



# *Overlay (and P2P) Networks*

## Part II

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Samu Varjonen

**Ashwin Rao**



# Kademlia

Petar Maymounkov and David Mazières. 2002. Kademlia: A Peer-to-Peer Information System Based on the XOR Metric.

A nice video summarizing Kademlia

<https://www.youtube.com/watch?v=w9UObz8o8lY>



# Sybil

John R. Douceur. 2002. The Sybil Attack. In Revised Papers from the First International Workshop on Peer-to-Peer Systems (IPTPS '01).



# Summary

# Unstructured or semi structured networks

	BitTorrent	Freenet v0.7	Gnutella v0.4	Gnutella v0.7
Decentralization	Centralized model	Similar to DHTs, two modes (darknet and opennet), two tiers	Flat topology (random graph), equal peers	Random graph with two tiers. Two kinds of nodes, regular and ultra nodes. Ultra nodes are connectivity hubs
Foundation	Tracker	Keywords and text strings are used to identify data objects. Assumes small world structure for efficiency	Flooding mechanism	Selective flooding using the ultra nodes
Routing function	Tracker	Clustering using node location and file identifier. Path folding optimization (opennet). Location swapping (darknet).	Flooding mechanism	Selective flooding mechanism
Routing performance	Guarantee to locate data, good performance for popular data	Search based on Hop-To-Live, no guarantee to locate data. With small world property $O(\log(n)^2)$ hops are required, where n is the number of nodes.	Search until Time-To-Live expires, no guarantee to locate data	Search until Time-To-Live expires, second tier improves efficiency, no guarantee to locate data
Routing state	Constant, choking may occur	With small world property $O(\log(n)^2)$	Constant (reverse path state, max rate and TTL determine max state)	Constant (regular to ultra, ultra to ultra). Ultra nodes have to manage leaf node state.
Reliability	Tracker keeps track of the peers and pieces	No central point of failure	Performance degrades when the number of peer grows. No central point.	Performance degrades when the number of peer grows. Hubs are central points that can be taken out.



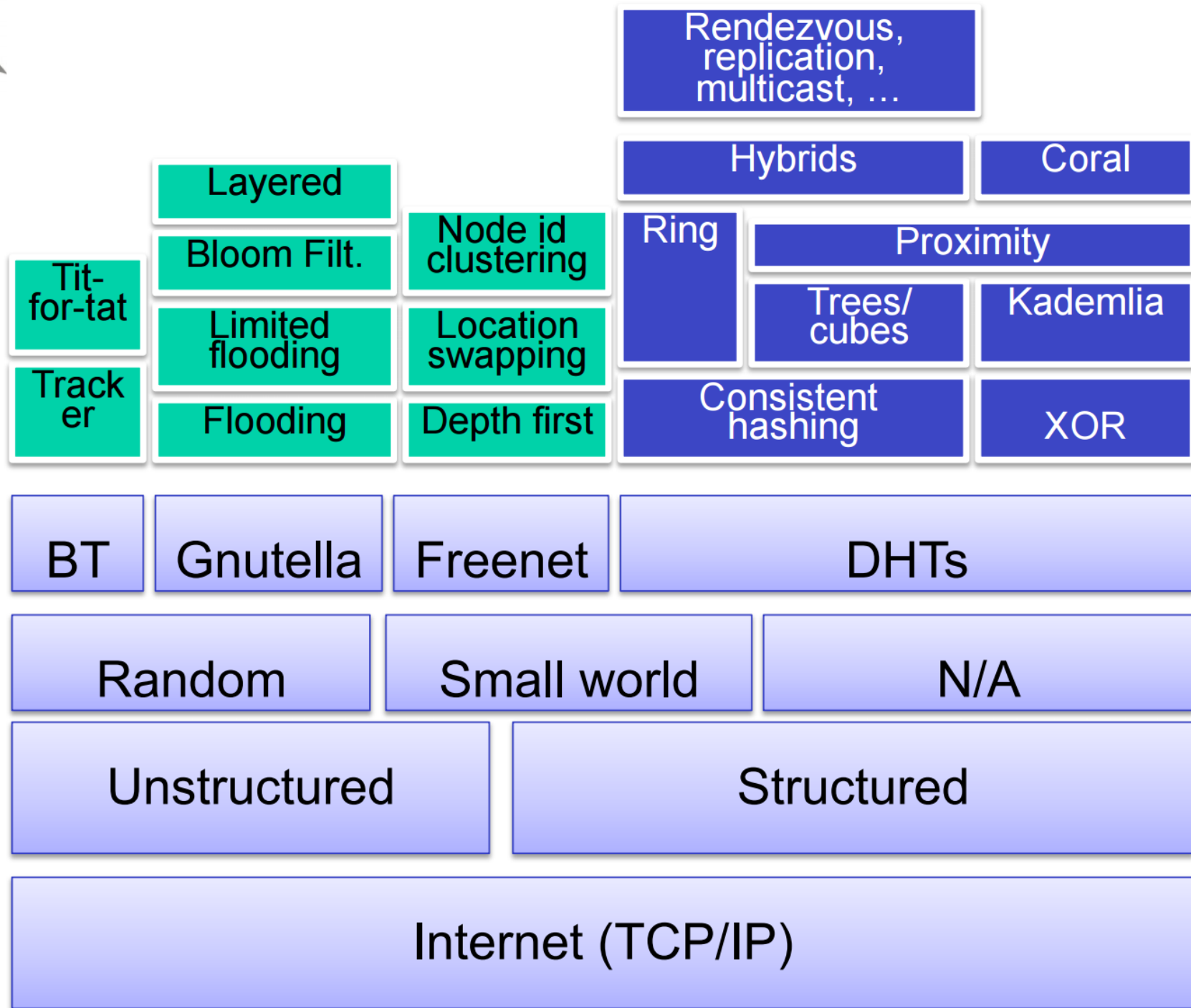
# Structured networks

	CAN	Chord	Kademlia	Pastry	Tapestry
Foundation	Multi-dimensional space (d-dimensional torus)	Circular space	XOR metric	Plaxton-style mesh	Plaxton-style mesh
Routing function	Maps (key,value) pairs to coordinate space	Matching key and nodeID	Matching key and nodeID	Matching key and prefix in nodeID	Suffix matching
System parameters	Number of peers N, number of dimensions d	Number of peers N	Number of peers N, base of peer identifier B	Number of peers N, base of peer identifier B	Number of peers N, base of peer identifier B
Routing performance	$O(dN^{1/d})$	$O(\log N)$	$O(\log_B N) + \text{small constant}$	$O(\log_B N)$	$O(\log_B N)$
Routing state	$2d$	$\log N$	$B \log_B N + B$	$2B \log_B N$	$\log_B N$
Joins/leaves	$2d$	$(\log N)^2$	$\log_B N + \text{small constant}$	$\log_B N$	$\log_B N$



# Summary of Datastores and Related Systems

Name	Type	Data placement	Data can be located	Replication	Stabilization
Dynamo	1-hop DHT	Key→node, consistent hashing	Yes	Yes, clockwise nodes	Eventual consistency: anti-entropy, gossip
Chord	Wide-area DHT	Key→node, based on consistent hashing	Yes	Add-on	Stabilization mechanism
PAST	Wide-area DHT	Key→node, based on Plaxton mesh	Yes	Yes, close-by nodes	Part of Pastry routing
Freenet	P2P	Key→closest node, approximate small world routing table	No guarantee	Yes, reverse-path	Path folding (opennet) and location swapping (darknet)
Gnutella	P2P	Client	No guarantee	No	No (ultranode layer in principle)





Consistent hashing alleviates network problems and eventual consistency can be achieved through replication and synchronization

Example: Dynamo

Replication, Gossip, etc.

Selective flooding

Consistent hash (O(1) DHT)

Search

Storage

Rendezvous

Cluster

Good for arbitrary data and search functions, can aggregate routing info, structure improves scalability

Examples:  
Gnutella and Freenet

Example:  
BitTorrent

Limited flooding / depth first / Bloom filters

Tracker

Search

Storage

Rendezvous

Wide-area  
(unstructured)

Good for name/value data, note flat address space, one node is responsible, churn is a concern

Examples:  
Lookup: Chord, CAN, Kademlia  
Storage: PAST  
Rendezvous: Scribe (for multicast), i3

DHT

Search

Storage

Rendezvous

Wide-area  
(structured)

Internet (TCP/IP)

Main theme	Prerequisites	Approaches learning goals	Meets learning goals	Deepens learning goals
Overlay and peer-to-peer networks: definitions and systems	Basics of data communications and distributed systems (Introduction to Data Communications, Distributed Systems)	<p>Knowledge of how to define the concepts of overlay and peer-to-peer networks, and state their central features</p> <p>Ability to describe at least one system in detail</p>	<p>Ability of being able to compare different overlay and p2p networks in a qualitative manner</p> <p>Ability to assess the suitability of different systems to different use cases</p>	Ability to give one's own definition of the central concepts and discuss the key design and deployment issues
Distributed hash tables	<p>Basics of data communications and distributed systems (Introduction to Data Communications, Distributed Systems)</p> <p>Big-O-notation and basics of algorithmic complexity</p>	<p>Knowledge of the concepts of structured and unstructured networks and the ability to classify solutions into these two categories</p> <p>Knowledge of the basics of distributed hash tables</p> <p>Ability to describe at least one distributed hash table algorithm in detail</p>	<p>Ability of being able to compare different distributed hash table algorithms</p> <p>Ability of designing distributed hash table-based applications</p> <p>Knowledge of key performance issues of distributed hash table systems and the ability to analyze these systems</p>	<p>The knowledge of choosing a suitable distributed hash table design for a problem</p> <p>Familiarity with the state of the art</p>
Reliability and performance modelling	<p>Basics of probability theory</p> <p>Basics of reliability in distributed systems</p>	<p>Ability to model and assess the reliability of overlay and peer-to-peer networks by using probability theory</p> <p>Knowledge of the most important factors pertaining to reliability</p>	<p>Ability of analytically analyzing the reliability and performance of overlay and peer-to-peer networks</p> <p>Understanding of the design issues that are pertinent for reliable systems</p>	Familiarity with the state of the art
Content distribution	Introduction to Data Communications	<p>Knowledge of the basic content distribution solutions</p> <p>Ability to describe at least one overlay and p2p network based content distribution solution</p>	<p>Knowledge of different content distribution systems and the ability to compare them in detail</p> <p>Knowledge of several content distribution techniques</p>	Familiarity with the state of the art
Security	Basics of computer security	<p>Knowledge of the basic security issues with overlay and p2p networks</p> <p>Knowledge of the sybil attack concept</p>	<p>Ability to discuss how security problems and limitations can be solved</p> <p>Knowledge of how to prevent sybil attacks</p>	<p>Knowledge of how to prevent sybil attacks</p> <p>Familiarity with the state of the art</p>



# Have a nice spring!

(Remember to submit course feedback)