Dynamic and fault-tolerant cluster management

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CHALMERS

Outline

- Why peer-to-peer resource management is interesting?
  - Large scale event dissemination
  - Ordered event delivery
- Problem description
- Cluster management algorithm
- Properties
- Conclusion and Future Work

Peer-to-peer resource management?

- Focus
  - Scalability, reliability, and responsiveness of peer-to-peer services

- Observe
  - Many peers may be interested to access similar resources
    - Based on local decision
  - Response time of services depends on the number of peers competing for the service
  - Reliability can only be provided if the number of concurrent peers is limited

- Approach
  - To perform an action a process needs to acquire a resource
  - number of processes to access a resource is restricted

Example1: Event dissemination

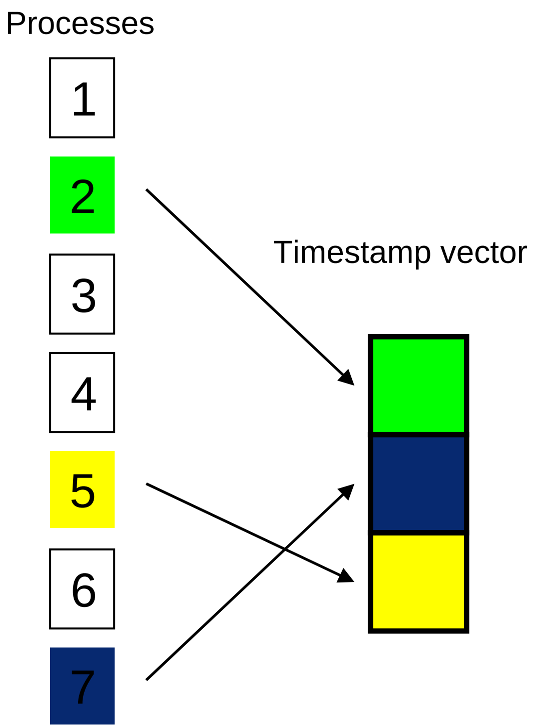
- Event dissemination / Group communication
  - Scalability and reliability
    - #peers : well addressed by current work
    - #events : ignored
  - Problem: too many events disseminated concurrently

    $\Rightarrow$ buffer overflow, too many messages per process etc.

- Possible improvement:
  - Restrict number of concurrent senders
  - Number of concurrent peers corresponds to number of peers which are allowed to share a resource in the system

Example 2: Causal event delivery

- Achieved using vector clocks
- Problem vector clocks grow linearly with the number of peers which send messages
  $\Rightarrow$ long latencies for large number of processes
- The vector clock is a resource to be used by at most n processes concurrently
- Benefits:
  1. dynamic reuse of vector clock entries
  2. Message sizes stay constant
     $\Rightarrow$ Scalability



This work

- Resource management for P2P services
  - can improve scalability
  - can improve reliability
- Best applicable where an action of a single peer causes a large number of peers to perform work

- Present a cluster management algorithm
  - Manages resources decentralised
  - Fault-tolerant

Basic Resource Management Model

- Event-based system
  - set of resources $R=\{r_1, \ldots, r_l\}$
  - Using $r_i \simeq$ sending event

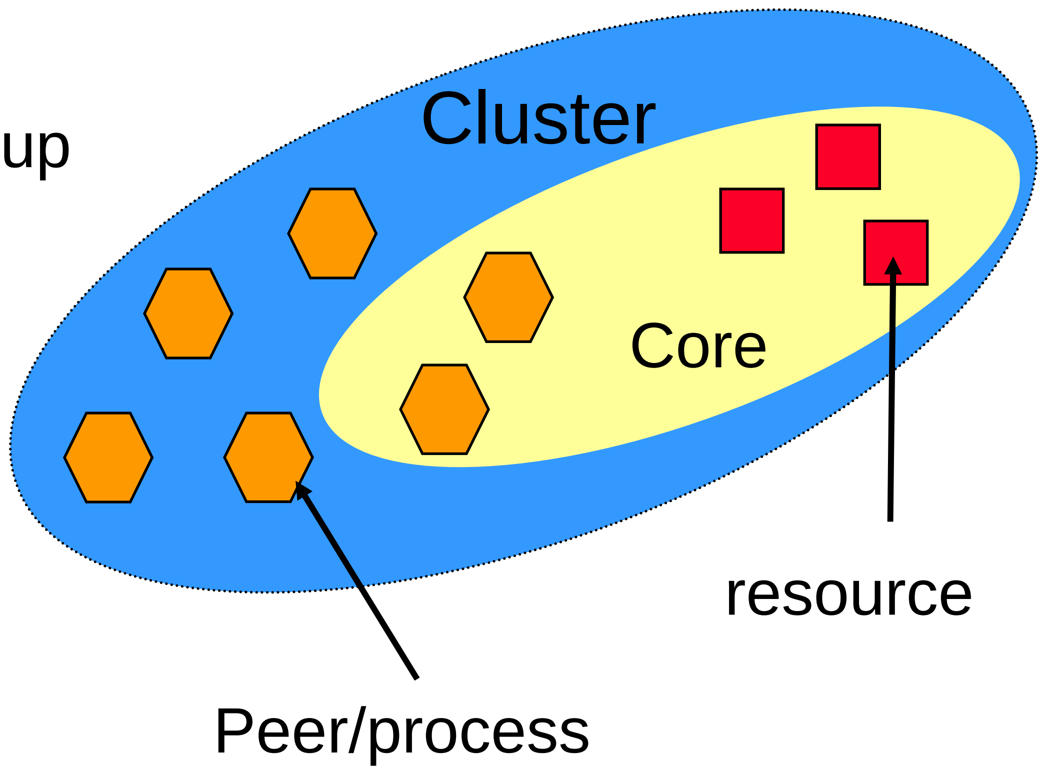
- Cluster Model:
  - resources are partitioned into several disjoint clusters
    $C_1, C_2, \ldots$ with $\cup_i C_i = R$
  - Cluster manages n distinguishable tickets $t_0, \ldots, t_{n\text{-}1}$
  - Process uses a resource only if it obtained a ticket from the cluster managing the resource

- Cluster ensures
  - Never two processes own the same ticket

Cluster Management

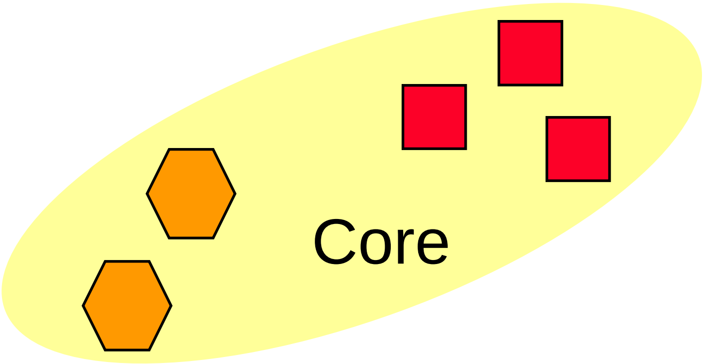
- Each cluster corresponds to a process group
- Interested peers join
- Observers – everyone
  - Join the process group
- Using a resource
  - At most n at a time
  - Core of the cluster

  $\simeq$ obtain a ticket



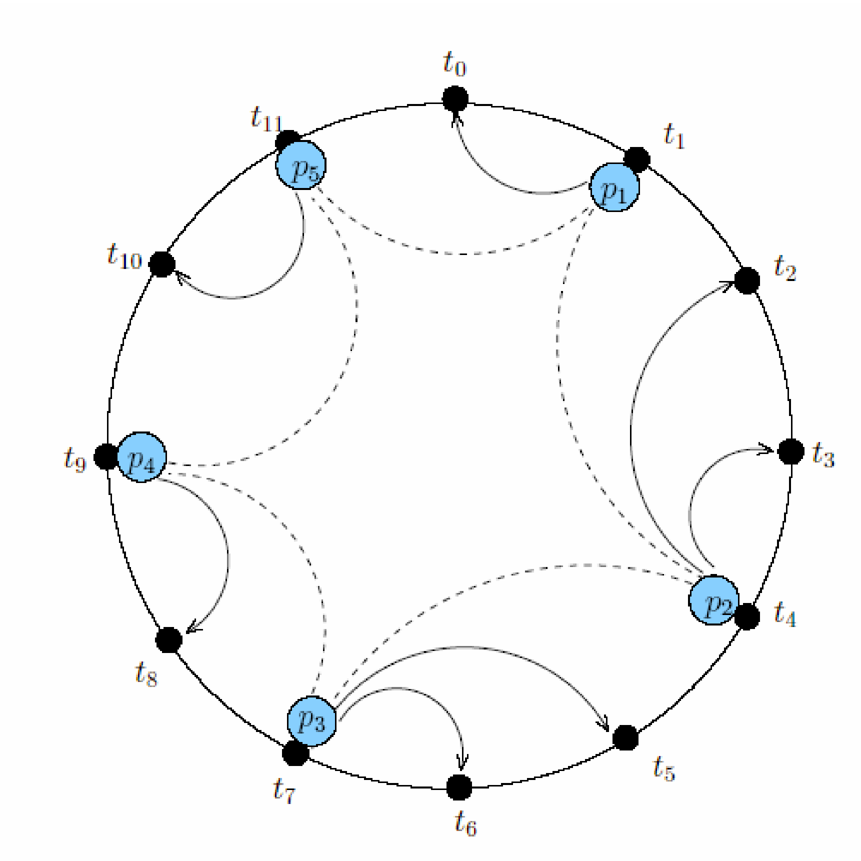
Problem description

- Decentralised management of tickets
  - Two processes never
    own the same ticket
  - Fault tolerance
    - Stop failures
    - Communication failures
  - Reclaim tickets from failed peers
- Communication paradigm
  - Speed of clocks approximately synchronised
  - Message passing



Cluster Management Algorithm

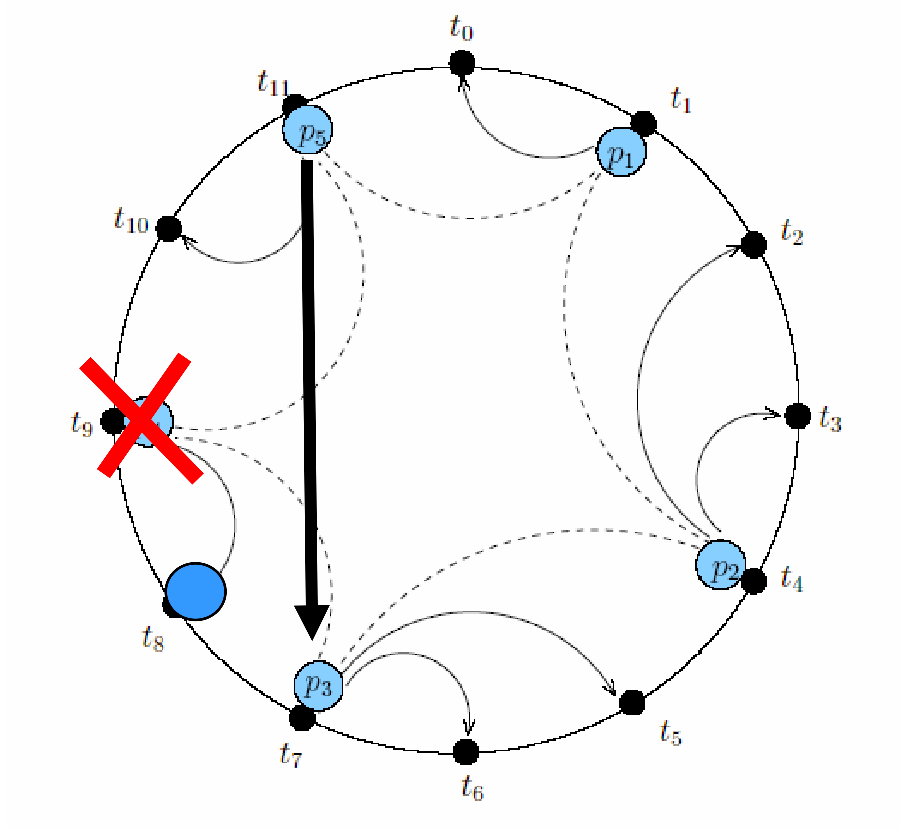
- Ring Structure
  - peers form a cycle (max n)
  - Predecessor and successor are determined by the ticket a peer obtained
  - Each peer manages entries in betwe[en] its own ticket and its successor ticket



- Join
  - Contact any coordinator
  - Notify successor if given an entry
  - Notify all about the new coordinator

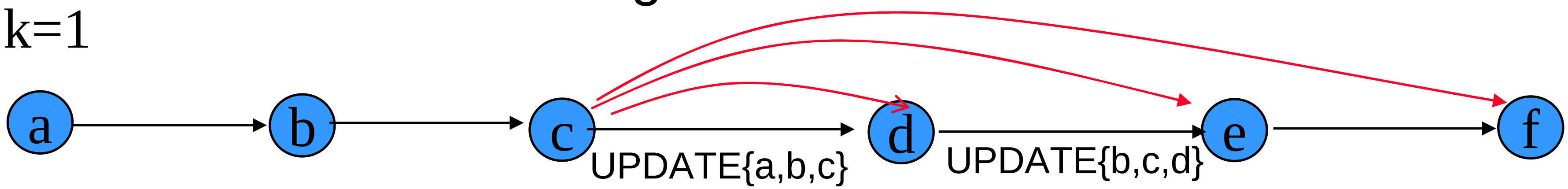
Dealing with failures

- Problem: If a process fails need to be able to reclaim vector entries
- Solution idea: Sending alive messages to 2k+1 successors
- Process to proceed needs to receive k+1 alive messages from known processes
- Detect successor failing:
  - Exclusion algorithm contacting the closest successor
  - At the end either initiator succeeds in exclusion or fails
- Can tolerate k failures of 2k +1 known processes



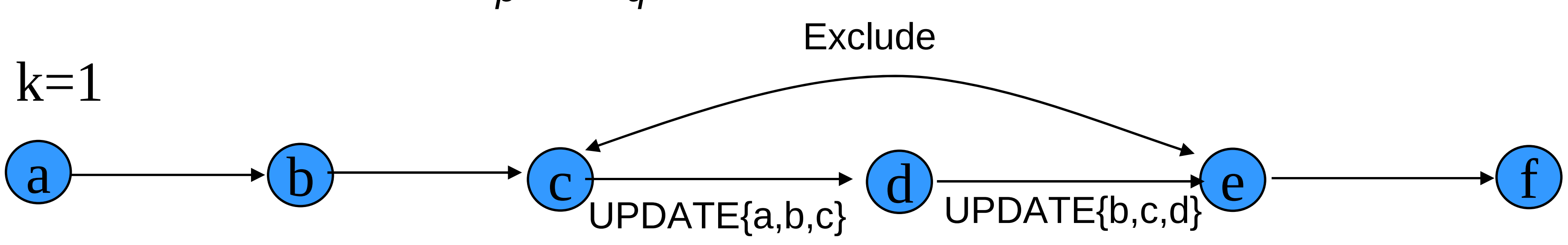
Basic Idea of Exclusion algorithm

- Two party negotiation not feasible
  - partitioning
- Instead peer determines set of 2k+1 closest predecessors for its immediate successor
- In each round
  - Send Update(2k+1 closest predecessors) to immediate neighbours
  - Send ALIVE message to 2k+1 closest successors



Cont. Exclusion Algorithm

- Determine two sets
  - L_p = {predecessor received by the last UPDATE}
  - R_p = {predecessors successfully send by last UPDATE}
  - E.g. $L_d = \{a,b,c\}$, $R_d = \{b,c,d\}$
- Exclusion(p,q) succeeds if
  - $L_p \cap R_q > k+1$
  - $k+1$ peers in $L_p \cap R_q$ confirm exclusion



Algorithms Properties

- Correctness
  - Proof in the paper
- Overhead in messages
  - *2k+1* heartbeat messages send in each round
  - Successful ticket acquisition is followed by a Multicast
- Availability of tickets
  - During exclusion of failed tickets coordinators cannot release tickets
  - Analysis:

    p_f : failure rate α: fraction of taken tickets

    In equilibrium failing and joining peers:

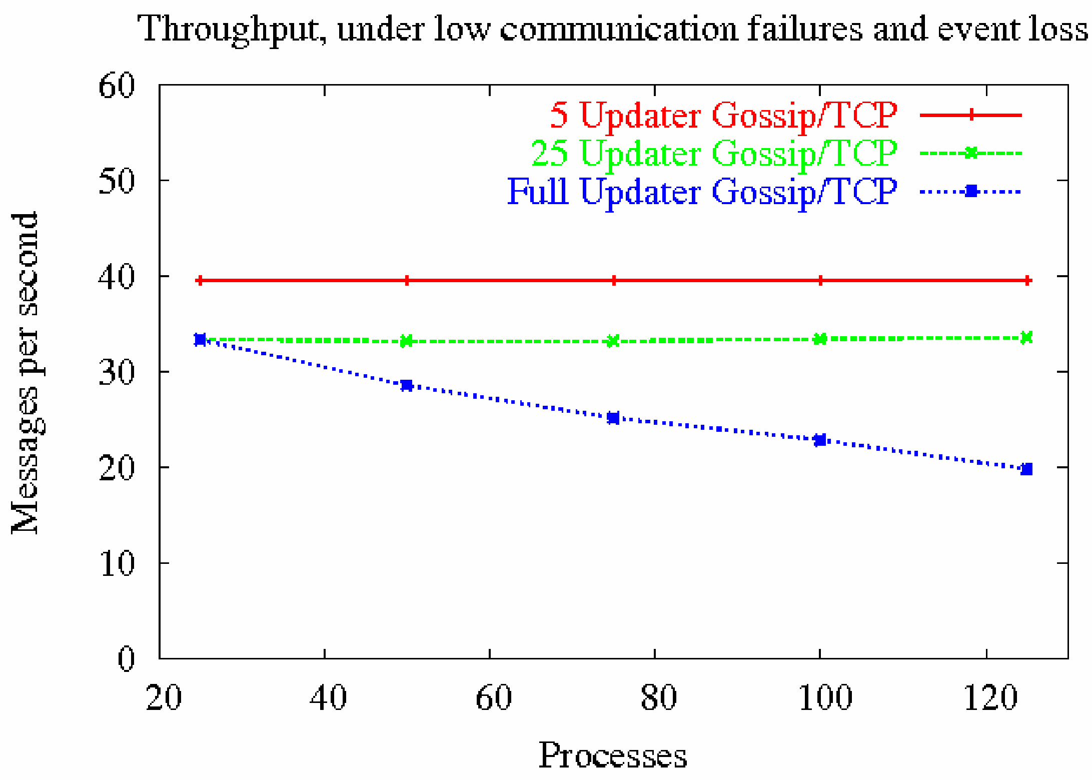
    Peer succeeds w.h.p. to acquire a ticket if

    $p_f < \frac{1}{2}(1-\alpha)$

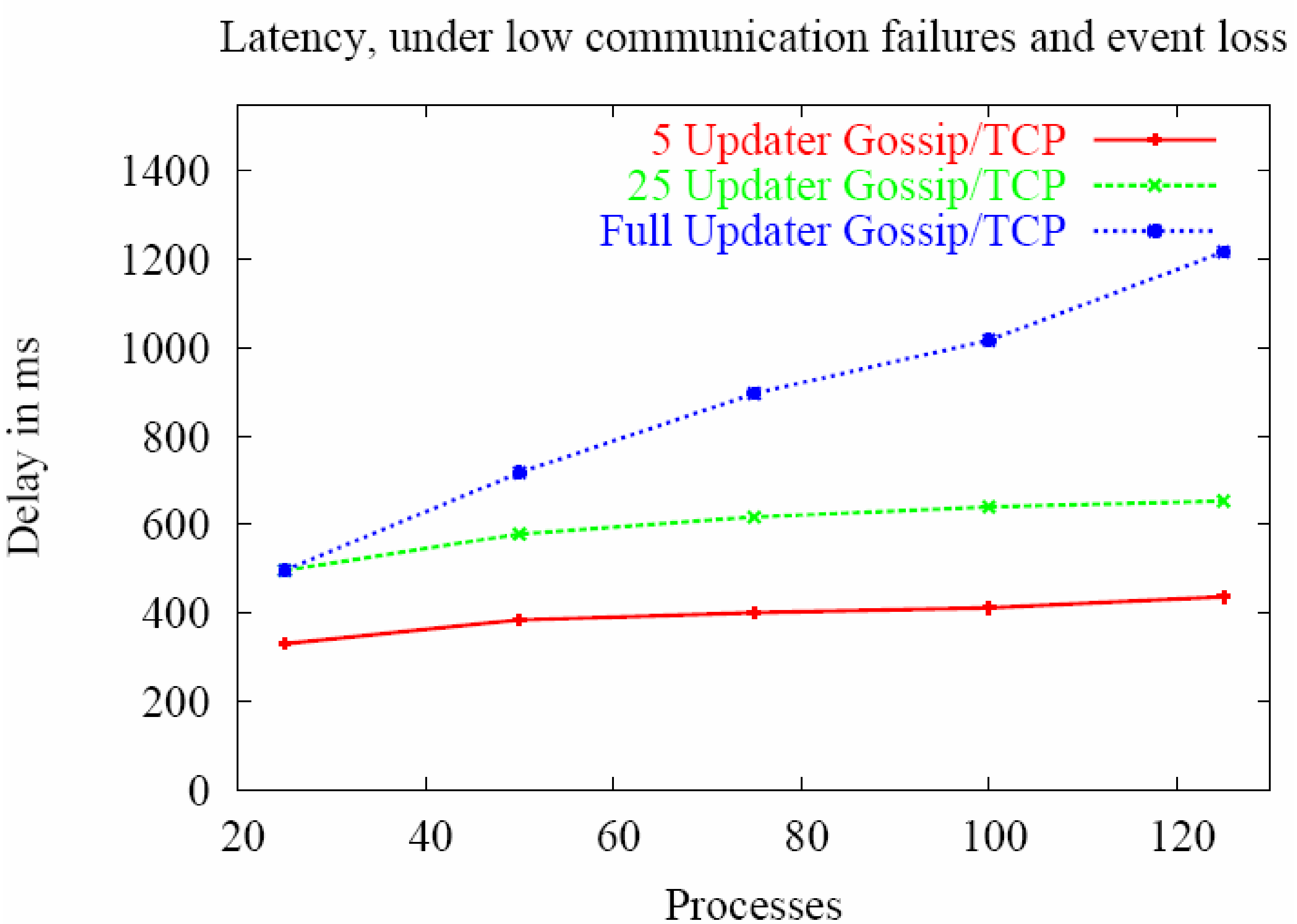
Conclusion and Future Work

- Fault-tolerant cluster management model
  - Can support scalable and reliable peer-to-peer services
- Presented an algorithm
  - Decentralised situation
  - Proven correctness in the occurrence failures
    - Stop failures, message omissions
  - Low message overhead
  - Good availability of tickets in the occurrence of failures
- Future work
  - Combining and testing with peer-to-peer services
    - Beyond examples introduced
  - Practical evaluation of algorithms properties
    - Availability of tickets
  - Fairness properties

Experiments: Scalability



Experiments: Scalability



Experiments: Reliability