

# Markets for Virtual Network Services

*David Hausheer*

*Communication Systems Group CSG, Department of Informatics IFI, University of Zurich  
Binzmuehlestrasse 14, CH-8050 Zurich, Switzerland  
hausheer@ifi.uzh.ch*

Network Virtualization: Challenge

Virtual Network Model and Requirements

Market Design and Implementation

Application Example and Conclusion



# Network Virtualization

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



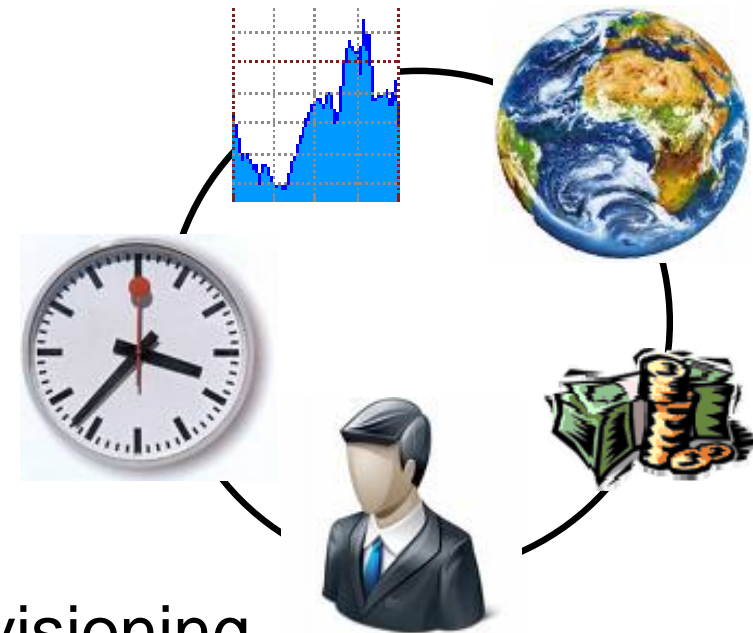
Cisco CRS-1 Carrier Routing System

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



# 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

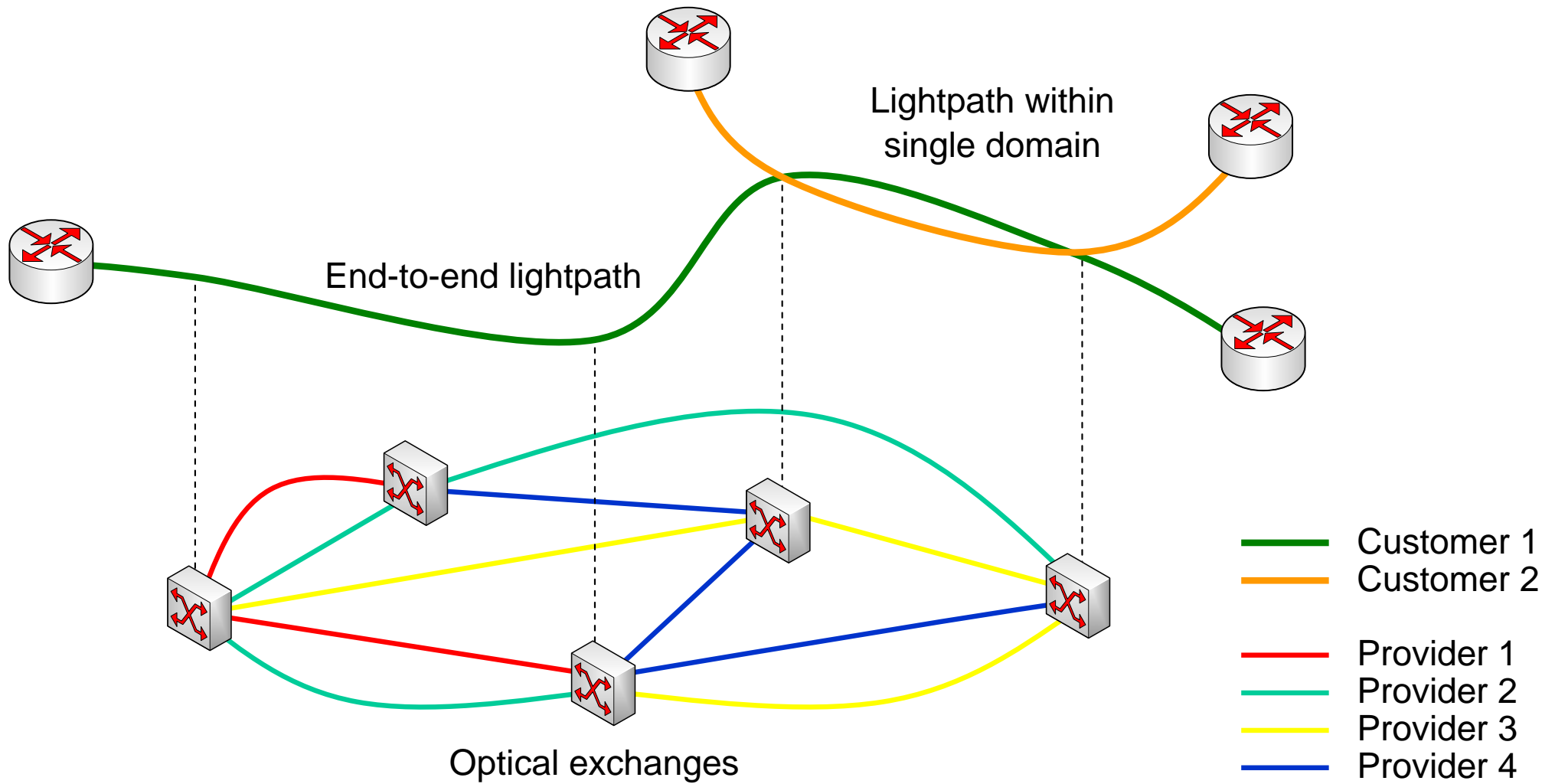


# Are we ready for a new Bandwidth Market?

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- 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

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## □ 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

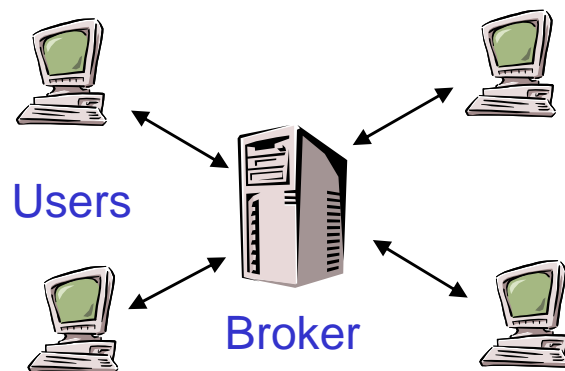
## □ Performance requirements

- **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

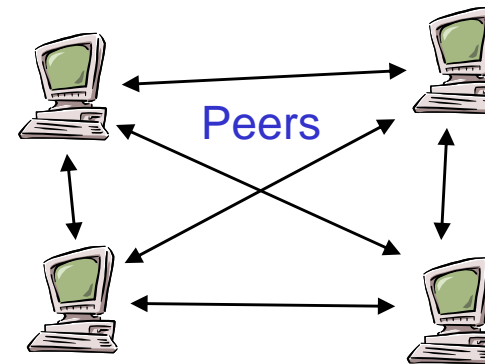
## ❑ Centralized Marketplace

- + 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

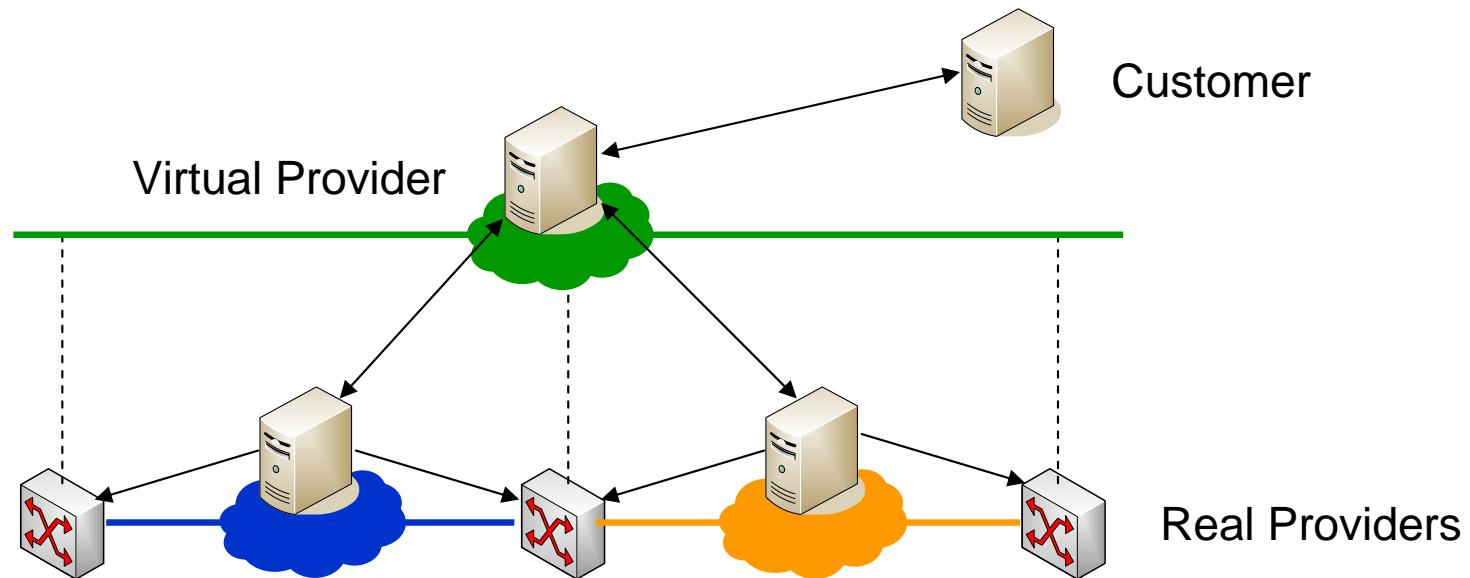
## □ Service Parameters:

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

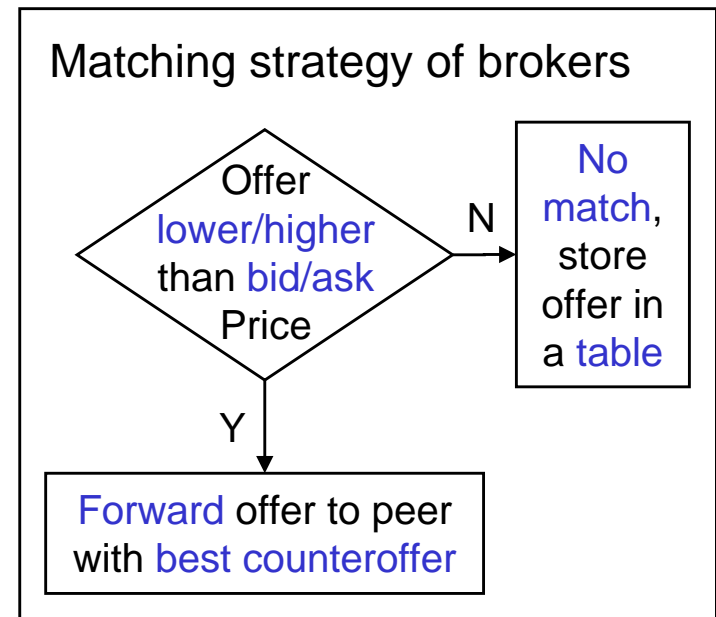
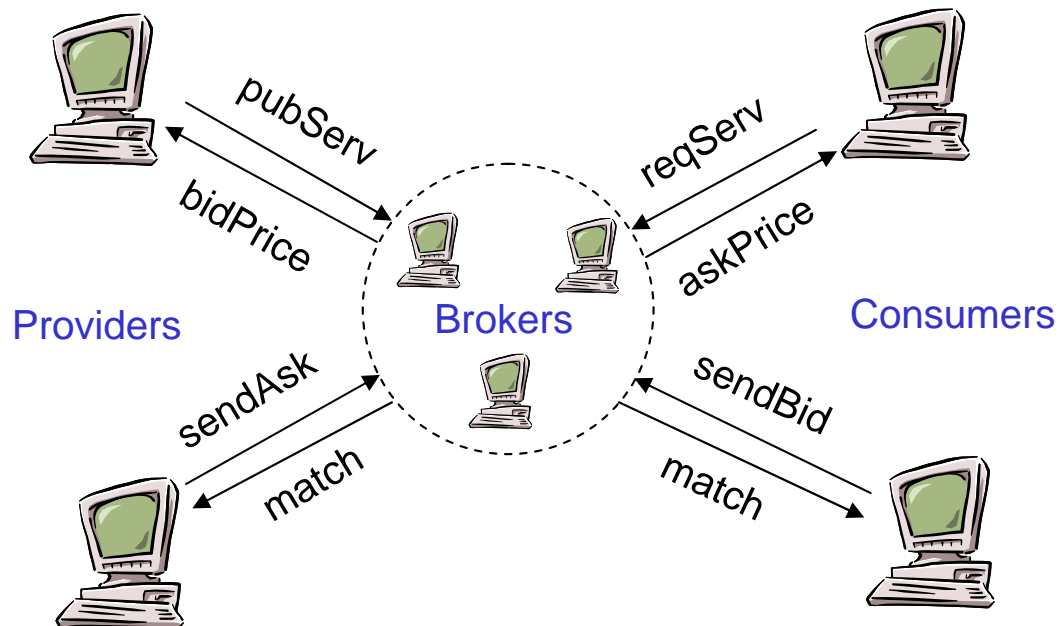
## □ Definition:

- 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

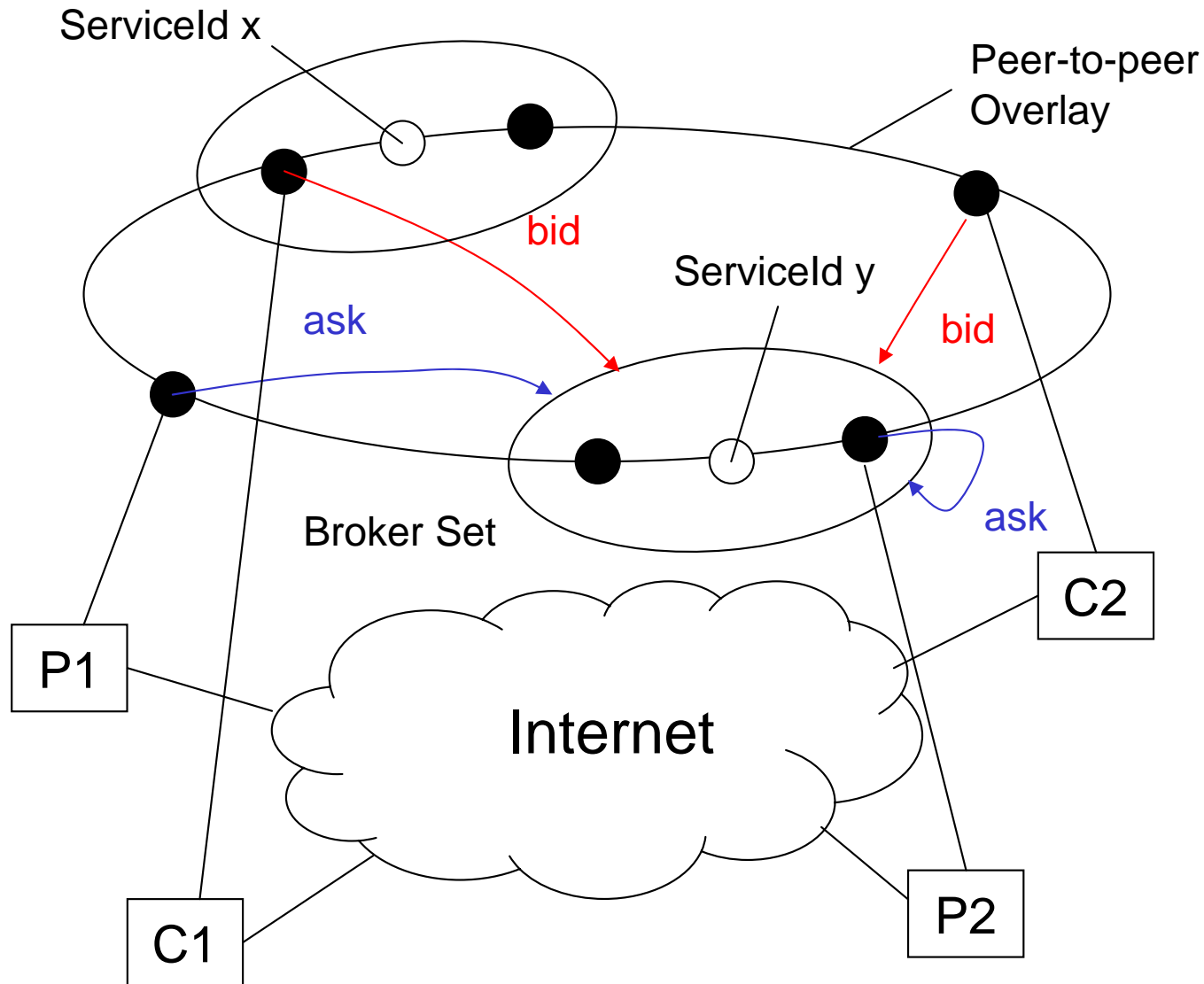


# Market Design: Basic Concept

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



# Market Design: P2P Overlay

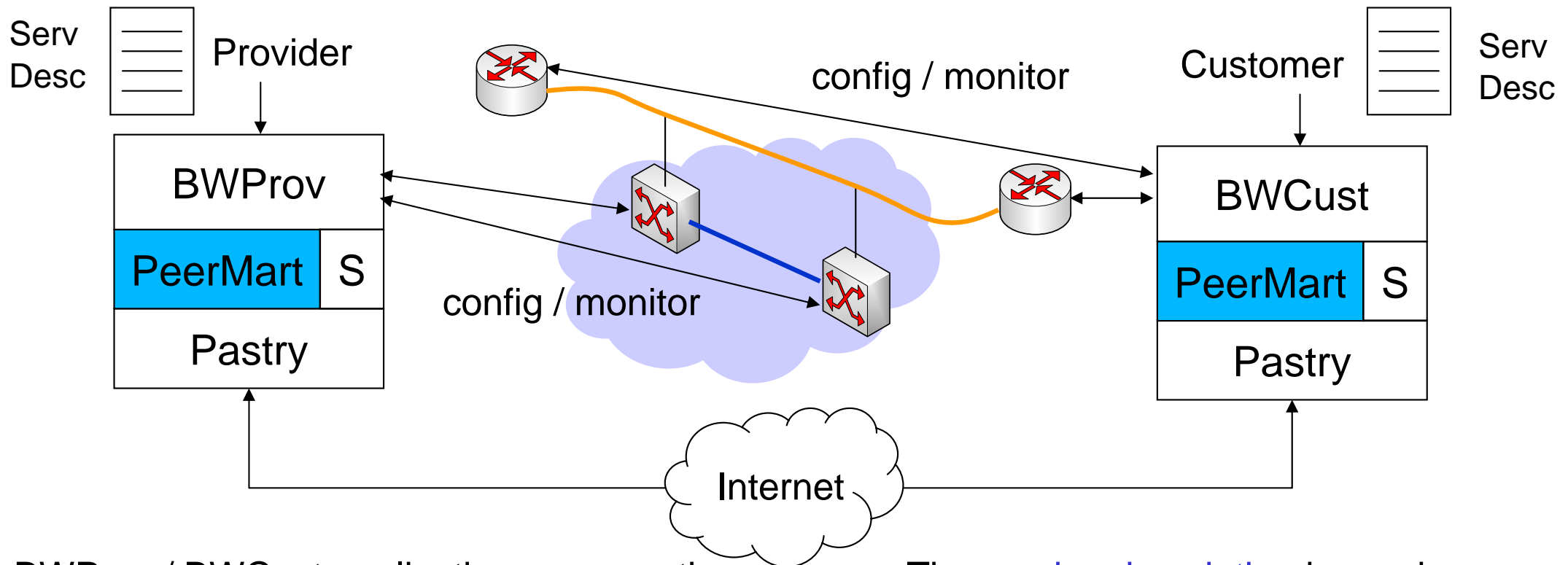


Each peer has a unique **nodeld**, peers form a **structured P2P overlay network**

Services have **unique serviceld**

N peers numerically closest to serviceld form a **broker set**

# Implementation and Node Architecture



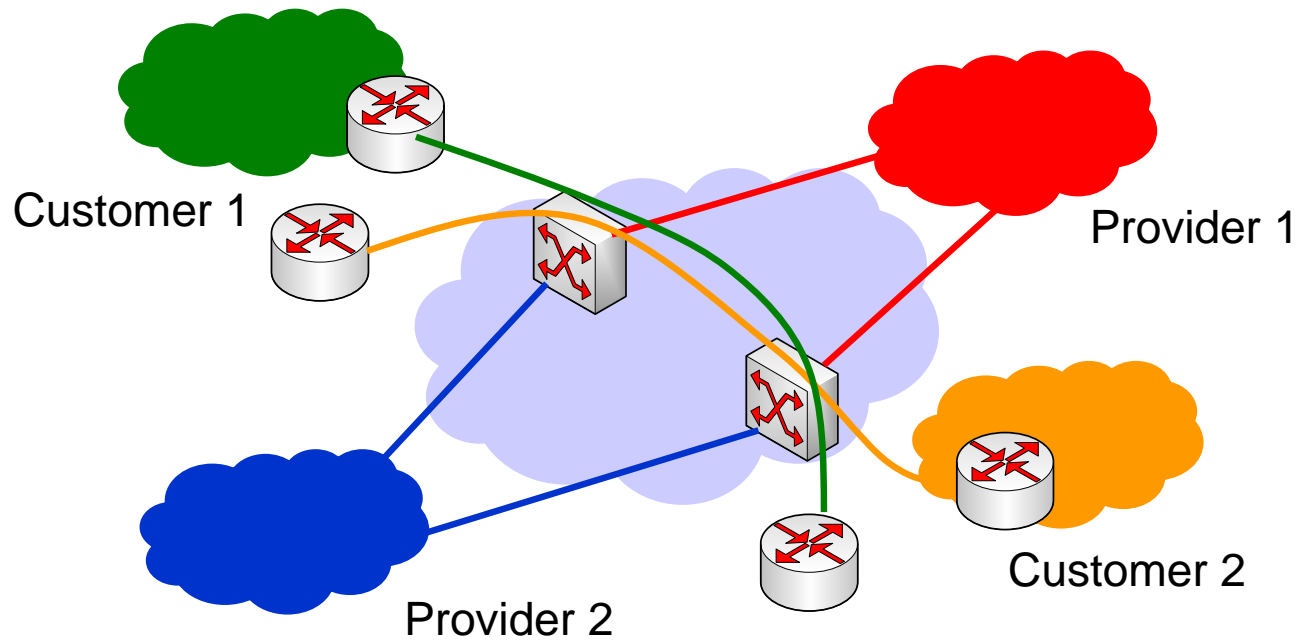
BWProv / BWCust application serve as the **bidding agent**.

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.

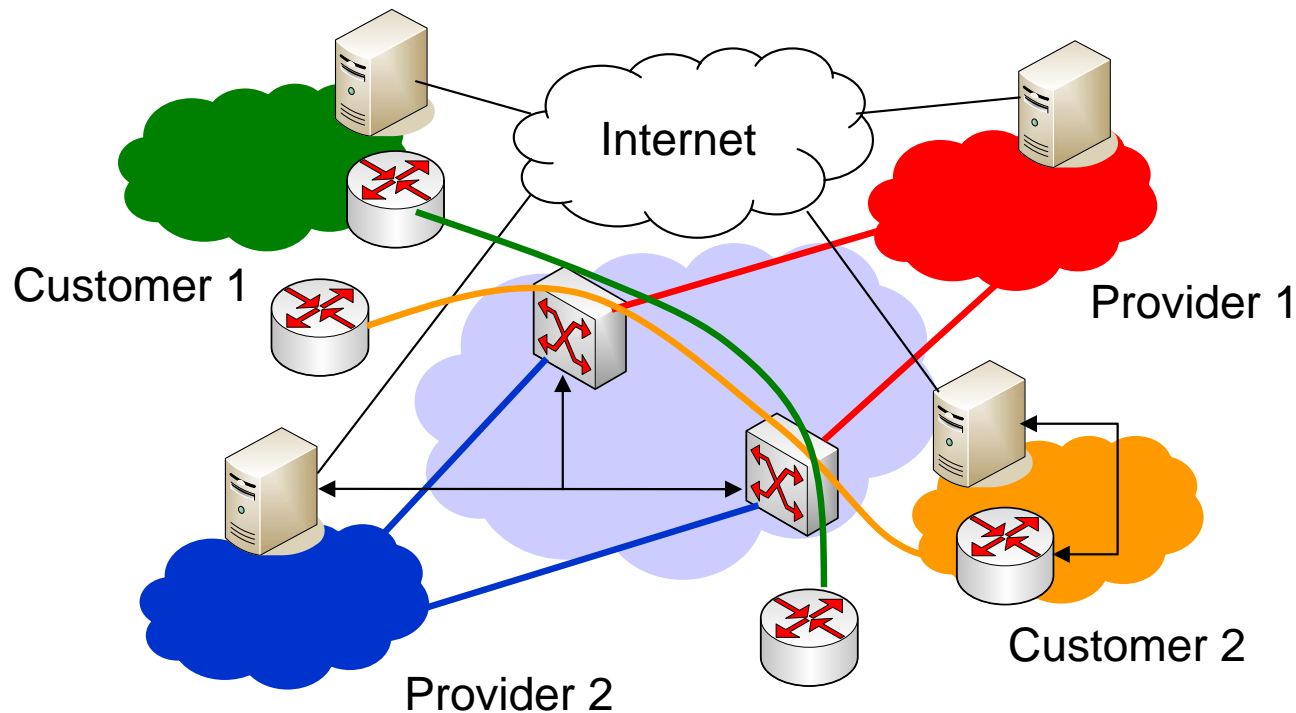
The **distributed search** component ("S") enables to publish and search for service descriptions.

# Application Example (1)



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

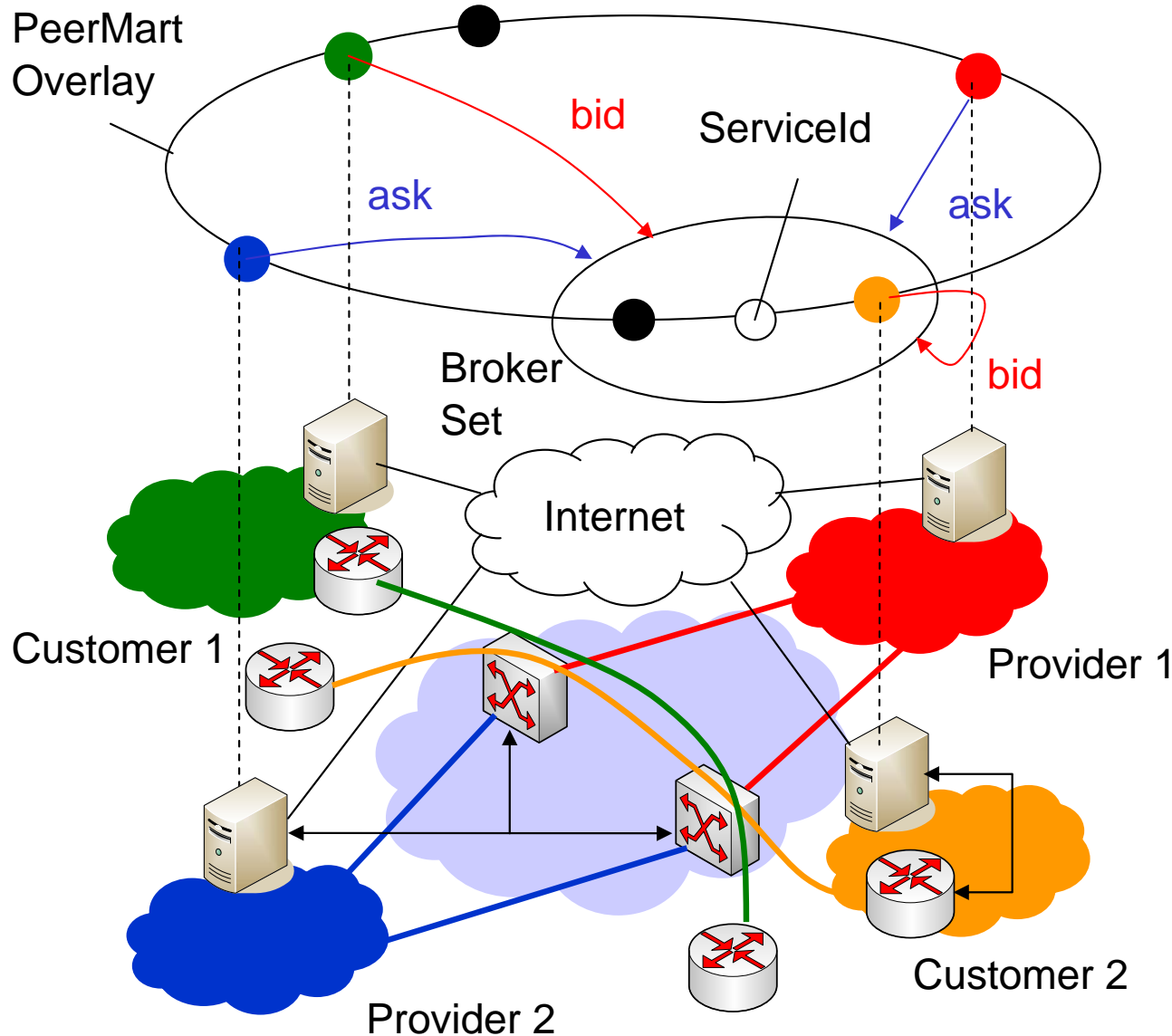
# Application Example (2)



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

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## □ 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!

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