

Auctions for Virtual Network Environments

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Talk Outline

□ Part I

- Introduction
- Virtual Network Scenario
- Market Infrastructure Requirements
- Bandwidth Trading Markets

□ Part II

- PeerMart
- Service Specification
- PeerMart Application
- Implementation
- Summary and Conclusion

Virtual Network and Router Infrastructures

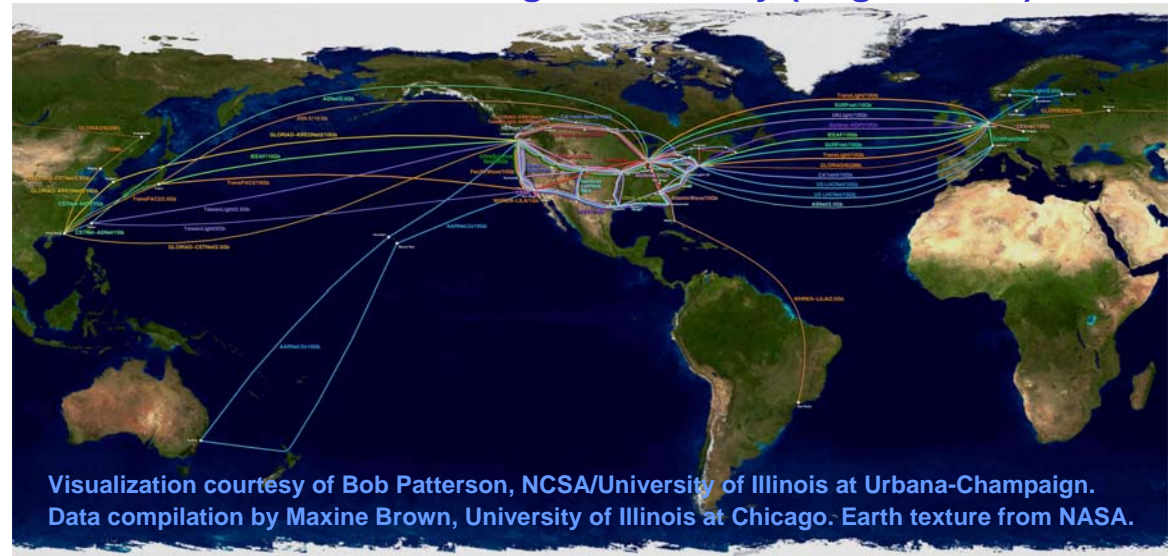
Global Environment for Network Innovation



Cisco CRS-1 Carrier Routing System



Global Lambda Integrated Facility (August 2005)



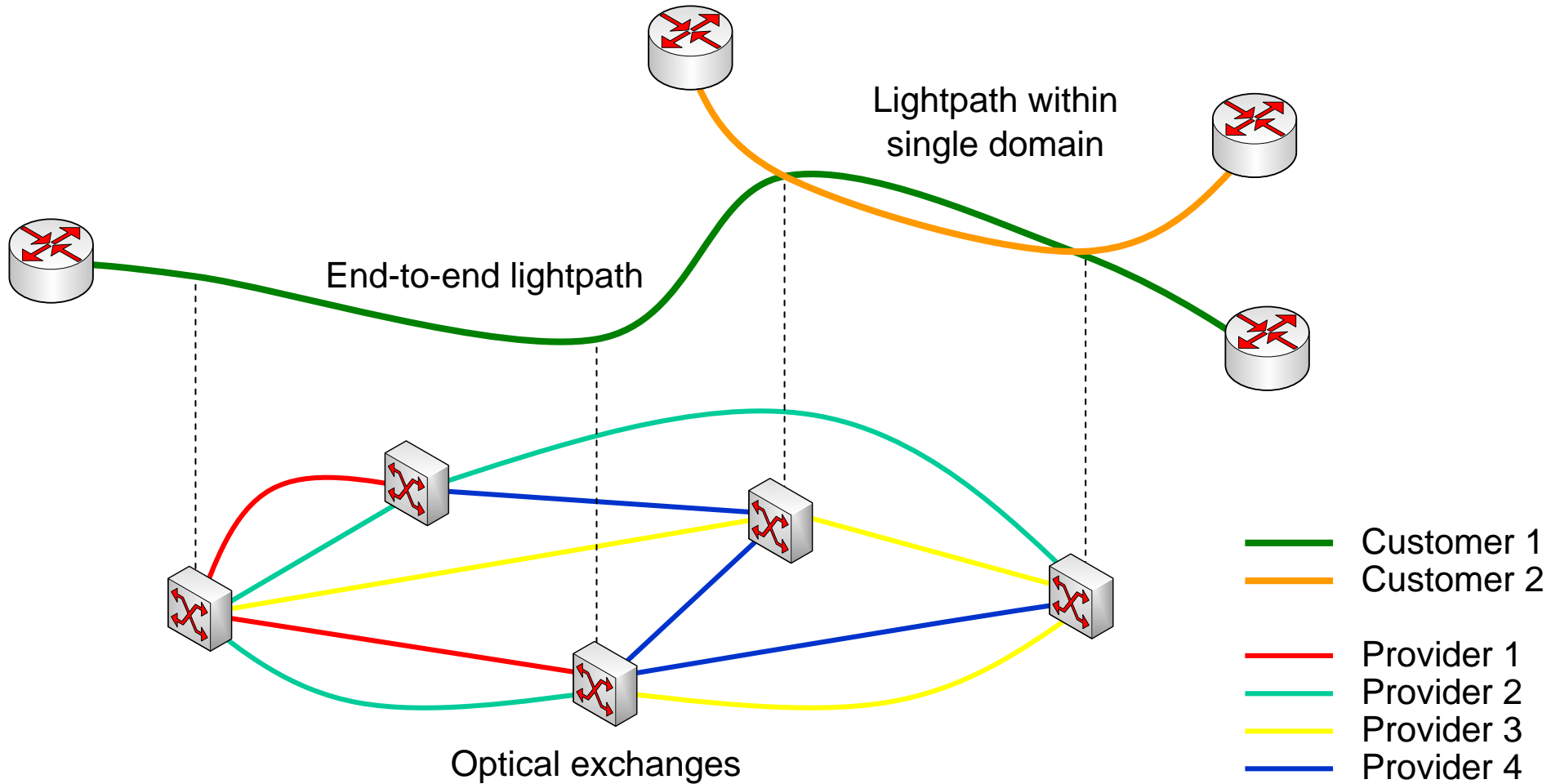
Visions and Trends

- The near future will show bandwidth services being used for higher-level applications just as other **commodities**
 - Such as electricity, gas, or water

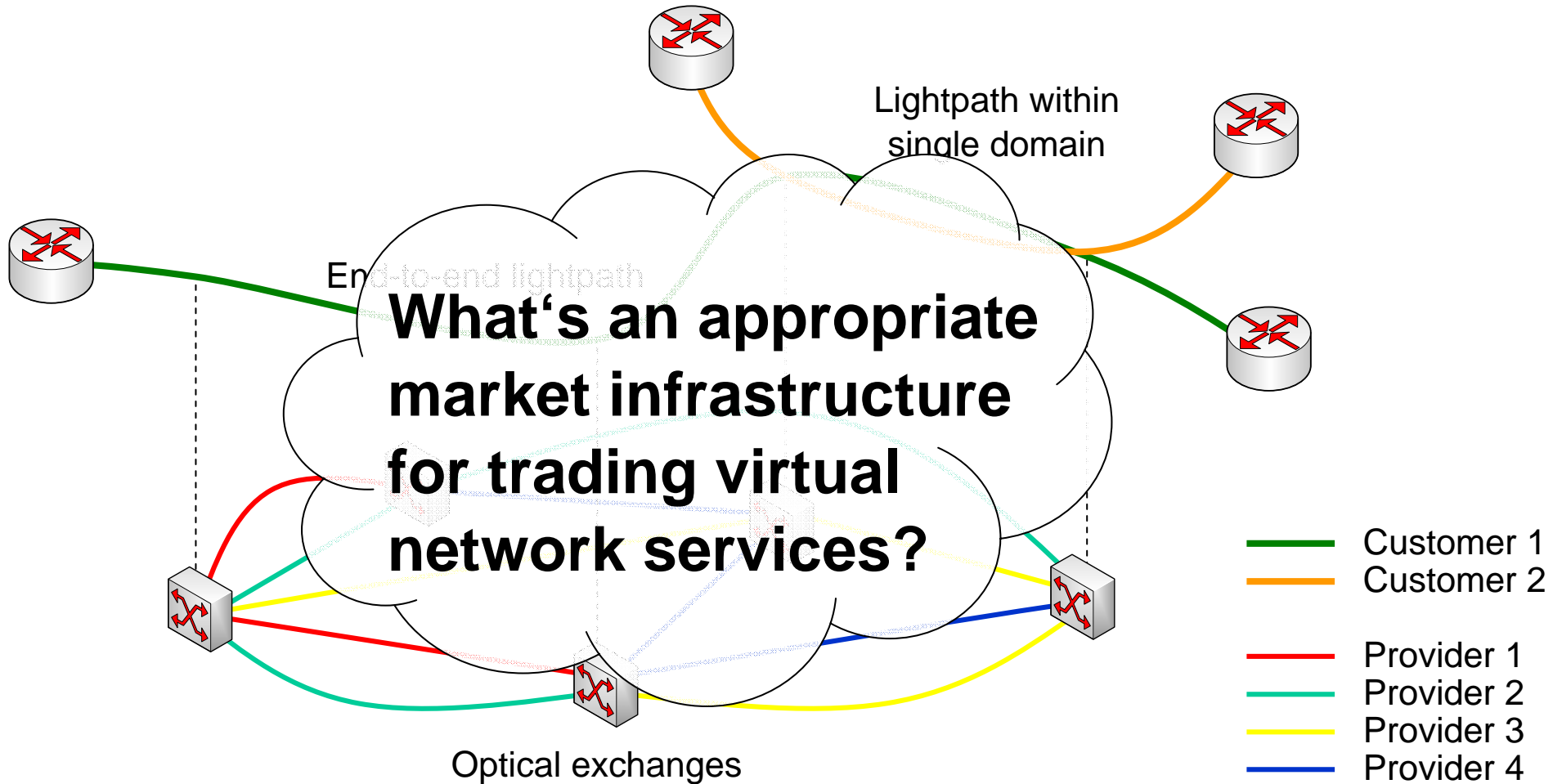
- There is a trend towards “**on-demand**” provisioning of bandwidth for application services at a large scale
 - *E.g.*, for large sporting events or cultural open air activities

- New optical network management systems enable to establish **end-to-end lightpaths**
 - Across multiple independent optical network provider domains

Virtual Network Scenario



Virtual Network Scenario



Market Infrastructure Requirements

□ Functional requirements

- Allow customers and providers to **buy and sell** bandwidth services for different applications
- Support the trading of bandwidth **on demand** as well as **in advance**
- Allow the trading of bandwidth among **multiple** providers and customers
- Support the **reselling** of bandwidth services
 - E.g., an end-to-end network service or an unused link

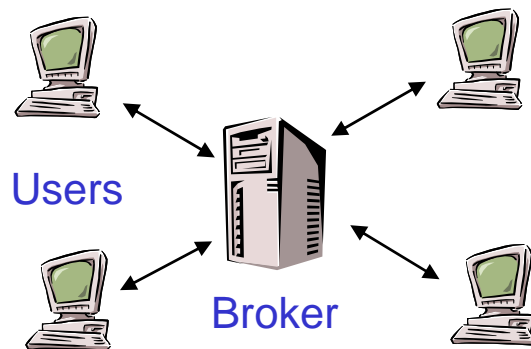
□ Performance requirements

- Lead to an **economically efficient allocation** of bandwidth services
 - Bandwidth allocation should maximize the benefit through its use
- Be **robust** against individual failures and attacks
- Be **scalable** up to a large number of providers and customers

Centralized versus Decentralized Marketplace

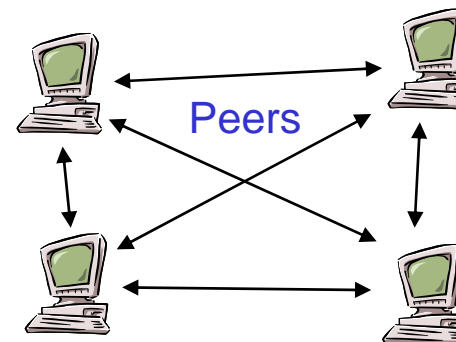
□ Centralized Marketplace

- + 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**

A Short History of Bandwidth Trading

- ❑ **Electronic marketplaces** for trading bandwidth emerged since the late 1990's
 - Market mechanisms were developed to allow companies to trade bandwidth just as other commodities
- ❑ Seriously hit by the **economic downturn** in 2001
 - Trading markets disappeared with the bursting of the telecom bubble
- ❑ Today, bandwidth normally provided under the umbrella of **long-term bilateral agreements**
 - Between **individual** providers and customers

Are we ready for a new Bandwidth Market?

□ Network virtualisation

- Allows to allocate bandwidth much **easier** and **faster**
 - May become a **key driver** for “**on-demand**” bandwidth trading
- Enables **transparent sharing** of physical network equipment
- Offers numerous **benefits** to customer and provider
 - *E.g.*, security, flexibility, reliability, independence, multiplexing

□ Emerging **P2P** networking concepts provide **new potentials**

- Support of bandwidth trading in a fully decentralized manner
 - Clear advantages in terms of **reliability and scalability**
- P2P-based marketplaces like PeerMart enable the trading of services over the Internet in a **technically and economically feasible** way

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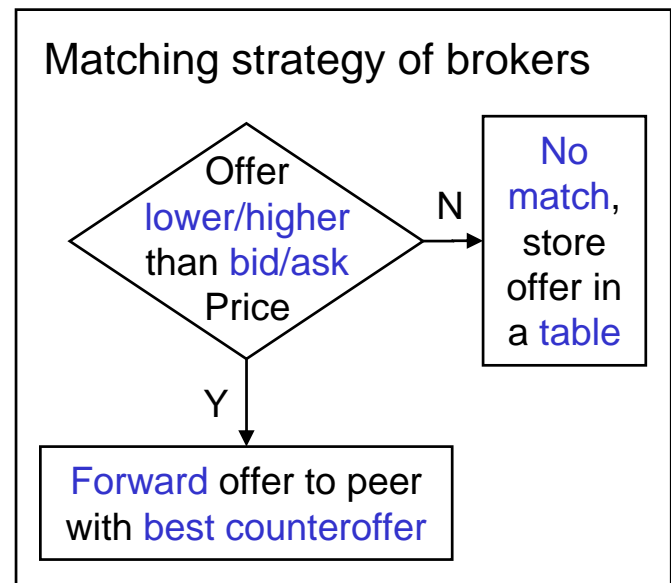
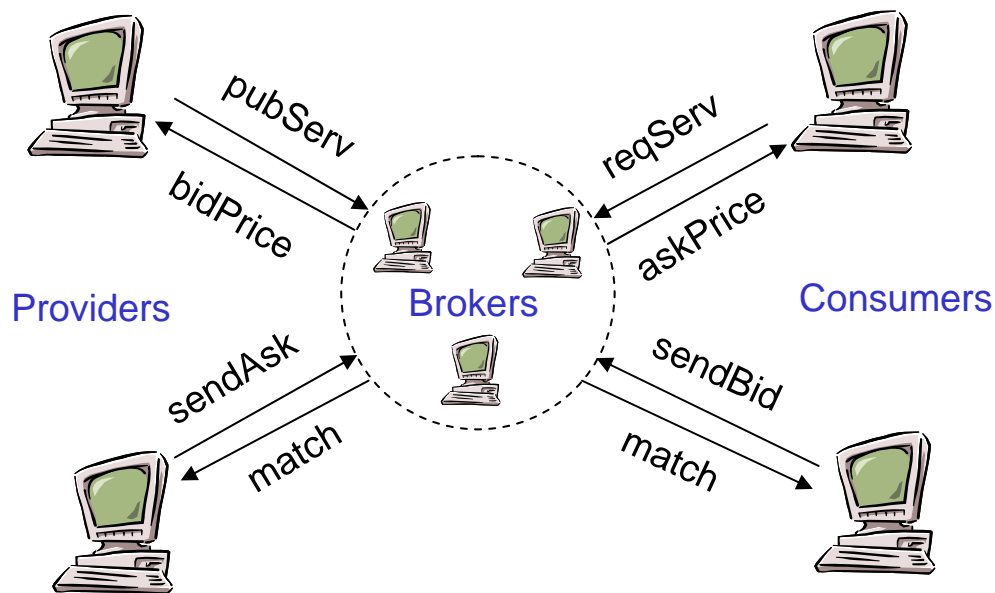
PeerMart: Decentralized Auction-based Market

- ❑ Fully decentralized and secure
- ❑ PeerMart combines efficiency and scalability
 - Economic efficiency of double auctions
 - Technical performance and robustness of P2P networks
- ❑ PeerMart can also support other types of auctions
 - Requires only few adaptations
- ❑ Enables reliable, market-based pricing of any service
- ❑ Applicable to any specific scenario
 - Generic design has to be appropriately refined and extended to meet the individual requirements of a particular application
 - Most suitable for services with many providers and many consumers

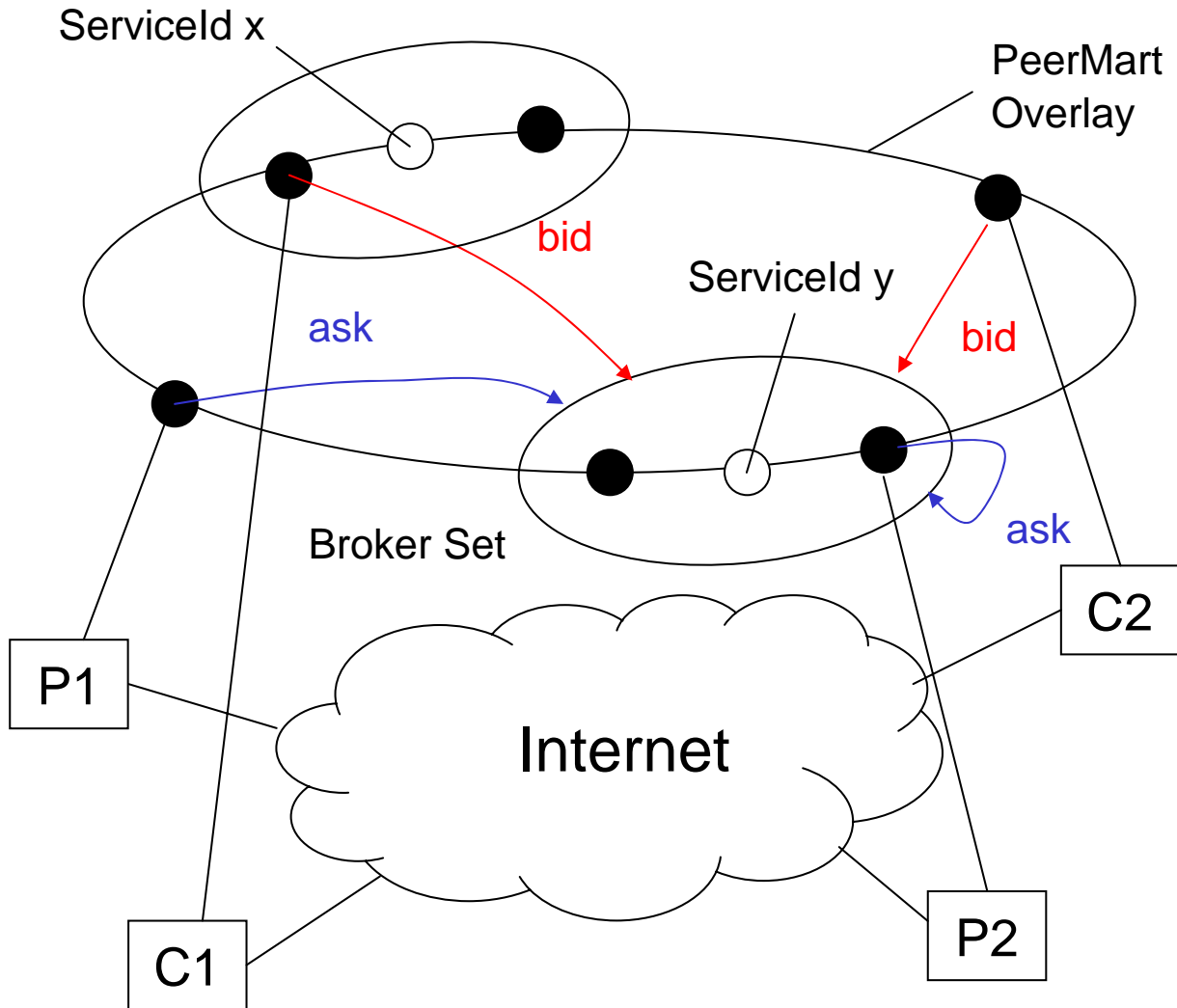
PeerMart: Decentralized Double Auctions

□ Basic Concept

- Each **service** is traded in a **Double Auction**
- Each **auction** is mapped onto a **set of broker peers**



PeerMart 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**

Virtual Network Service

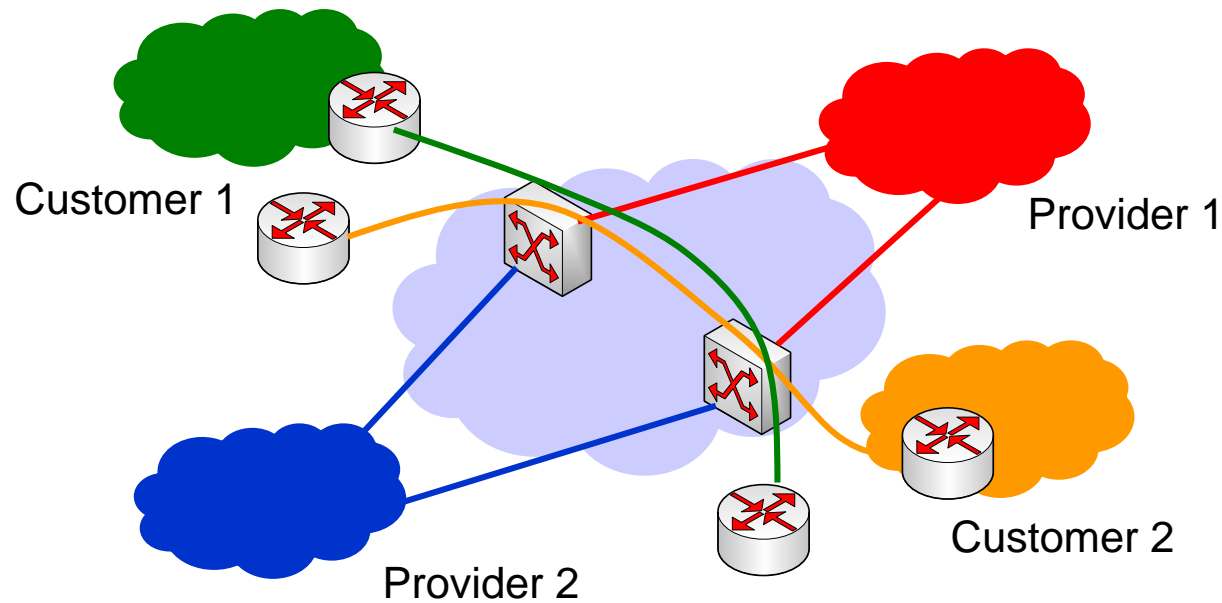
□ Definition:

- An virtual link between any two sites, or combination thereof
- May be within a single providers domain or across several domains

□ Service Parameters:

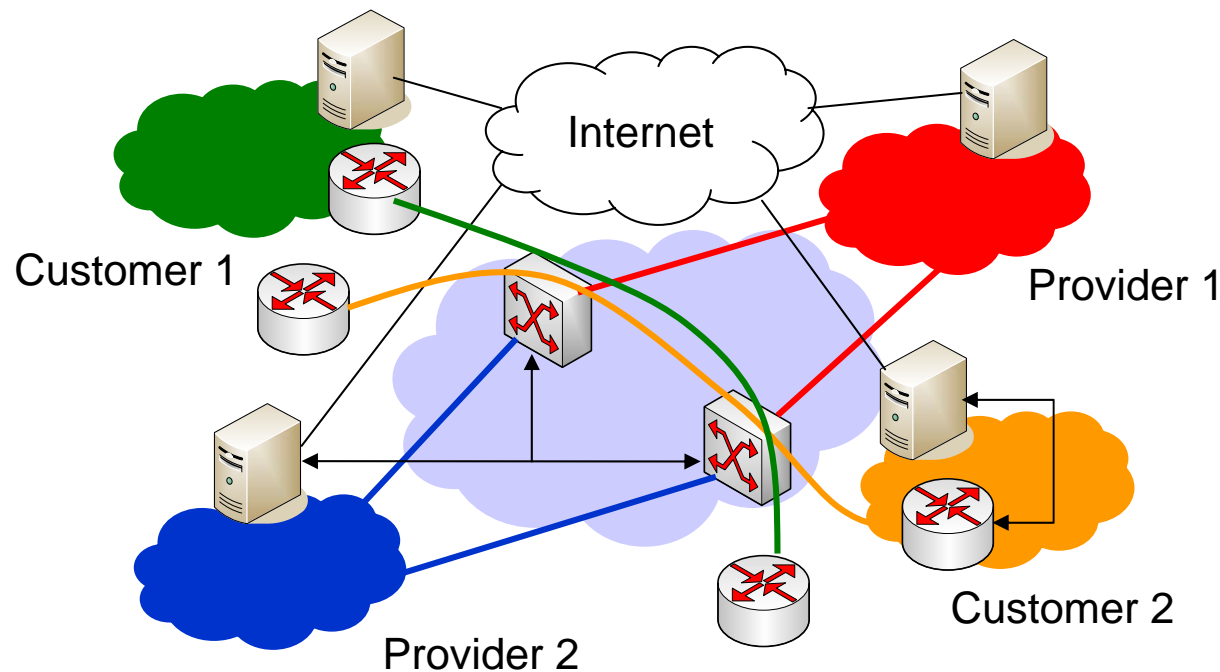
Parameter	Value
Bandwidth	May be fixed, variable, or at discrete levels Best effort or guaranteed
Reliability	In terms of expected service uptime/availability rate
Start-time of the service	May be starting at regular intervals => Ability to reserve ahead and resell services
Duration of the service	May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

Applying PeerMart to Virtual Network Scenario



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

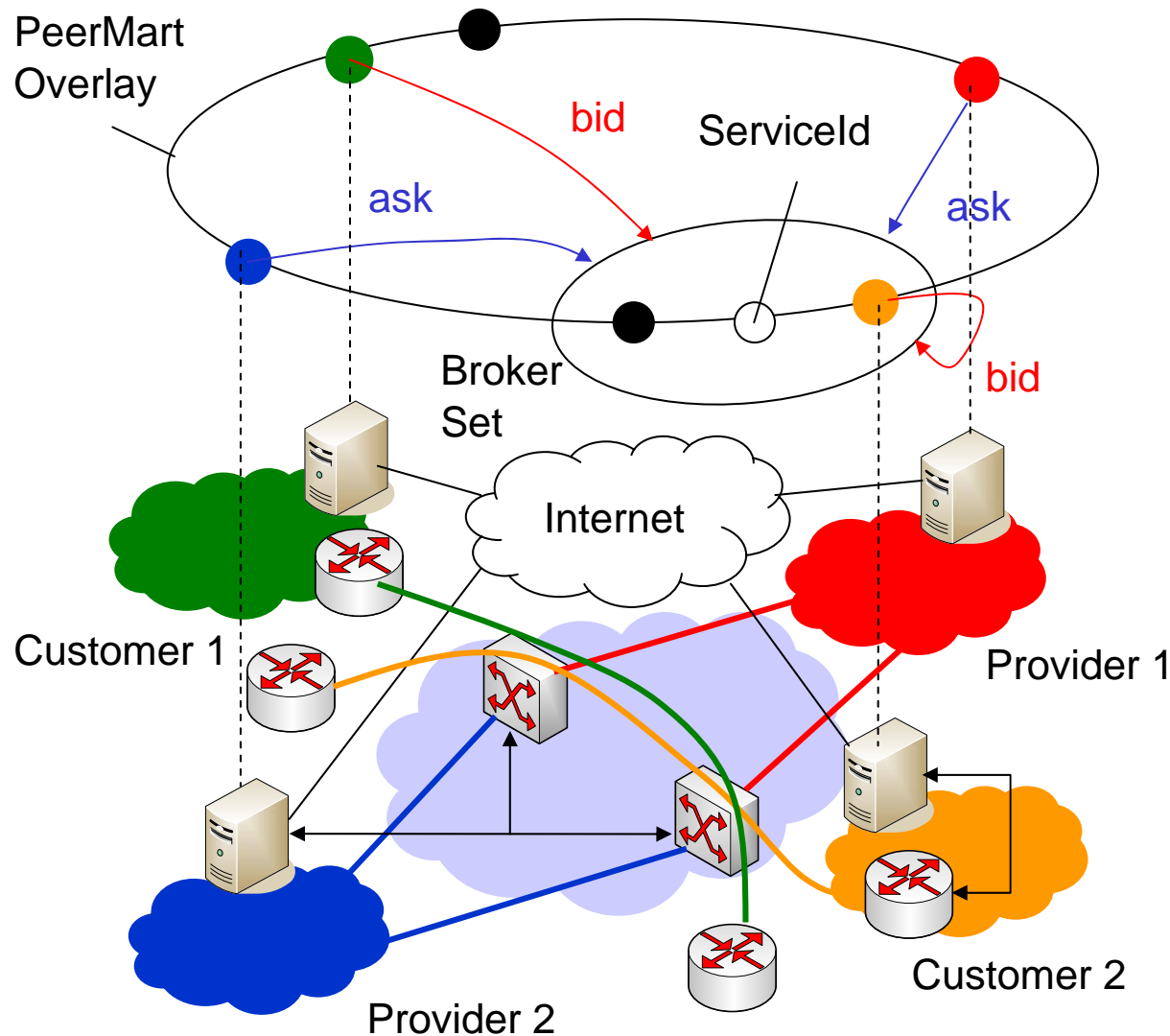
Applying PeerMart to Virtual Network Scenario



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.

Applying PeerMart to Virtual Network Scenario

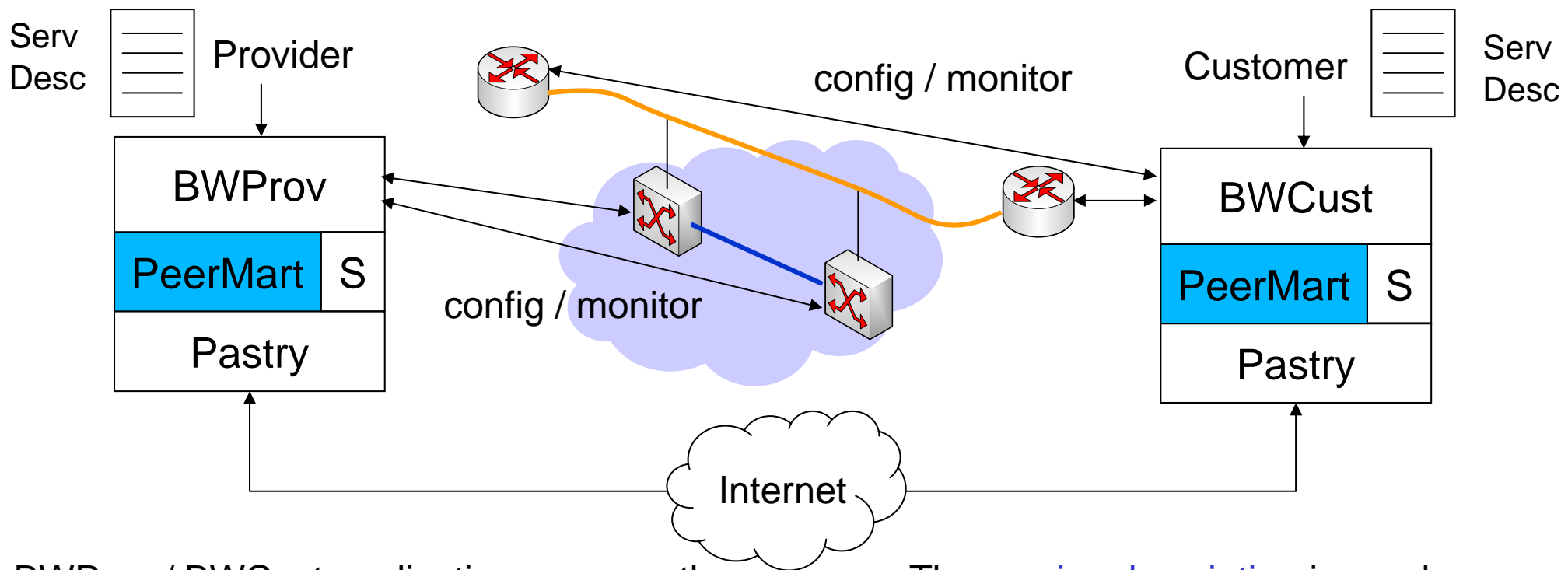


All PeerMart nodes build an overlay network over the Internet, which is used to trade the bandwidth among providers and customers.

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

Implementation and Node Architecture



BWProv / BWCust application serve as the **bidding agent**.

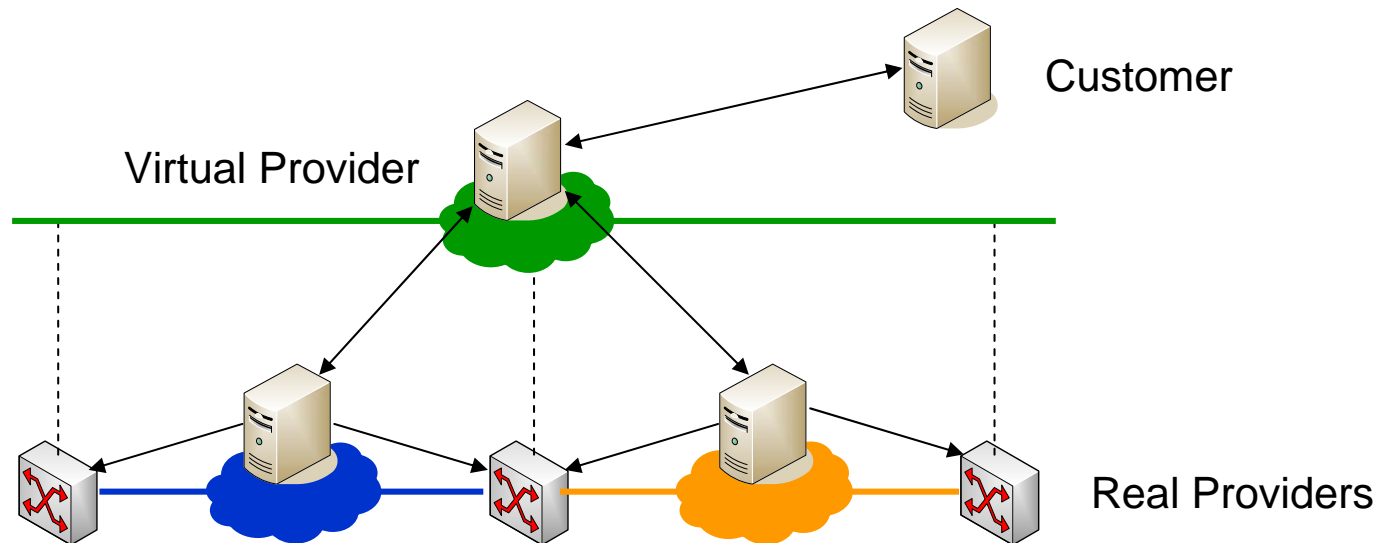
Additionally, they allow to **configure and monitor** the service according to the outcome of a successful transaction

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.

Reselling Virtual Network Services

- Virtual 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



Conclusion and Future Work

□ Conclusion

- Network virtualisation will be a **key driver** for bandwidth markets
- A **P2P auction-based market** is a suitable approach
 - Provides **economic efficiency** and **scalability**
 - 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?