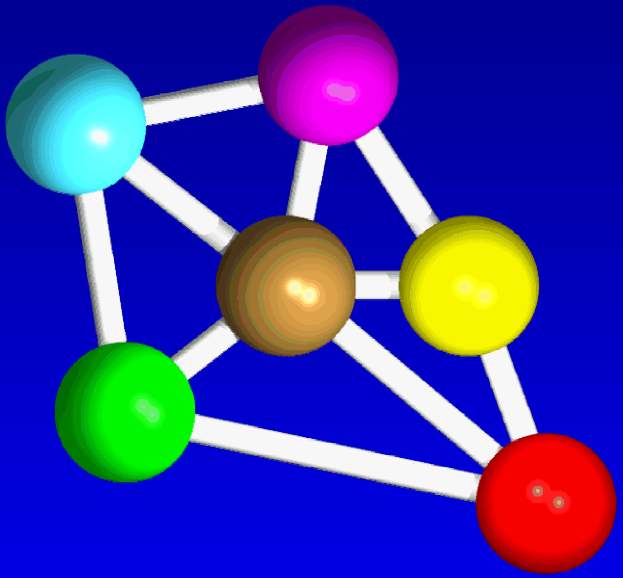
Peer-to-peer under the hood



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Peer-to-peer under the hood

- This talk will be about p2p algorithms. Not about specific p2p software.
- David has researched p2p algorithms since 1997 and full time since autumn 2000.
- David is making a p2p-programming library. So that other programmers can build advanced p2p applications easily, without having to spend years on research first.

Note that slides with a red X are not shown during talks but are added in printed and online versions to make the slides more comprehensible.

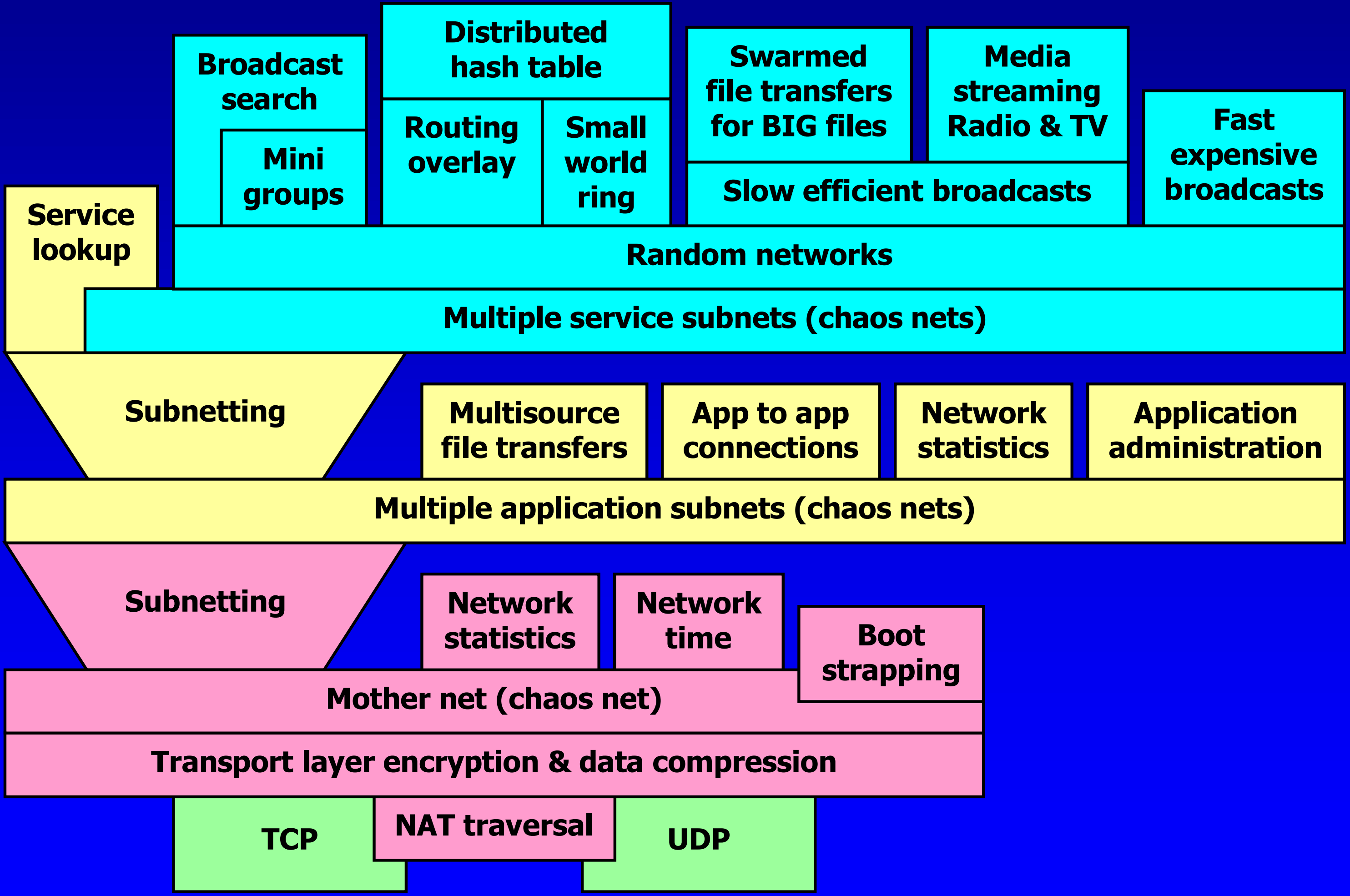
Ideal p2p systems

- Fully distributed
- Totally serverless
- Fully scalable
- Globally searchable
- Bandwidth efficient
- Robust
- Encrypted
- Stealthy
- Preferably anonymous

Target applications

- File sharing
- Chat systems
- Instant messaging
- Internet telephoning
- Internet games
- Radio & TV (sent from home users computers)
- Distributed calculation systems
- And many more applications

The Randpeer layer model



Broadcast search

Mini groups

Distributed hash table

Routing overlay

Small world ring

Swarmed file transfers for BIG files

Media streaming Radio & TV

Slow efficient broadcasts

Fast expensive broadcasts

Service lookup

Random networks

Multiple service subnets (chaos nets)

Subnetting

Multisource file transfers

App to app connections

Network statistics

Application administration

Multiple application subnets (chaos nets)

Subnetting

Network statistics

Network time

Boot strapping

Mother net (chaos net)

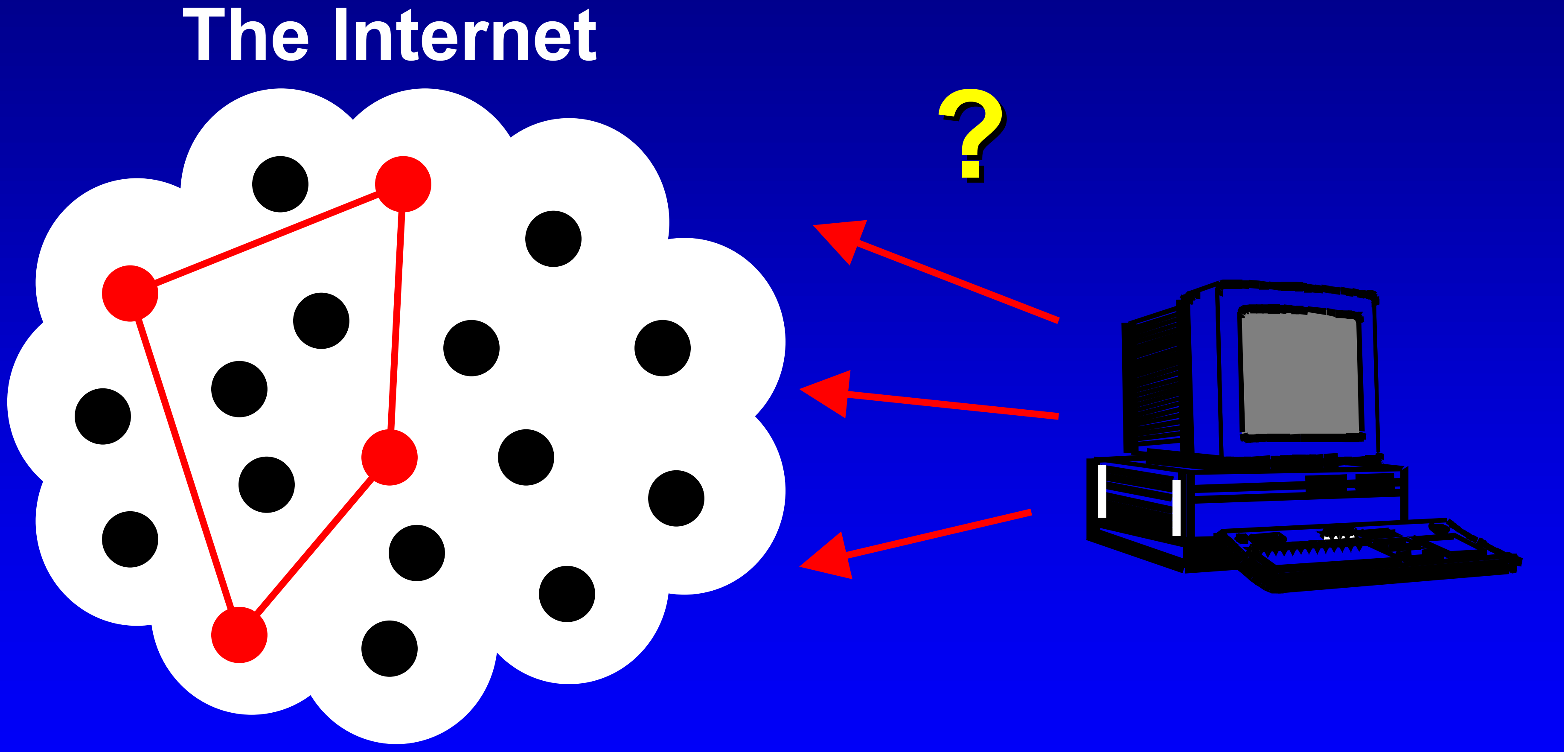
Transport layer encryption & data compression

TCP

NAT traversal

UDP

Bootstrapping



How to find the other peers on the Internet?

Bootstrapping 2

When a node joins a p2p network it needs some way to find the network.

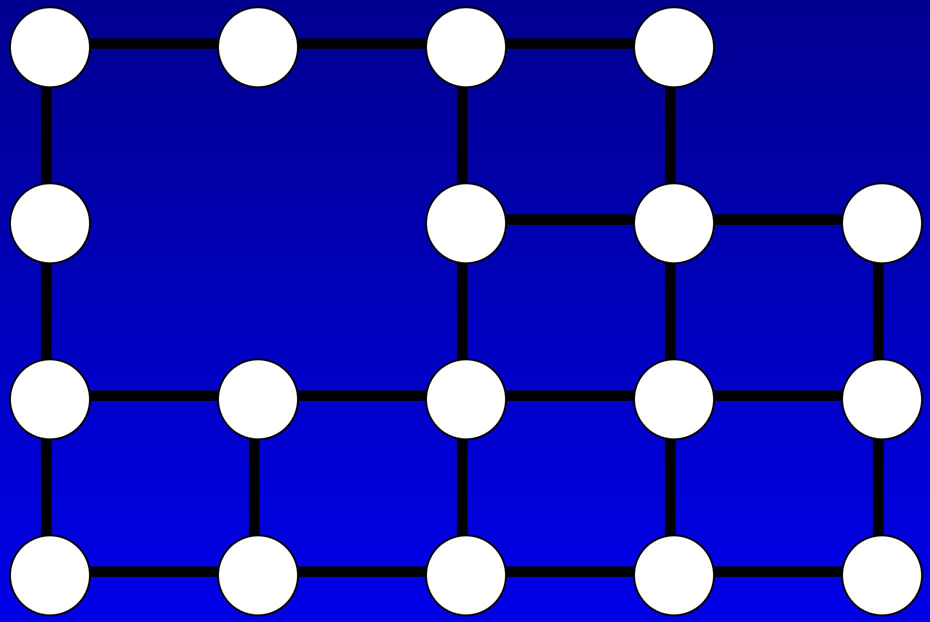
Centralised approach:

- Start servers / reflectors. Reachable at fixed IPs or fixed DNS names.

Distributed serverless approach:

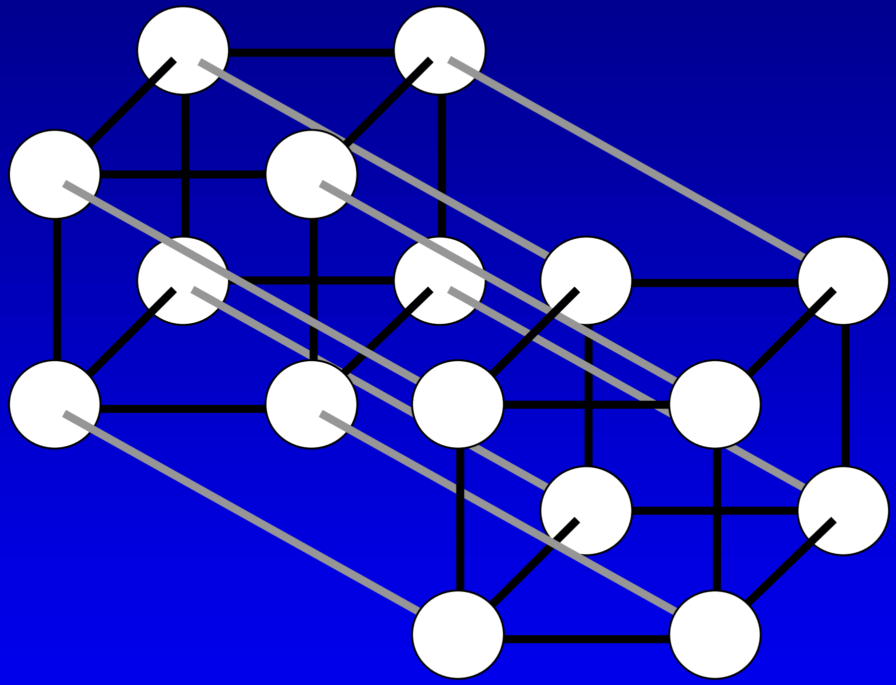
- Start lists: Nodes remember nodes that are online often and much with the same IP.
- Old nodes use their start list to find the network.
- New nodes get a start list in the install package.
- If the start list is too old, get a fresh one from the web or IRC or from a friend via email or diskette.

Two dimensional grid



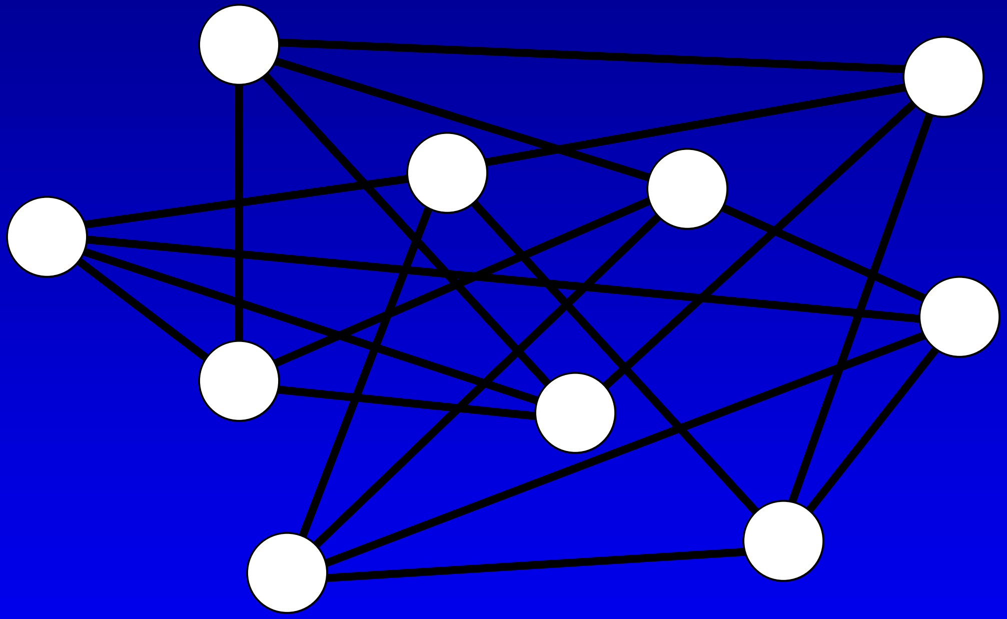
- Easy to understand
- Tricky to code and maintain
- Inefficient (Long jump distances)

Hypercube



- Easy to understand
- Tricky to code and maintain
- Efficient (Short jump distances)

Random network
(Small world network)



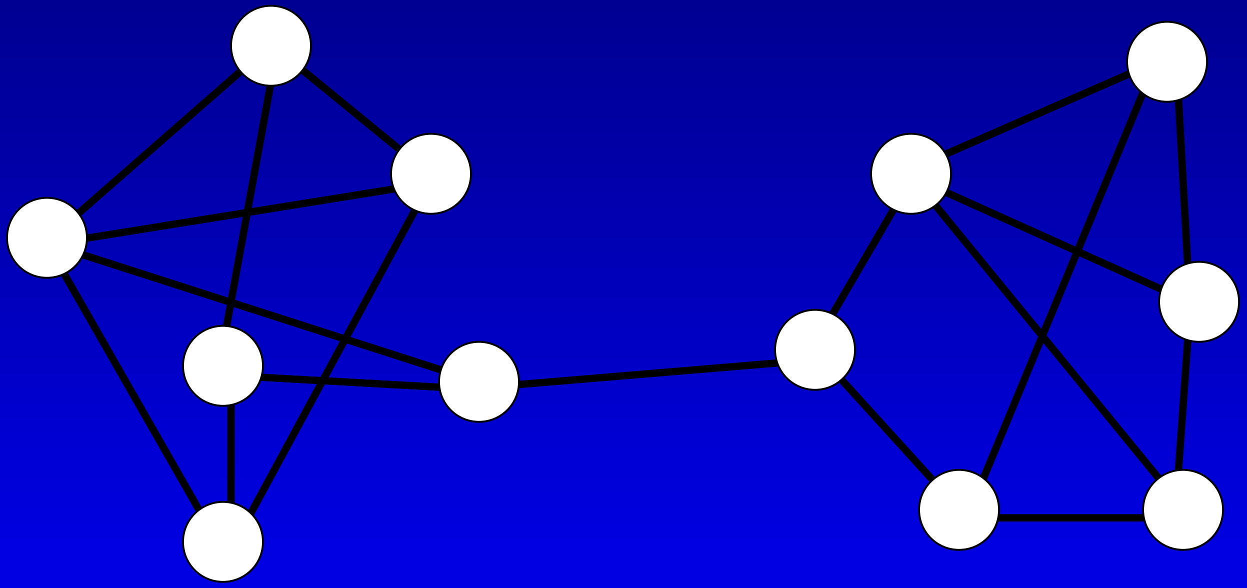
- Slightly tricky to understand
- Easy to code and maintain
- Efficient (Short jump distances)

Internet problems

- High node churn = Home users often turn their computers off
- Erroneous ISP routers = All nodes can not reach each other
- Firewalls and NAT routers = All nodes can not reach each other

This means random networks are easier to maintain then “well organised” grids.

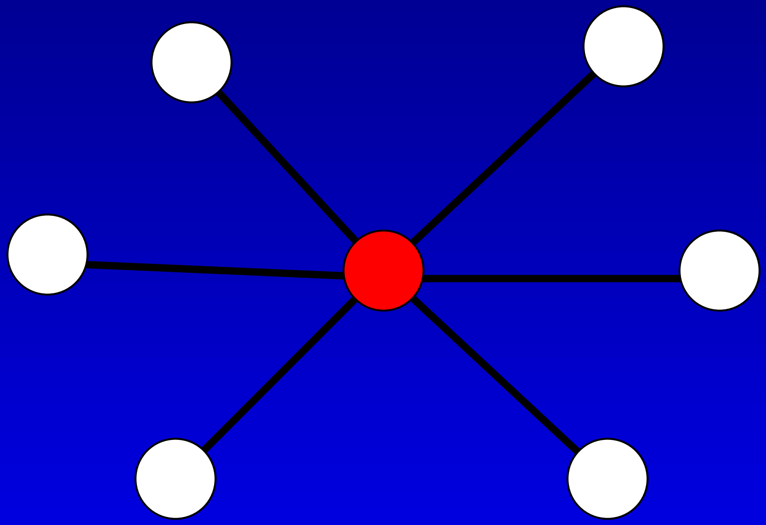
Netsplit prevention



We need random (far away) node addresses:

- Node address announcements
- Random walkers
- Chaos nets (David’s own solution)

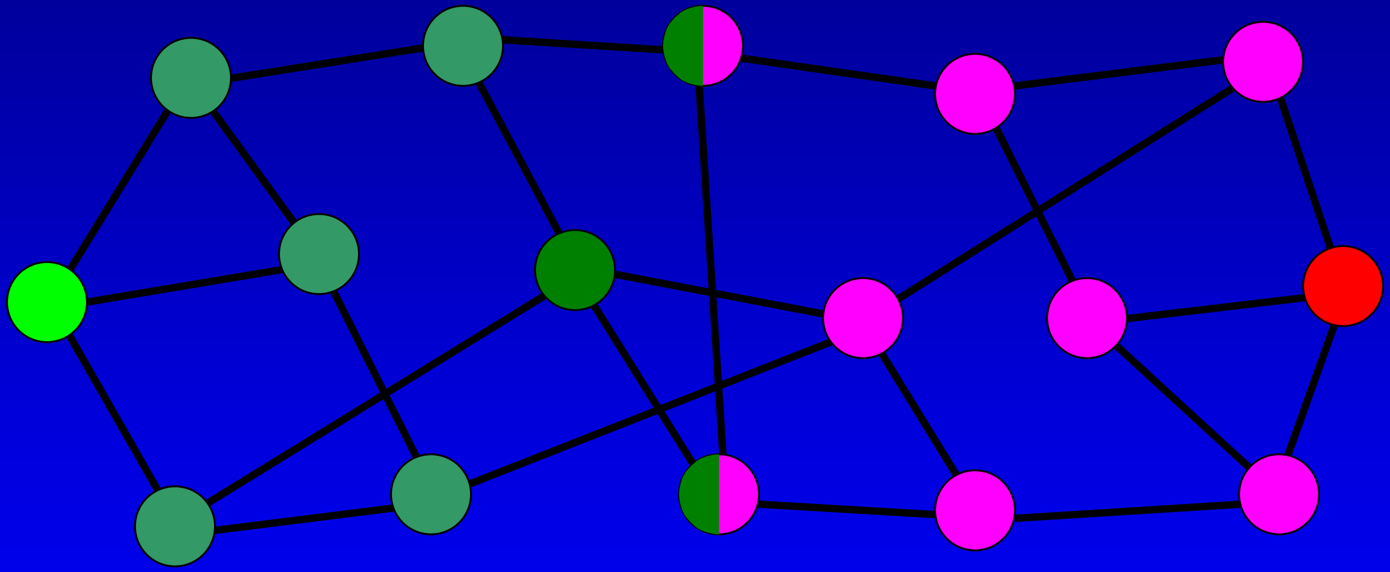
Flooding / Overloading



Methods to prevent overloading of nodes:

- Round based algorithms
- Throttling
- Randomised algorithms (to spread load evenly)

Throttled balanced broadcasts



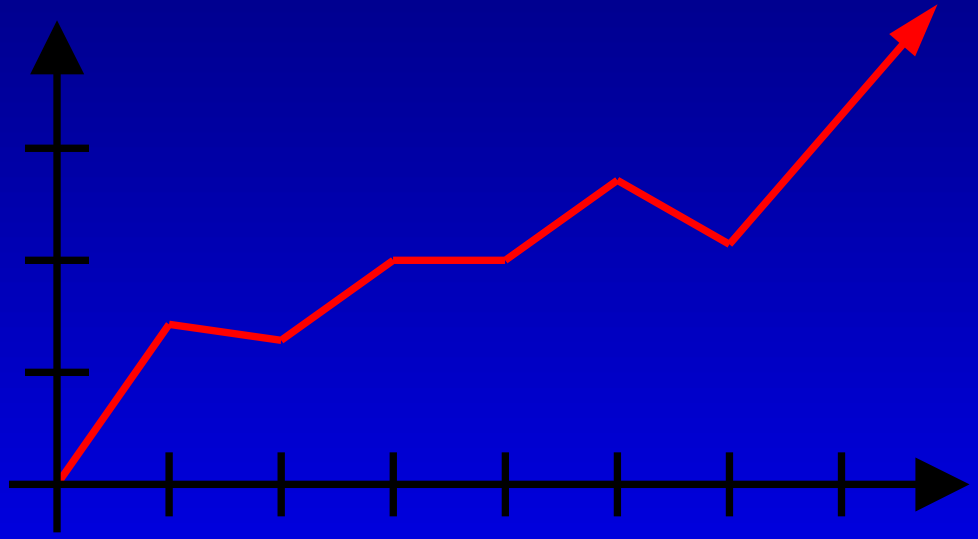
Often a node doesn't need to see *all* broadcasted messages, only *enough* messages

Throttled balanced broadcasts 2

Often nodes don’t need to broadcast to all nodes, instead nodes need to receive enough messages:

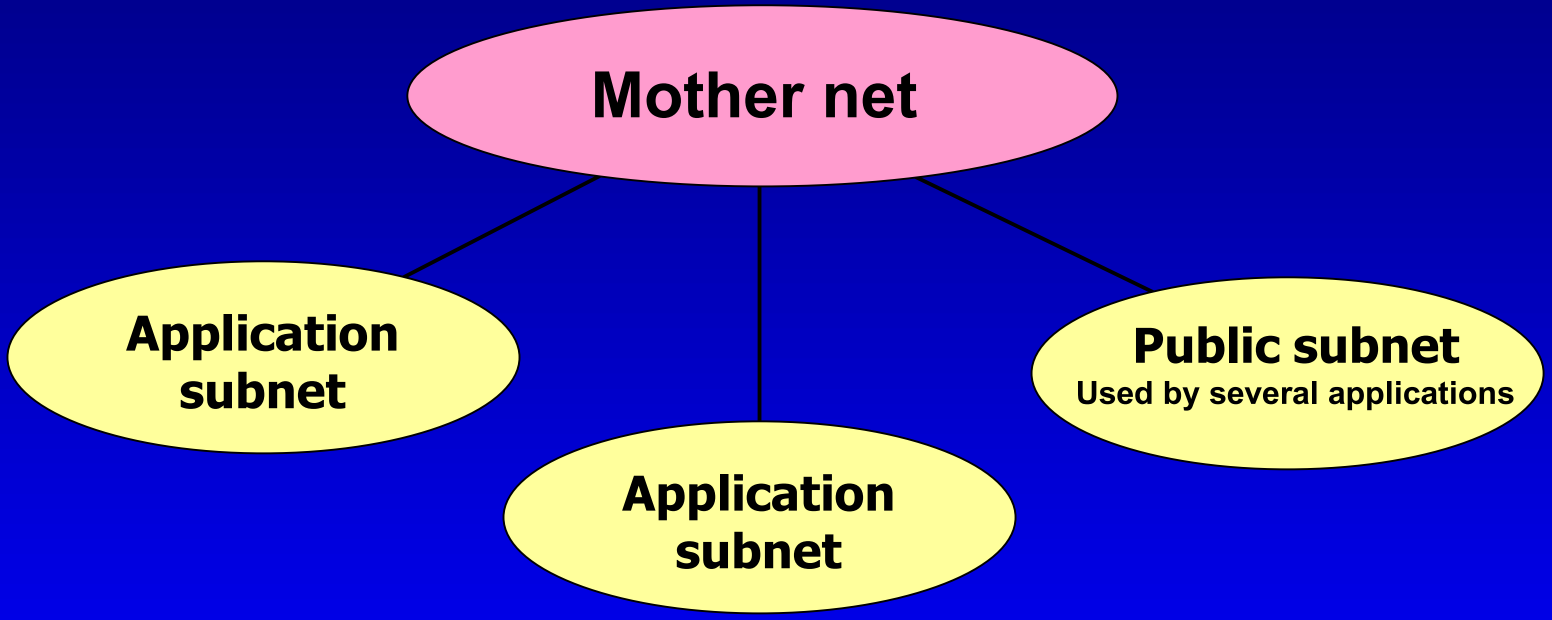
- Jump counter instead of TTL (Time To Live) (Count up instead of down)
- Youngest message is forwarded
- Each originating node reaches about the same amount of nodes
- Forward some messages per link per round
- Different message types can / should be handled separately = “slotted broadcasting”

Network statistics



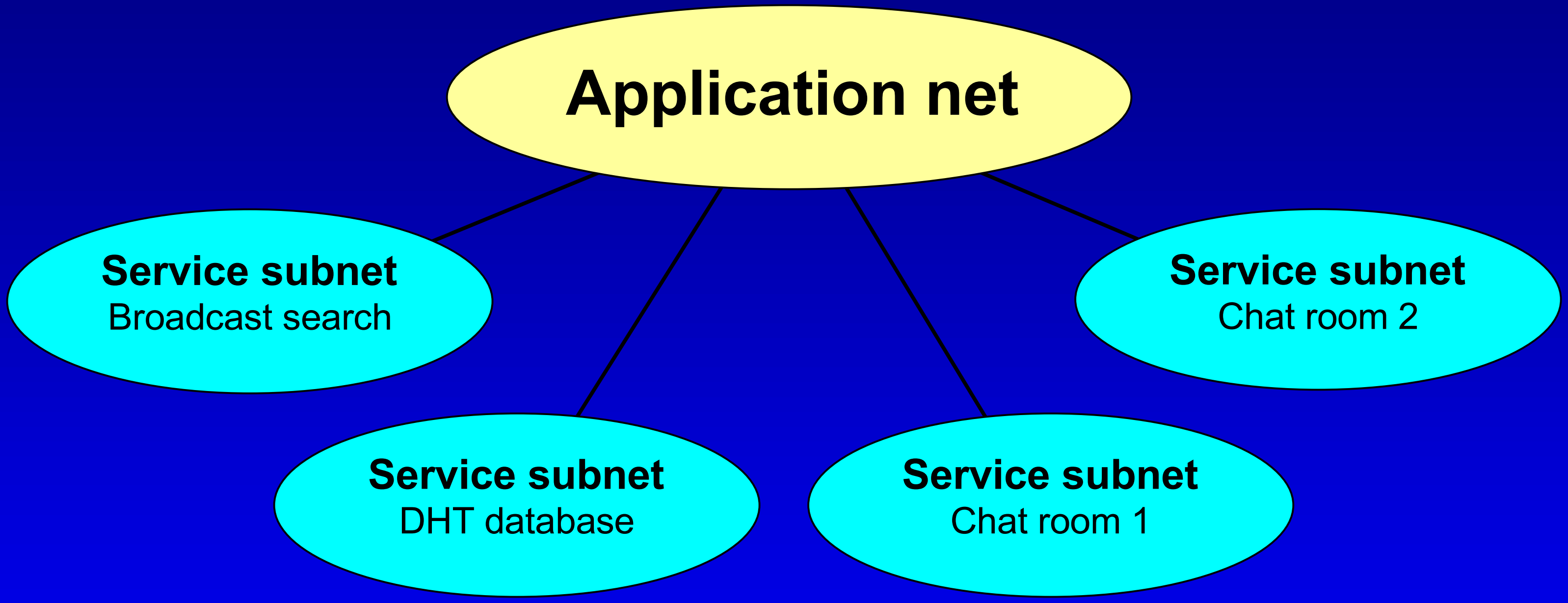
- Number of nodes online
- Number of unique nodes per month
- Network averages, medians, max and min
- Network totals (sums)
- Network time

Application subnets



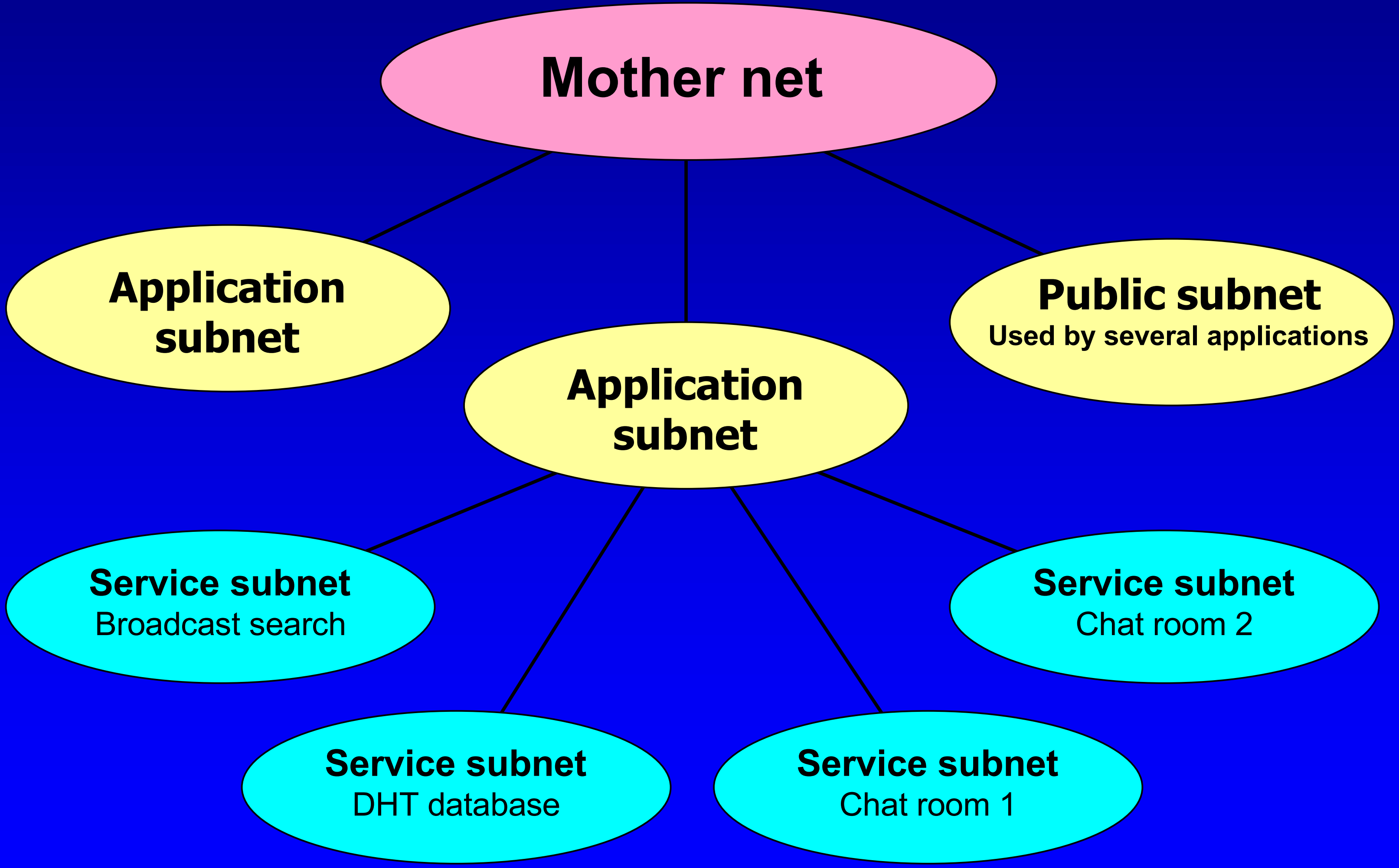
- New nets can bootstrap off old nets
- Small nets help each other with bootstrapping
- Old shrinking nets can bootstrap of new big nets
- "Public subnets" for co-operating applications

Service subnets
(Rendezvous service)



- Chat rooms and file transfer swarms as subnets
- User IDs and servers as subnets
- Algorithms / protocols as subnets: Plug in new kinds of search databases later on!

Subnetting overview



Mother net

Application subnet

Application subnet

Public subnet
Used by several applications

Service subnet
Broadcast search

Service subnet
Chat room 2

Service subnet
DHT database

Service subnet
Chat room 1

Subnetting

If you don’t know the name and the key you should not be able to “see” the subnet:

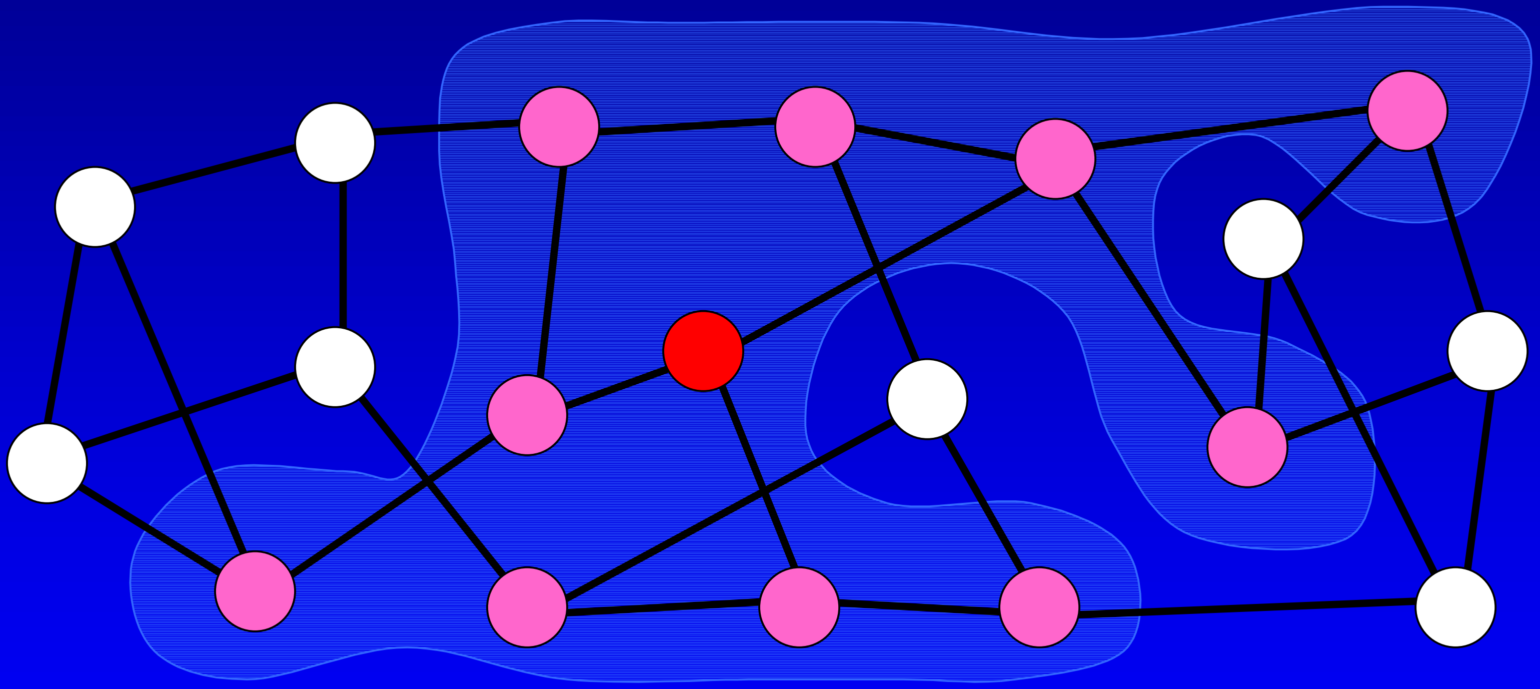
subnet address = hash(subnet name + subnet key)

Huge subnets must be able to coexist with small subnets.

Ways to implement subnet lookup (rendezvous):

- Broadcast search
- Distributed Hash Table (DHT)
- Subnets under subnets

Broadcast search



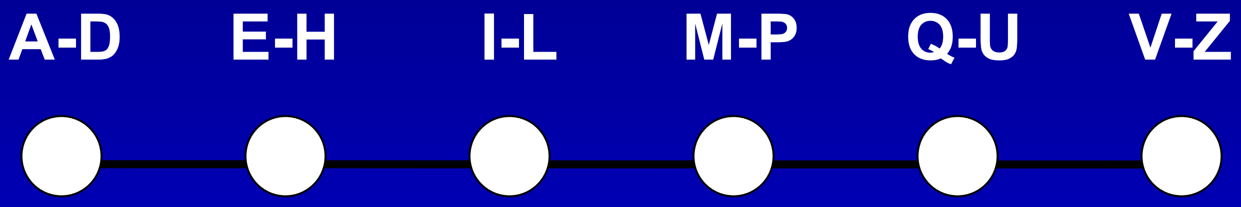
Preferably uses throttled balanced broadcasts

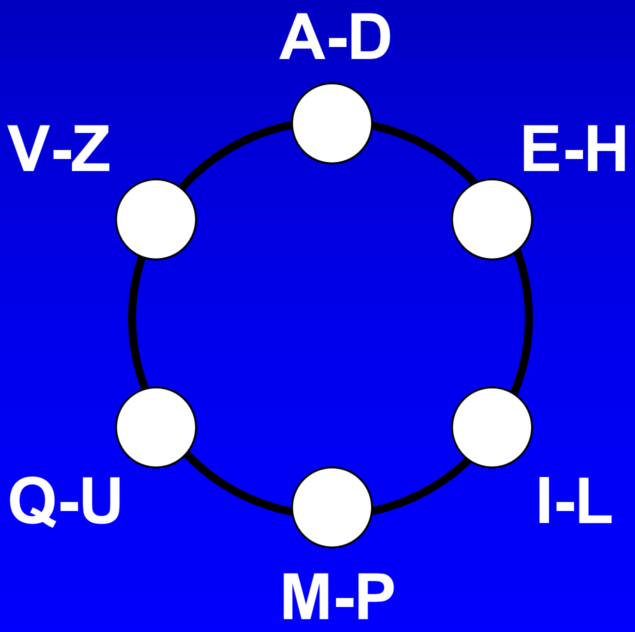
Broadcast search 2

Gnutella, Kazaa and many more:

- Uses a random network
- Search limited by a TTL or jump counter
- Search horizon = Only reaches the closest nodes
- Uses very much bandwidth
- Very good at handling complex searches such as “ccc AND video AND NOT Berlin”
- Width first or depth first search
- Some optimisations can increase the horizon: supernodes, search filters, mini groups

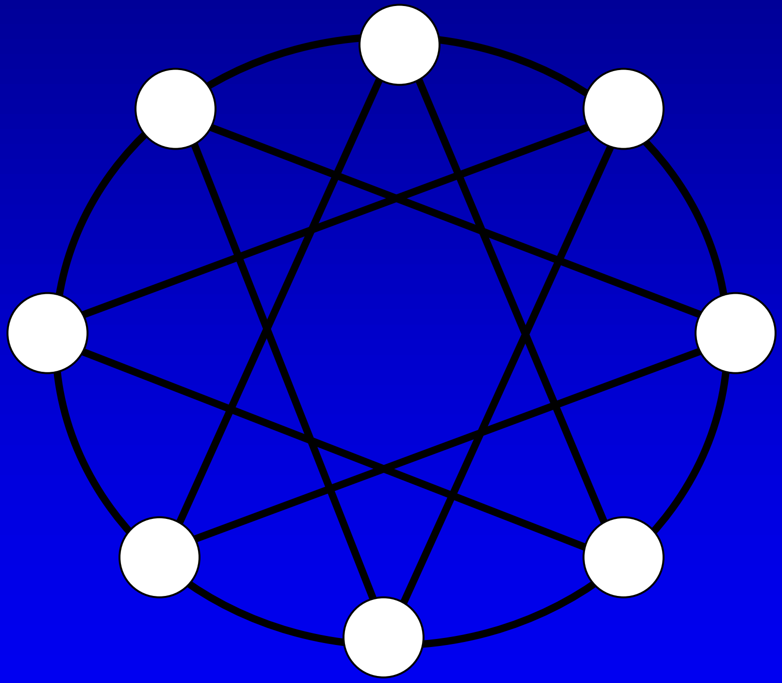
Distributed Hash Tables 1





Nodes organised
in address order
in a list or a ring
or a hypercube

Distributed Hash Tables 2



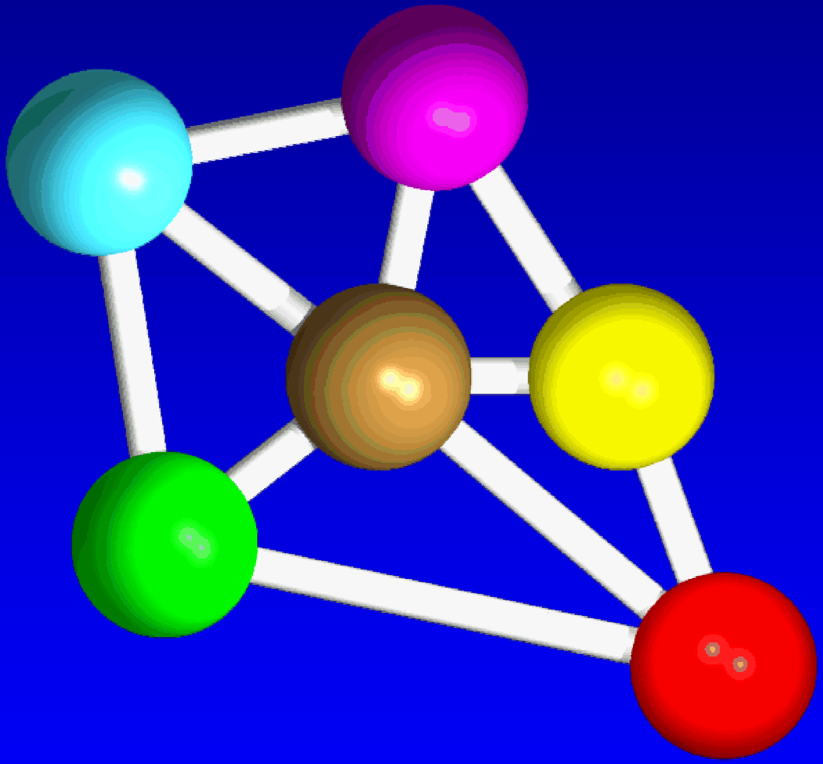
Routing overlay = Shortcuts across the ring make lookups much faster.

Distributed Hash Tables 3

Chord, Pastry, Kademlia and many more DHTs:

- Nodes often connected in a ring
- Shortcuts = Routing overlay
- Some DHTs are hypercubes instead of rings
- Item key = hash(item name)
- Search among millions of nodes = If one node has what you want, you find it
- Can not do complex searches, only key lookup
- Complex to implement and vulnerable to attacks
- Problems with unevenly distributed data (Hashing only partly fixes the problem)

The end



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