Network Virtualization from P2P Perspective

Mosharaf Chowdhury

Outline

1. What — is Network Virtualization ?
2. Why — P2P concepts might be useful ?
3. Where — can we use those concepts ?
4. How ? — Now, that's a good question.

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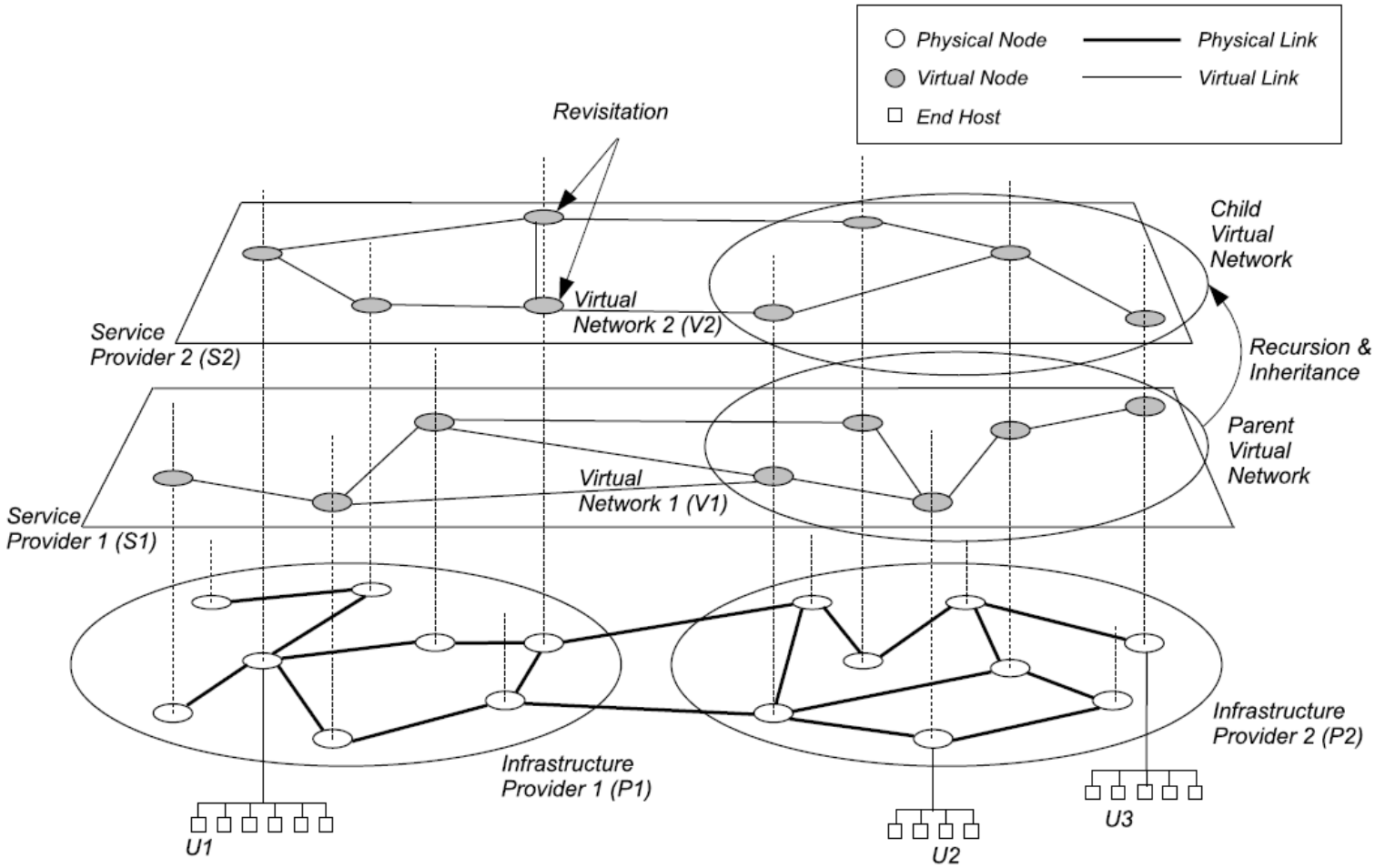
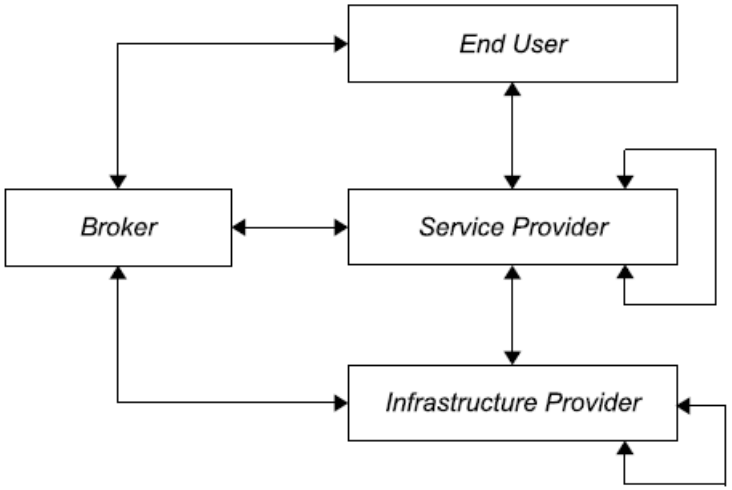
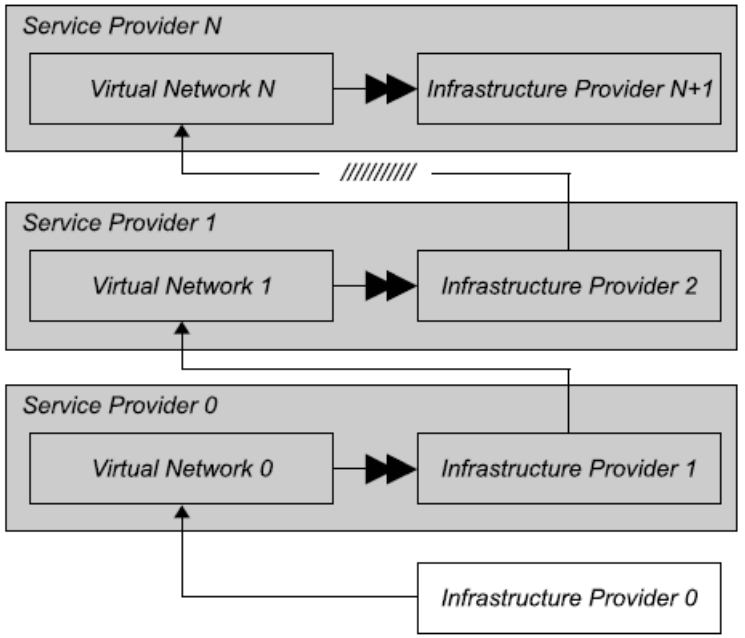
Network Virtualization Architecture [7]



Network Virtualization Business Model [7]



(a) Relationship between players



(b) Hierarchy of roles

Design Goals [7]

- **Flexibility**
  - Customized VN topology, routing, and forwarding functions etc.
- **Manageability**
  - Clear separation of management between SPs and InPs
- **Scalability**
  - Coexistence of multiple VNs
- **Security and isolation**
  - Every VN is isolated and secured from others
- **Programmability**
  - Of network elements
- **Heterogeneity**
  - Of underlying networking technologies, and deployed VNs
- **Experimental and deployment facility**
- **Legacy support**

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Advantages of P2P [8]

- **Improved scalability/reliability**
  - No single point of failure
  - Resource discovery and search algorithms
- **Dynamism**
  - Resources enter and leave the system dynamically
- **Interoperability**
  - Aggregation of heterogeneous resources
- **Increased autonomy**
  - Independence from servers
- **Anonymity/privacy**
- **Cost reduction**
  - Through cost sharing
- **Customizability**

References

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Resource Trading / NV Economics

- SPs must buy/lease resources from multiple InPs to create *basic* end-to-end VNs
- SPs might also depend on other SPs to create *compound* VNs

- **Market infrastructure requirements** [13]
  - *Functional*
    - Allow multiple SPs and InPs to trade resources
    - On-demand and in-advance trading
    - Support reselling
  - *Performance*
    - Economically efficient allocation of resources
    - *Robust* against individual failures, and attacks
    - *Scalable* up to a large number of participants

Resource Trading / NV Economics (Contd.)

- **PeerMart** [10, 13]
  - Fully decentralized, double-auction based P2P market for VN *bandwidth* trading
  - Agents from each party create a *structured* overlay to create the market
- **FairPeers** [14]
  - Micro-payment based fair economic model
  - Modularized approach
- Bocek *et al* [12]
  - Introduced *CPU time* as a scarce resource in P2P-based distributed DNS system

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Interaction Between SPs and InPs

- Different forms of interactions
  1. SP ↔ SP
  2. InP ↔ InP
  3. SP ↔ InP
  4. SP ↔ Customers

- Studied in the context of P2P overlays
  - Interaction between multiple overlays [16, 17]
  - Interaction between overlays and underlays [15, 18, 19]
  - Tussle between multiple ISPs with shared overlay [20]
  - Strategies to improve routing performance of overlays as well as underlays [15, 18, 21]

- Game theoretic, heuristics and approximation algorithm, Linear programming, and finally, empirical analysis

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Dynamism in NV Environment

- **Macro Level**
  - Connect multiple smaller VNs to create larger end-to-end VNs
  - Aggregate VNs providing basic services to create composite services
  - Concepts of hierarchical P2P and DHT systems might be useful [22-30]
  - Level of dynamism: Low

- **Micro Level**
  - Dynamic *join* and *leave* operations, as in P2P networks, of virtual nodes will simplify VN creation, operation, and management
  - Migration of virtual machines, and virtual routers across LAN, MAN, even WAN is now reality [31-37]
  - Use of *migration* as an integral part of NV environment will ease management tasks [36]
  - Level of dynamism: Moderate

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More P2P Concepts in NV Context

- **P2P-XBone** [38]
  - Introduce self-organization, fault-tolerance, and content-based routing to virtual IP networks
- **Virtual Ring Routing (VRR)** [40, 42]
  - DHT-based intra-domain routing protocol implemented *directly* on top of link layer
  - Location independent address
- **Routing on Flat Labels (ROFL)** [41, 42]
  - Hierarchical DHT-based inter-domain routing protocol based on Canon [25]
- **Naming and mobility management in Autonomic Service Architecture (ASA) using P2P substrate** [43, 44]
  - Hierarchical DHT-based naming architecture
  - Supports horizontal and vertical mobility of customers and network elements
- **P6P** [39]
  - Connects isolated IPv6 sites using P6P tunnels over IPv4 network
  - Separates the two roles of addresses: *identifiers*, and *locators*
  - Enables multihoming and dynamic addresses

References

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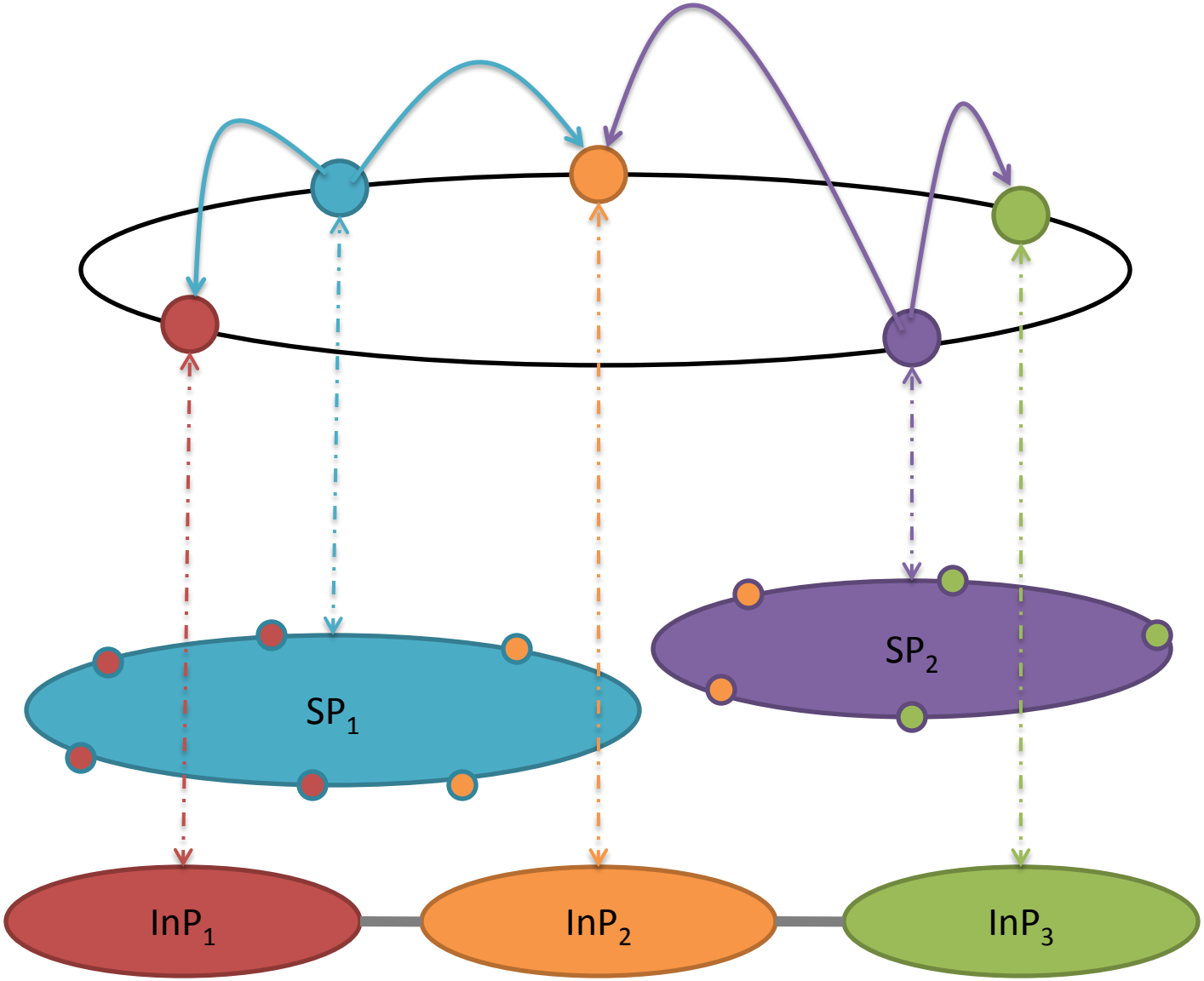
Outline

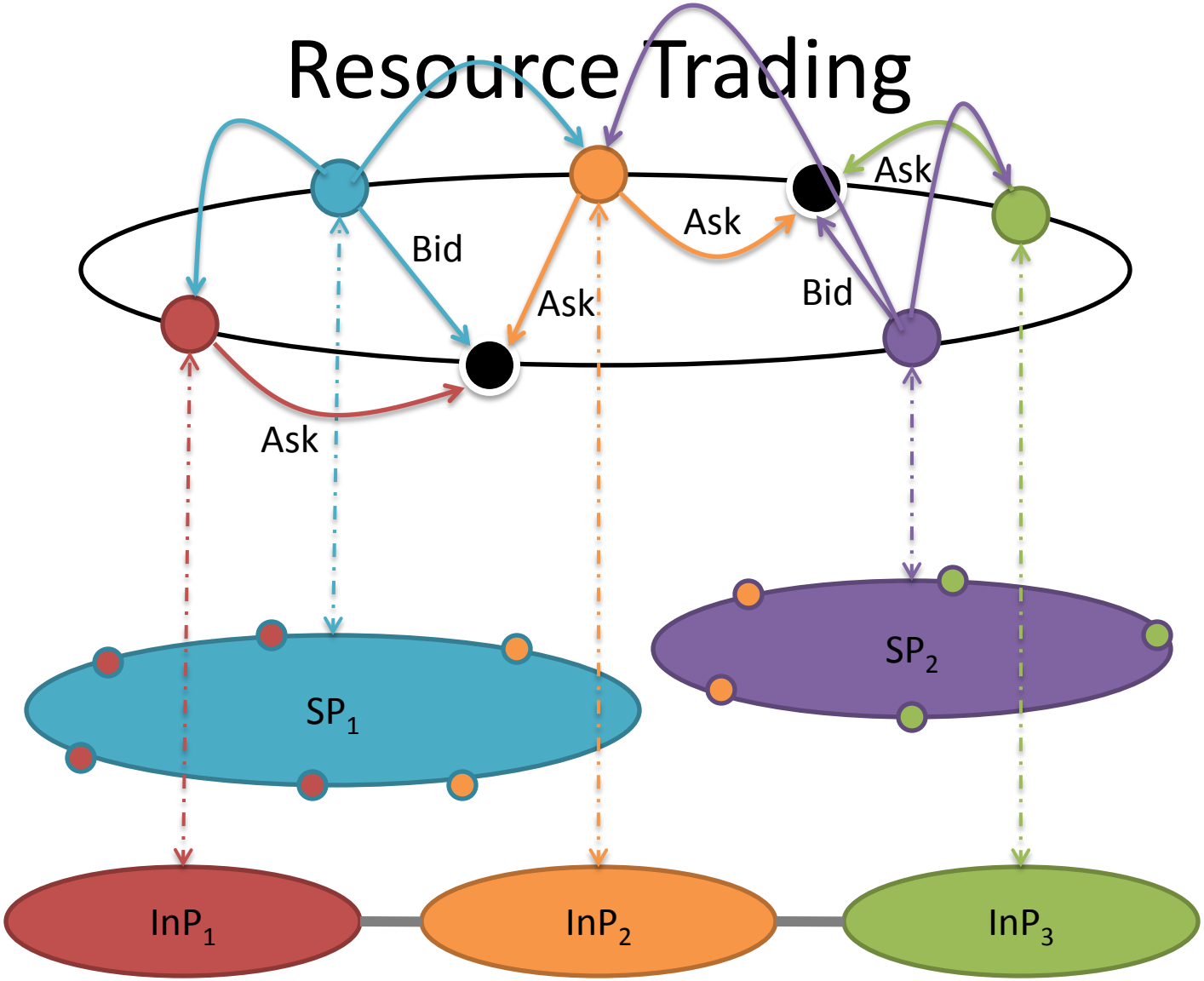
1. What — is Network Virtualization ?
2. Why — P2P concepts might be useful ?
3. Where — can we use those concepts ?
4. How ? — Let's See.

Framework Design Goals

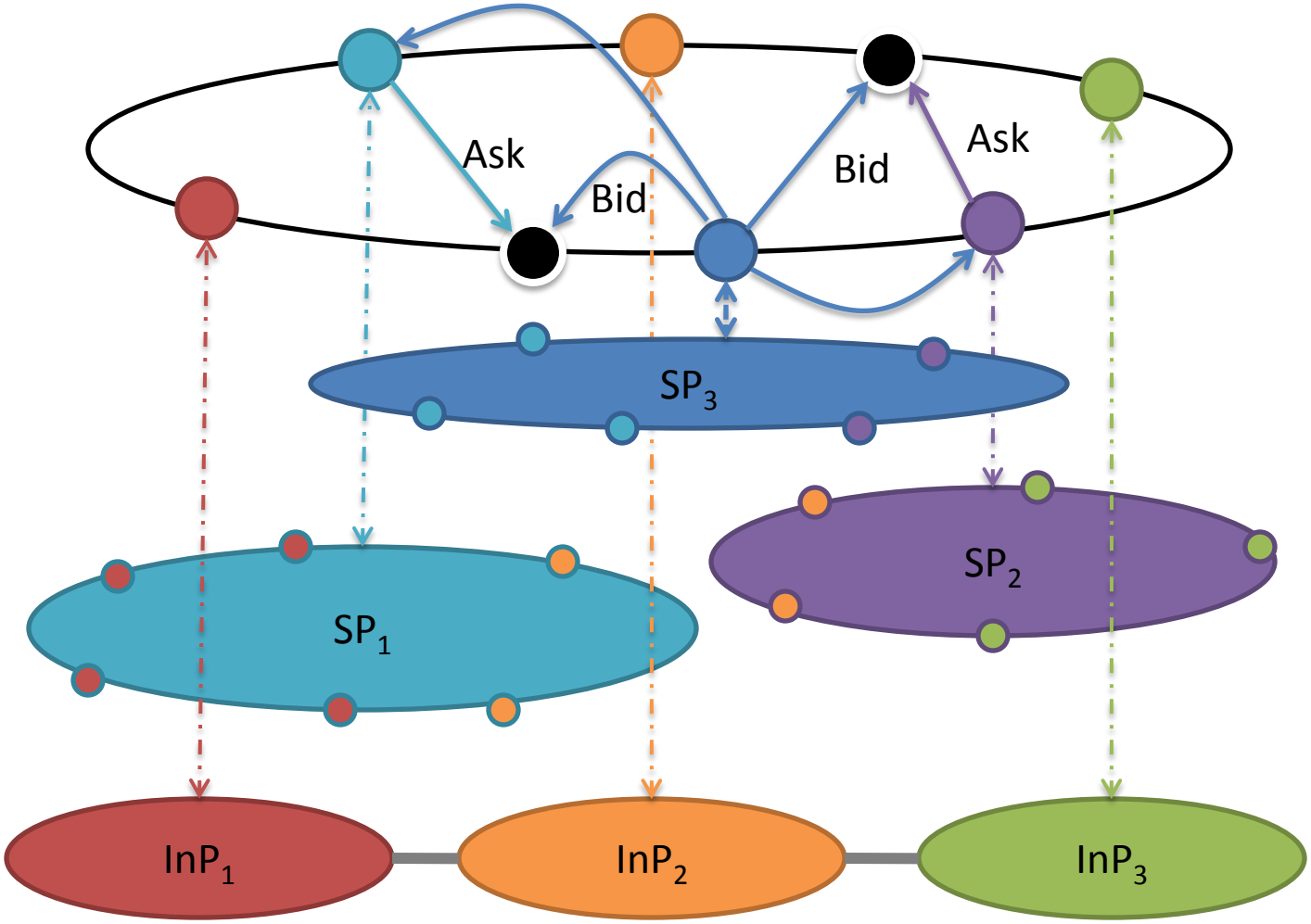
- VN Provisioning and Creation
  - A common marketplace for trading of *basic*, and *composite* VN resources
- Dynamism
  - Aggregate multiple VNs/services to create composite ones quickly and without hassle
  - Fast and easy to add, remove, or move virtual nodes/resources
- Naming and Addressing
  - Separation between *Identity* and *Location*
  - Support *Mobility*, and *Multihoming* in the form of simultaneous connection to multiple VNs
- Identity based Routing


SP1
SP2
InP1
InP2
InP3

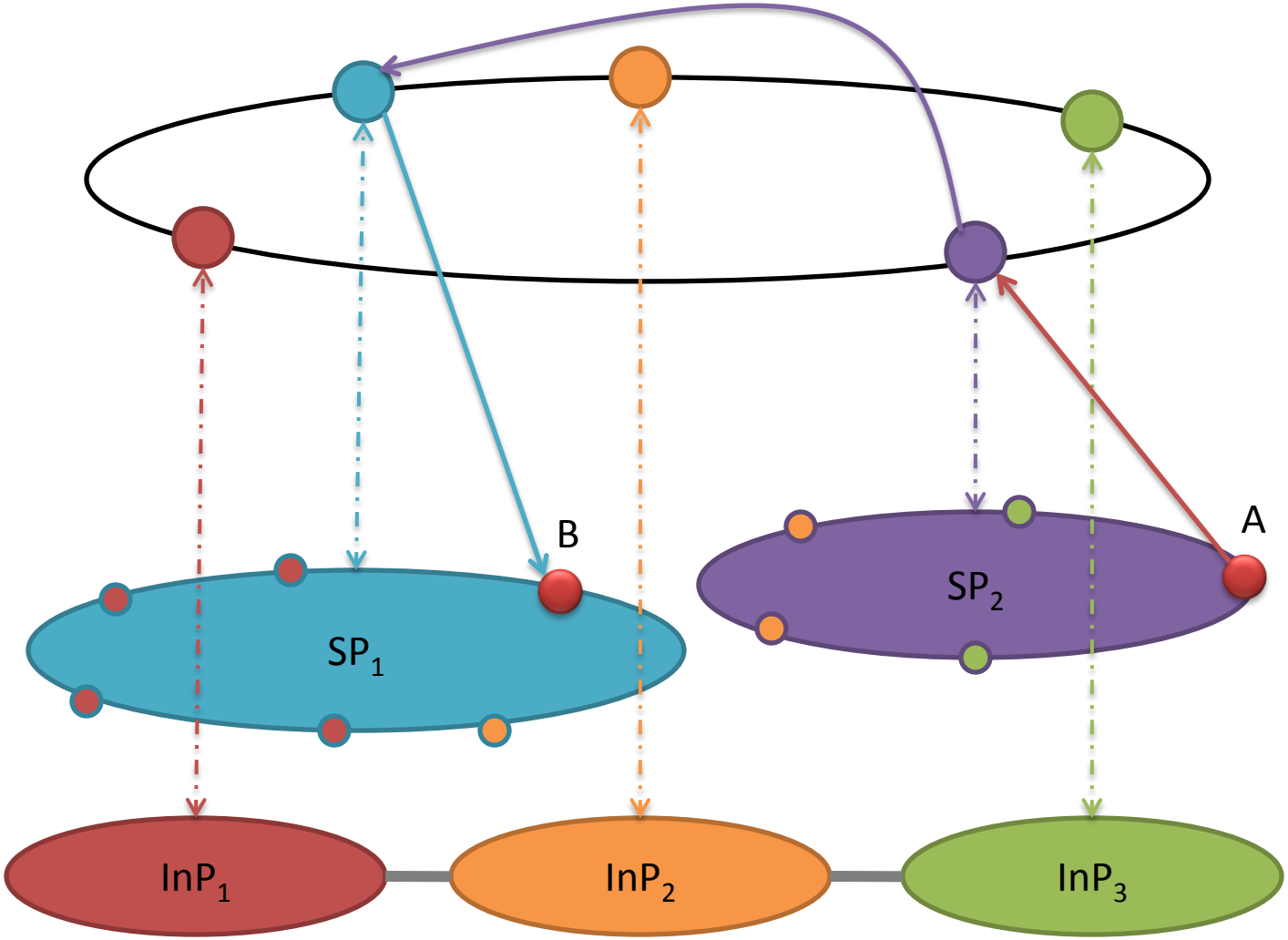
Resource Trading



Creating Composite VNs



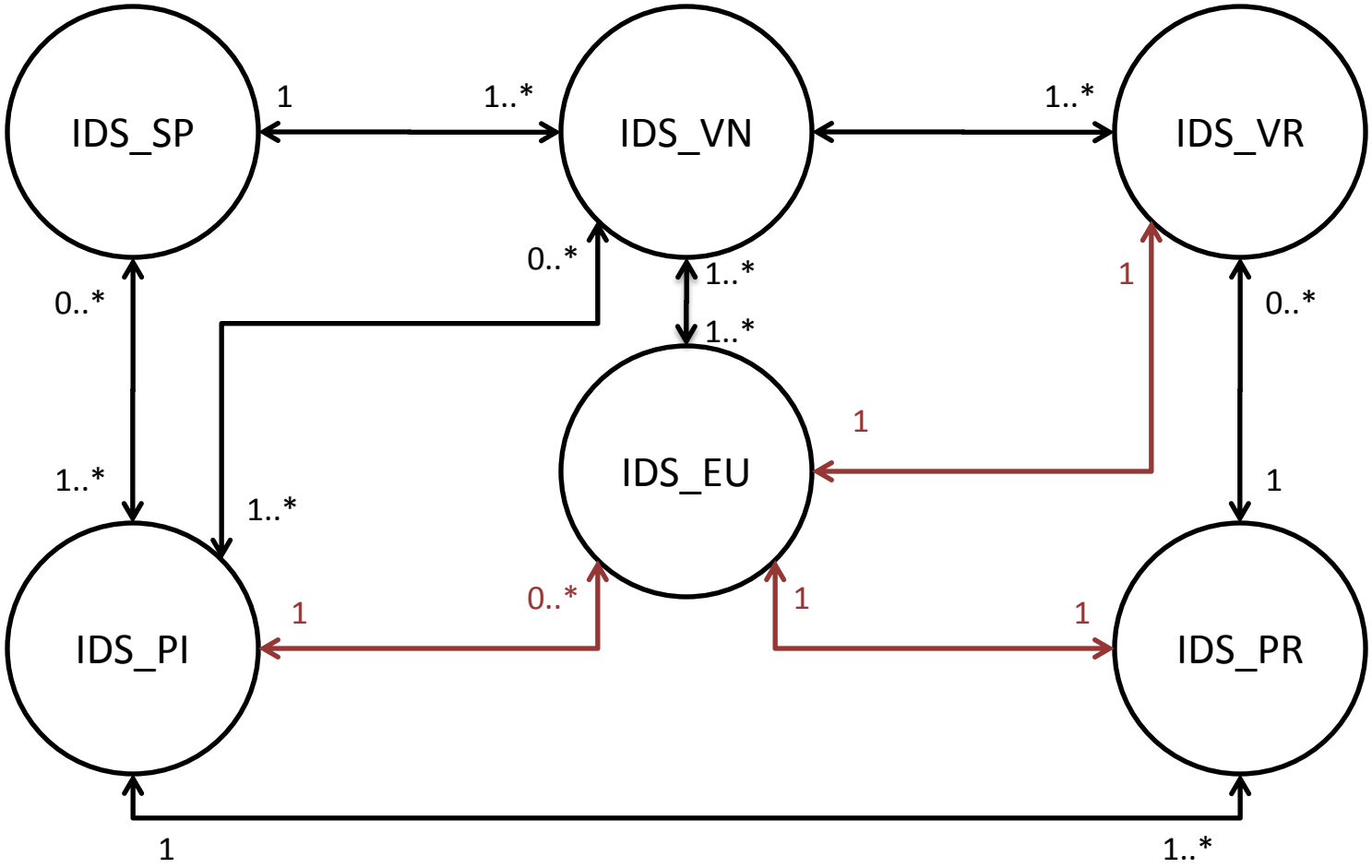
Inter VN Pair-wise Communication



P2P-based Naming in VN Environment (1)

- **Identifier Spaces** [43, 44]
  1. Service Providers (IDS_SP)
  2. Virtual Networks (IDS_VN)
  3. Virtual Resources (IDS_VR)
  4. Infrastructure Providers / Physical Networks (IDS_PI)
  5. Physical Resources (IDS_PR)
  6. End Users (IDS_EU)

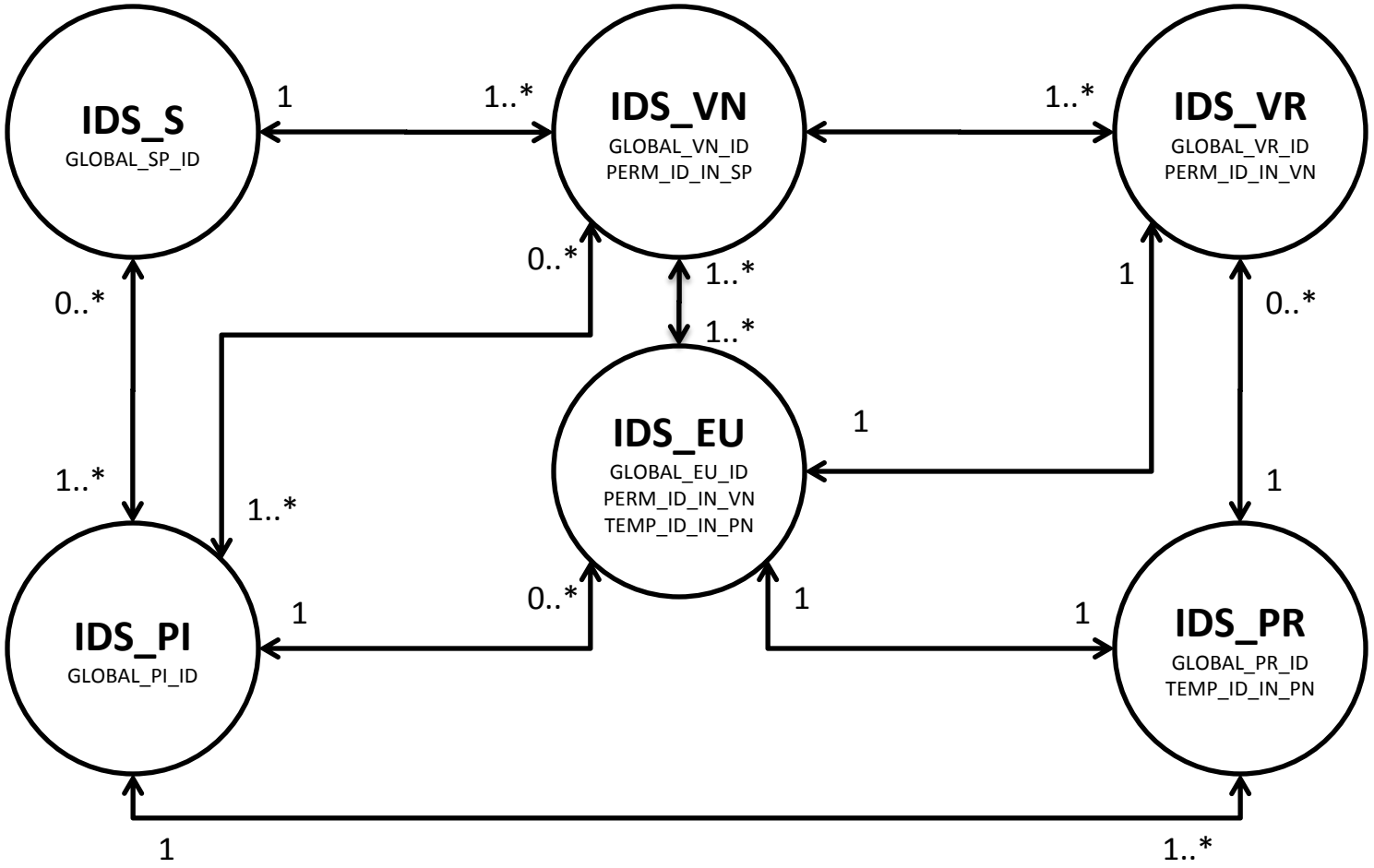
P2P-based Naming in VN Environment (2)



P2P-based Naming in VN Environment (3)

ID_SPACE	**IDs**
IDS_SP	GLOBAL_SP_ID
IDS_VN	GLOBAL_VN_ID, PERM_ID_IN_SP
IDS_VR	GLOBAL_VR_ID, PERM_ID_IN_VN
IDS_PI	GLOBAL_PI_ID
IDS_PR	GLOBAL_PR_ID, TEMP_ID_IN_PN
IDS_EU	GLOBAL_EU_ID, PERM_ID_IN_VN, TEMP_ID_IN_PN

P2P-based Naming in VN Environment (4)



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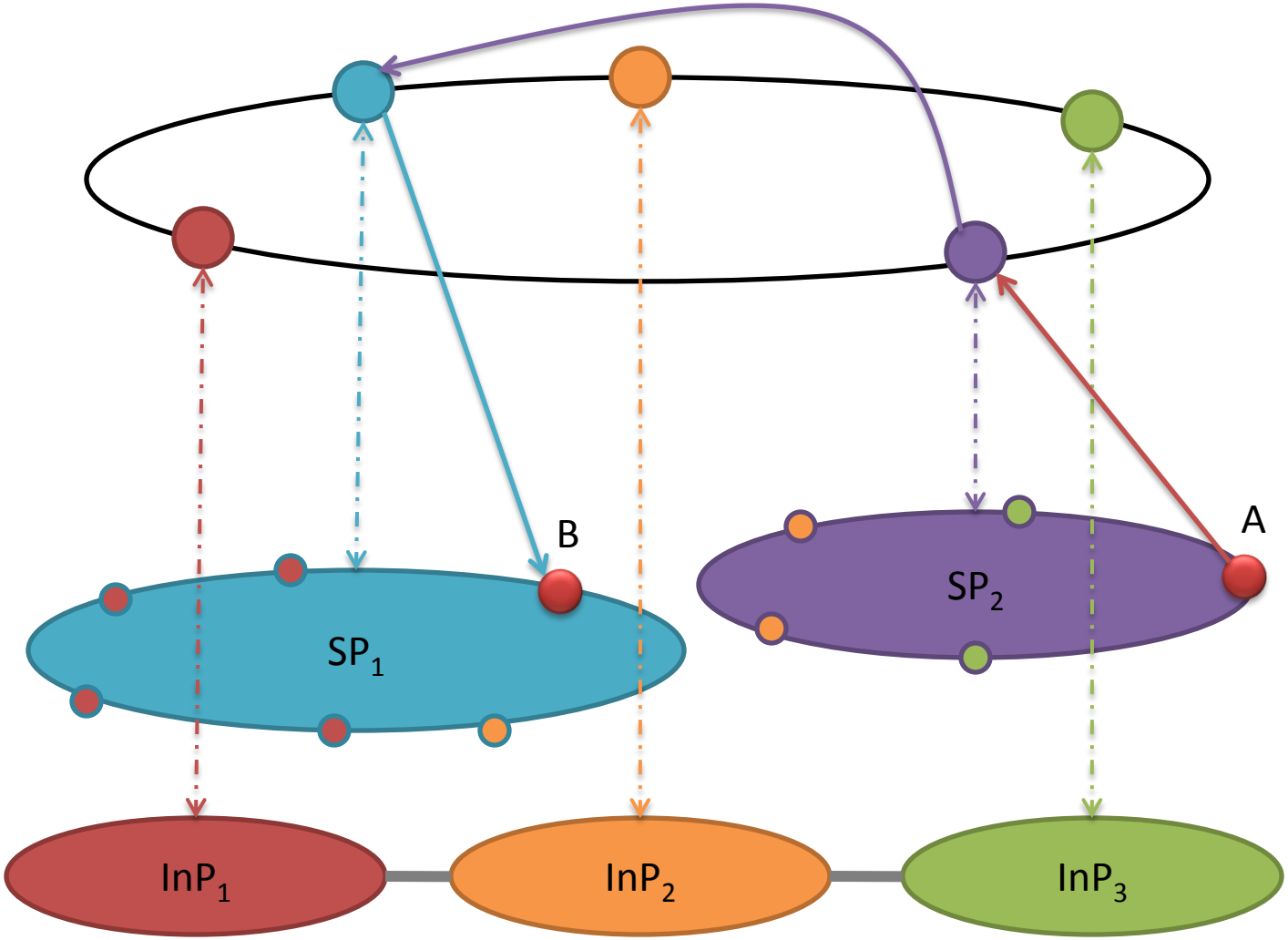

TO DO

1. Complete defining *Identifier Spaces* (*ID_SPACEs*)
2. Complete the mappings between different IDs internal and external to *ID_SPACEs*
3. Resolve the issues regarding global and local placement of mappings
4. Finalize the *join*, *leave*, and *update* algorithms
5. Analyze and compare the performance of the proposed framework with other options (e.g. VRR, ROFL) qualitatively and quantitatively (if possible)

Summary

1. What	is Network Virtualization ?
2. Why	P2P concepts might be useful ?
3. Where	can we use those concepts ?
4. How ?	Hierarchical DHT, identity-based routing etc.

Questions? || /*Comments*/