Cluster consistency for multipeer collaborative applications

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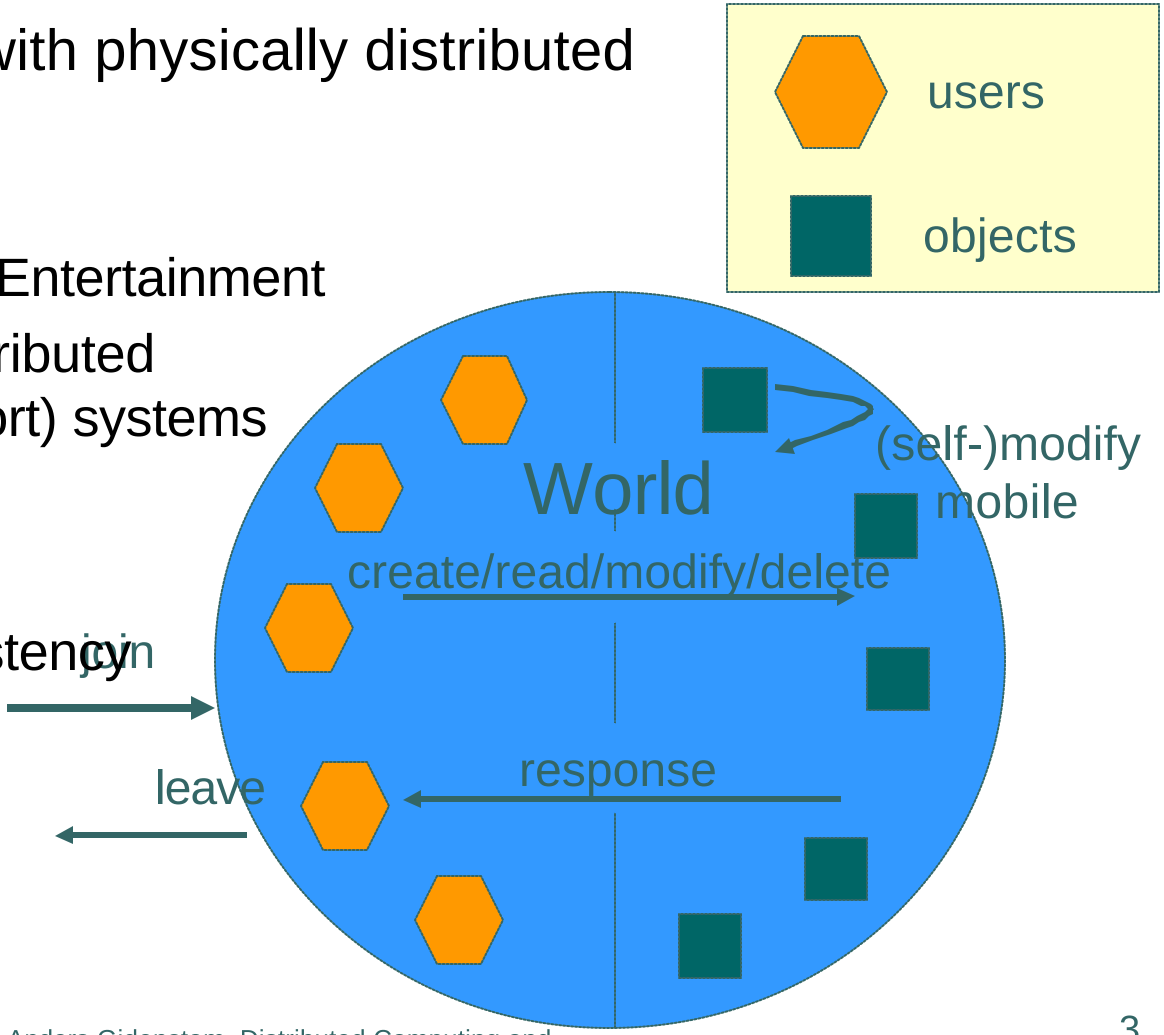
Outline

- Introduction
  - Collaborative Environments
  - Group communication
- Causal Cluster Consistency
  - Achieving optimistic causal order
  - Managing senders
- Future Work

Collaborative Environments

- Possible applications with physically distributed “users”:
  - Conferencing, CVEs
  - Simulation, Training, Entertainment
  - Administration of distributed (e.g. telecom, transport) systems
  - Ad-hoc networks
- Trade-off
  - Overhead v.s. Consistency

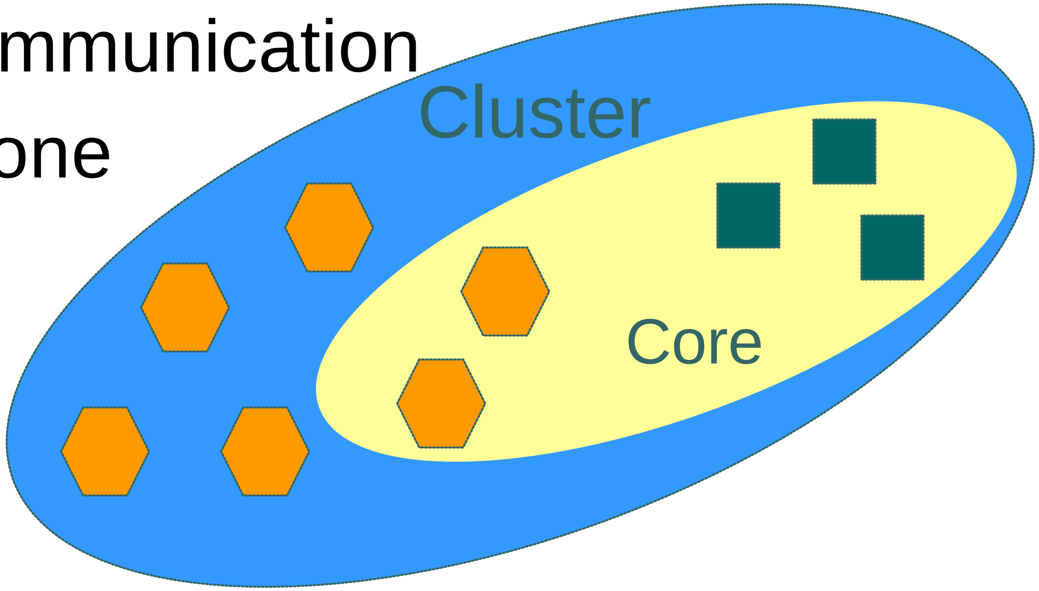


Defining the problem

- Multicast for a large group
  - Event delivery in causal order
  - Scalability important
- Opportunities
  - Delivery with high probability is enough
  - Limited per-user domain of interest
    - Nobody is interested in everything at once
  - Events have lifetimes/deadlines
  - Often more observers than updaters

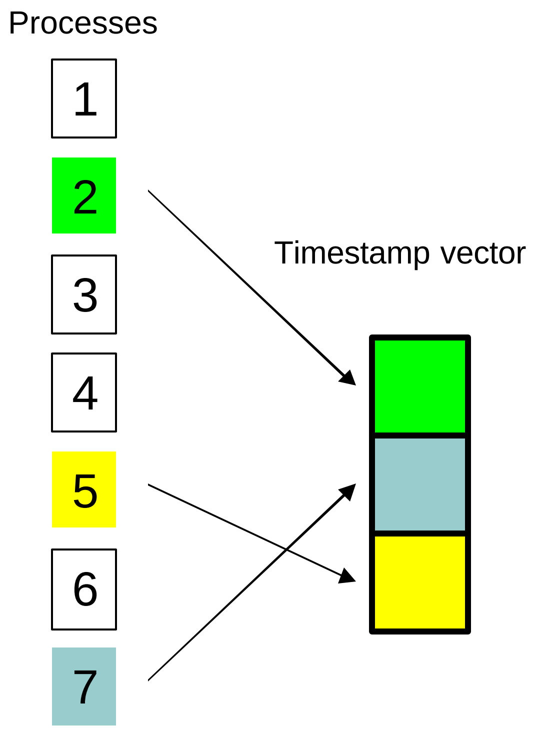
Scalable group communication with ordering guarantees

- Clusters - Disjoint subsets of objects
  - Interested processes join
  - Gossip-based communication
  - Readers – everyone
  - Updaters
    - Only a limited number at a time
    - Core of the cluster



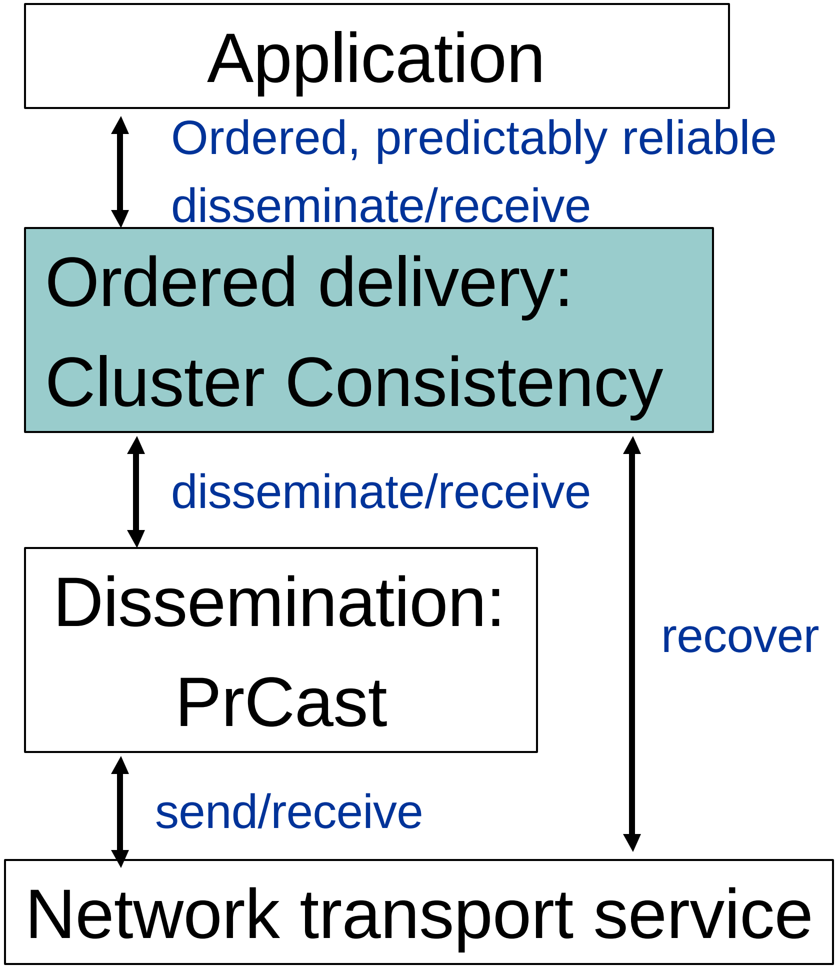
Causally ordered delivery

- Vector timestamps
  - For each event in cluster
  - #simultaneous updaters limited => limited number of vector entries in timestamps
  - Can detect missing dependencies
    - Recovery may be attempted
      - Ask the source
      - Ask k peers
  - Deliver in causal order
    - Skip events not recovered in time



Implementation: A Layered approach

- Implemented in C++
- Causal layer
  - Causal delivery
  - Recovery
- Dissemination layer
  - Gossip protocol
  - Reader membership
- Point-2-point communication layer
  - TCP
    - Concurrent connections
  - UDP



Application

Ordered, predictably reliable disseminate/receive

Ordered delivery: Cluster Consistency

disseminate/receive

recover

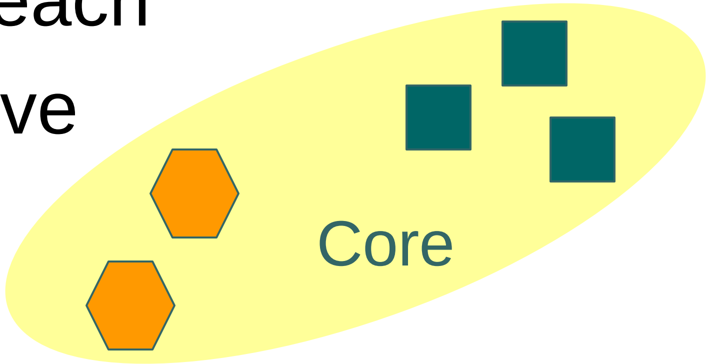
Dissemination: PrCast

send/receive

Network transport service

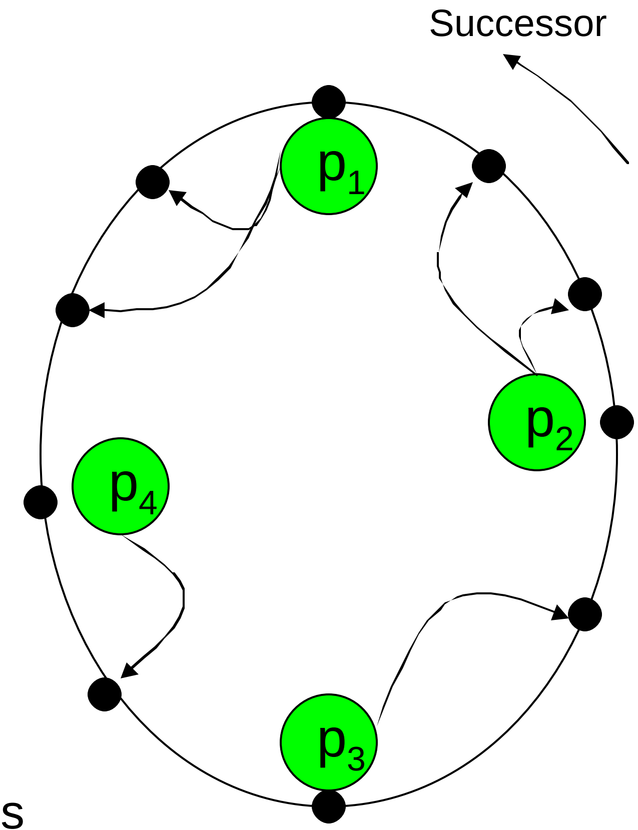
Managing the Core

- At most *n* members/coordinators at any time
  - One unique vector entry each
  - Coordinators join and leave
  - Coordinators might fail
    - Stop failures
    - Communication failures

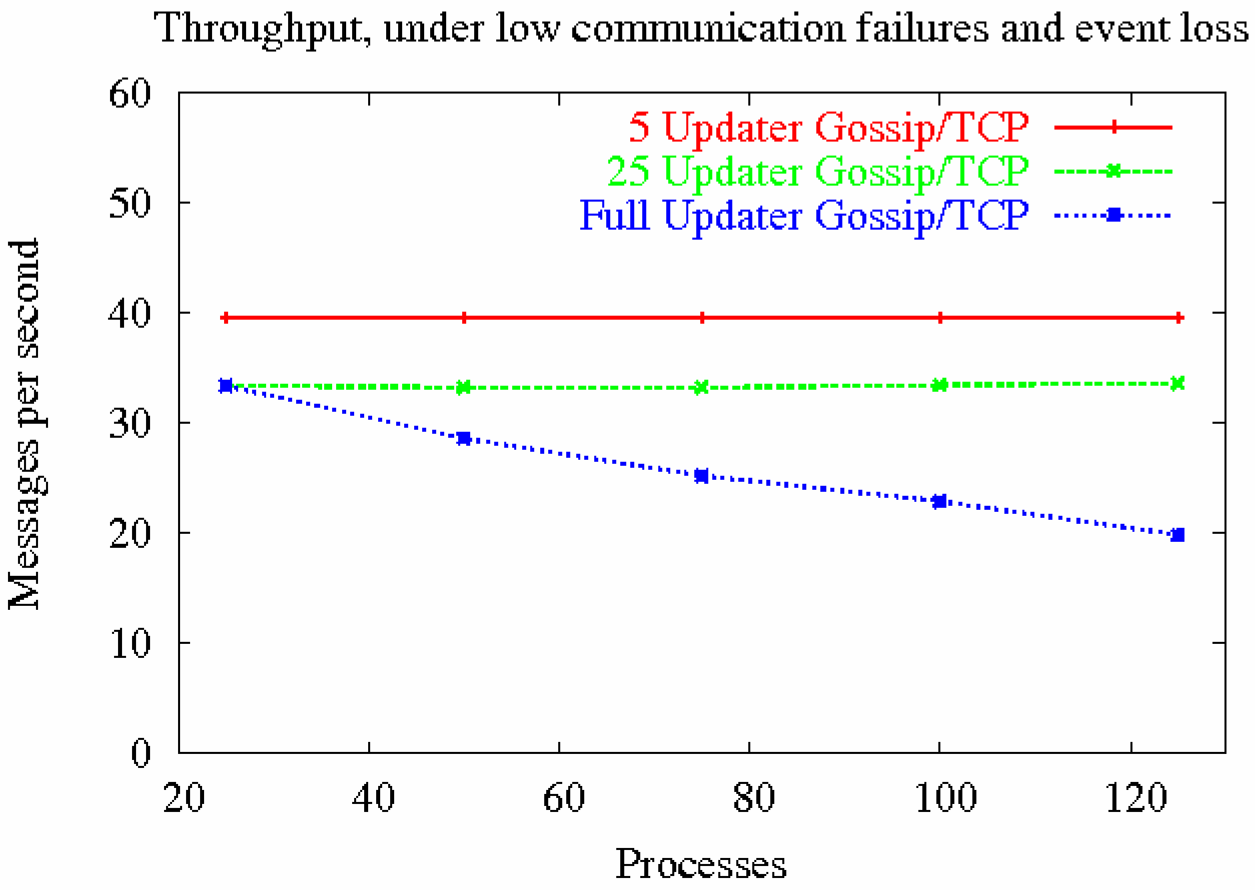


Cluster Management Algorithm

- Inspired by DHT
  - Clock entry Ids form a cycle
  - Each process manage the entries immediately before it.
- Contact any coordinator to join
  - Notify successor if given an entry
  - Notify all about the new coord.
- Failure detection
  - Heartbeats
    - Send to 2k + 1 closest successors
    - Receive from 2k + 1 closest predecessors
    - If < k + 1 received, stop



Experiments: Scalability



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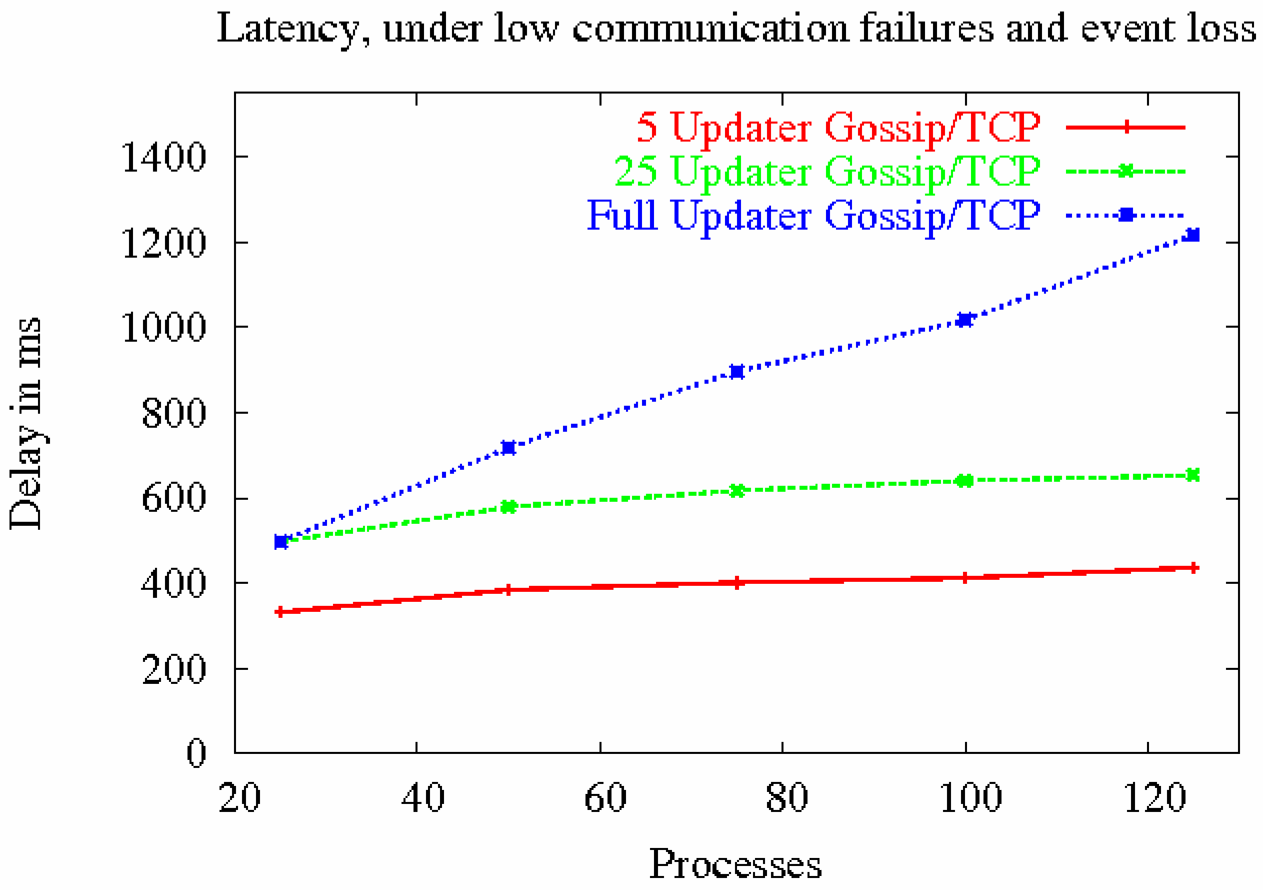
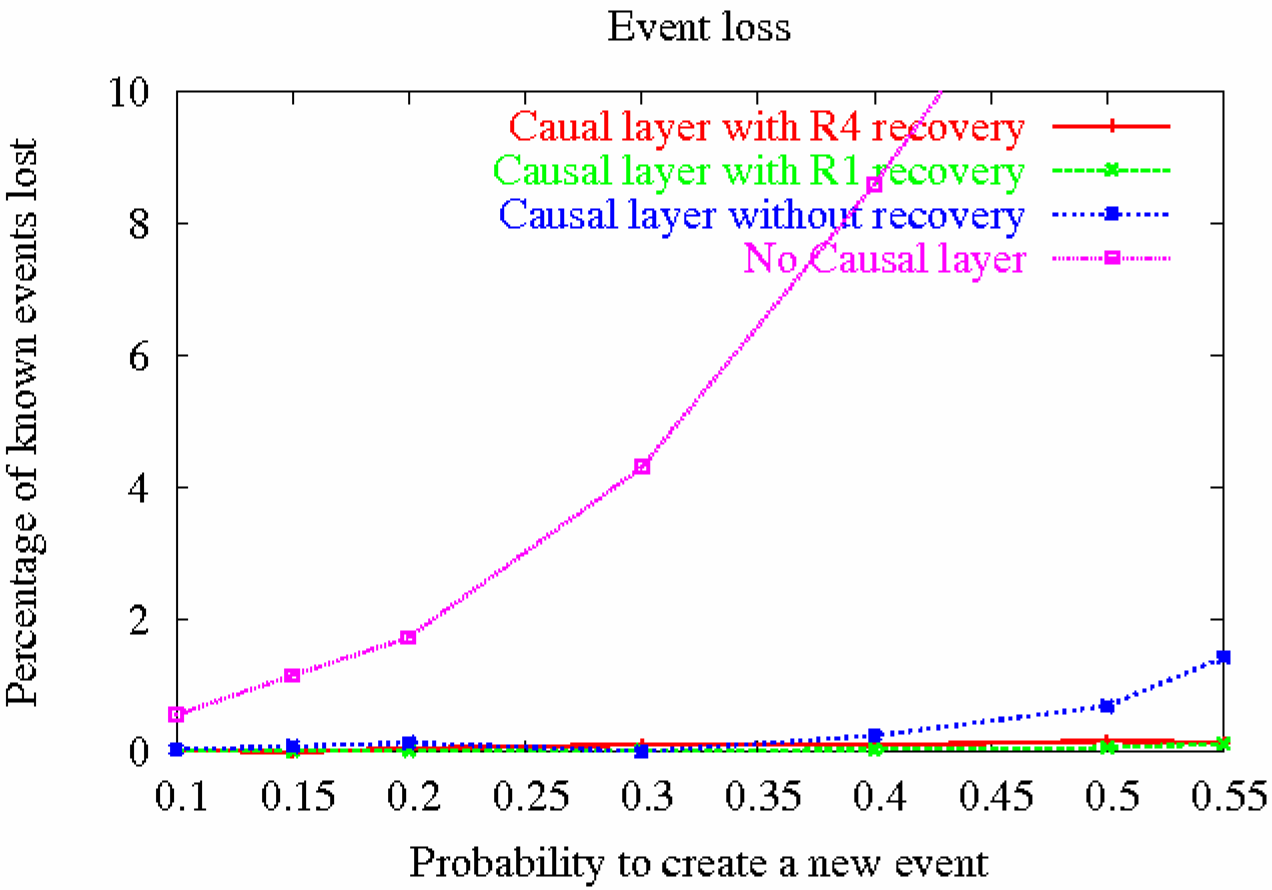


Experiments: Reliability



Discussion

- Summary
  - Optimistic causal multicast
    - Based on gossip dissemination
    - Analysis of buffering for event recovery
  - Decentralized cluster management algorithm
    - Fault-tolerant
- Towards lightweight solutions
  - Reliable multicast -> gossip dissemination
  - Causal order -> optimistic causal order

Future Work

- Causal Cluster Consistency
  - Application case study
    - E.g. distributed monitoring
  - Mobile and/or self-modifying objects
  - Self-stabilizing fault-tolerant group communication
  - Plausible clocks for ordering
    - Alternative to the cluster vector clock
    - No strict need to limit #updaters
    - Event recovery not (easily?) possible

Questions?

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    http://www.cs.chalmers.se/~dcs
    http://www.cs.chalmers.se/~andersg
- Technical reports
  - TR 2005-09 “Causal Cluster Consistency”
  - TR 2005-10 “Dynamic and fault-tolerant cluster management”