

Economics of Peer-to-Peer Systems

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Outline

- Economics of P2P Systems
- P2P Market Place
 - Obstacles
 - Pricing Mechanisms
- Design Options for Pricing
 - Auction-based Approach
 - P2P-based Stock-Market
- Conclusion and Open Issues



Economics of P2P Systems

□ Motivation

- Peers are autonomous => cooperation cannot be enforced technically
- Achieved performance is much lower than what might be possible
- ⇒ Economical and social mechanisms are necessary to balance resource usage and effort in P2P systems

□ P2P Economics focusses on market mechanisms for P2P systems

- Accounting and charging mechanisms
- Micro-payment and virtual currency systems
- Pricing and incentive-compatible marketing mechanisms
- Reputation for trust and quality rating mechanisms



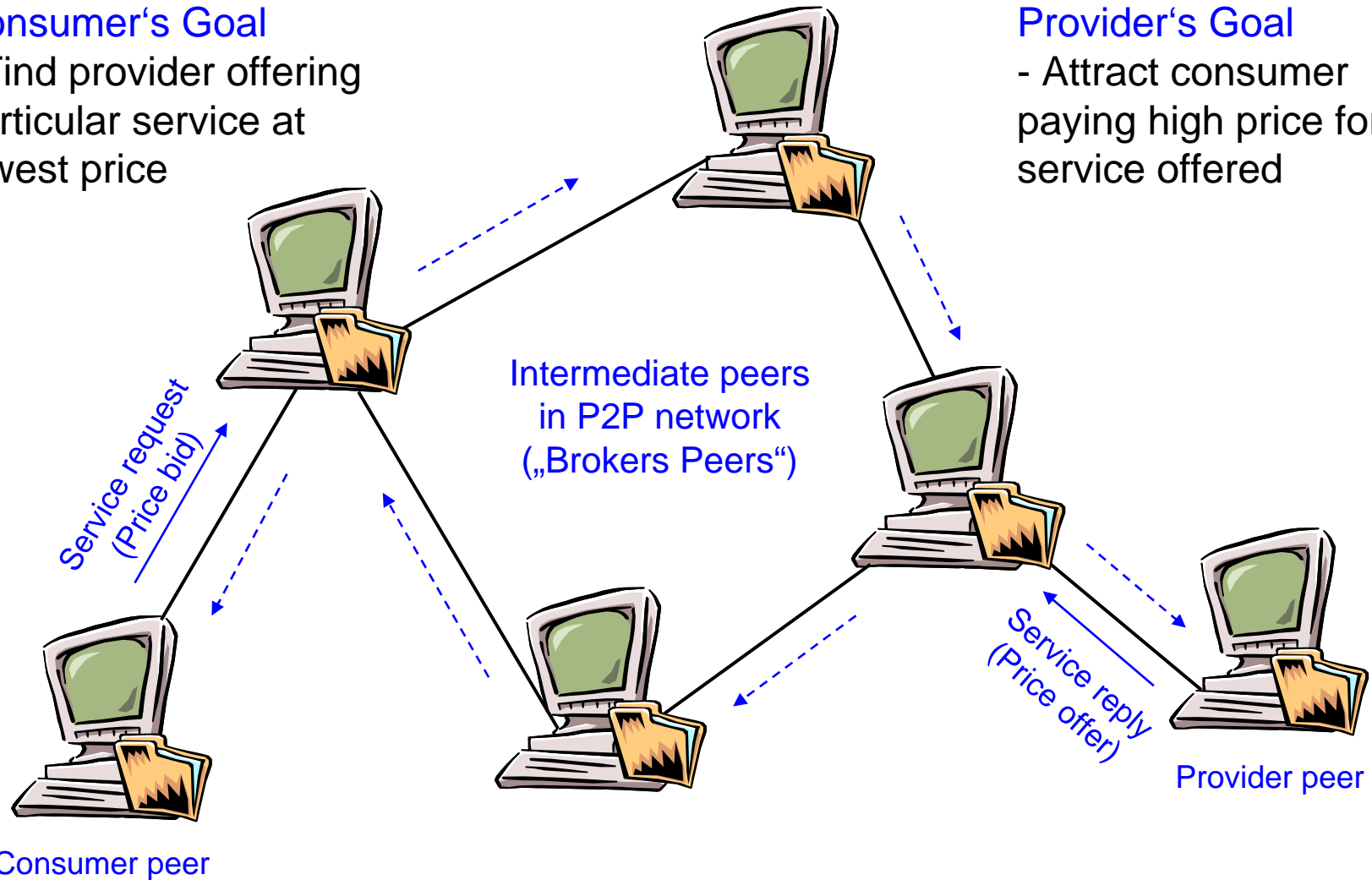
Market Place for P2P Services

Consumer's Goal

- Find provider offering particular service at lowest price

Provider's Goal

- Attract consumer paying high price for service offered



Obstacles

- Why should intermediate peers **cooperate**
 - **Forwarding** messages (requests / bids / offers etc.)
 - **Caching / Processing** data on behalf of other peers
- Cooperation is **costly**
 - Intermediate peers have simply **no incentives** to cooperate
- Even worse: Intermediate peers might be **competitors**
 - **Provider peers** could lose opportunity to **sell** a service
 - **Consumer peers** could lose opportunity to **buy** a service

- ⇒ Peers act in a **rational** and **selfish** way
 - Needs to be taken into account for dissemination of **business sensitive data**
 - Currently not considered by most P2P algorithms



Two Different Types of „Freeriders“

- Peers not providing **services** (like files or other resources)
 - This problem is **simpler** (not simple!) to solve
 - There are answers for that:
 - Answer 1: Reward service providers (**micro-payment** approach)
 - Answer 2: Exclude non-providers (**membership/rules** approach)
 - Many more answers (**reputation, public accounts** etc.)
- Peers not providing **base functionality** (like forwarding or caching service offers)
 - Much more **complicated**
 - How to detect that intermediate peer did **not forward** query?
 - Doing **Accounting** for base functionality probably **not feasible**



Pricing Mechanisms

□ Price determination

- Mechanism / strategy to **set price** for particular service
- Usually done by provider, e.g. **cost-based, demand-based pricing**

□ Price dissemination

- Exchange of **pricing information** (e.g. included in a service offer) between providers and consumers over a set of **intermediate peers** which **forward** or **cache** this information on behalf of them

□ Price evaluation

- Mechanism / strategy to **evaluate quoted price** for particular service
- Usually done by the consumer, e.g. **rating-based evaluation**



Design Options for Pricing

□ Simple approaches

- Consumers **ask** each provider for price offer (pull)
- Providers regularly **advertise** price offer to all consumers (broadcast)
 - Consumers may **subscribe** for price advertisements (multicast)
- Opposite solution also possible (less frequent in real life)
- Problem:
 - Not scalable

□ Scalable but more complex approach

- Price offers **stored** at intermediate peers (e.g. in DHT)
 - Requests could be **routed** according to pricing information
 - ⇒ “Intelligent” search (integrating search and price evaluation)
- Problems
 - **Price validity** (e.g. dynamic / personalized prices)
 - Intermediate peers may not behave correctly



Auction-based Approach

□ Idea

- Many consumers might be interested in the same service
- Provider holds an auction for that service

□ Algorithm

- Consumer asks price for service offered by particular provider
- Provider quotes highest current bid
- Consumer bids a price which remains valid for specified duration
- Repeatedly, provider selects highest bidder from list of valid bids whenever enough resources are available for provisioning

□ Drawbacks

- Consumers still have to contact each provider individually
- Providers have more control than consumers

□ Can we do better?



P2P-based Stock-Market: Vision or Reality?

□ Idea

- **Providers** offer prices for services, **consumers** bid for them
- Offers and bids are **optimally „matched“** by intermediate broker peers

□ Algorithm

- Providers **publish services** they provide
 - Broker peers reply **bid price** (current highest pay price)
- Consumers send **service requests**
 - Broker peers reply **ask price** (current lowest sell price)
- Matching Strategy
 - **Case A:** Provider offers a price for the service
 - If **offer > bid price** => no match, offer is stored for later use
 - Else => offer forwarded to consumer bidding highest price at $\min(\text{offer}, \text{bid})$
 - **Case B:** Consumer bids a price for the service
 - If **bid < ask price** => no match, bid is stored for later use
 - Else => bid forwarded to provider offering lowest price at $\max(\text{bid}, \text{offer})$



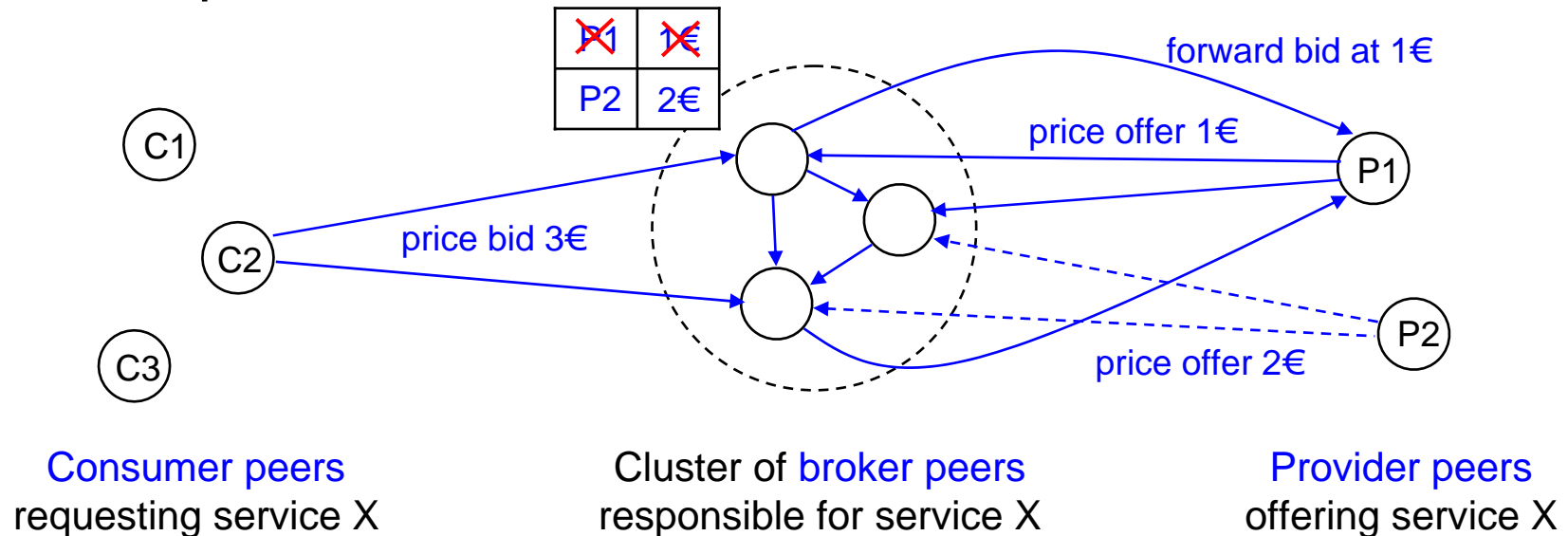
P2P Stock-Market: Design

- Assumption: Services have **unique IDs** (e.g. hash value)
- Service IDs can be mapped onto cluster of „**broker**“ **peers**
 - E.g. choose n peer IDs closest service ID, $n > 0$
 - Redundancy increases reliability and trustworthiness
- Each broker peer keeps table of **m highest bids** and **m lowest offers**
 - Lower bids and higher offers are **dropped** or **rejected**
- Fraction of broker peers **randomly selected** by consumers / providers
 - Tables are synchronized using **majority decisions**



P2P Stock-Market: Design (cont'd)

□ Example



□ Optimization

- Message might arrive before tables are synchronized
 - Use **slotted time**, delay messages by one time slot
- Only synchronize if highest bid / lowest offer changes

Conclusion and Open Issues

- Price dissemination over P2P networks is challenging
 - Peers are **rational**, may not be willing to forward/cache data
 - Stock-Market approach seems ideal solution, but implementation is complex
- What to do if a broker doesn't behave correctly
- What if peers not stay to offered / bidden price
 - Use **Reputation for Trust** mechanisms?
- **How long** shall offered / bidden prices be **valid**

