Cornell University

Trees versus meshes: Is the Debate Over?

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P2P Streaming Workshop, Sep. ‘06

“Mesh” approaches to P2P streaming are popular

- Coolstreaming
- Lots of startups use meshes
  - (as far as I know)

- Simple
- Robust
- Acceptable overhead (high volume apps)

But I've been working on "tree" based approaches

- So, motivated to show that tree-based approaches are better than mesh-based
  - Don't want to have wasted my time!
- Therefore came up with this title of talk when Pablo asked me to speak:
  - Trees versus Meshes: Is the Debate Over?

Some caveats

- Only talking about live streaming
- Not sure I'm really ready to give this talk
  - Haven't done a good study of trees versus mesh pros and cons
    - Though I plan to
- Therefore may be holes in my logic
  - This is a workshop!
  - Food for thought…

What I have done (with Vidhya Venkatraman)

- Design of an unstructured tree-based P2P multicast protocol
- Chunkyspread
  - ICNP ’06
  - Multi-tree
  - Scalable
  - Supports heterogeneity
    - Good control over transmit load
  - Performs better than Splitstream

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- Both optimize on volume
  - Most bytes follow the path of a tree
- Both effectively utilize send capacity of all peers
  - Multi-tree

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  - Meshes use blocks, trees use slices
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  - This difference isn't really important
- Trees are push and meshes are pull?
  - But when a child selects a parent in the tree, it effectively requests (pulls) a slice

The basic difference:

- Meshes:
  - *Peers advertise what they already have*
- Trees:
  - *Peers advertise what they expect to have in the future*
  - The path in a tree is a “chain of promises”
  - But this doesn’t mean trees are fragile per se: a tree can repair itself
    - Fairly simply…

Evaluation criteria

- Delay
  - Rather subtle
- Overhead
  - Trees are good…meshes can amortize at high volume
- Simplicity
  - Trees not as bad as you might think
- Robustness
- Control over send load
  - Chunkyspread good…not sure where meshes stand

Causes of delay

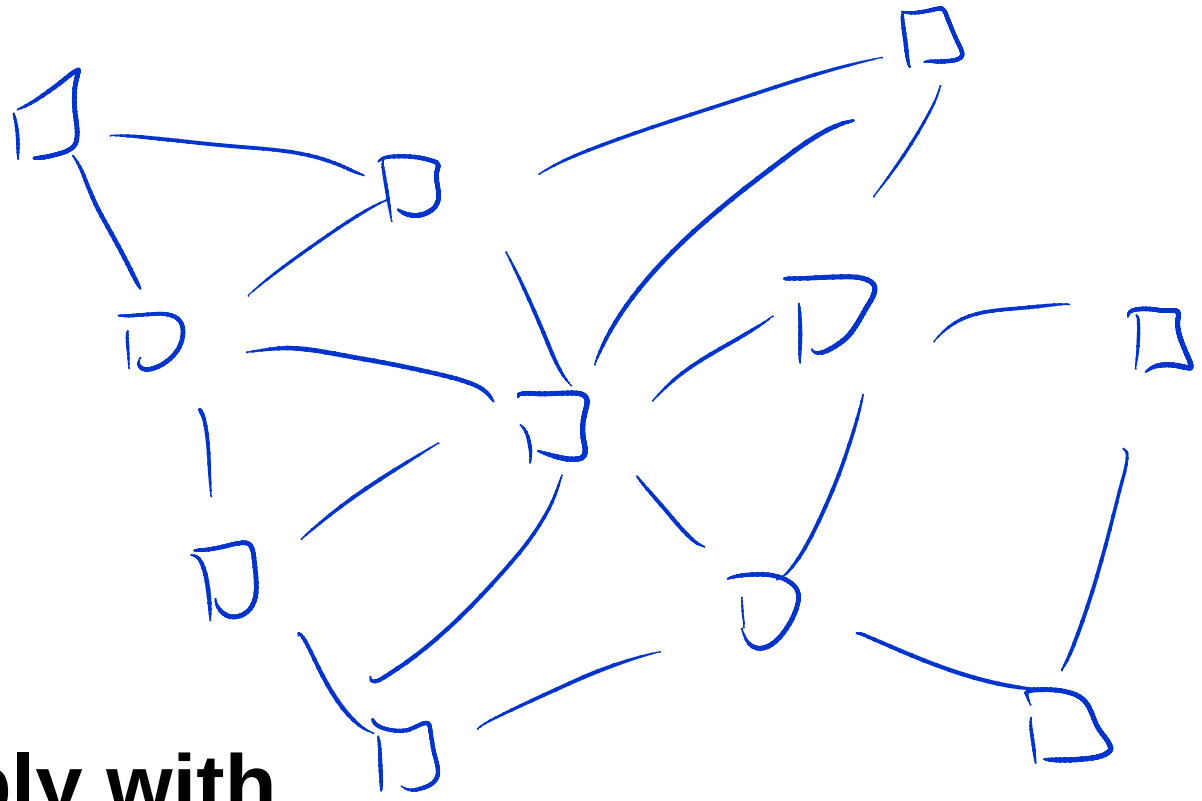
- Mesh:
  - Sender buffers a block of data
  - Advertises block to neighbors
  - Neighbors request block
  - Does this every hop
- #hops x buffering time
  - Trade-off between overhead and delay
- Tree
  - When failure:
  - Detect interruption in data flow
  - Repair tree (start data flow from new parent)

Key observation:

- If tree can repair faster than mesh buffering time (x #hops), *then trees should always perform better than meshes!*
- Why?----worst case, tree nodes always buffer for time of tree repair
  - Play out of buffer when parent is lost until tree repaired

Chunkyspread:

1. Build sparse random mesh



Built scalably with random walks (Swaplinks, Infocom ‘06)

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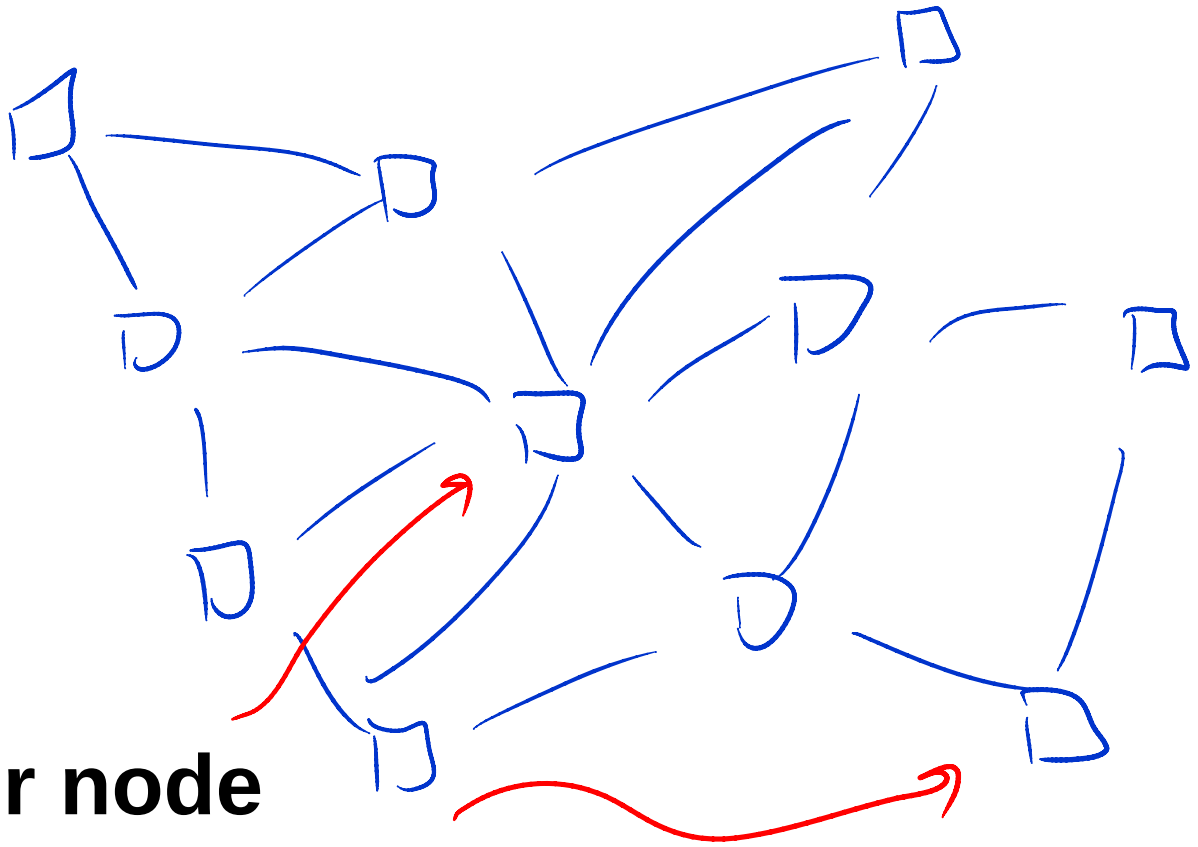
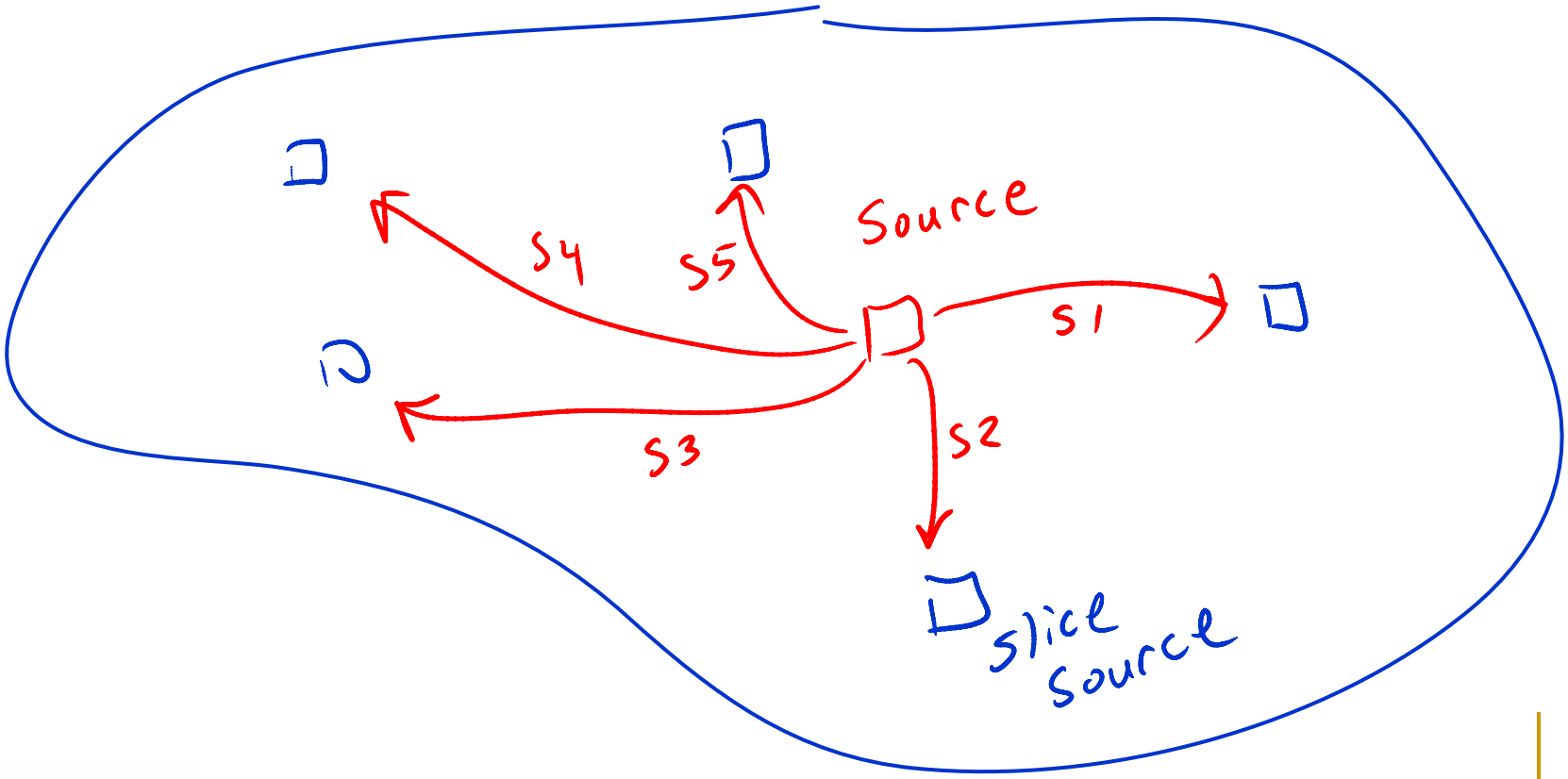
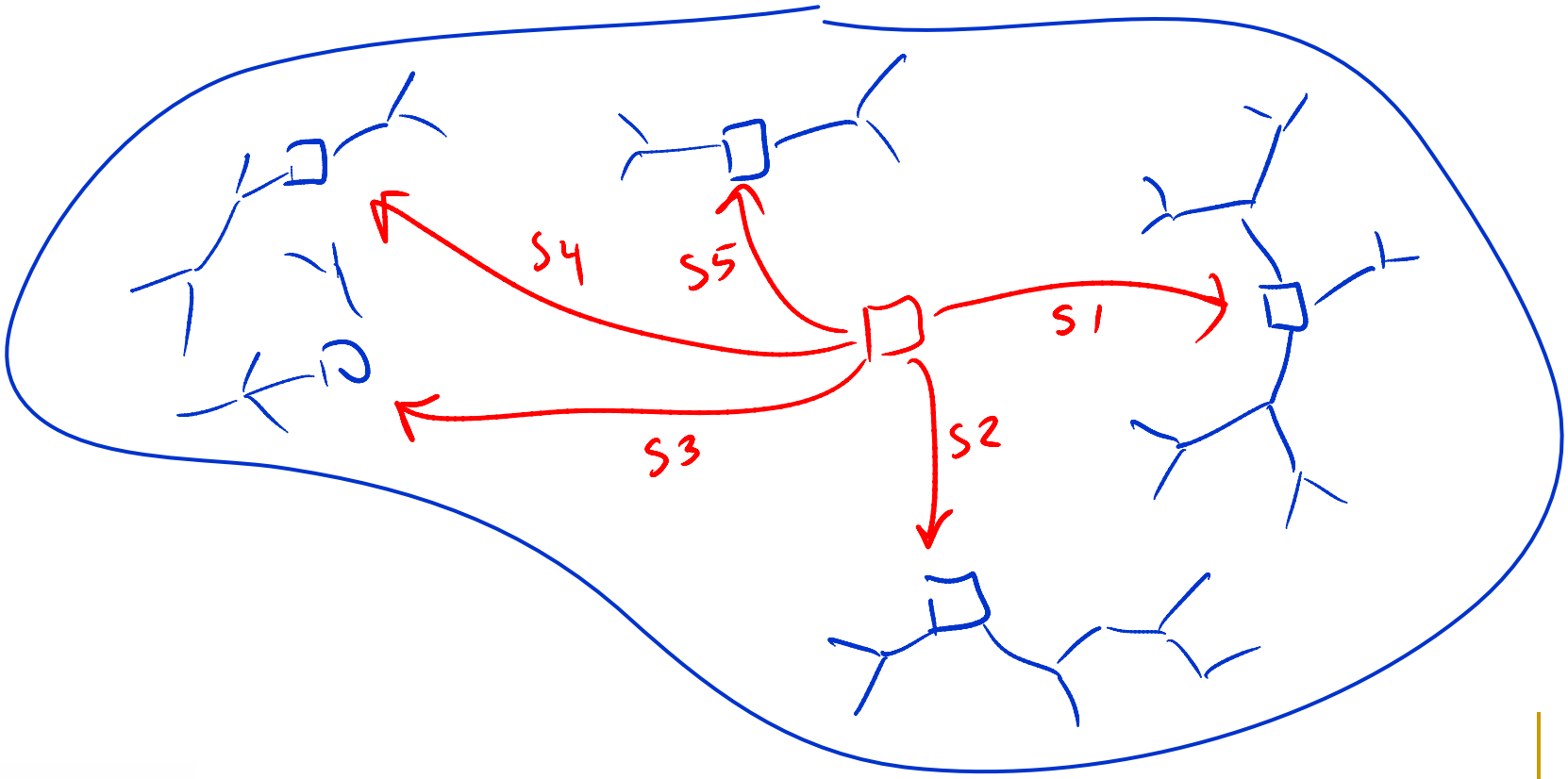


Control over node degree (heterogeneity)

Chunkyspread:
2. Stream source selects random slice sources



Chunkyspread:
3. Each slice source is root of slice tree



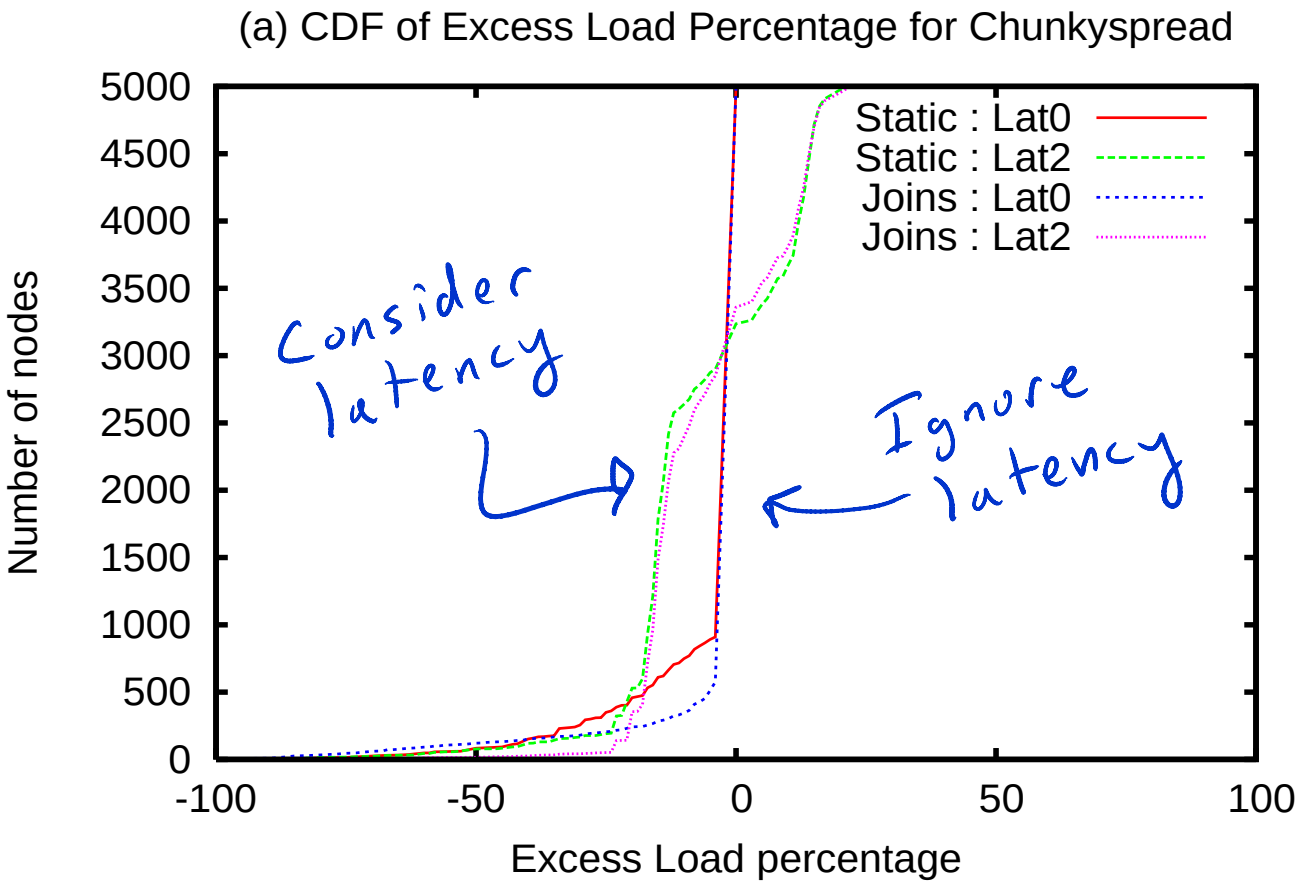
Chunkyspread: Loop avoidance and detection

- Each data packet contains path to slice source
  - Parent, parent's parent, etc. . .
  - Compressed using Bloom filter [Whitaker '02]
- Detect loop in one data packet cycle
- Each peer tells its neighbors its current path for each slice
  - Don't select neighbor if loop would result

Chunkyspread: Parent selection

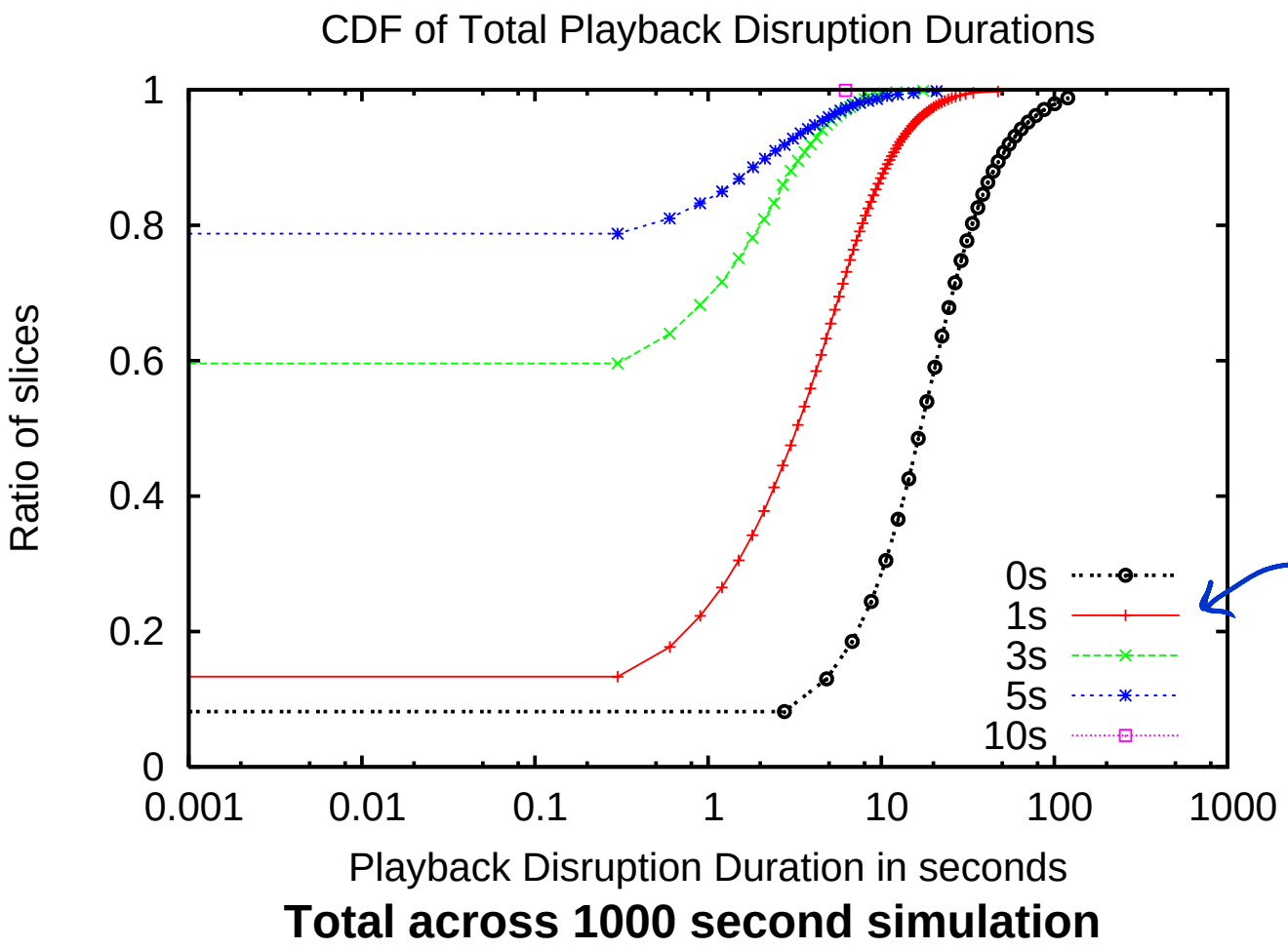
- For each slice, select a parent from among neighbors based on several criteria:
- Avoid loops
- Consider load on parent
  - Peers advertise desired load (heterogeneity)
- Minimize delay
  - Simple method of estimating delay for each slice

Quality of load balance



Roughly 5:1 ratio of node capacities

Recovery from ancestor failure



Total across 1000 second simulation

Pareto churn with 300 sec mean

Size of playout buffer

Some conclusions

- Tree-based protocols not as complex as you might think
- Tree-based has less overhead
- Tree-based probably performs better for latency
- Only useful for live streaming
- More to come….