DISTRIBUTED SYSTEMS
Vector Clocks, CHORD

Plan
- Where We Are
- Vector Clocks
- CHORD

Announcements
- Lab 1 Is Out

- Office Hours
  - In-Person?
  - Monday 3-4 PM?
  - E-mail for more?
- Correctness - Deciding that the distributed system does what we want.

- Safety

- Liveness

- Traces - What events are happening and when

- Clocks

- Lamport clocks
  - Issues?

- Vector clock

Times for 010:
- E00 (1,0,0)
- E11
- E22
- E33

Time:
- 014

Increment each
Turning This Into A Trace?

Vector Clocks In Practice
- Pip ⇆ XTrace
- Spans with Links: Dapper, Open Tracing.

Chord

\[ e_{00} \rightarrow e_{10} \]

\[ x \leq a \quad y \geq b \]

\[ \langle x, y, z \rangle \leq \langle a, b, c \rangle \]

\[ x \leq a \quad y \geq b \quad z \leq c \]

Chord

\[(1, 2, -1) \quad \Rightarrow \]

\[a \cdot \text{hello} \quad [\text{SMS}]\]

\[b \cdot \text{bar} \quad [\text{SMS}]\]
Why Discuss Chord?

Historic Context 2000 - 2007

- Napster + Metallica
- Decentralization

The Protocol

Range: 0 - 1024

Hash: 1, 64, 270, 856
Consistent Hashing

CRYPTO
L \rightarrow V\cdot low collision probability
L \rightarrow Hash key value

Lookup w/o Fingers

Complexity?
O(n)

Fingers
m \cdot nt^2

Lookup Complexity?
Correct?

What does correct mean?

Lookup is correct.

Node agree on pred and succ

\[270 \rightarrow 280\]

Ideal Chord Ring

- Pred & SCLCC are not null.
- All nodes are a part of the ring.
- There is a path through the successor pointers between any two nodes.

For any node \( u \), \( \exists \ v \) s.t. \( v = c(u, u.succ) \)

Correctness in terms of Ideal?

If no new nodes join or leave eventually, ideal ring holds.
Is Chord Correct?

n.succ = Changes:
not vs (n.succ)

856

280 [64]
450 [270]

450
280

270

856

270

450
270

856

270

450
Fixing / Completing The Protocol

1 node addition

2 node

1

2 6