Markets for Virtual Network Services

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Network Virtualization: Challenge

Virtual Network Model and Requirements

Market Design and Implementation

Application Example and Conclusion

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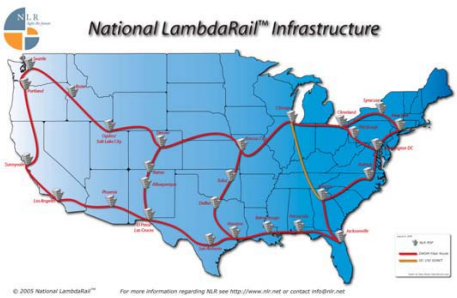
Network Virtualization

- Rapid technological progress
  - New optical fiber technology (e.g. DWDM)
  - Virtual router infrastructures (e.g. CSR-1)

Cisco CRS-1 Carrier Routing System

- Benefits
  - Sharing of physical network equipment
  - „On-demand“ bandwidth allocation
  - Security, reliability, independence



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Challenge

- Provisioning of bandwidth
  - In the right amount
  - At the right location
  - At the right time

- Suitable business models needed
  - Targeted at on-demand bandwidth provisioning
  - Providing appropriate incentives for providers and customers
  - Maximizing overall social welfare

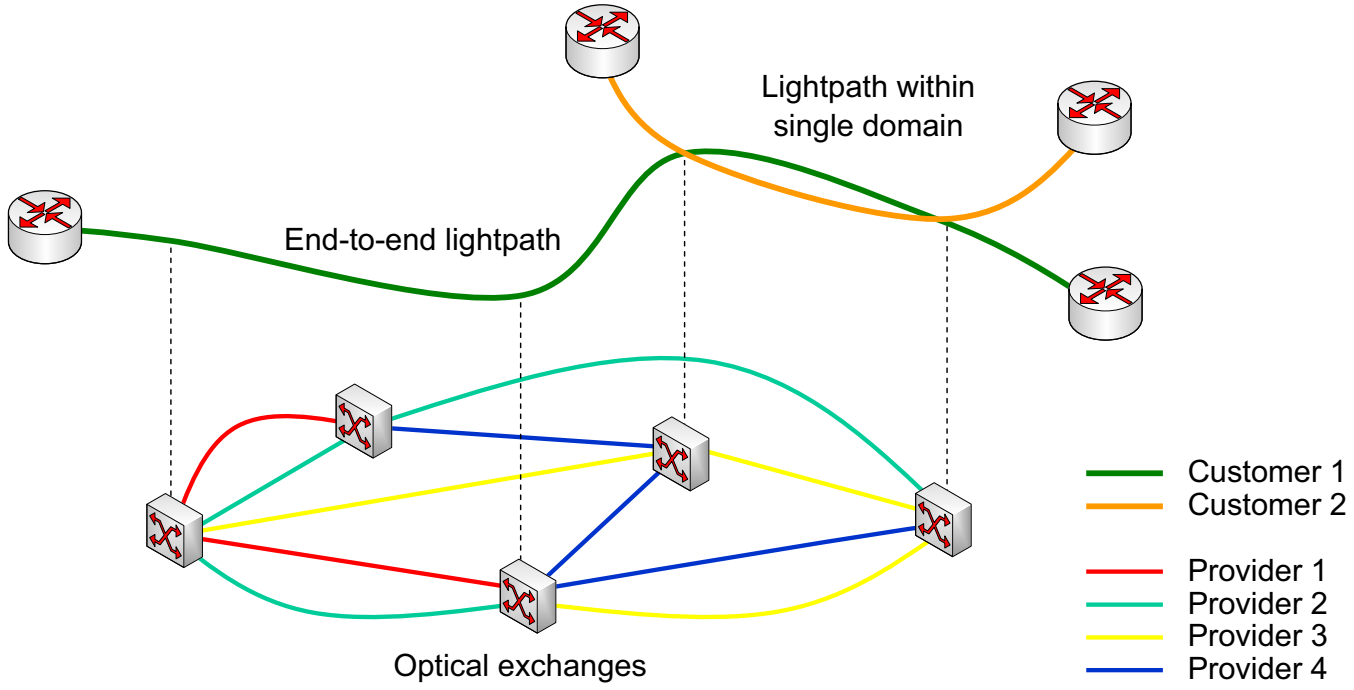
➢ Goal: Develop an appropriate market infrastructure for trading virtual network services on-demand

Are we ready for a new Bandwidth Market?

- A short history of bandwidth trading
  - Electronic markets for bandwidth emerged late 1990's
  - Seriously hit by the economic downturn in 2001
  - Today, bandwidth normally provided under the umbrella of long-term bilateral agreements

- New situation today
  - Technology: Network virtualization allows to provide bandwidth much easier and faster („on-demand")
  - Concepts: P2P-based infrastructures enable the trading of services in a fully decentralized and scalable manner

Virtual Network Scenario

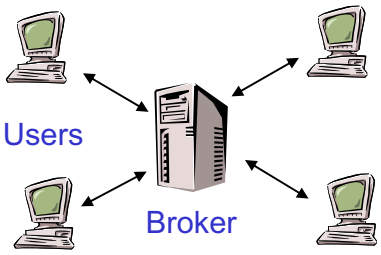


Market Requirements

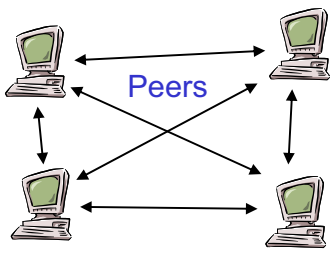
- Functional requirements
  - Enable buying and selling virtual network services for different applications
  - On demand as well as in advance
  - Among multiple providers and customers
  - Support reselling of virtual network services
- Performance requirements
  - Economically efficient allocation of physical network resources (maximize benefit through its use)
  - Robustness against individual failures and attacks
  - Scalability up to a large number of providers and customers

Centralized versus Decentralized Marketplace

- Centralized Marketplace
  - \+ Efficiency
  - \- Single Point of Failure
  - \- Vulnerable against attacks
  - \- Scalability



- Fully Decentralized Marketplace
  - \+ Extensibility
  - \+ Fault-tolerance
  - \- Vulnerable against selfish and malicious behavior of peers
  - \- Efficiency



A suitable marketplace needs to be efficient and scalable

Virtual Network Service

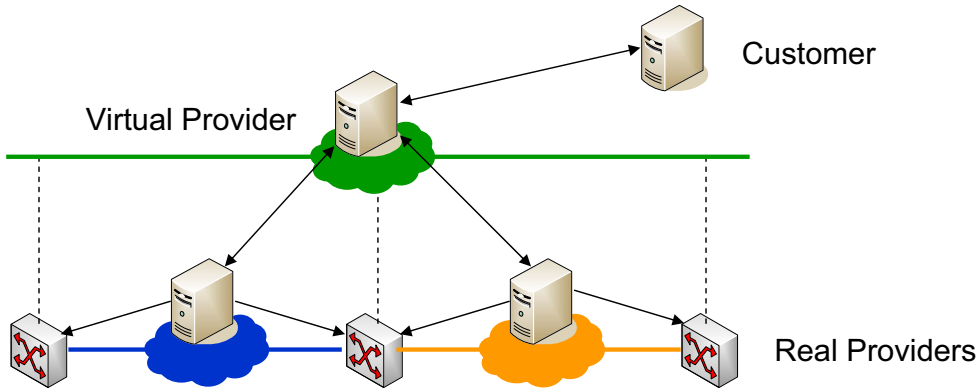
- Definition:
  - A virtual link between any two sites, or combination thereof
  - Within a single provider domain or across several domains

- Service Parameters:

Parameter	Value
Bandwidth	May be fixed, variable, or at discrete levels Best effort or guaranteed
QoS	In terms of expected service uptime/availability rate
Start-time	May be starting at regular intervals => Ability to reserve ahead and resell services
Duration	May be dynamic or fixed, e.g. 1 day
Price	As offered by the provider / customer

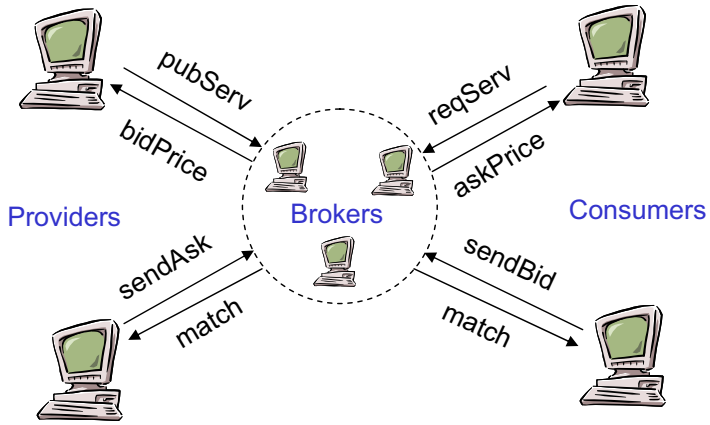
Virtual Network Provider

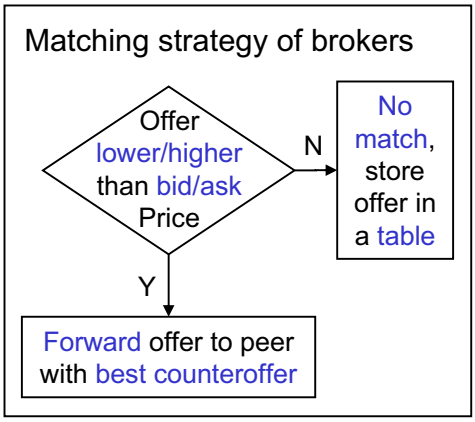
- Definition:
  - An entity reselling a link or a combination of links
  - Allows a customer to resell an unused link
  - Enables to offer end-to-end virtual links across several network providers domains



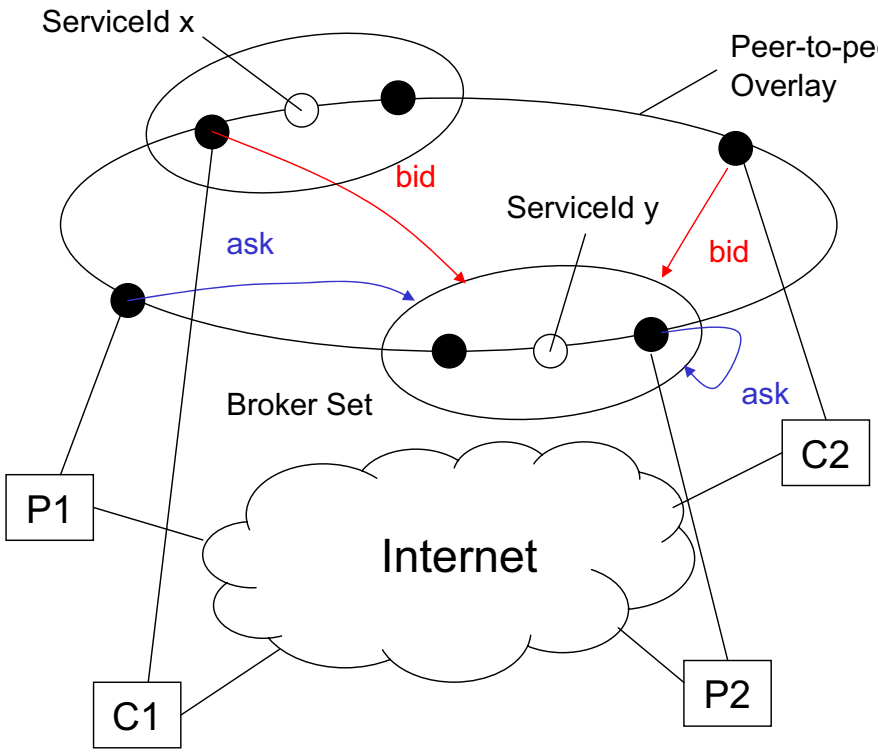
Market Design: Basic Concept

- Each service is traded in a Double Auction
- Each auction is mapped onto a set of brokers





Market Design: P2P Overlay

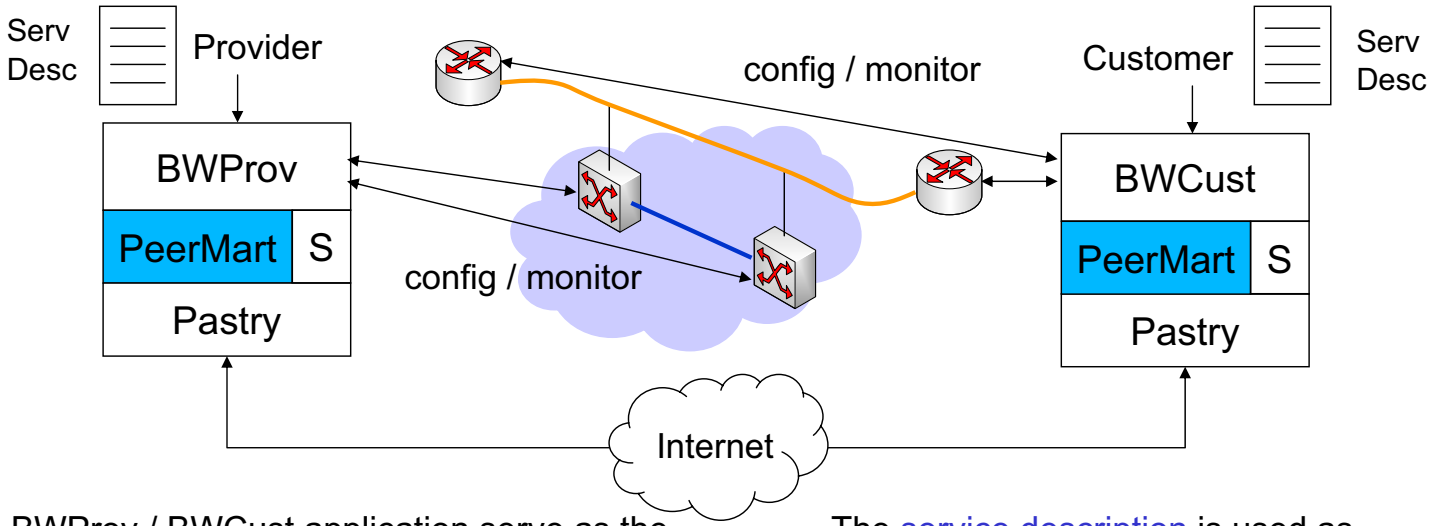


Each peer has a unique nodeId, peers form a structured P2P overlay network

Services have unique serviceId

N peers numerically closest to serviceId form a broker set

Implementation and Node Architecture



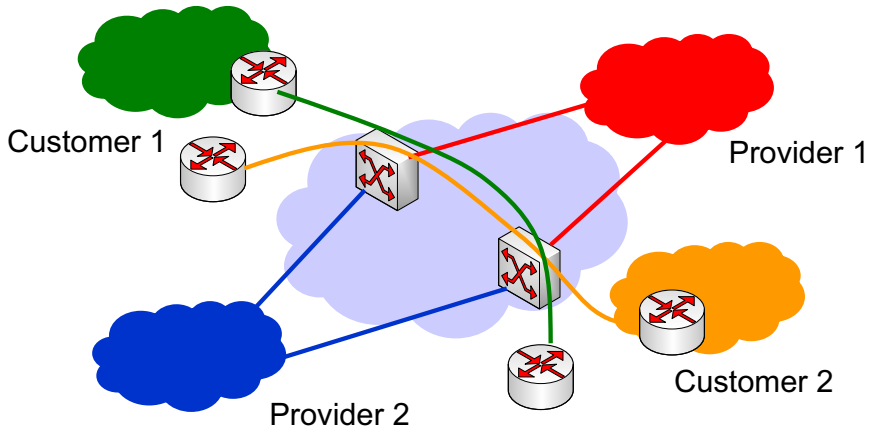
BWProv / BWCust application serve as the bidding agent.

Additionally, they allow to configure and monitor the service according to the outcome of a successful transaction

The service description is used as input to calculate a unique service id.

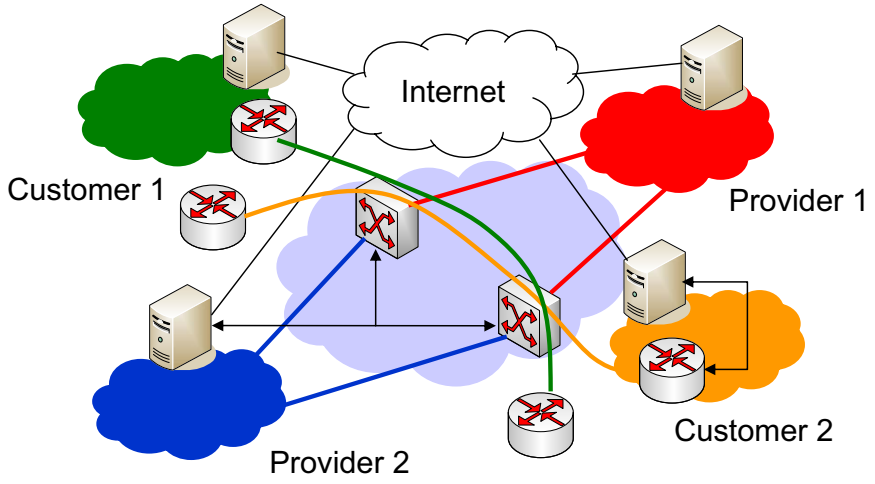
The distributed search component ("S") enables to publish and search for service descriptions.

Application Example (1)



Virtual network environment with 2 optical links provided by 2 different providers

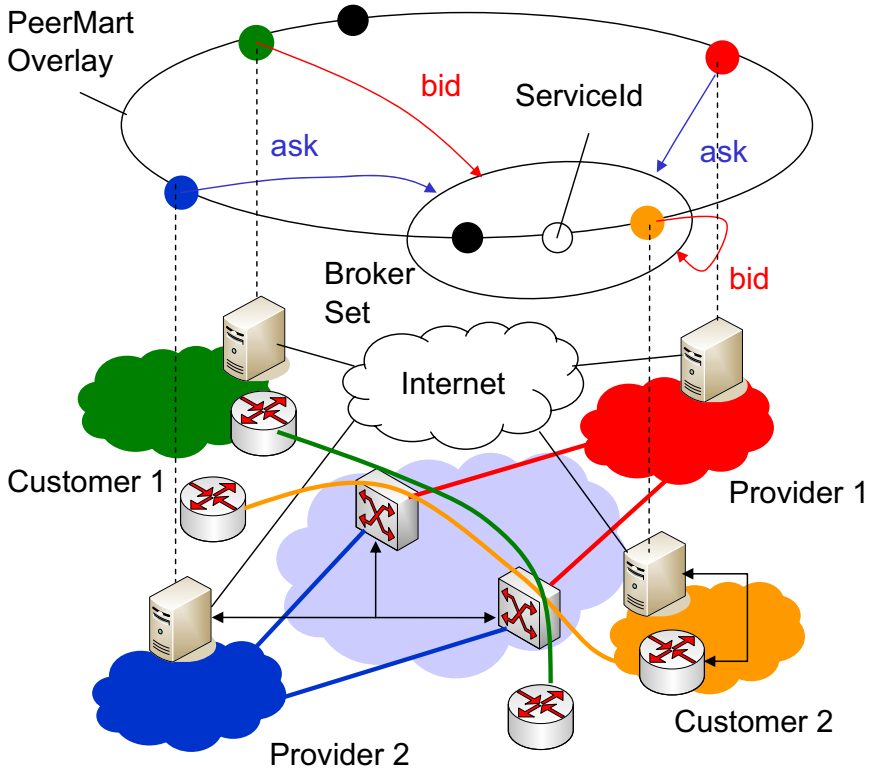
Application Example (2)



All providers and customers have a node in their domain with PeerMart installed and connected to the Internet. The node is able to access the network equipment.

Virtual network environment with 2 optical links provided by 2 different providers.

Application Example (3)



All nodes build an overlay network over the Internet, which is used to trade the bandwidth among providers and customers.

All providers and customers have a node in their domain with PeerMart installed and connected to the Internet. The node is able to access the network equipment.

Virtual network environment with 2 optical links provided by 2 different providers

Conclusion and Future Work

- Conclusion
  - Fully decentralized auction is a suitable market infrastructure for trading virtual network services
  - Combination of
    - Economic efficiency of double auctions
    - Technical performance and robustness of P2P networks
  - ➢ Approach is economically and technically feasible

- Future work
  - Who to blame if there is a problem?
  - How to deal with similarity in the service model?

Thank you for your attention!