A Repair Mechanism for Fault-Tolerance for Tree-Structured Peer-to-Peer Systems

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Outline

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Context

- Resource discovery
- Target platforms
  - large scale
  - no central infrastructure
  - dynamic joins and leaves of nodes
- P2P systems
  - Purely decentralized algorithms
  - Scalable algorithms to retrieve objects
  - Fault-tolerance

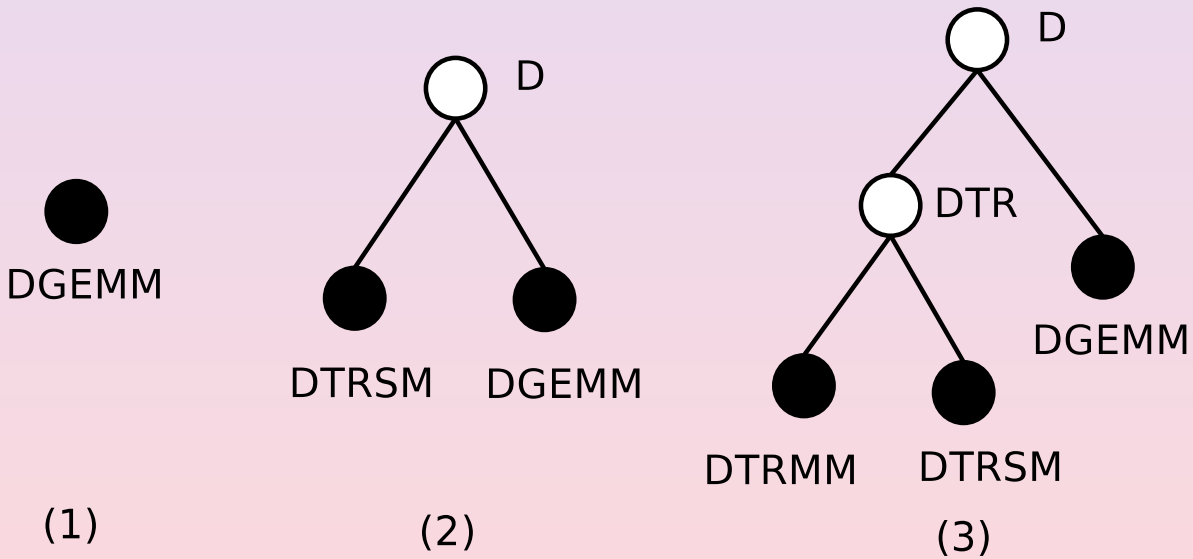
Trie-based lookup

- Range queries (logarithmic latency)
- Approaches
  - Skip Graphs (Aspnes and Shah – 2003)
  - PHT (Ramabhadran, Ratnasamy, Hellerstein, Shenker – 2004)
  - Nodewiz (Basu, Banerjee, Sharma, Lee – 2005)
  - P-Grid (Datta, Hauswirth, John, Schmidt, Aberer – 2005)
  - DLPT (Caron, Desprez, Tedeschi – 2006)

Outline

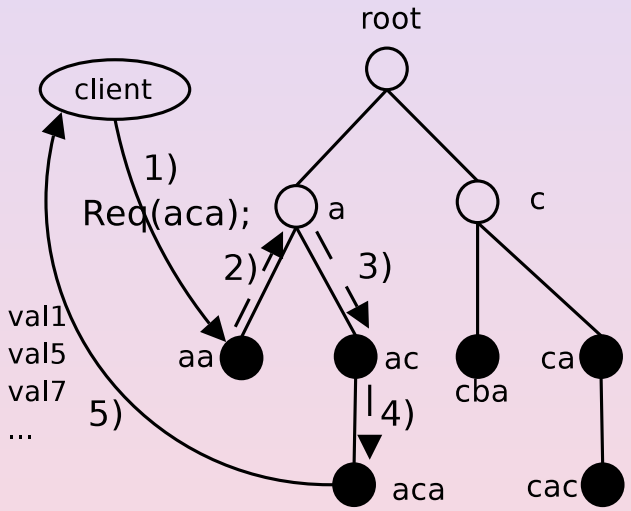
DLPT

- Distributed Lexicographic Placement Table
- Based on a greatest common prefix tree (GCP Tree)
- Distributed and dynamic building and mapping



Querying the GCP tree

- Exact match query
- Range query (automatic completion)
- Multicriteria lookup



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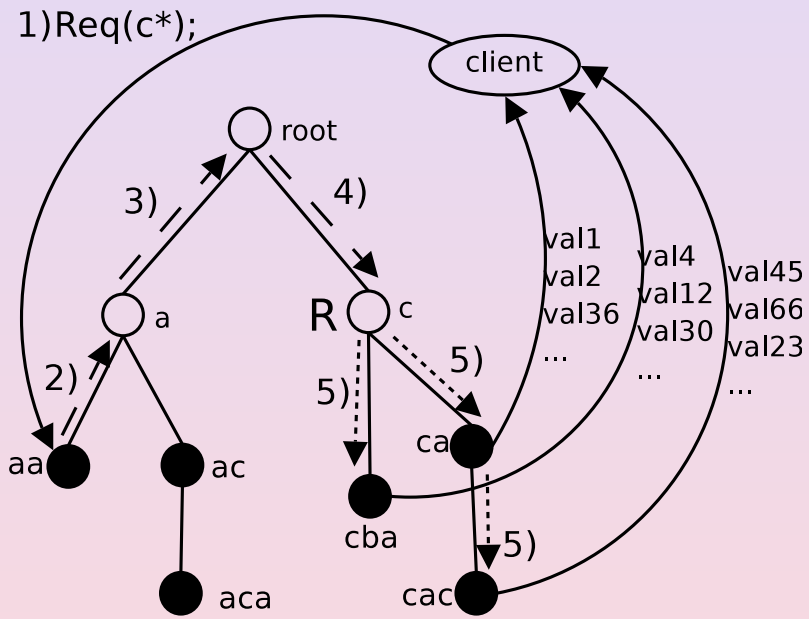

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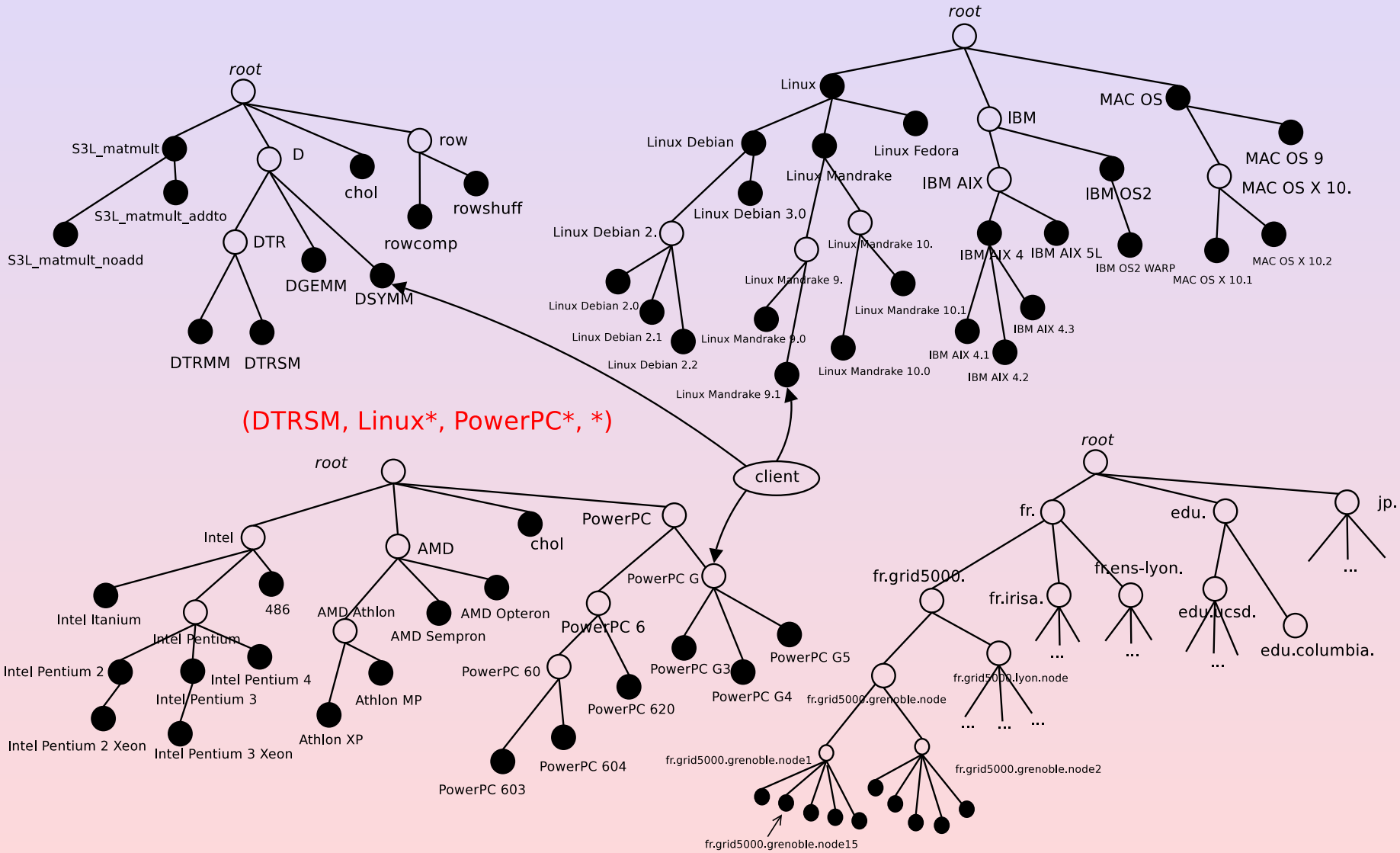


Replicating or repairing ?

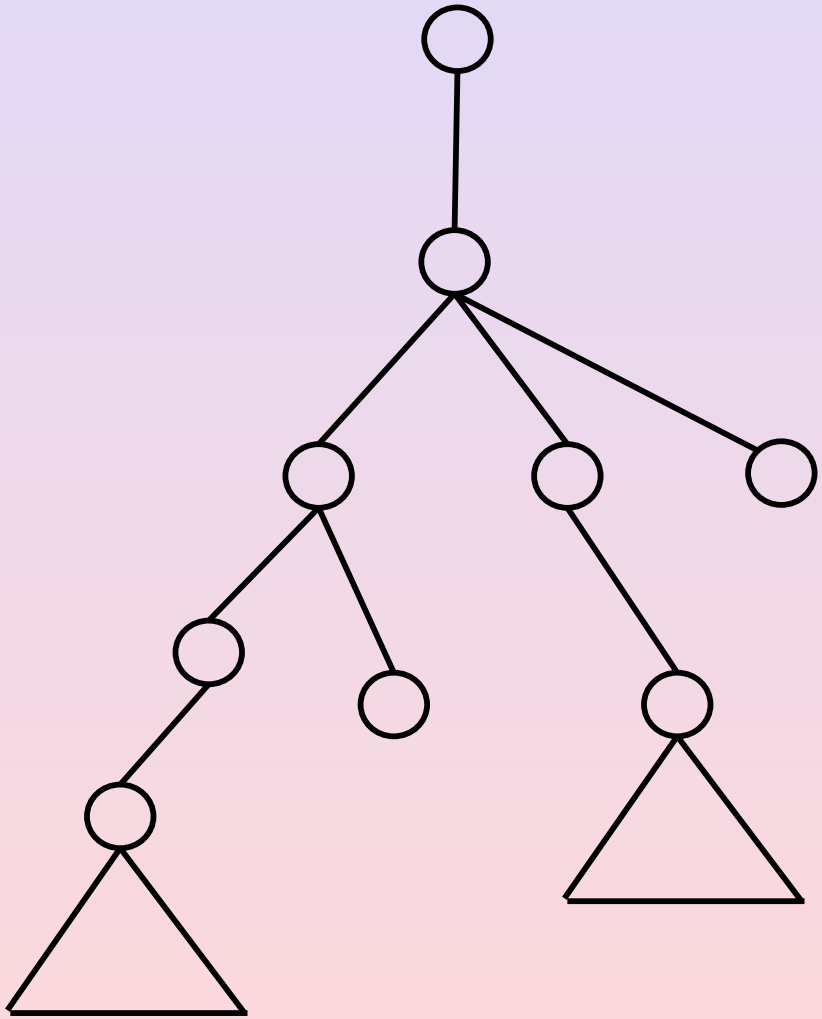
- Replication of the tree
  - preventive approach
  - how to tune the replication factor ?
  - costly to maintain (resources/local state)
- Repair
  - let the tree split into a forest
  - *a posteriori* reconnection and reordering of nodes

Outline

Two phases

- Tree recovery (forest $\rightarrow$ tree)
- Tree reorganization (tree $\rightarrow$ GCP tree)

Tree reconnection



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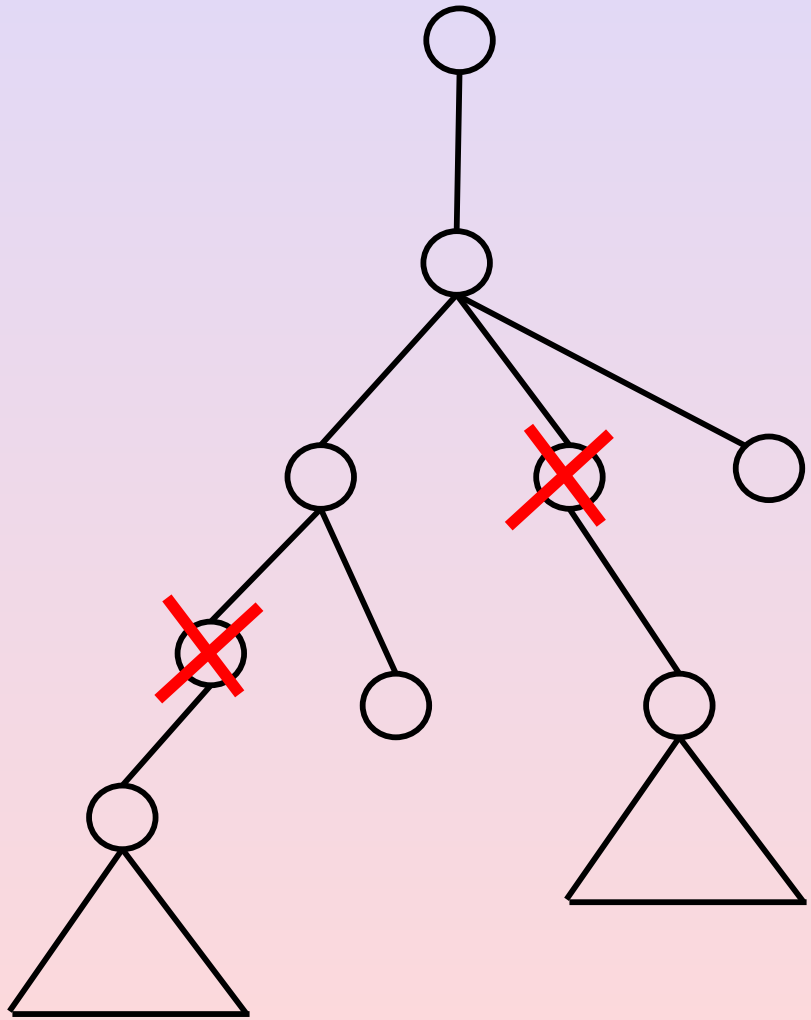

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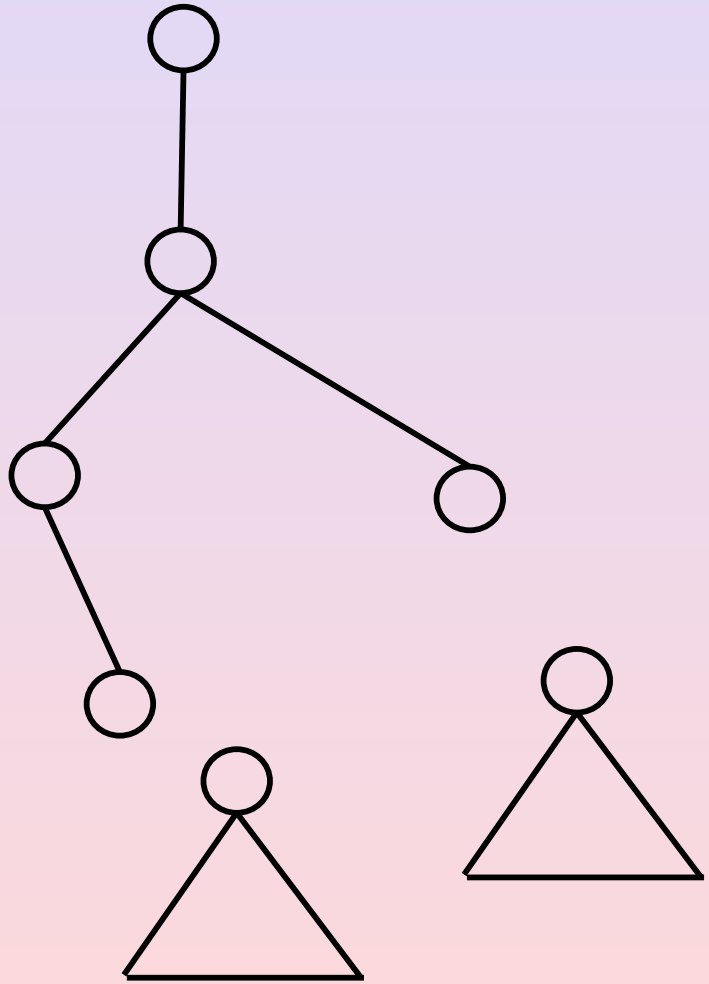

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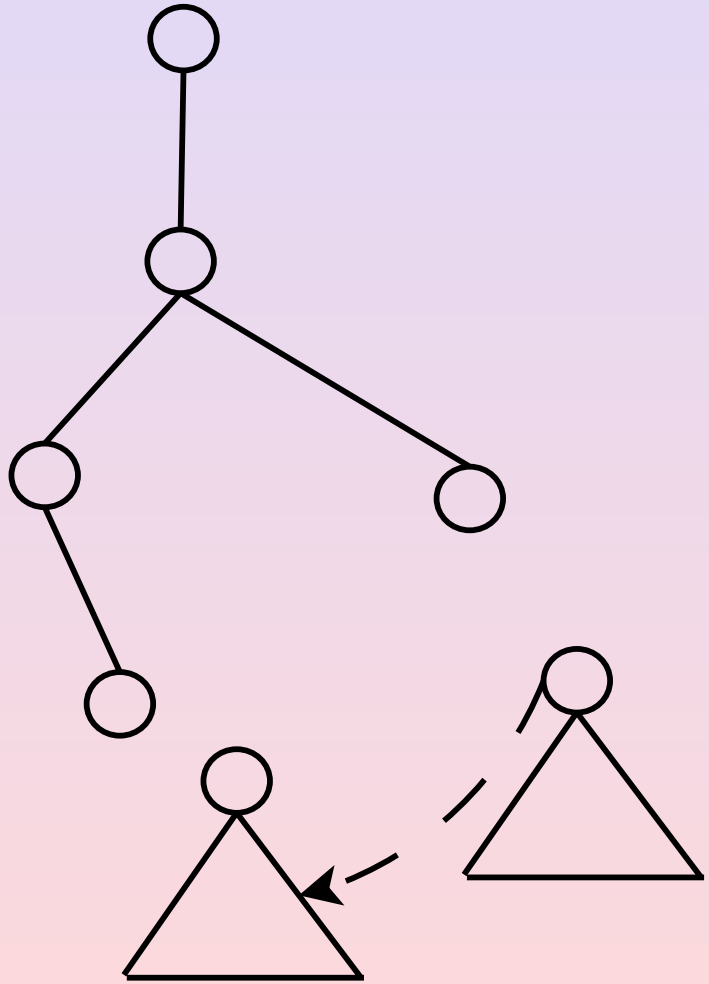

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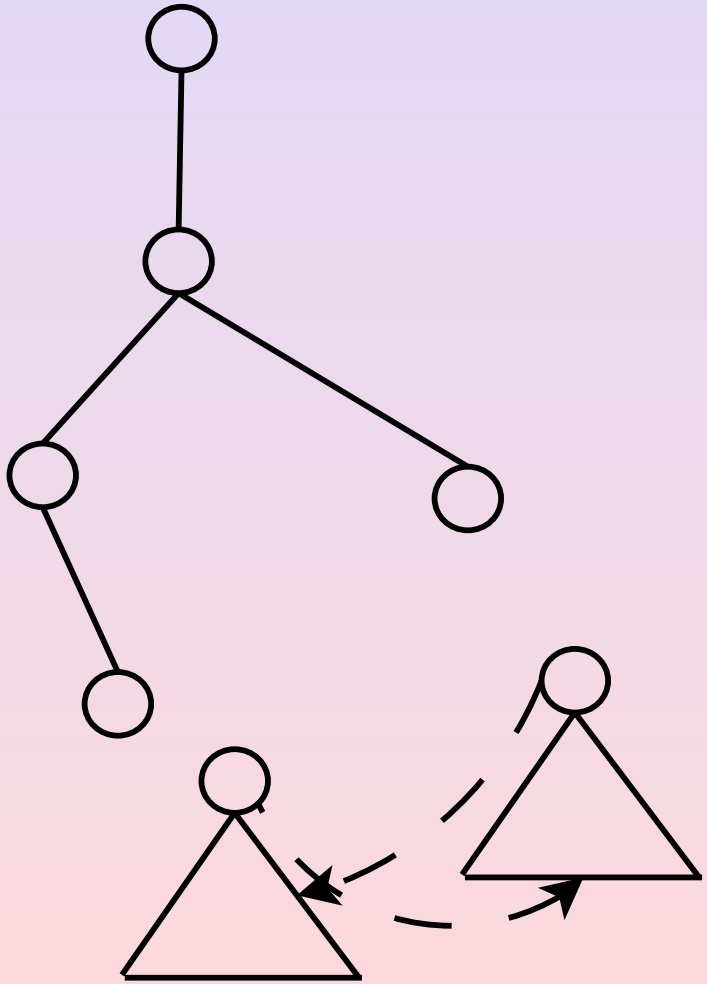

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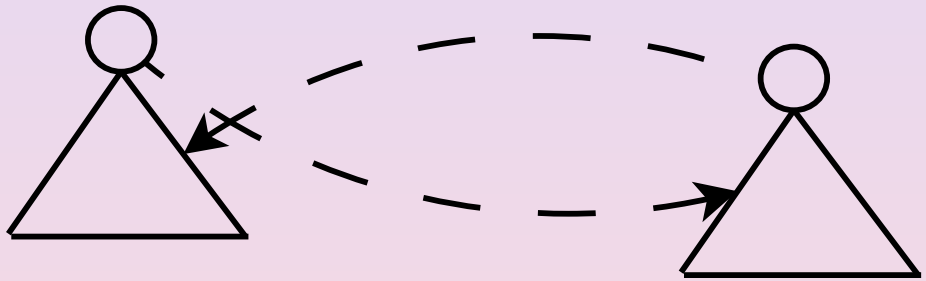

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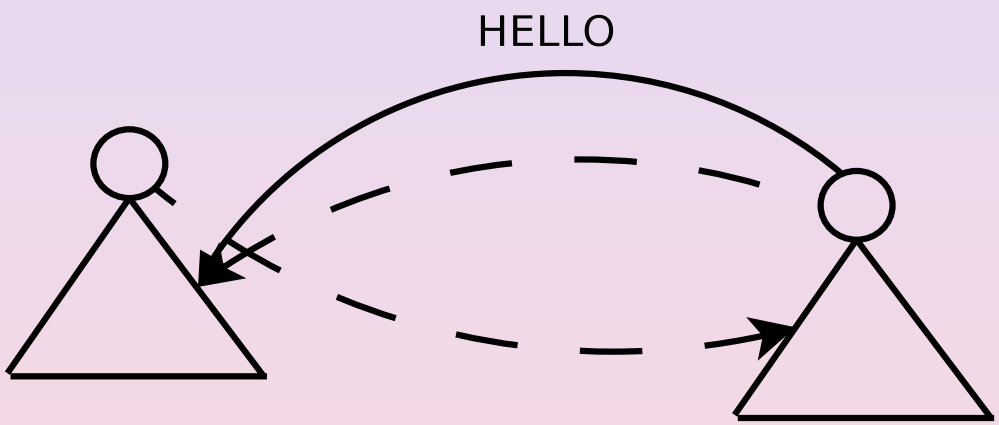

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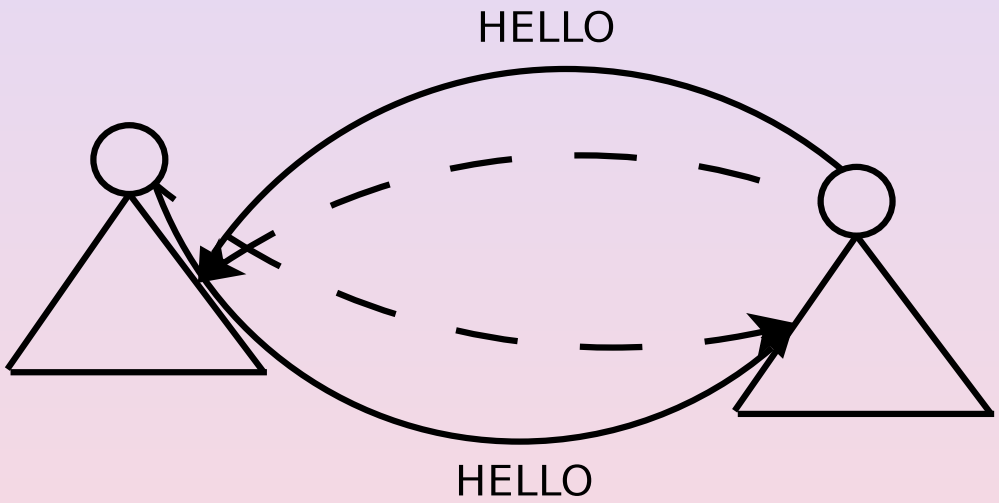

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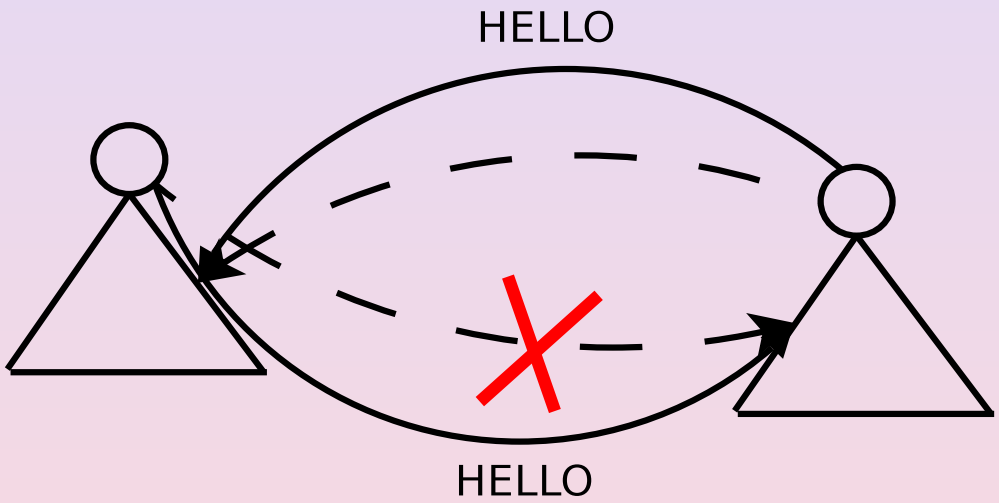

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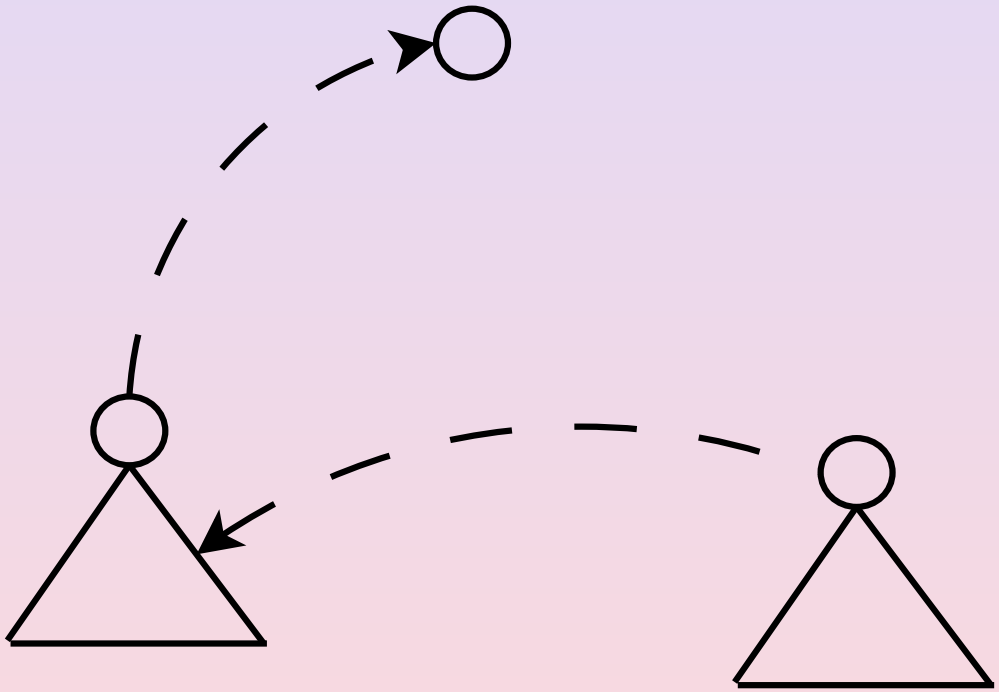
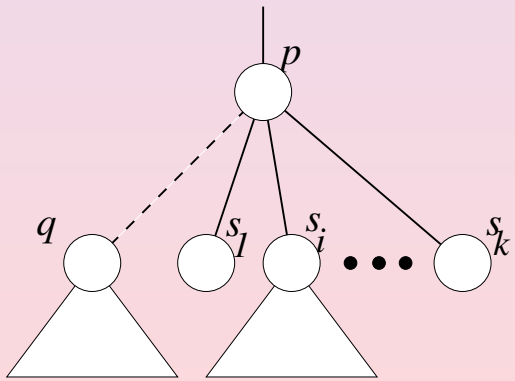


Routing the false sons (1/2)

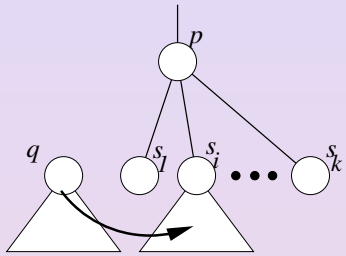
Each node p having a false son q initiates the routing of q
Two cases :

- $p = q$, `MERGE` between q subtree and p subtree
- No relation of prefixing between p and q
  - p moves q to its father, if exists
  - Creation of a common father otherwise
- $q = prefix(p)$, p moves q to its father
- $p = prefix(q)$, four cases.

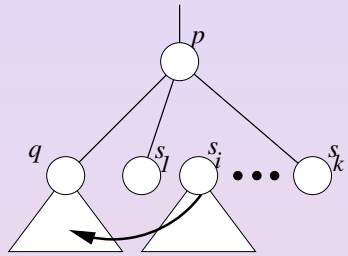


(i) $p.val = prefix(q)$ and $p.val = GCP(s_1, \ldots, s_k)$.

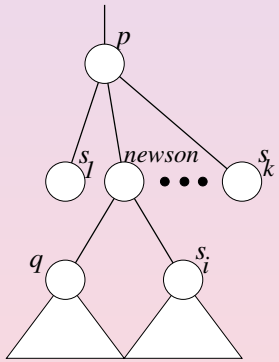
Routing of the false sons (2/2)



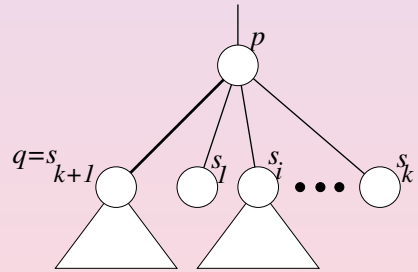
(*a*) There exists s_i such that $s_i.val = prefix(q.val)$



(*b*) There exists s_i such that $q.val = prefix(s_i.val)$

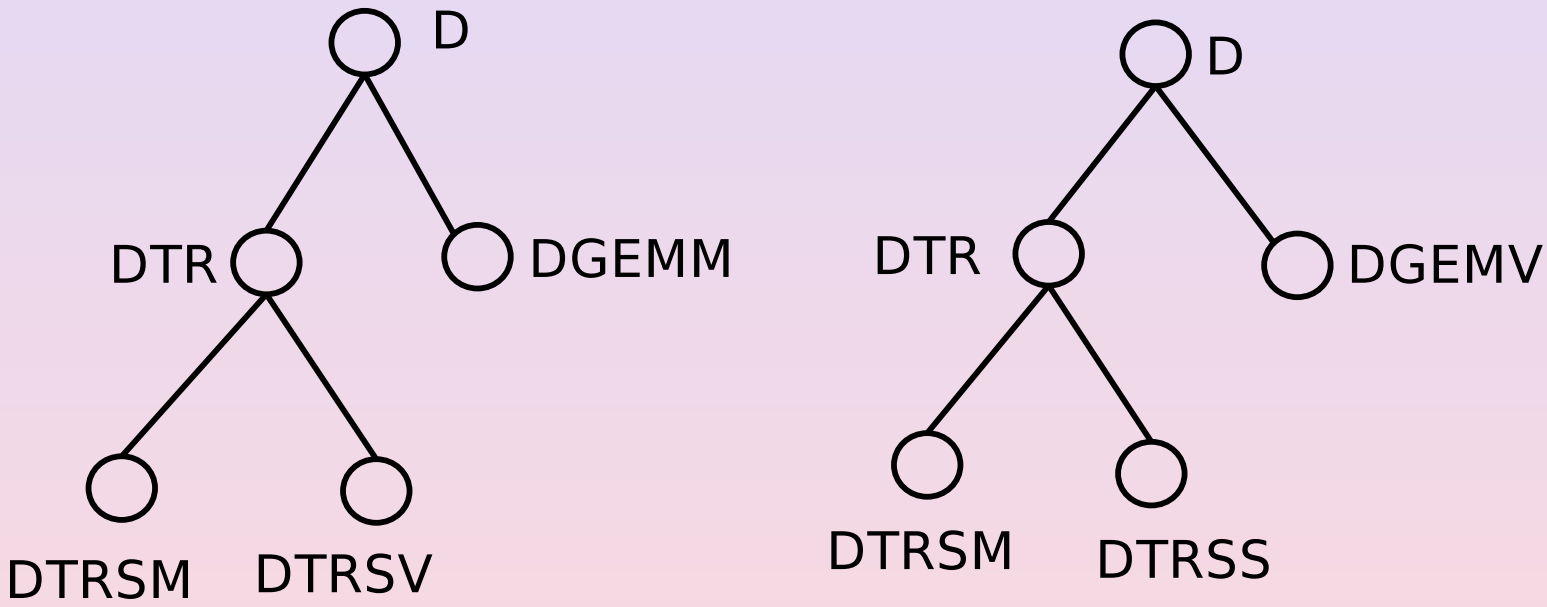


(*c*) There exists s_i such that $GCP(q.val, s_i.val) > p.val$



(*d*) $p.val = prefix(q.val)$

MERGE of two GCP trees



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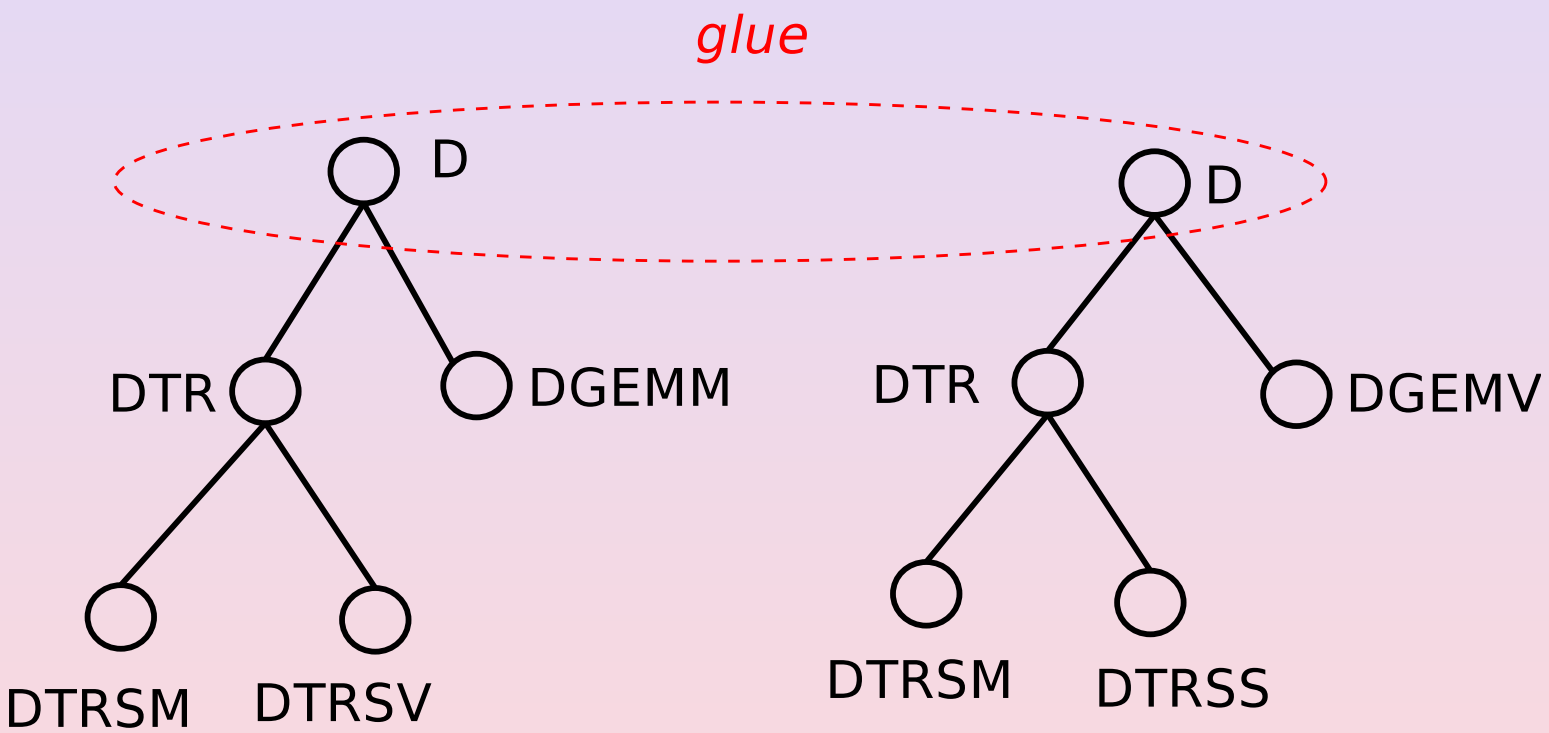

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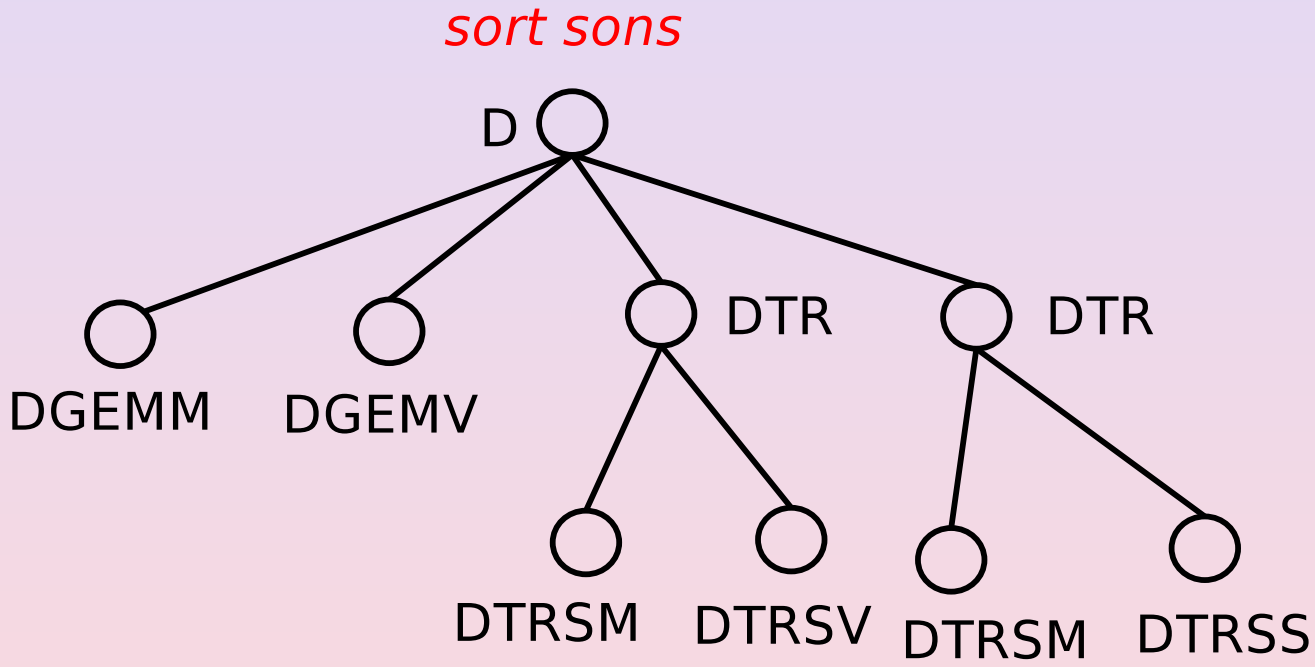

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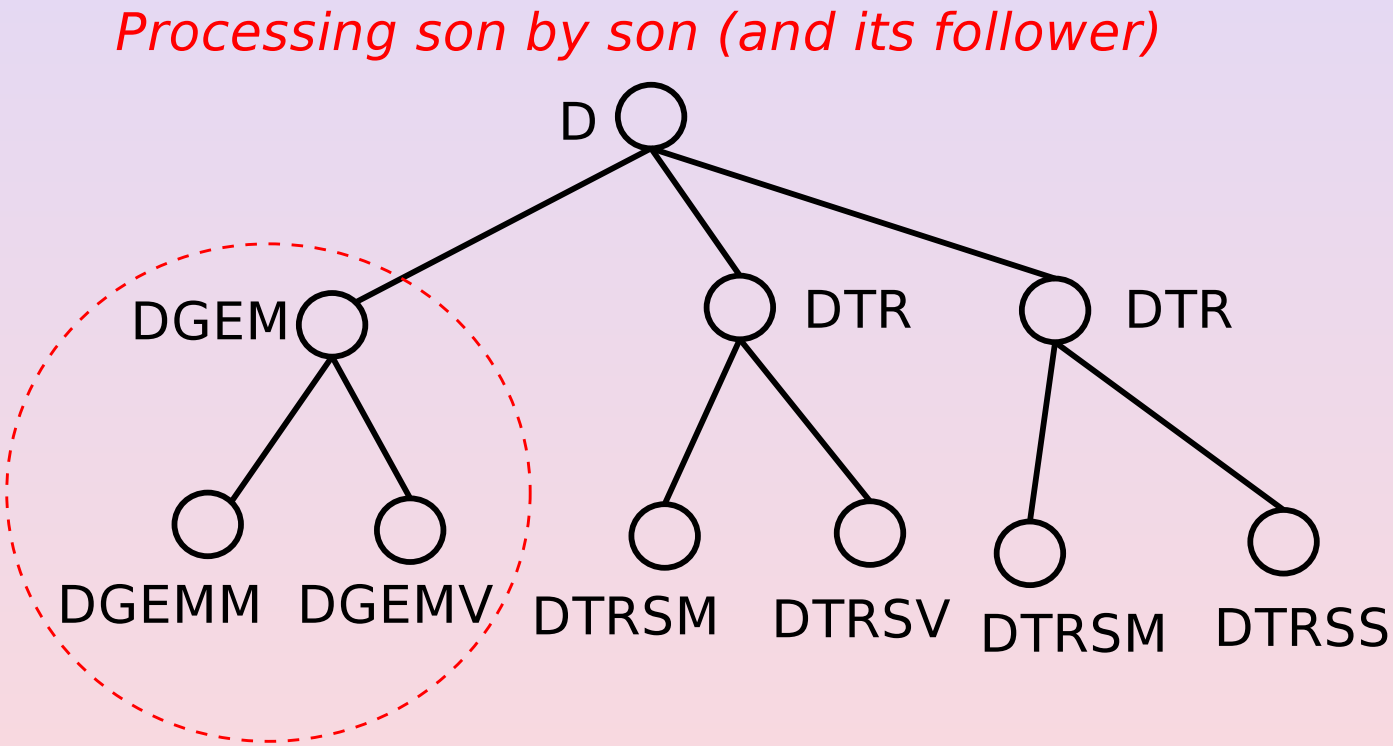
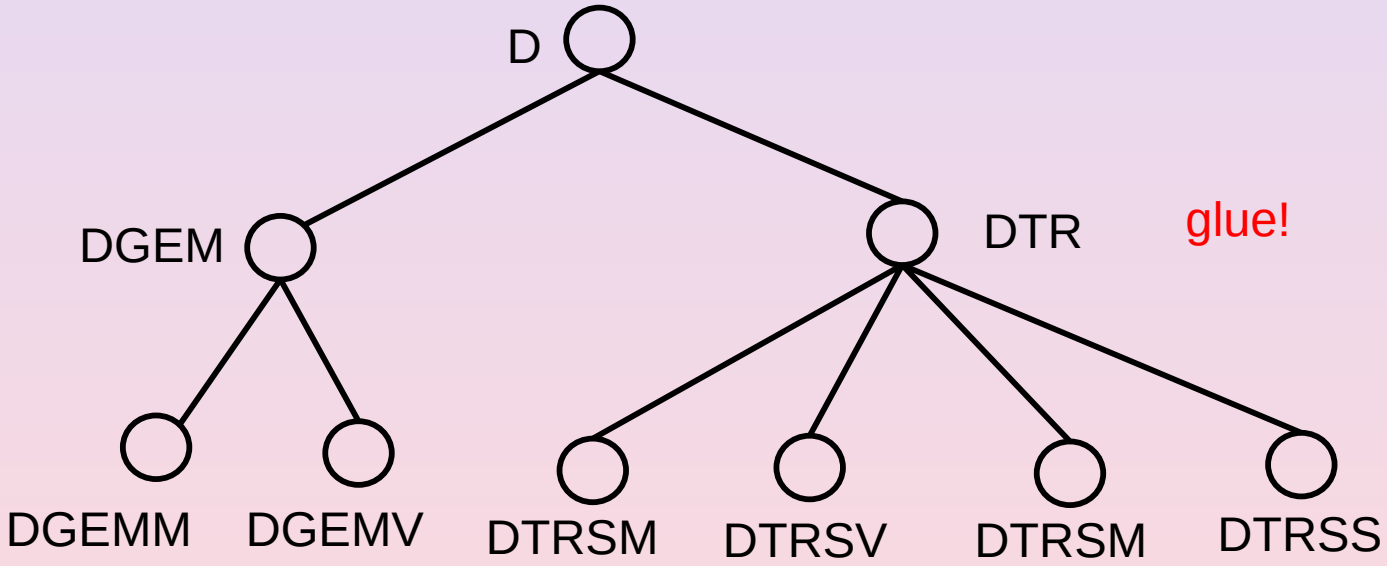


MERGE of two GCP trees

Processing son by son (and its follower)
and launching MERGE recursively



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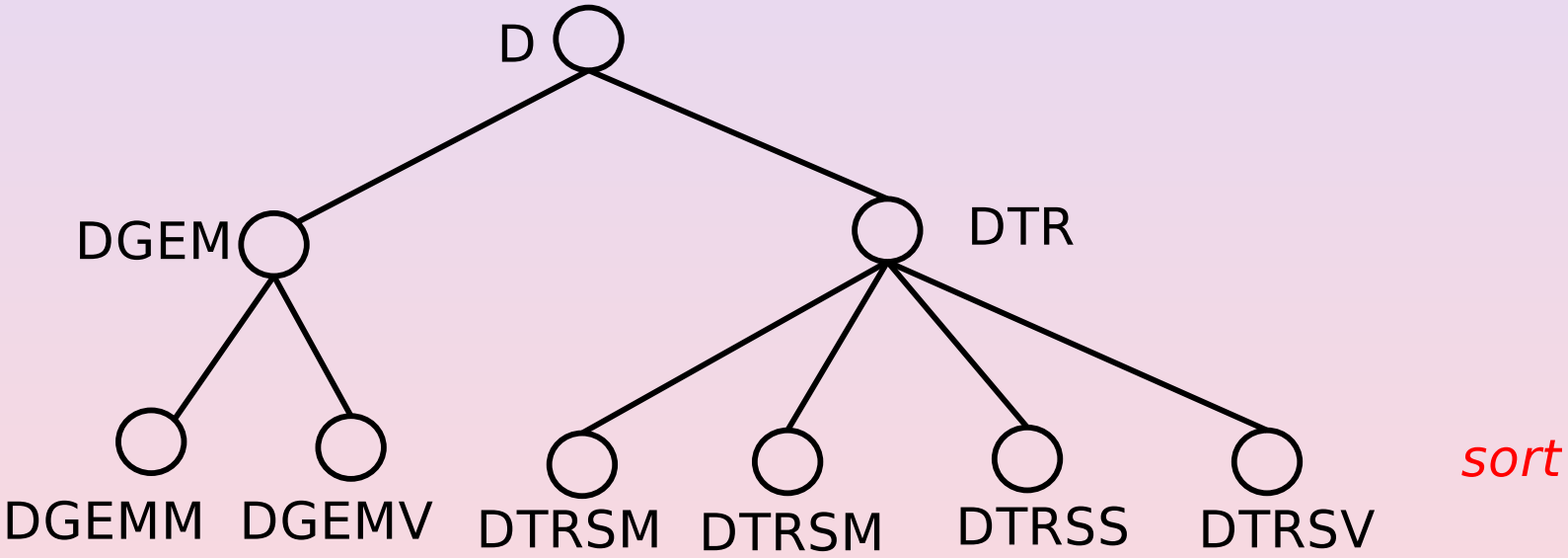

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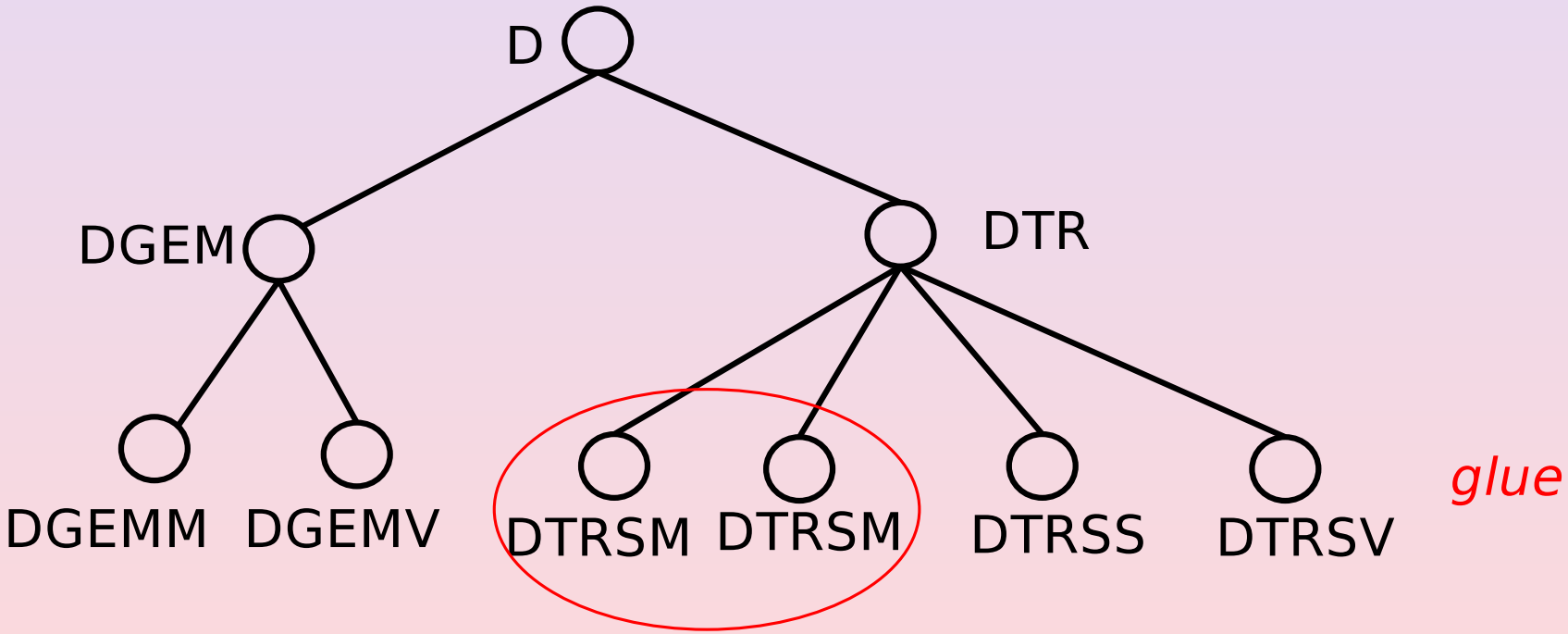

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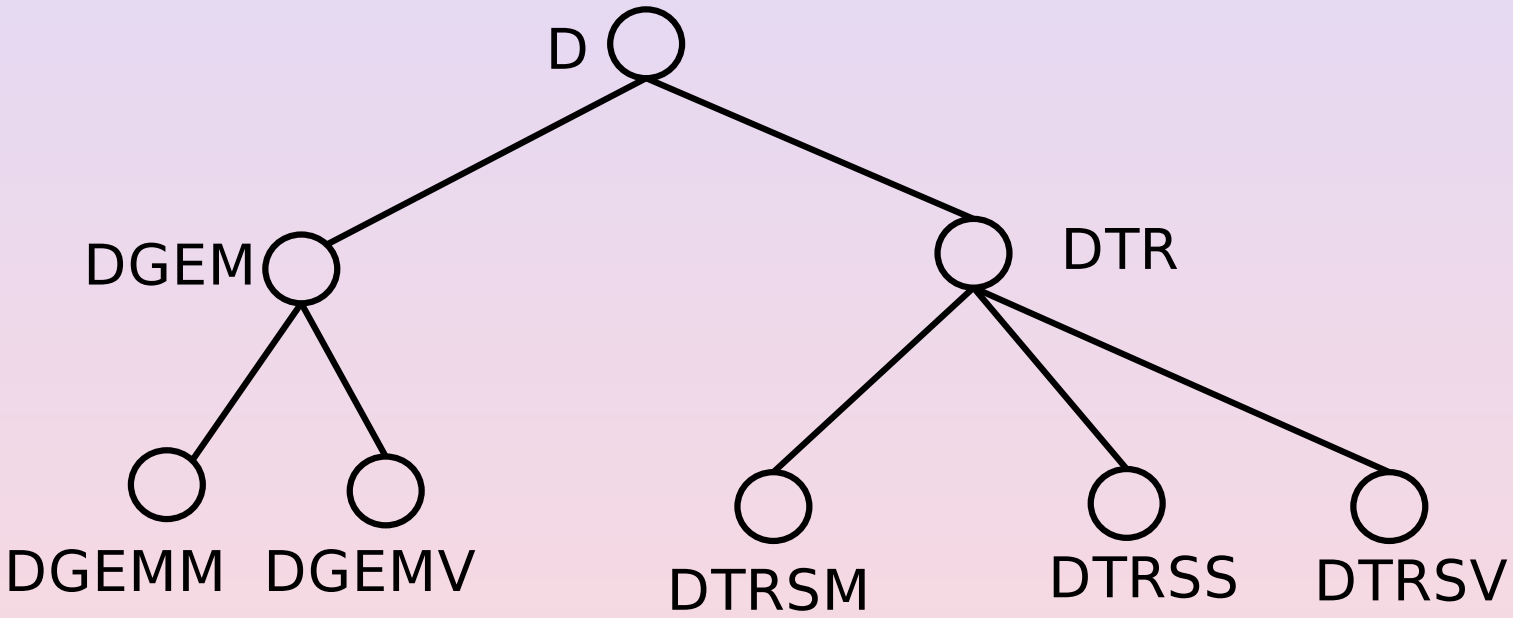

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Conclusion

- Repair protocol facing node crashes in a GCP Tree
  - Reconnection and reorganization of subtrees
  - GCP tree recovery after a finite time (proofs in the paper)
  - Avoid/reduce the cost of a replication strategy
- Future Work
  - Connecting replication and repair mechanisms to minimize the cost of fault-tolerance
  - Develop and validate a prototype on the Grid'5000 platform