Introduction on Peer to Peer systems

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Goal of this Lecture

- What can P2P do, not only as a buzzword
- What it can't do
- Shows some examples & algorithms

A Survey and Comparison of Peer-to-Peer Overlay Network Schemes, by Eng Keong Lua and al.
in *IEEE Communications survey and tutorial* March 2004

Harnessing the Power of Disruptive Technologies
published by O'Reilly, 2001

Plan

Universal

What have in common

- Net Meeting, Skype, Ekiga
- Irc, Msn, Icq, Jabber
- Kazza, Freenet, Napster, Gnutella
- Seti@Home, Folding@Home
- Ebay, Flickr, Facebook

Definition

Philosophical one

Participants gathering their resources in order to achieve a common goal

Why ?

Available resources

- Large Hard Drives
- Powerful CPUs
- Correct connexion to Internet

Users want

- More freedom
- No link to commercial companies
- No infrastructure cost

A new (?) solution : Peer to Peer systems

Definition

Participant gathering their resources in order to achieve a common goal

- Computers are running the same code
- There is no global view of the system
- View is limited to neighboors
- Everyone has the same rights and duties

Peer-to-Peer: New name, old concept

An architecture already there

- Internet connects most of existing computers
- Most computers are not fully used
  - Idle time $>$ 75% on personal computers
  - Storage systems are mostly empty

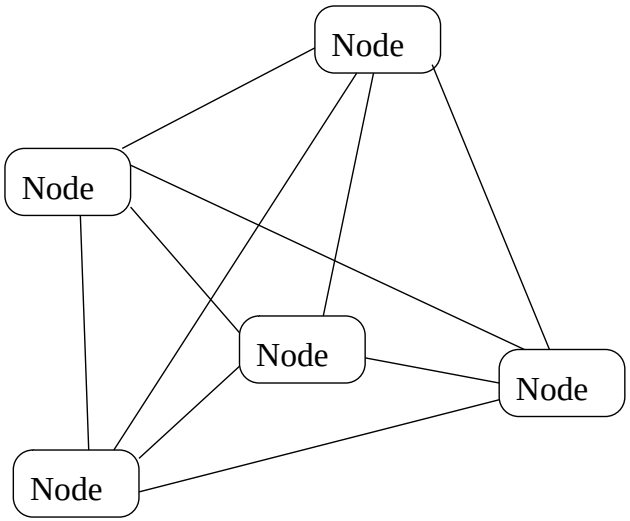
Already used between servers

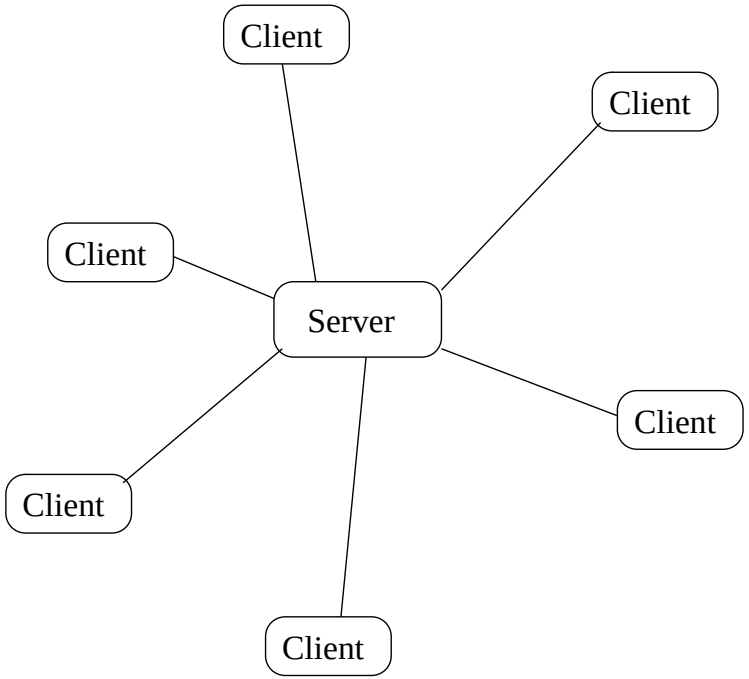
- Usenet
- DNS
- IP Routing

Comparison with Client/Server

- In client/Server each node is either a Client or a Server. Usually there are a few Servers and lots of Clients.
- Client/Server systems suffer from *single point of failure*.
- Client/Server are mostly static, at least the Servers. Peer to Peer systems are dynamics.
- Client/Server systems need *human* administrators
- Client/Server does not scale

Comparison with Client/Server II





Comparison with Client/Server II

When a new participant joins a service, the service increase the resource consumption

- **Client/Server** : increases the server power/connectivity
- **Peer to Peer** : uses the resources given by the participant

Not so easy

Wanted

- Scalability (1K,100K,1M nodes)
- Dynamicity
- Security (user, task)
- Transparent
  - For the user (CPU,memory,disk)
  - For the network
- Heterogeneity
- Self-organization
- Participation (66% of Free riders)
- Go through NAT/Firewall

Self-organization

Participants

High volatility & voluntary

- No central administration
- Resource discovery
- Heterogeneity
  - Hardware
  - Users (15% of users have 94% of files)
- Distribution of the resources
- Trust

What's not new

Partial solutions

- Scalability : Farm of web servers
- Dynamism : Cell phones
- Fault tolerance : Redundant servers

Current Peer to Peer systems

Available applications

- *File sharing*
- Distributed storage
- Content delivery
- Distributed computing
- Telephony/Chat
- Games

Current Peer to Peer systems (cont)

Widely used

2004 : According to British Web analysis firm CacheLogic, BitTorrent accounts for an astounding 35 percent of all the traffic on the Internet – more than all other peer-to-peer programs combined – and dwarfs mainstream traffic like Web pages

Start-ups

- Skype (ok, no more a small start-up)
- BitTorrent
- UbiStorage

Two worlds

Internet Users

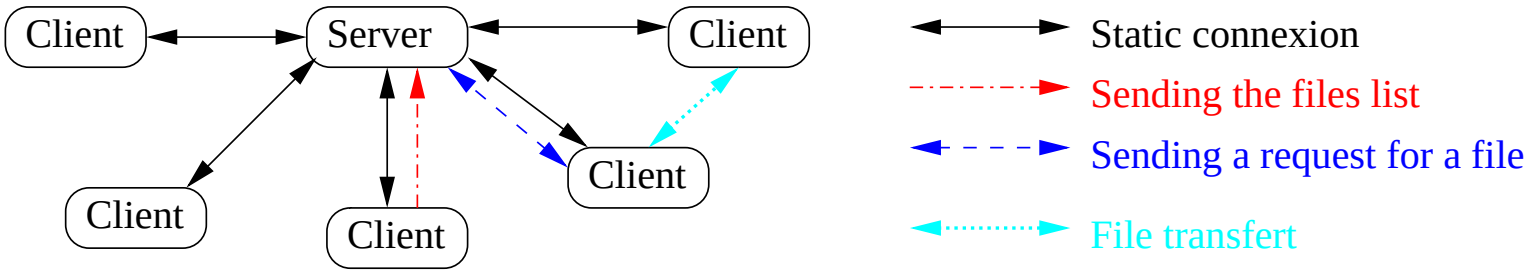
- Problem of security
- Large scale
- No control
- Motivation needed

Private Area (Corp., Univ.)

- Other mean of security
- Medium to large scale
- Total control

Plan

Index Method



- Users send the list of their files to a server
- To find a file, you send a request to the server
- It answers with the list of clients owning the file
- You directly contact the owners for the transfer

Index Method II

Systems

Napster, Mojonation, Yaga, Filetopia, Seti@Home

Problems

- Scaling
- Price
- HotSpot
- Attack
- Single point of failure

Useful when...

- Small number of client
- Need a total control of transfers (video game industry)
- Performance is more important than cost

BitTorrent

Same approach as Napster, but :

- Downloads are done in parallel
- One server per file
- Server manages all the details of transfers
- Server enforces the rule *The more you share, the more you get*

Differences

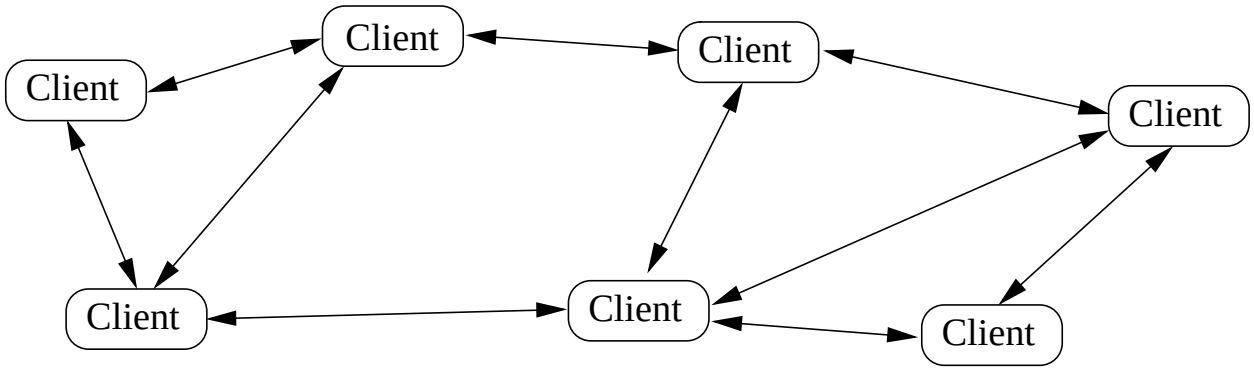
- Specialized for large files
- Distributed due to the *One server per file* rule

Privacy

No privacy

- Napster : The server knows all transfers
- BitTorrent : For each file, a server knows all transferts

Flooding



- You send your request to your neighbors
- They forward it to their neighbors, and so on until reaching the *Time To Live* depth
- Users with files corresponding to the request answer

Flooding II

Systems

Gnutella, Direct Connect

Characteristics

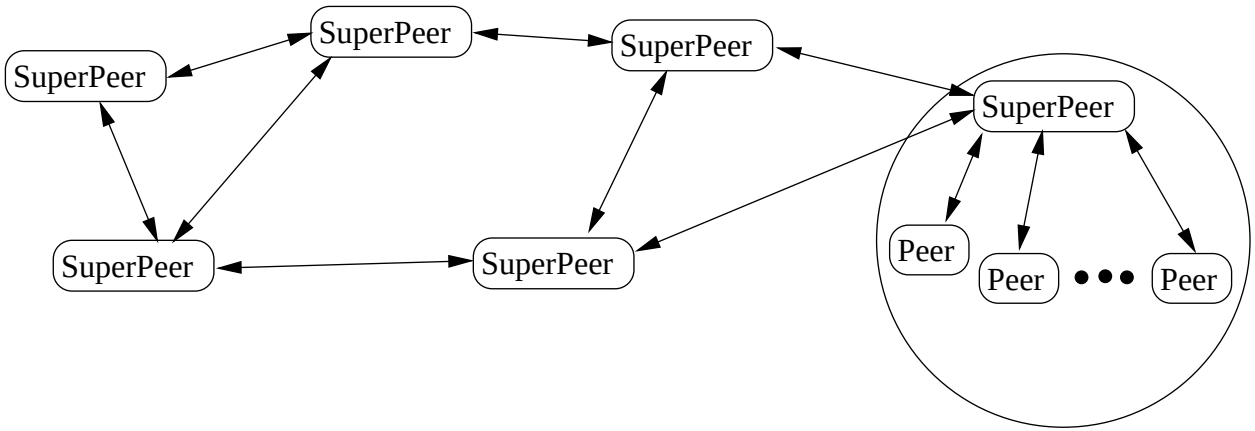
- Distributed structure
  - No single point of failure
  - Denial of service difficult (but possible)
- Not scalable
  - Resource consumption (network)
  - Not complete answers

Privacy

Average to good privacy

- Onion routing (good privacy)
- No global view of the system
- Usually easy to obtain the shared list of a node
- Difficult to have a global impact

Super Peers



Super Peers act as local servers

- Some reliable nodes act as super peers
- Super peers are connected with a gnutella protocol
- Each super peer acts as a local server for several peers

Super Peers II

Systems

Gnutella2, Kazaa

Characteristics

- Less distributed structure
  - Some nodes are more loaded
  - Some nodes are more important
- Scalable
  - Less resource consumption due to limits of number of answers

Plan

A case study : Freenet

Ian Clarke, University of Edinbourgh, (1999)

Keywords

- A peer-to-peer file sharing system
- Provide anonymity for authors and readers
- A web of Freedom

Principle

- Files are referenced by key
- The key is obtained by SHA-1 on the file
- The key is routed to localize the file

Content Driven routing algorithm

- Routing table contains a set of key/node pairs
- Take the nearest key in the routing table to obtain the next node to consult.
- Nearest key = by lexical comparison

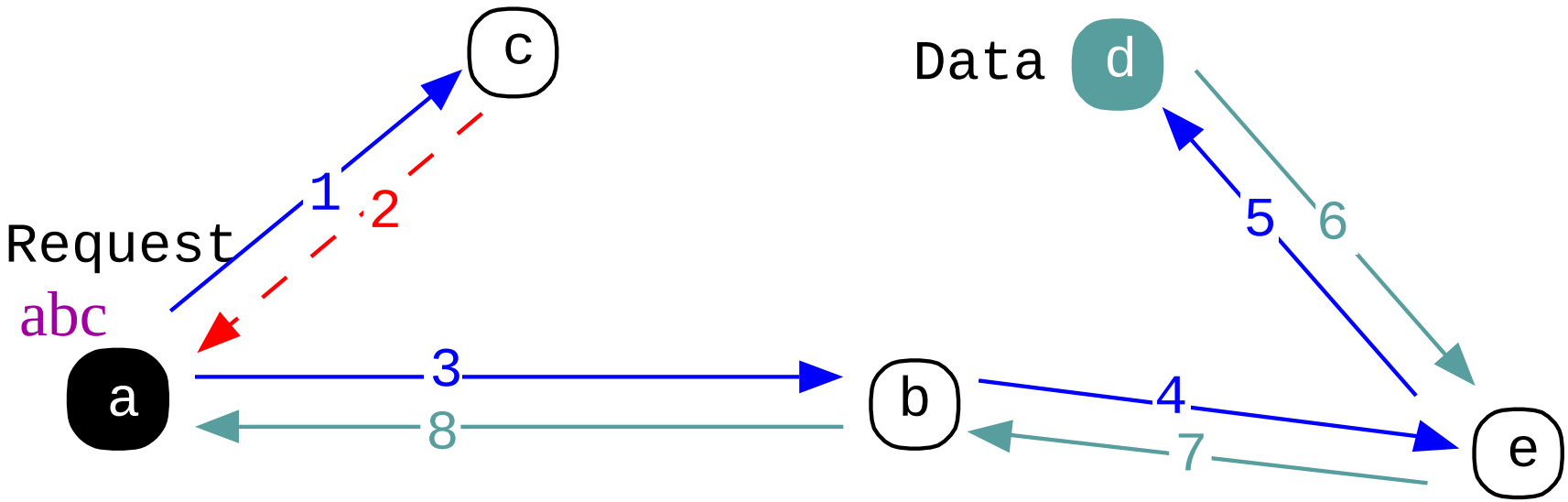


abb	node c
acd	node b

On the path of the answer

- File is replicated on the path in the cache
- Cache : variant of *L*ast *R*ecently *U*sed
- Routing tables are updated

$\rightarrow$ the graph evolves (new links = new entries)

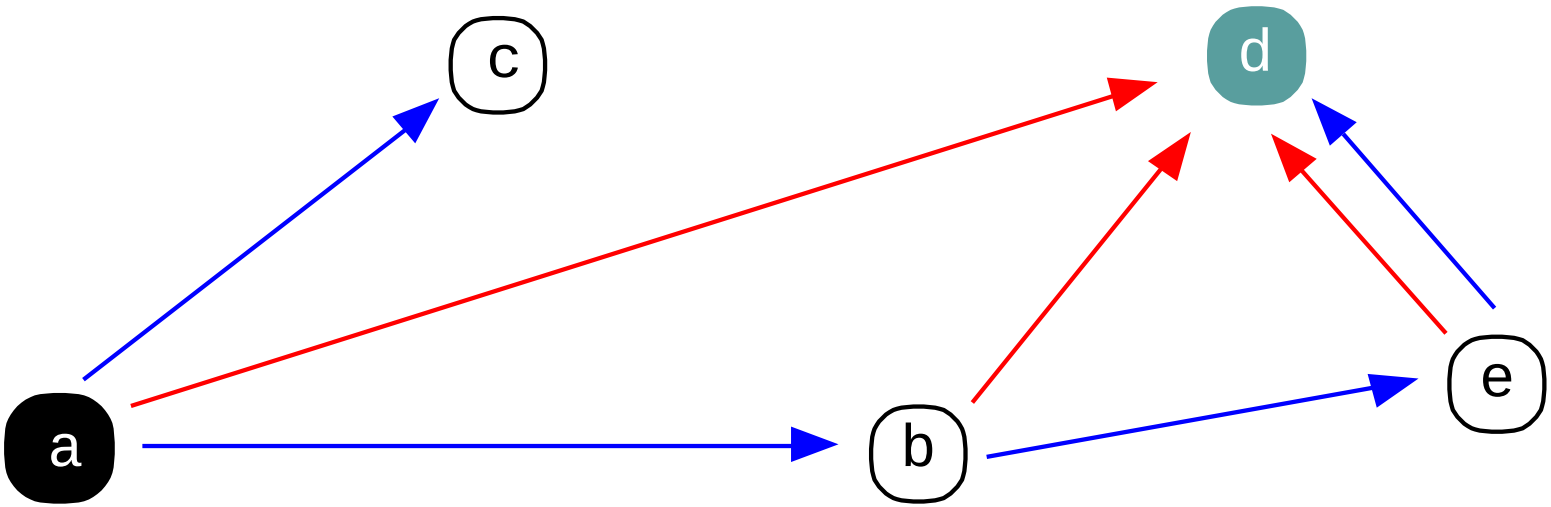


abb	node c
acd	node b
abc	node d

Old links

New links (entries)

Anonymity

Reader

- Impossible to know if a user is forwarding or initiating the request
- Impossible to know if a user is the last to receive a file

Writer

- Once in the system, the writer can disconnect
- Impossible to know if someone insert some file or forward it

Some properties

Self-organization of the graph

- Nodes specialize in files with close keys (learning process)
- Good properties (Small World)

File are automatically replicated in function of their popularity

- Hot-spots are limited
- Tolerant against attacks

Drawbacks

Counterpart

- Files might disappear (LRU cache)
- The network is heavily loaded
- Difficult to update a value
- Impossible to know what is hosted locally

Plan

Pastry

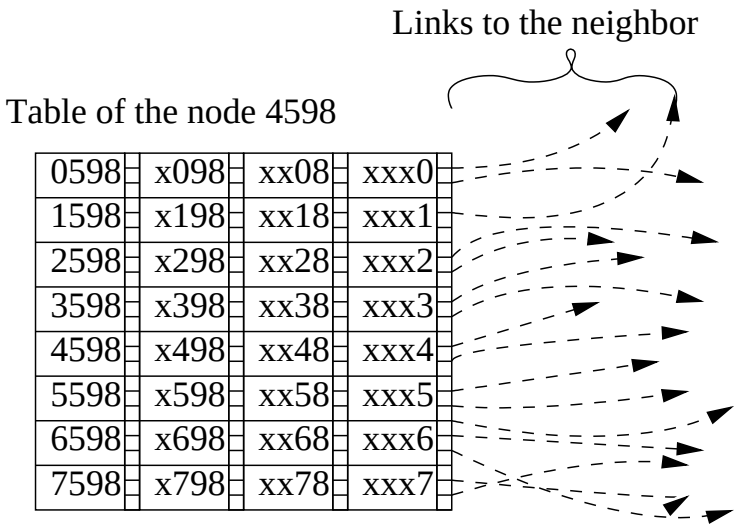
Principle

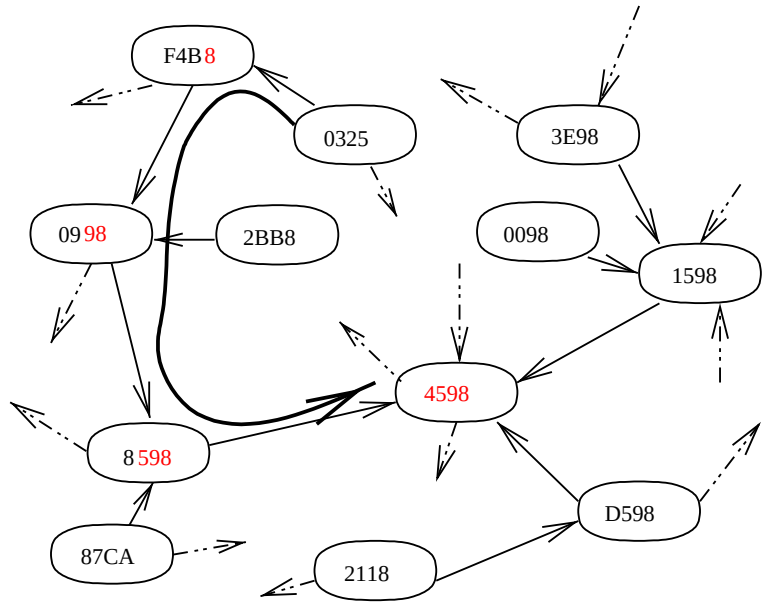
- Each file has a key
- Each node has an identifier
- Node with identifier *Id* manages keys whose values are near *Id*

Queries

- Content driven queries
- Suffix forwarding

Pastry II





- Neighbors of *Id* are chosen as to have the suffix of their identifier in common with *Id*

Pastry III

Pros

- $ln(n)$ messages guarantee
- Good path redundancy

Cons

- Difficult to keep a synchronized neighbor table
- Problem of data redundancy
- No adaptation to data dynamicity

Plan

Current state of Peer to Peer systems

- A lot of redundant systems
- Typically File Sharing

Common basic component

Distributed index (Key, Value)

- Key is typically the filename
- Value is typically the file content or where to obtain it

Each Key is associated with a node

Generic Interface

- Node Id : k-bit identifier (unique)
- Key : k-bit identifier (unique)
- Value : bytes (can be a file, an IP, ...)

Generic DHT (Distributed Hash Table)

- put(key, value)
  - Stores (key, value) on the node responsible of *key*
- value = get(key)
  - Retrieves the data associated with *key*

Current implementations

Software

- Kadmelia
- Chord
- CAN

Usage

- File sharing
- Naming
- Chat service
- Databases

Still limited

Fundamental Problems

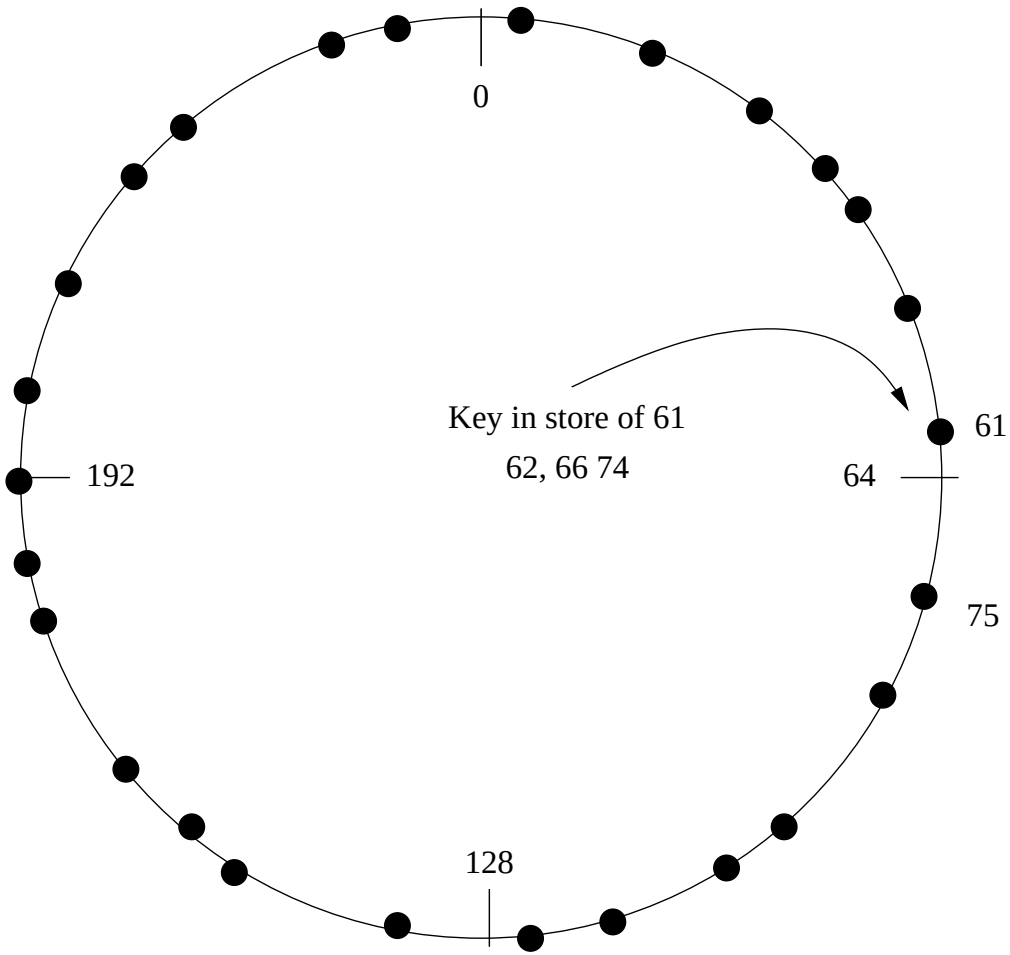
- Complex request
- Data coherence
- Request with several answer

Implementation difficulties

- Distribute workload evenly
  - Keys
  - Requests
- Only local information
- Dynamic information

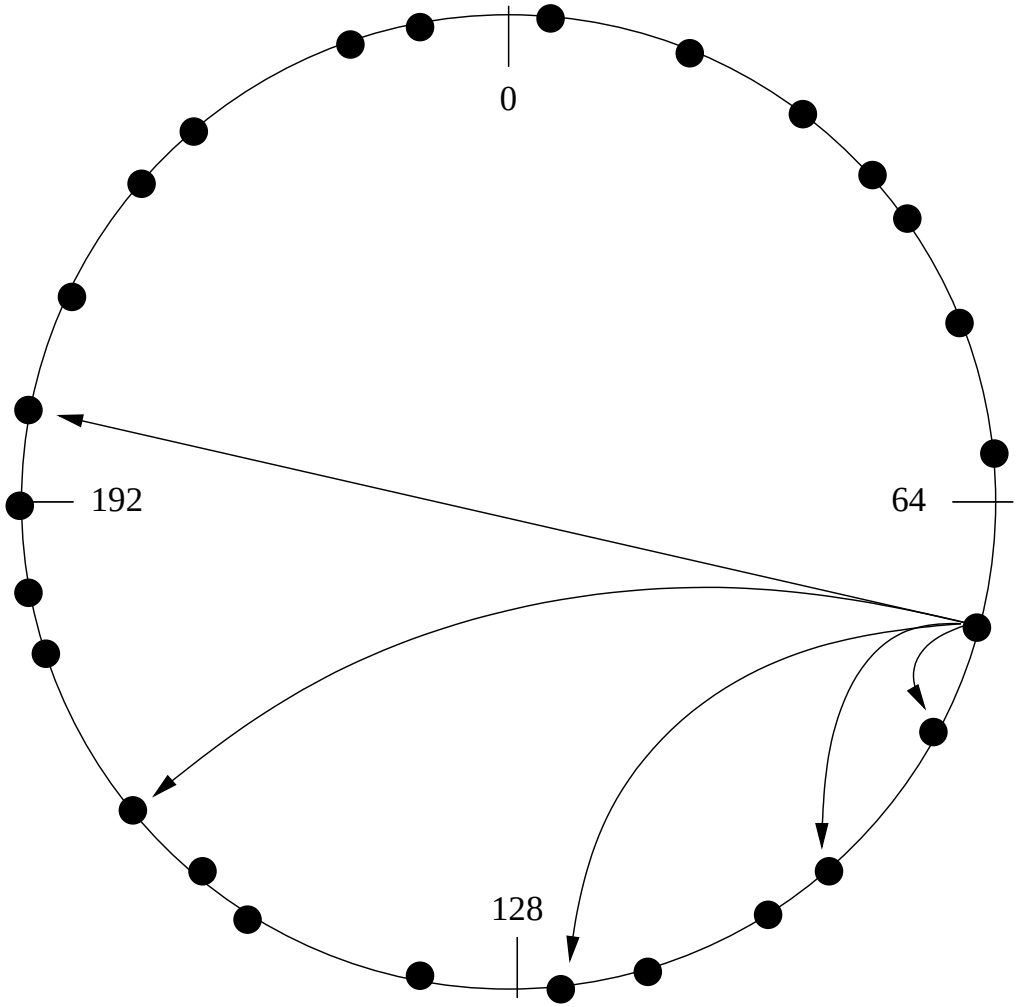
Chord structure

- Nodes are distributed on a circle
- Keys are assigned to the node with *Id* just before their value



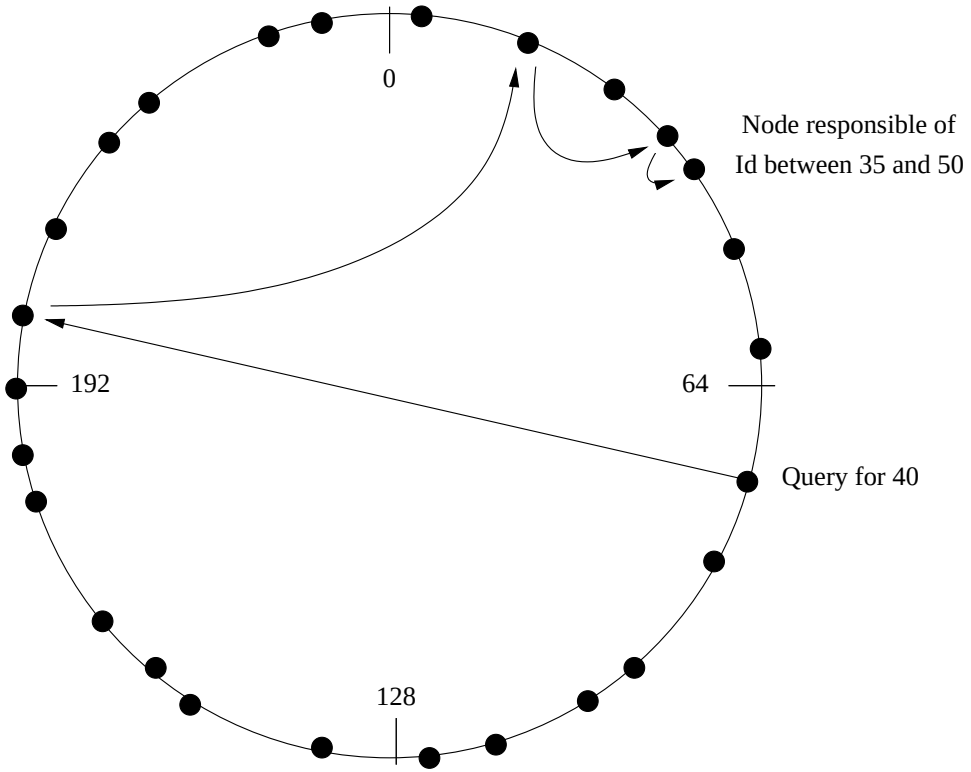
Neighbors

- $Log(N)$ neighbors
- Neighbors are nodes $Id + 1, Id + 2, Id + 4, ..., Id + 2^i, ..., Id + 2^{k-1}$ (modulo 2^k).



Routing algorithm

- Forward to the neighbor which is prior to the key
- Query needs at most $Log(N)$ messages



Chord characteristics

Efficient

- If a (key, value) exists, the query will find it
- Fast : $Log_2(1.000.000) = 23$
- Small neighbors table $Log_2(N)$

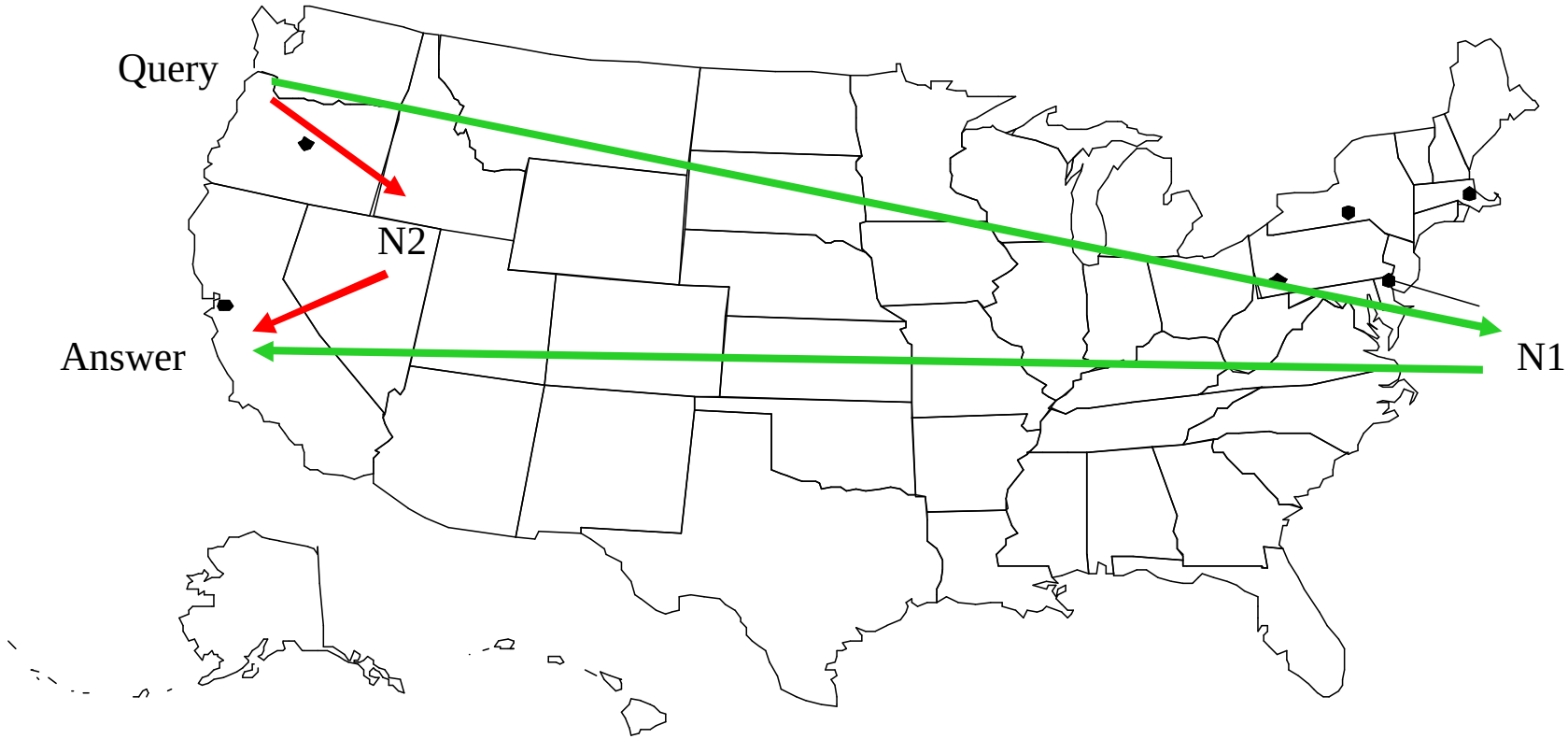
Chord characteristics

Some problems

- Security and privacy
- Attack
- How to test and evaluate such system ?
- Real performance (instead of number of messages)

Physical overlay

- Logical topology mapped in the physical network :



Plan

Conclusion

- Peer to Peer systems are efficient for several uses (using border resources)
- Recent systems are scalable
- Low cost alternative to Client/Server
- Field old enough to be used in real cases
- Still not perfect
  - Trust & certification
  - Anonymity
  - Security
  - Performance
  - Layers fees

When to use Peer to Peer systems

- Limited budget
- Large audience
- Trusted users
- Dynamic system, but not too much
- Do not need guarantee
- Do not need control

Vision of the future

User centered

No more servers
All content provided and served by users

- Only cooperation of peers
  - Wikipedia
  - Social networks
  - Youtube
  - *Good Ol' Time* web-pages