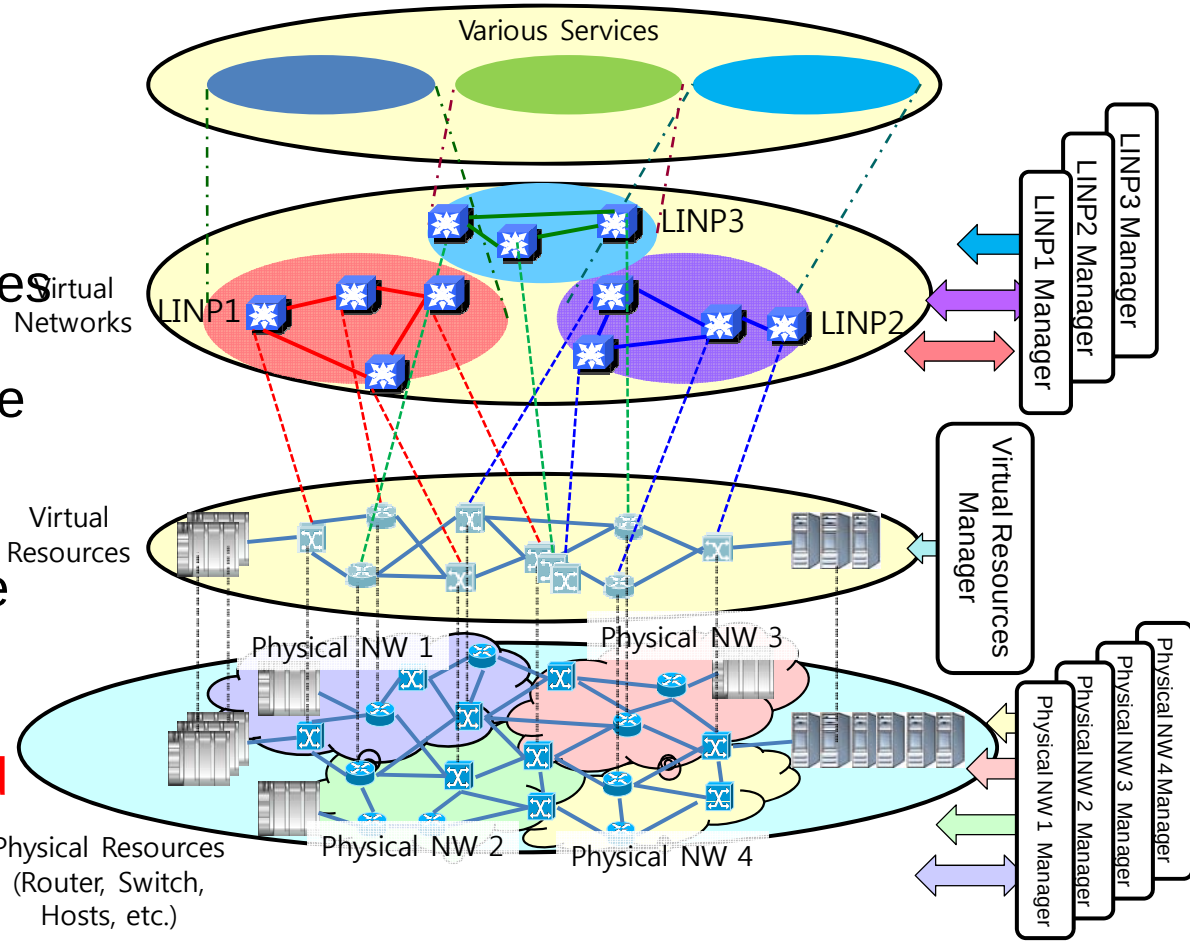
- A common means should be provided to accommodate the new heterogeneous architectures and innovative researches in a shared infrastructure
- Common means: set of virtual networks
- A network that is composed of multiple virtual resources which is isolated from other virtual networks
  - Virtual resource: an abstraction of physical or logical resource and its partition that inherit existing characteristics of physical resource
  - Programmability
  - Aggregation or federation with other virtual networks

Network virtualization definition

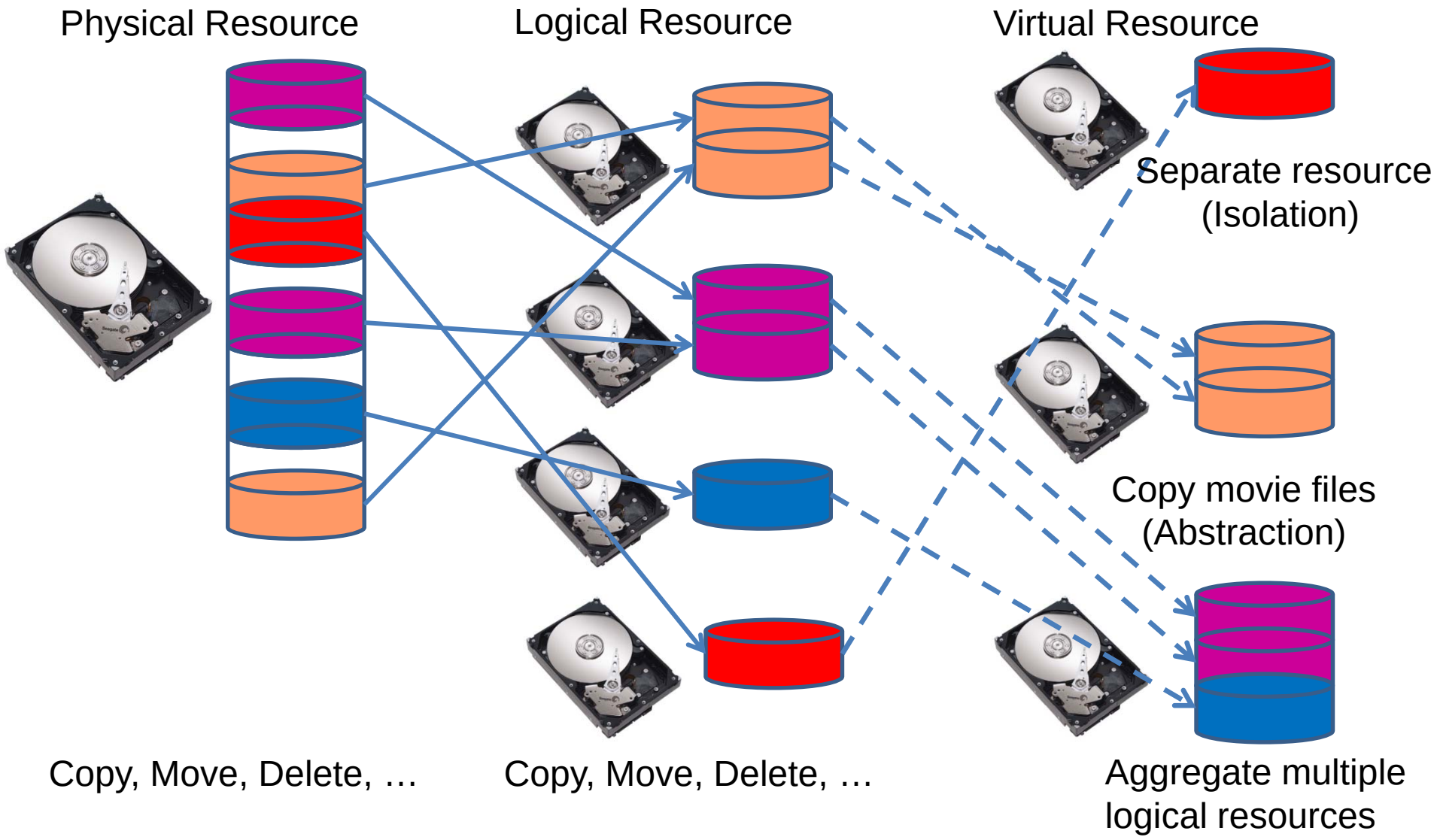
- A technology that enables the creation of logically isolated network partitions over shared physical networks so that heterogeneous collection of multiple virtual networks can simultaneously coexist over the shared networks. This includes the aggregation of multiple resources in a provider and appearing as a single resource.

Concept of network virtualization

- Network virtualization is required to be capable of providing multiple virtual infrastructures those are isolated from each other
- The virtualized infrastructures may be created over the single physical infrastructure
- Each virtual network is isolated each other and is programmable to satisfy the user's demand on the functionality and amount
- User's demand is conveyed to VN manager which is required to coordinate infrastructures so that appropriate network resource is provided to the user

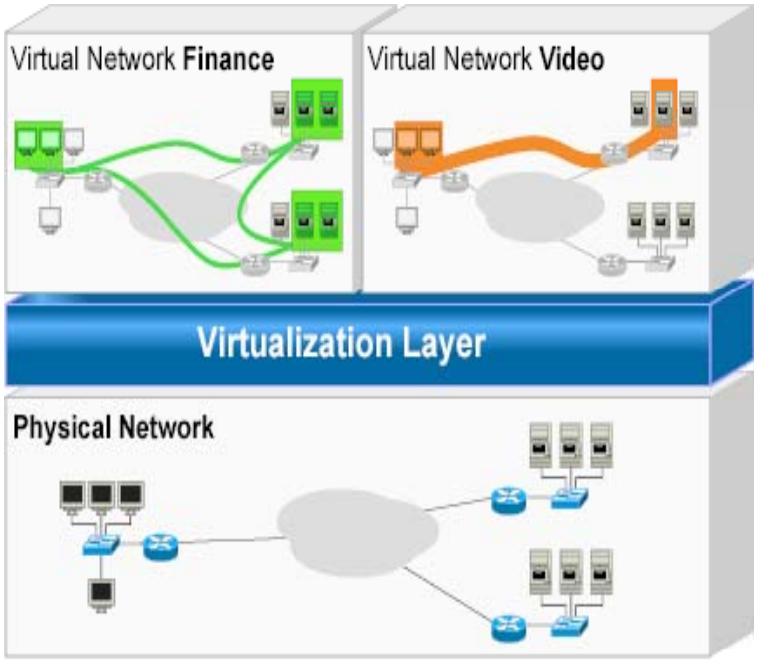


Virtual resources



Virtual networks

- Virtual networks
  - Partitioning network into multiple sub-networks
  - Used within a single domain or across multiple, independently managed domains
  - Increasing application performance by dynamically maximizing network asset utilization while reducing operational requirements



Some definitions…

- Logical resource: an independently manageable partition of a physical resource, which inherits the same characteristics as the physical resource and whose capability is bound to the capability of the physical resource.
- Virtual resource: an abstraction of physical or logical resource, which may have different characteristics from the physical or logical resource and whose capability may be not bound to the capability of the physical or logical resource.
- Logically isolated network partition (LINP) (Virtual Network): A network that is composed of multiple virtual resources which is isolated from other LINPs.

Key properties of virtual network

- Partitioning: each resource can be used concurrently by multiple VN instances
- Isolation: the clear isolation of any VN from all others
- Abstraction: in which a given virtual resource need not directly correspond to its component resources
- Aggregation: aggregate multiple instances to obtain increased capabilities

Key components for virtual network

- The key components of VNs include traditional network resources, such as hosts, routers, switches, links, etc. and virtual resources
  - Virtual resources: same mechanism as physical resource and inherit all existing mechanisms and tools for physical resource

- Additional components: methods for creating and managing the VNs

What are virtual networks used for?

- Same purposes as non-virtualized networks without interfering the operation of other virtual networks while sharing the key components among virtual networks
  - Coexistence of multiple VNs
    - Different VNs may use different network technologies without interference
    - Increase utilization
  - Can provide normalized set of interfaces and make it easier to provision VNs
  - Can support seamless migration/update of VNs

Acid tests for virtual network

- Control isolation: each virtual networks need to be separately configured and managed
- Access control and virtual network labeling: virtual resources should be able to uniquely identify virtual networks and enforce access control for users and applications
- Virtualization of address and port ranges: translation of virtual address into internal physical address at ingress/egress point of physical resource
- Regulation of resource usage: regulate the upper limit of resource consumption by each virtual network in order to maintain the overall utility and performance

Problem spaces of network virtualization

- Coexistence of multiple networks
  - Isolation of VNs, minimize the impact to other networks, and support diversity of application, service, network control, management, and architectures
- Simplified access to resources
  - Abstraction of physical resources' characteristics
  - Guarantee compatibility for accessing and efficient control for virtual resources
- Flexibility in provisioning
  - Quick reconfiguration of VNs to enhance adaptability to status changes
  - Adding or aggregating additional logical resources to a virtual resource to provide increased throughput with less cost than adding physical resources
- Evolvability
  - Build logically separated testbeds by allocating securely isolated LINPs to the logically isolated testbeds for the experimental purpose
  - Integrate legacy support by allocating the existing networks to LINPs. The LINPs will ensure the existing services and technologies can remain unchanged

Design goals of network virtualization (1/2)

- Isolation: isolation among the LINPs
  - Security isolation, performance isolation, etc.
- Network abstraction : allows hiding the underlying characteristics of network resources from the way in which other network resources, applications, or users interact with the network resources and establishing simplified interfaces for accessing the network resources
  - Allows selective exposure of key network functionalities in networks by defining of abstraction level
- Topology awareness and quick reconfigurability: update of LINP's capability needs to be done dynamically and without interrupting the operation of the current LINP

Design goals of network virtualization (2/2)

- Performance: how to reduce the performance degradation caused by virtualization layer or adaptation layer
- Programmability: programmable control plane and data plane so that users can use customized protocols, forwarding or routing functions in the LINP (flexibility)
- Management: how to provide independent management functions for each LINP
  - Manage both virtual and physical resources, interaction,…
- Mobility: movement of virtual resources including users and services
- Wireless: consider some unique characteristics such as limited resource usage, signal interference

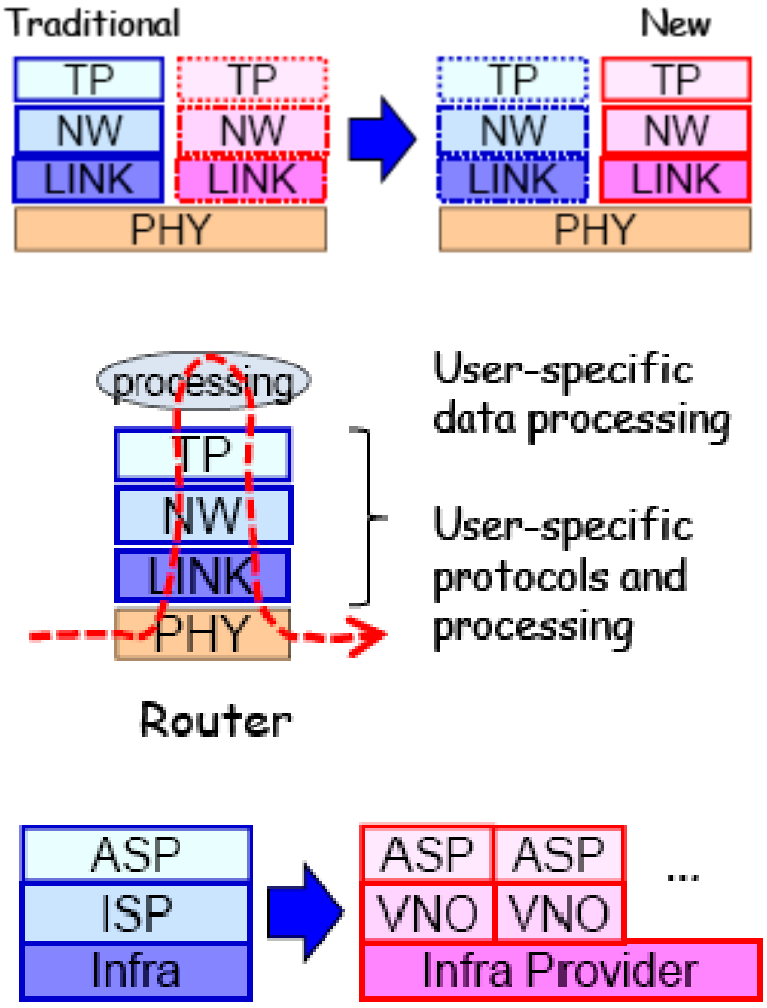
Benefits of network virtualization

- Goal
  - Infrastructure technology for diverse services, service programmability (independently customizable), architecture diversity
  - To reduce total cost by sharing network resources while still maintaining secure separation

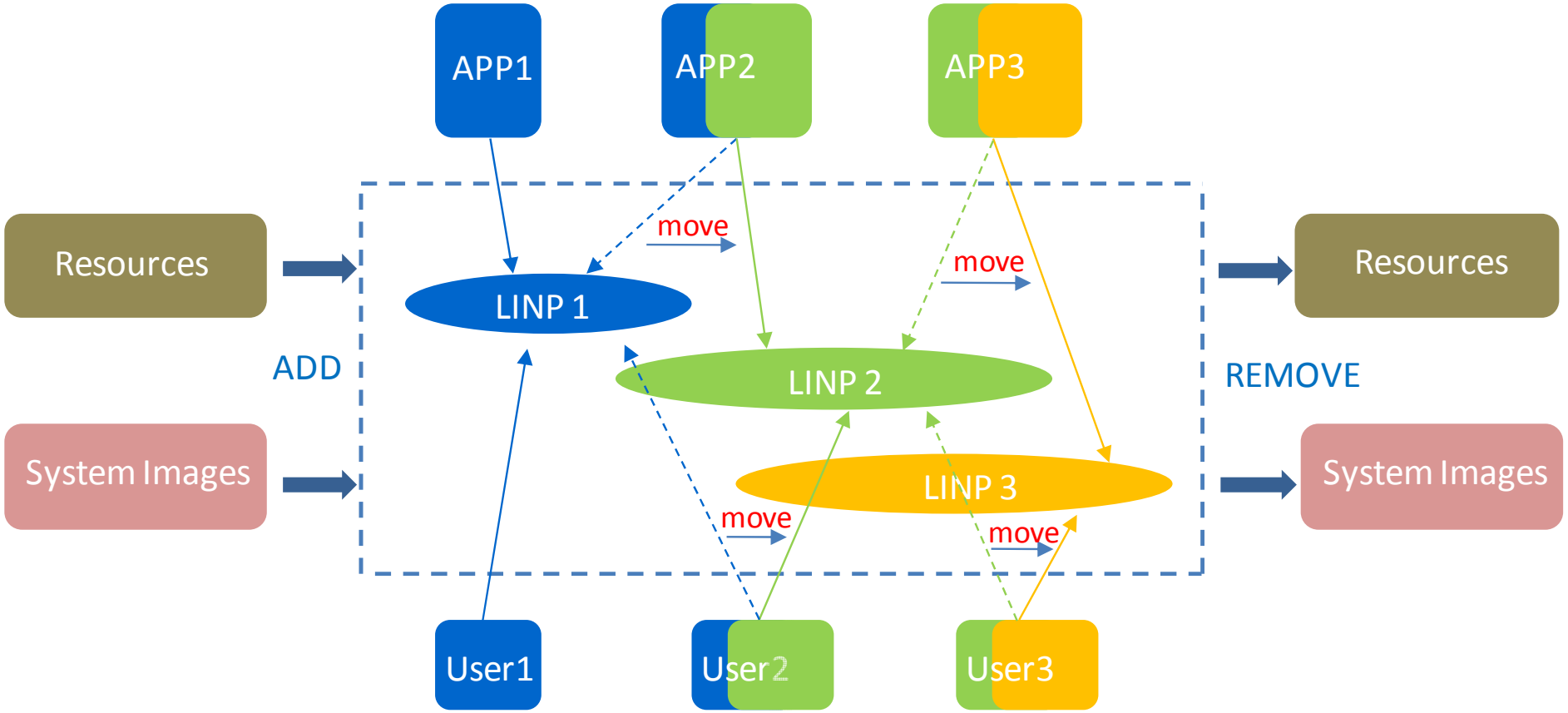
- It helps on de-ossifying the current network architectures
- It allows multiple virtual networks to coexist over a shared physical infrastructure
- It provides paths to the future networks approaches
- It allows the deployment of new business roles and players
- It reduces/shares cost of ownership
- It optimizes the resource (network infrastructure) usage

Use cases of network virtualization - evolution & virtual operator -

- Migration to new network architecture
  - Enable co-existence of traditional and new network architecture
  - Sustainable network architecture
- Innovation platform
  - Users can freely embed novel functions, protocols, or services into the routers
- Potential for new service and business model
  - VN Operators (VNO) can provide a unique network without physical infrastructure

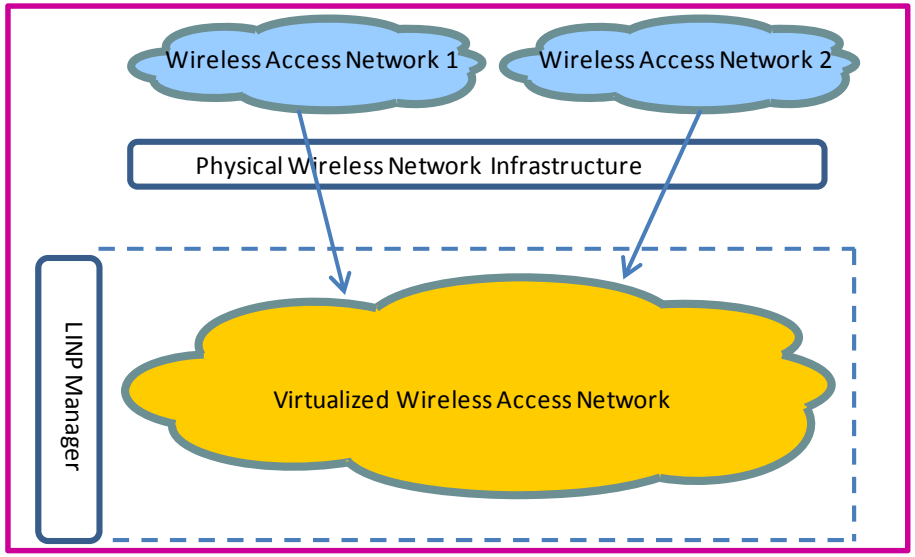


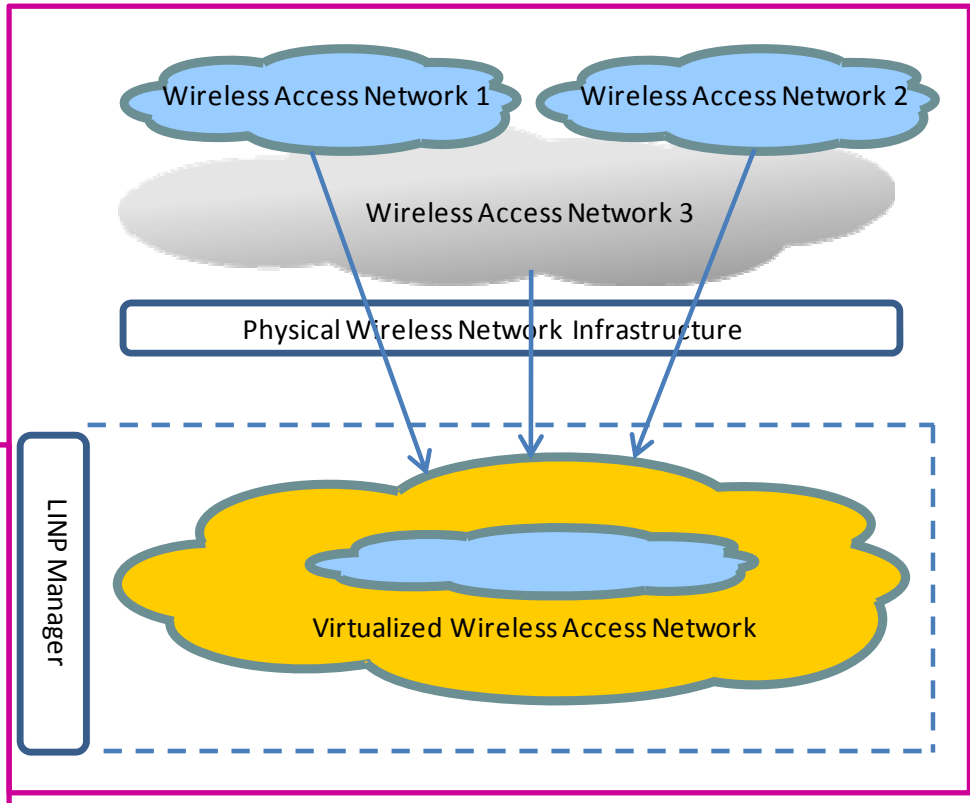
Use cases of network virtualization - mobility in virtual network -

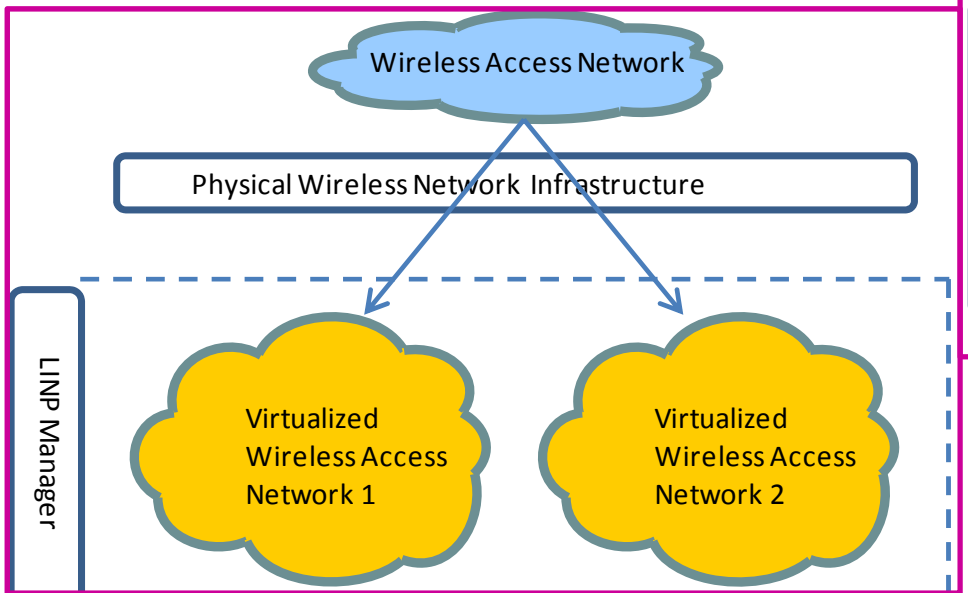


- Relationship between VNs and network elements

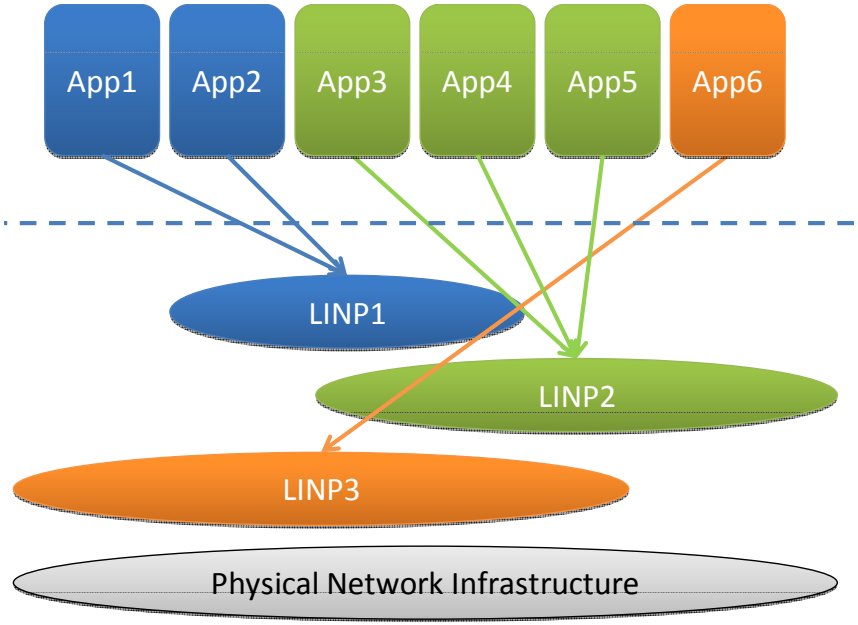
Use cases of network virtualization
- wireless access network virtualization -

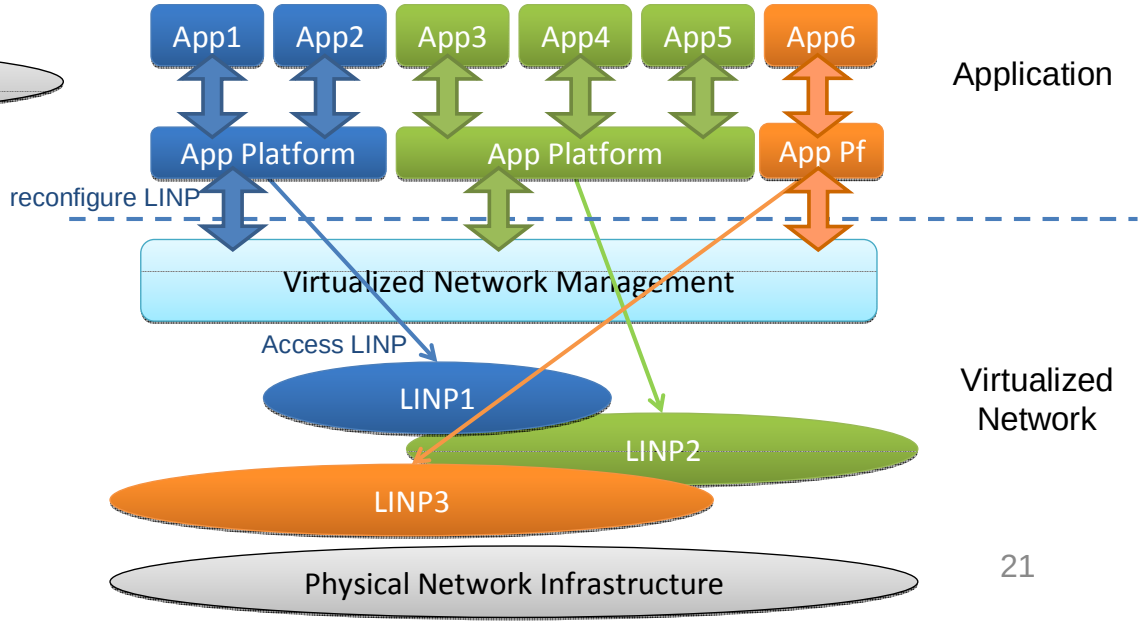






Use cases of network virtualization
- on-demand provision of VNs -





Conclusions

- Network virtualization is a key technology for realizing network optimization in data centers environment
- Research topics
  - Network resource discovery & allocation
  - How to support virtualization in network equipment
  - Baseline network/application model
  - Trust relationships model
  - Data center/cloud based applications
  - Key interfaces and their functionality
  - Responsiveness to application/network interaction