CLOUD COMPUTING CONCEPTS

with Indranil Gupta (Indy)

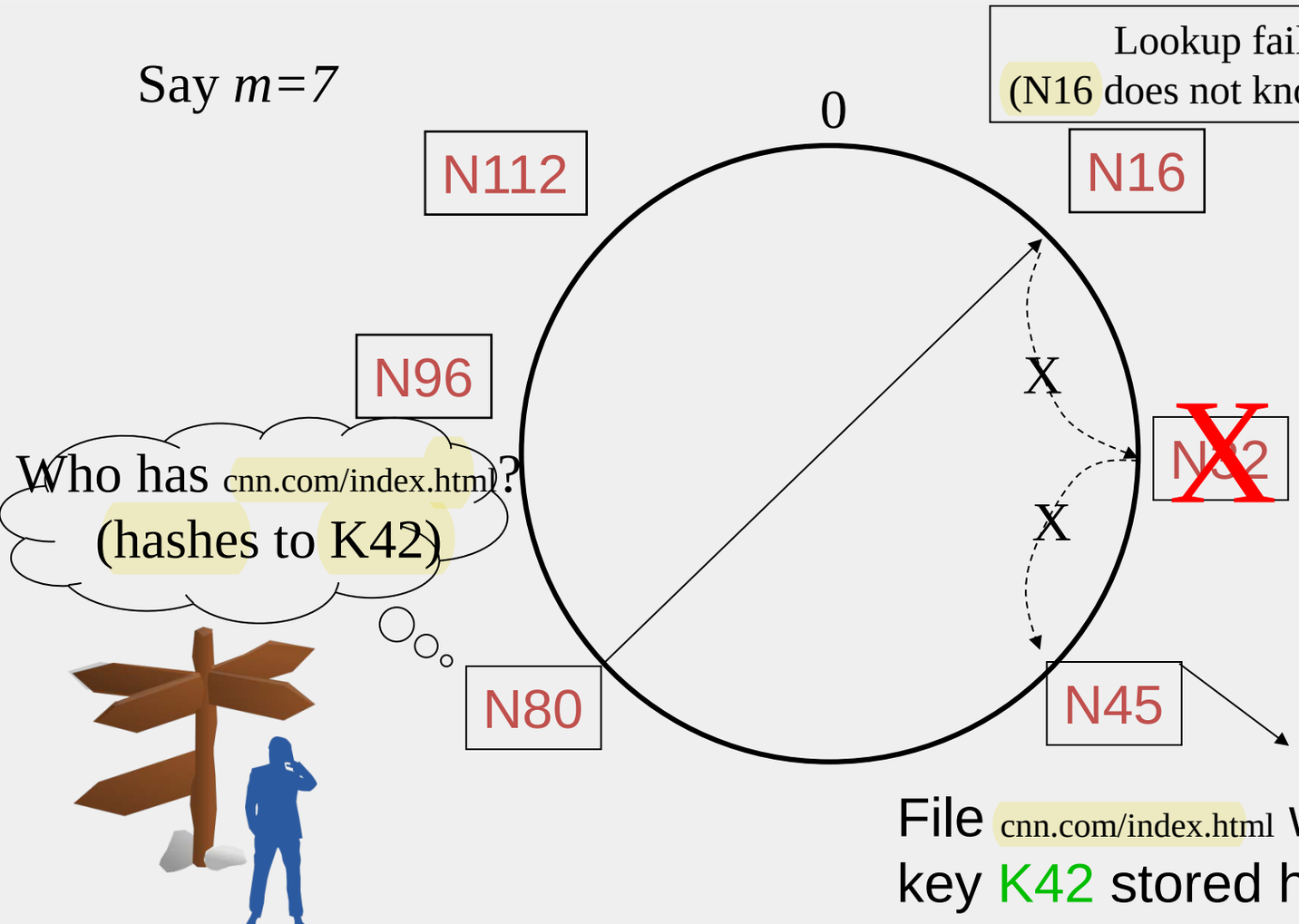
P2P SYSTEMS

Lecture F

FAILURES IN CHORD

Search under peer failures

Say *m*=7



Lookup fails
(N16 does not know N45)

N32 failed, since N16 only indexed N32 in its finger table

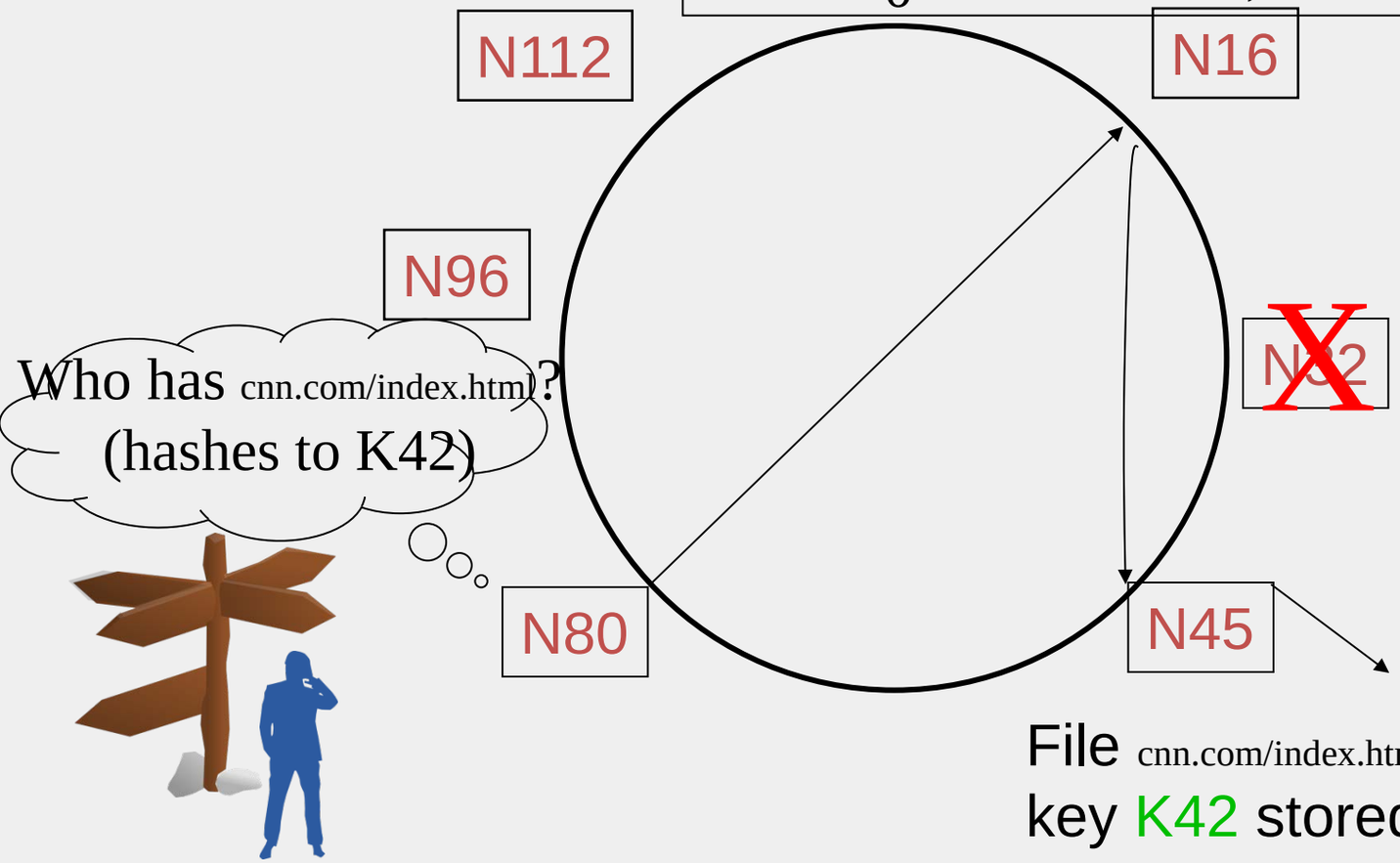
File cnn.com/index.html with key K42 stored here

Search under peer failures

Say $m=7$

One solution: maintain r multiple *successor* entries

0 In case of failure, use successor entries



File cnn.com/index.html with key K42 stored here

Search under peer failures

- Choosing *r=2log(N)* suffices to maintain *lookup correctness* w.h.p. (i.e., ring connected)
  - Say 50% of nodes fail
  - Pr(at given node, at least one successor alive)=

$$1-(\frac{1}{2})^{2\log N} = 1-\frac{1}{N^2}$$

  - Pr(above is true at all alive nodes)=

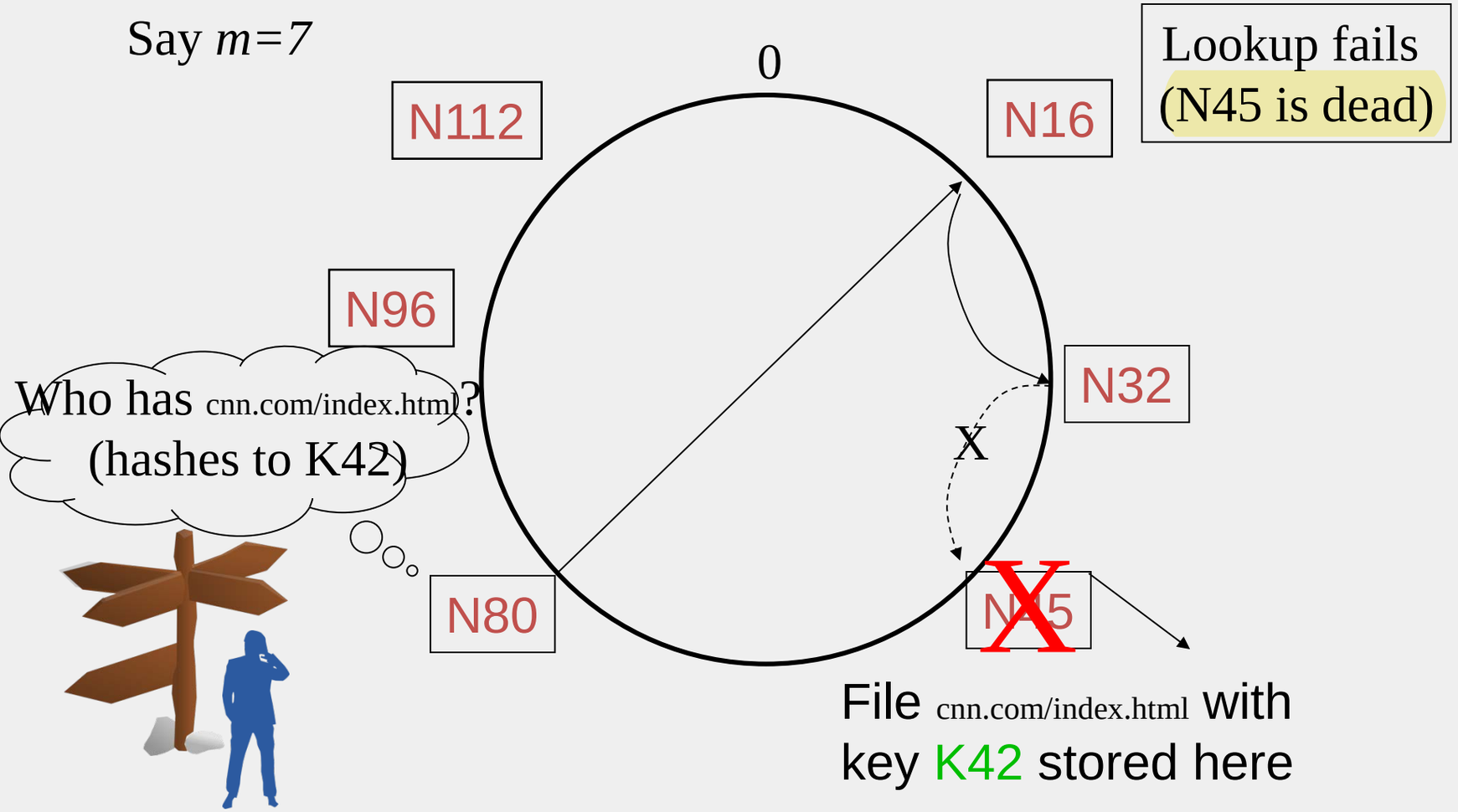
$$(1-\frac{1}{N^2})^{N/2} = e^{-\frac{1}{2N}} \approx 1$$

r == no. successors needed to keep peers alive

the question is framed so wrong == never ever 100% since as long as 1 node's all successors failed then ring is not connected, and there are 50% nodes failing

really he should ask if this runs 100M times, 50% failed rate, try to limit failed times to less than 1% == for all alive nodes, at least 1 successor is alive more than 99%

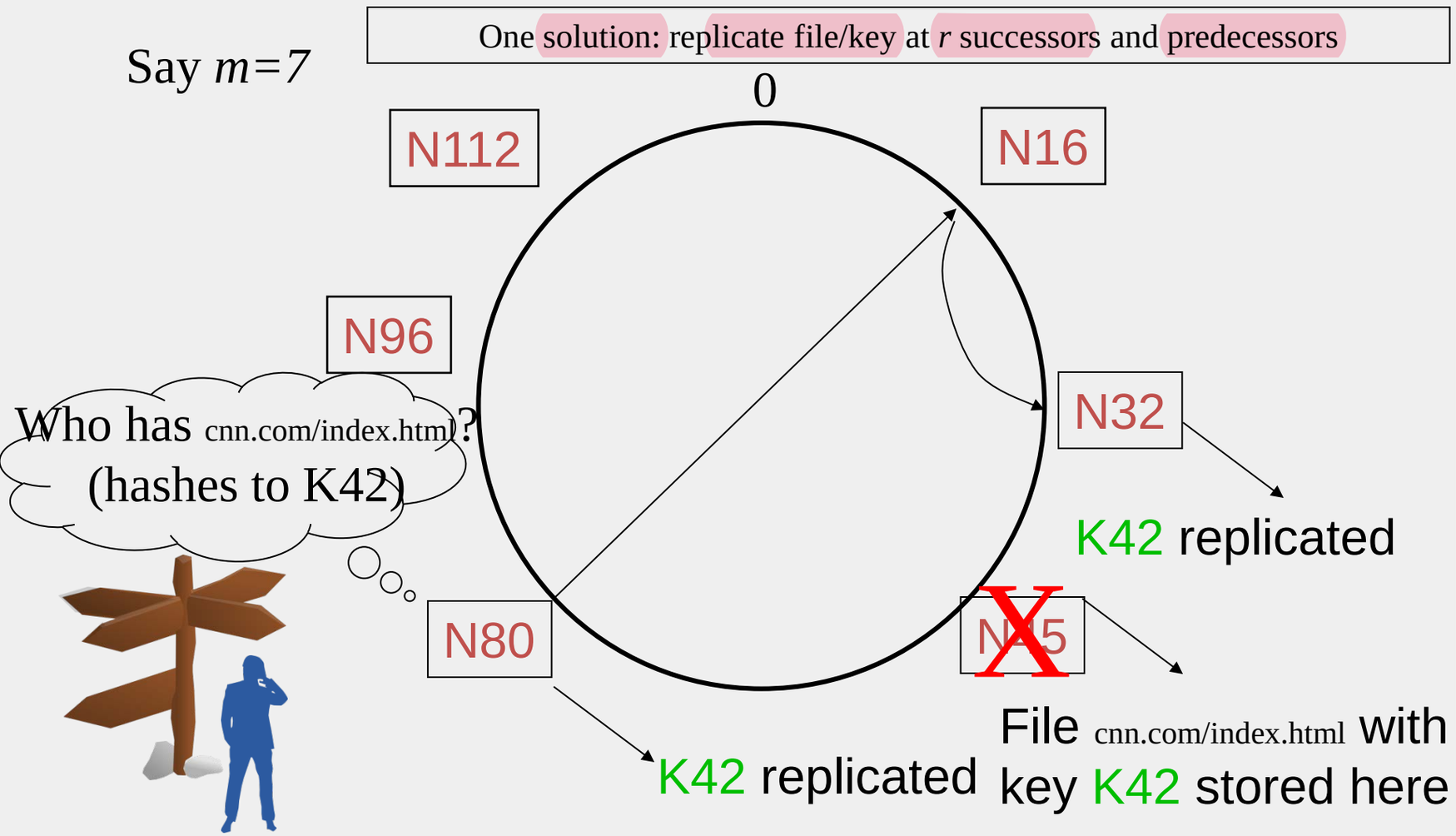
Search under peer failures (2)



Search under peer failures (2)

Say $m=7$

One solution: replicate file/key at r successors and predecessors



replicate file == in case node with file failed + load balancing

churn == join, leave, failed

need to notify successors to update finger table

justification for 2 more features:
1. replicate files at multiple predecessors n successors (if file server dies)
2. replicate routing entries at multiple nodes (if routing server dies)

Need to deal with dynamic changes

- ✓ Peers fail
- New peers join
- Peers leave
  - P2P systems have a high rate of *churn* (node join, leave and failure)
    - 25% per hour in Overnet (eDonkey)
    - 100% per hour in Gnutella
    - Lower in managed clusters
    - Common feature in all distributed systems, including wide-area (e.g., PlanetLab), clusters (e.g., Emulab), clouds (e.g., AWS), etc.

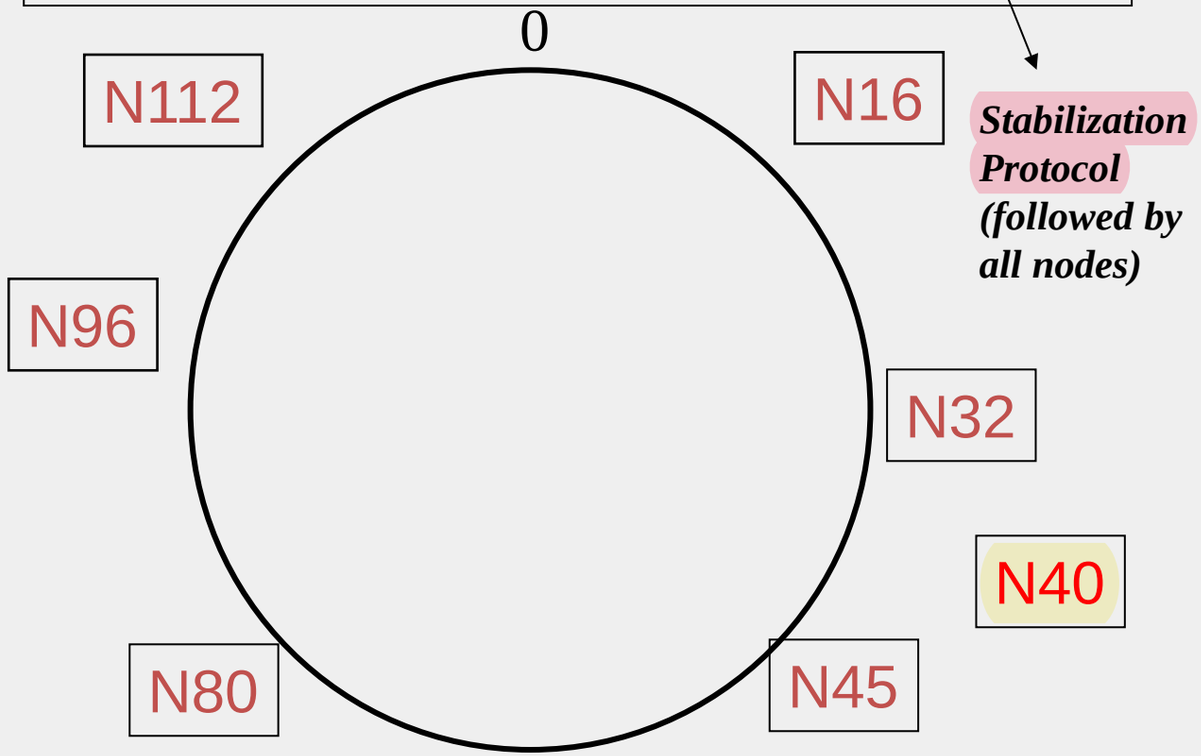
So, all the time, need to:

→ update *successor*s and *finger*s, and copy keys

New peers joining

Introducer directs N40 to N45 (and N32)
N32 updates successor to N40
N40 initializes successor to N45, and inits fingers from it
N40 periodically talks to neighbors to update finger table

Say $m=7$



Stabilization Protocol (followed by all nodes)

stabilization == regularly ping

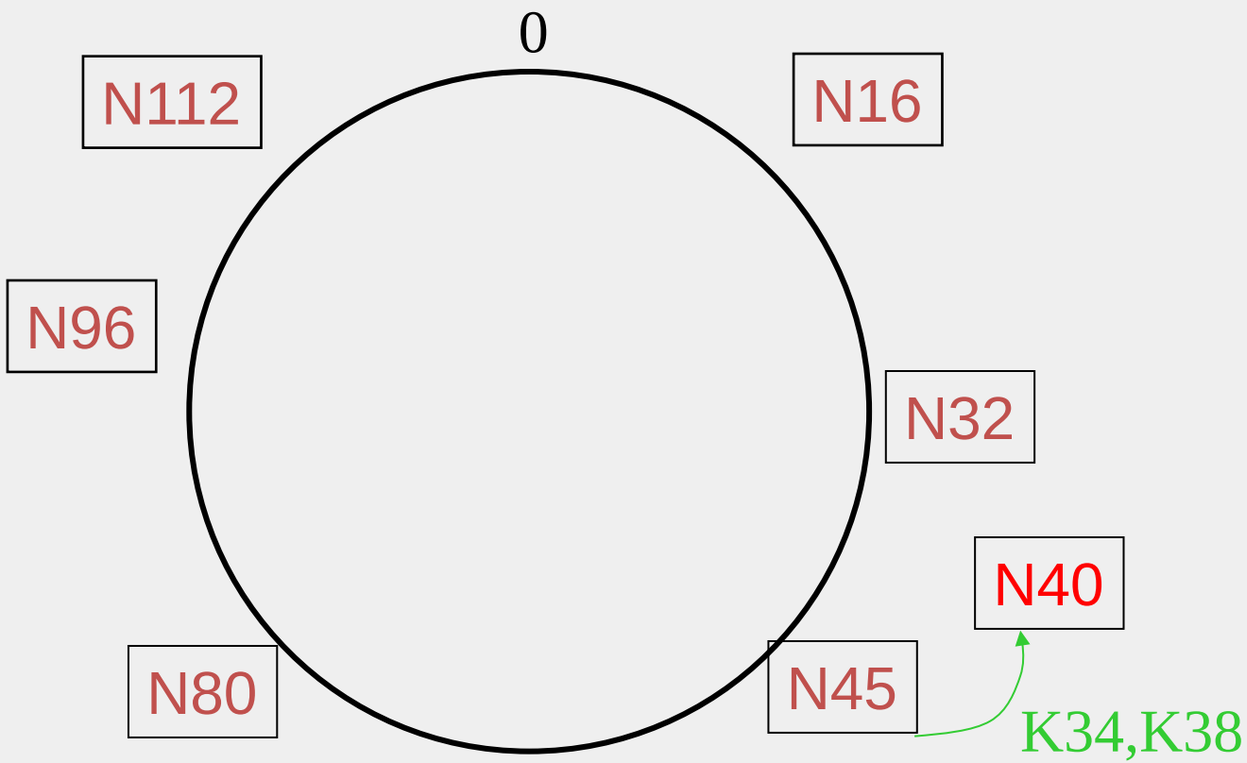
N40 == new pig meat

N45 gives its finger table to N40
not enough so N40 needs to ping everyone

New peers joining (2)

N40 may need to copy some files/keys from N45 (files with fileid between 32 and 40)

Say *m=7*



file transferring from disk to disk over rpc

tapestry wont do that

New peers joining (3)

- A new peer affects *O(log(N))* other finger entries in the system, on average [Why?]
- Number of messages per peer join= *O(log(N)*log(N))*

why ?? each node points to log(N) finger table entries

- Similar set of operations for dealing with peers leaving
  - For dealing with failures, also need *failure detectors* (we'll see these later in the course!)

e.g. N112 needs to update finger table entry from N45 to N40 since N40 is closer

no. msgs == network traffic

Stabilization Protocol

- Concurrent peer joins, leaves, failures might cause loopiness of pointers and failure of lookups
  - Chord peers periodically run a *stabilization* algorithm that checks and updates pointers and keys
  - Ensures *non-loopiness* of fingers, eventual success of lookups and *O(log(N))* lookups w.h.p.
  - Each stabilization round at a peer involves a constant number of messages
  - Strong stability takes $O(N^2)$ stabilization rounds
  - For more see [TechReport on Chord webpage]

Churn

- When nodes are constantly joining, leaving, failing
  - Significant effect to consider: traces from the Overnet system show *hourly* peer turnover rates (***churn***) could be *25–100%* of total number of nodes in system
  - Leads to excessive (unnecessary) key copying (remember that keys are replicated)
  - Stabilization algorithm may need to consume more bandwidth to keep up
  - Main issue is that files are replicated, while it might be sufficient to replicate only meta information about files
  - Alternatives
    - Introduce a level of indirection (any p2p system)
    - Replicate metadata more, e.g., Kelips (later in this lecture series)

rpc files
everynode's successors + finger table being updated constantly == huge network load

Virtual Nodes

- Hash can get non-uniform ➔ Bad load balancing
  - Treat each node as multiple virtual nodes behaving independently
  - Each joins the system
  - Reduces variance of load imbalance

Wrap-up Notes

- Virtual Ring and Consistent Hashing used in Cassandra, Riak, Voldemort, DynamoDB, and other key-value stores

- Current status of Chord project:
  - File systems (CFS, Ivy) built on top of Chord
  - DNS lookup service built on top of Chord
  - Internet Indirection Infrastructure (I3) project at UC Berkeley
  - Spawned research on many interesting issues about p2p systems

`http://www.pdos.lcs.mit.edu/chord/`