The Relaxed Approach for the Greater Good of Functionality and Elasticity

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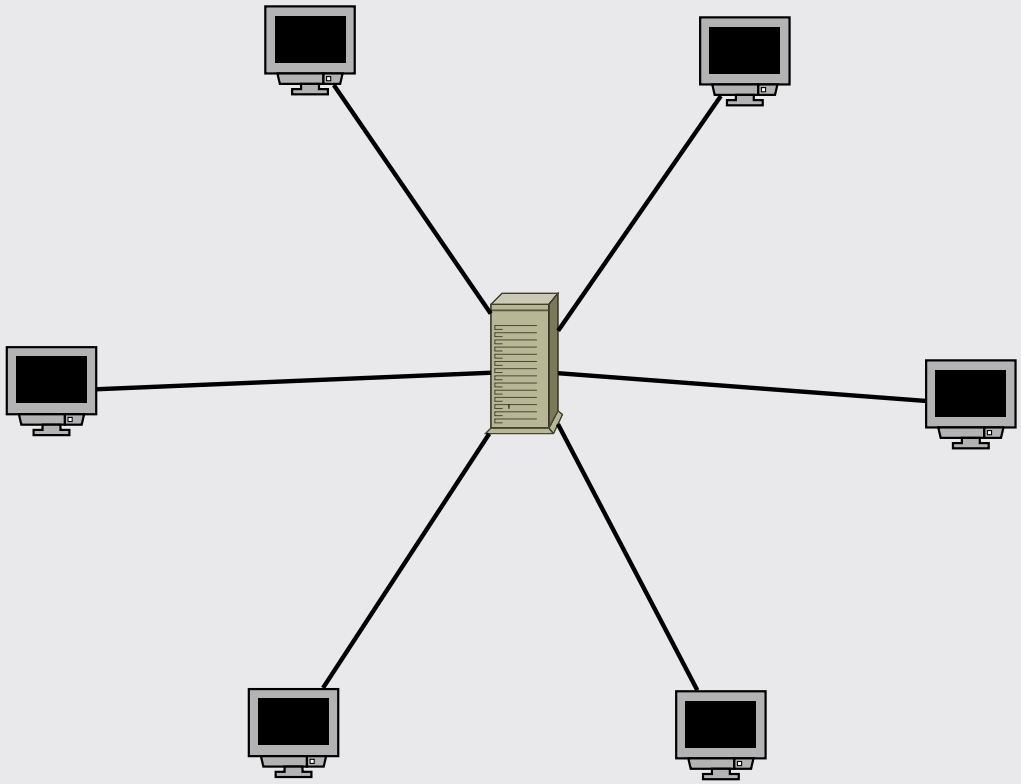
- Self management
  - Deals with complexity of decentralization
  - We want self-organization and self-healing behaviour.

The good old client-server architecture



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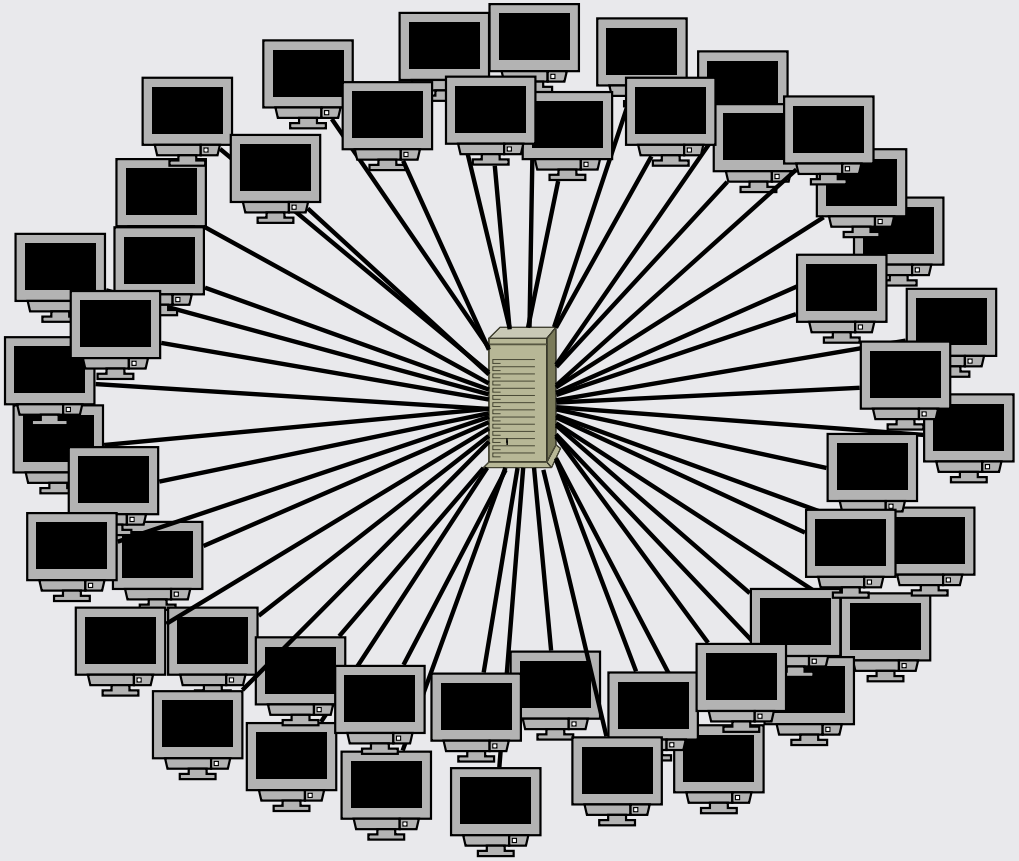

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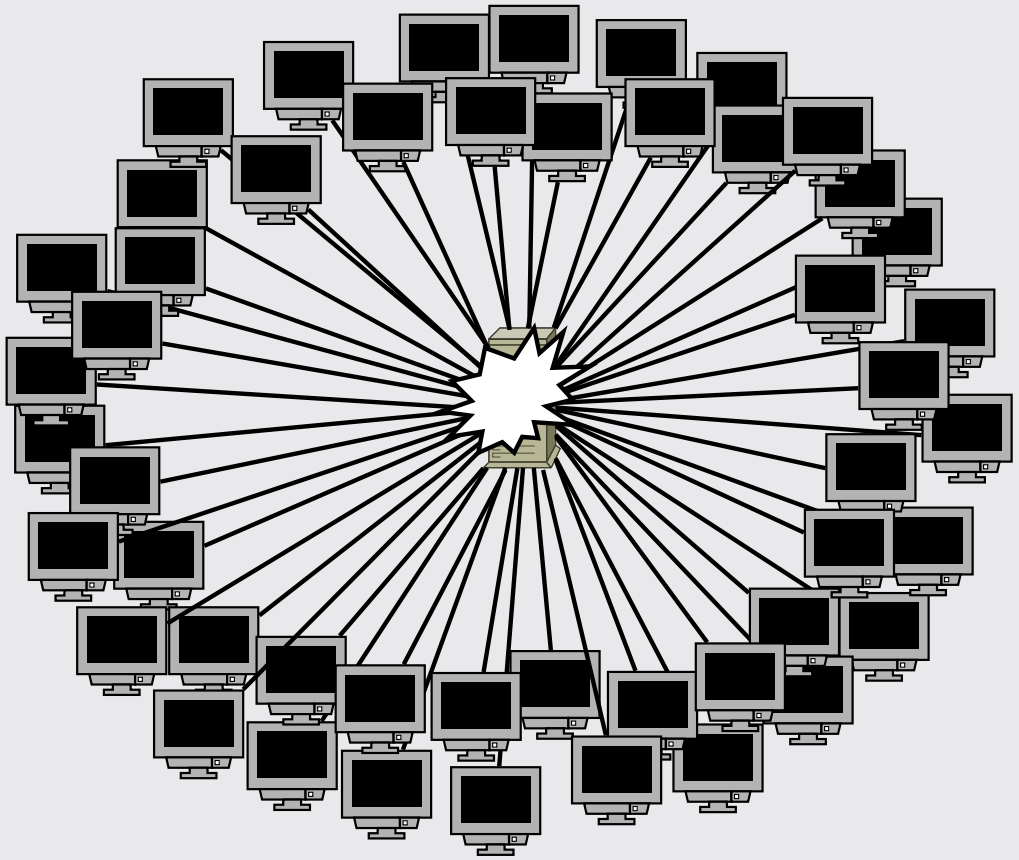

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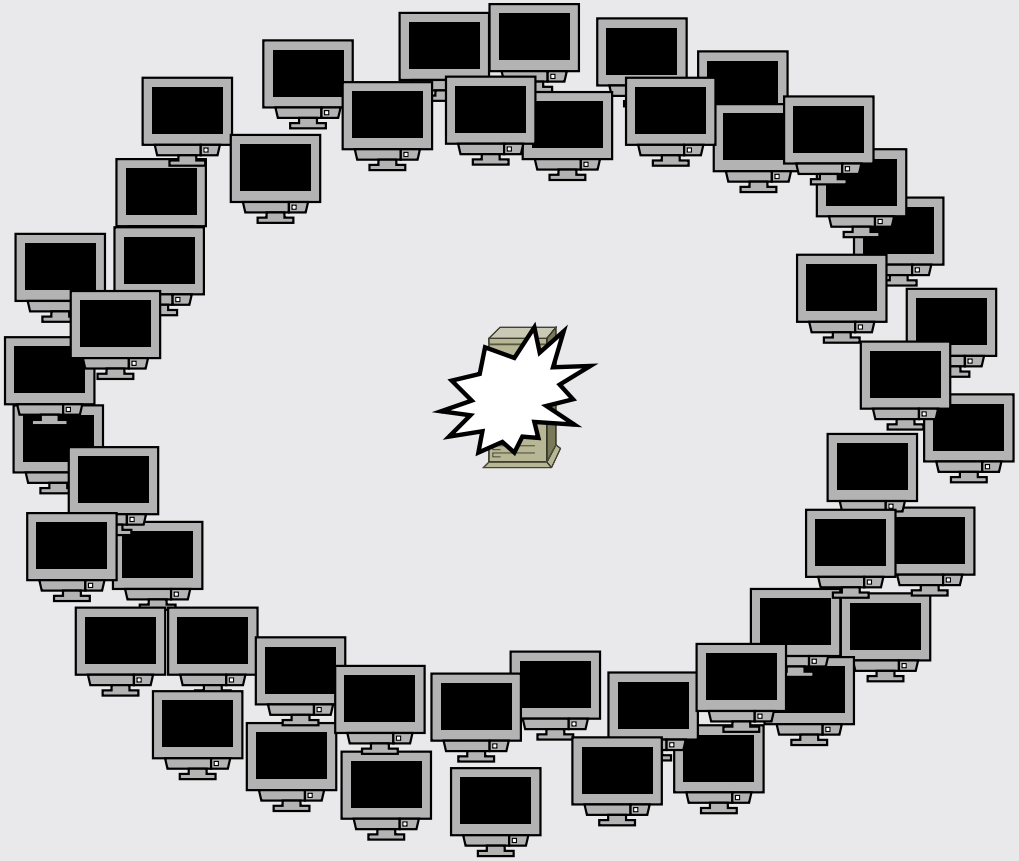
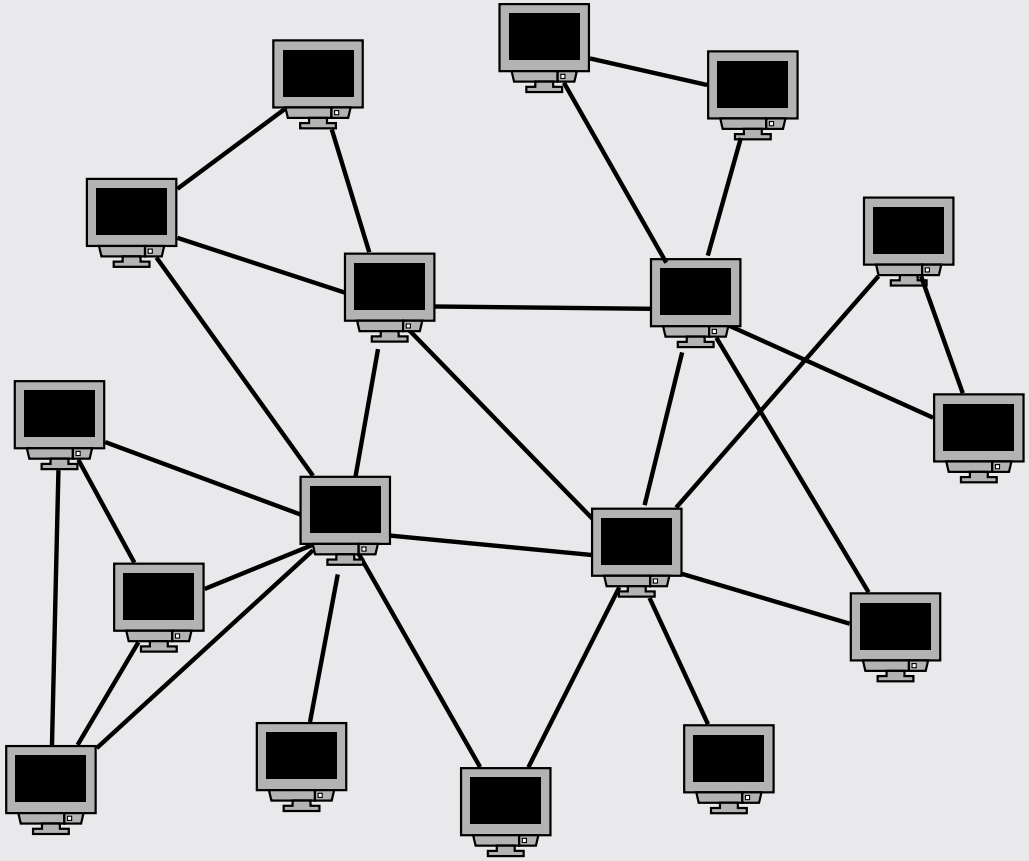


Decentralized systems (unstructured)



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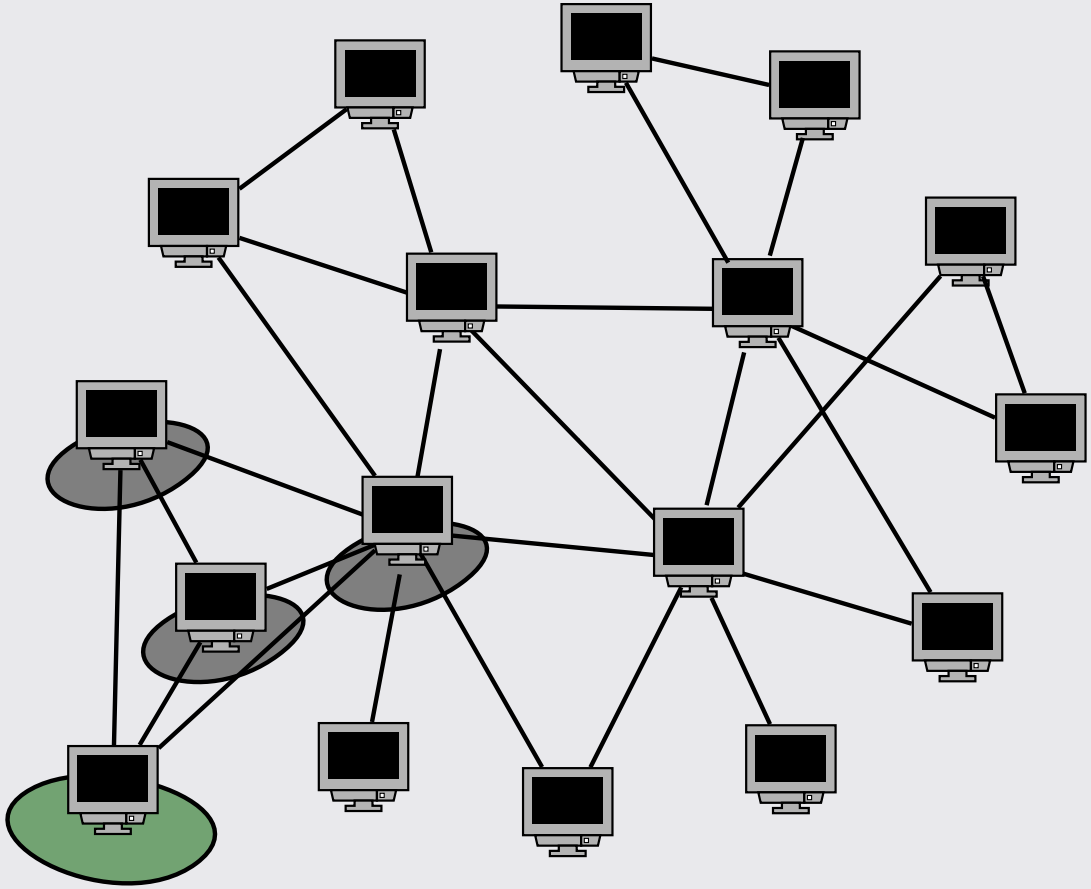

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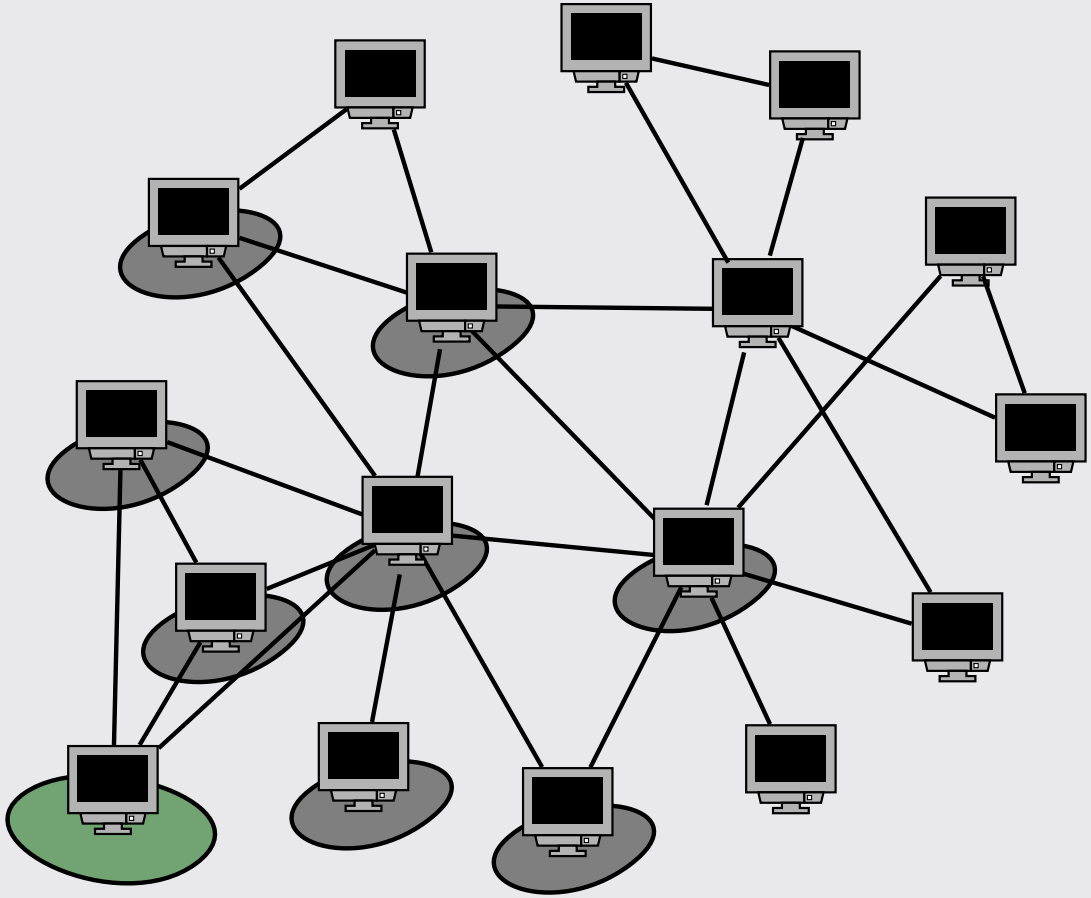

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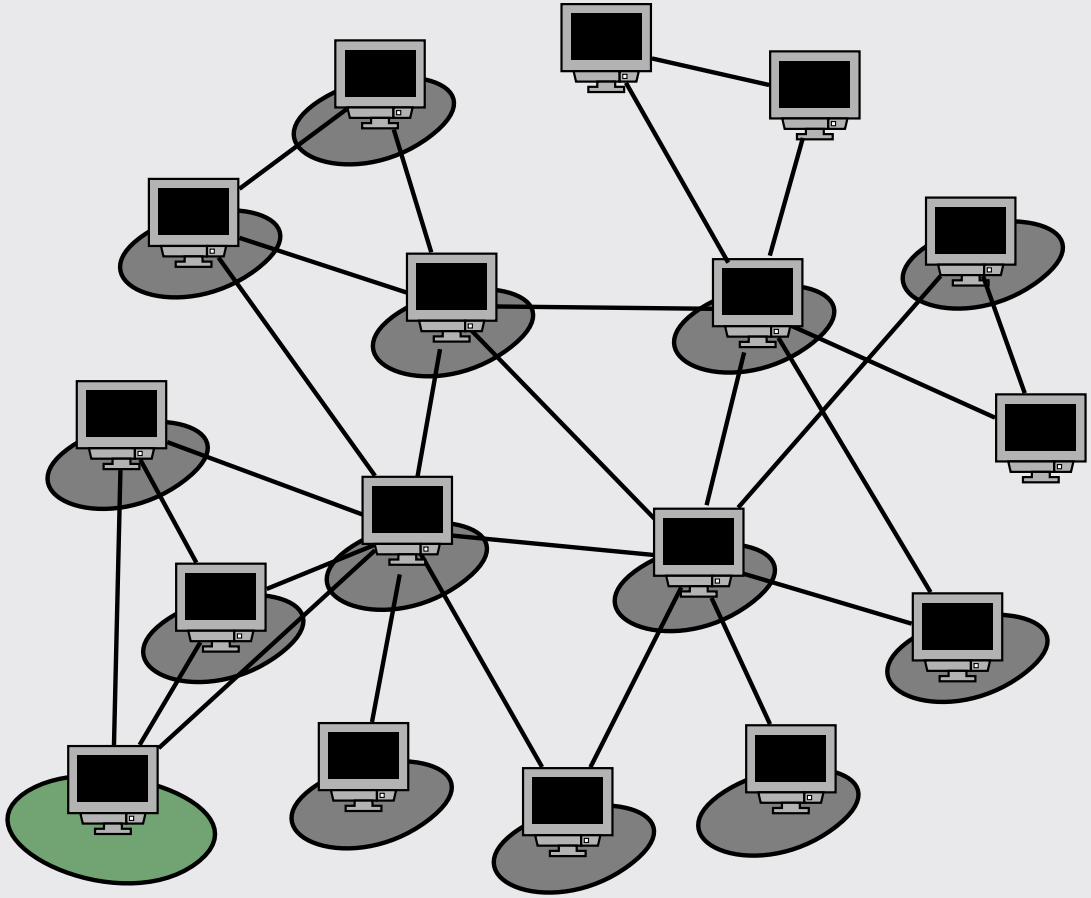

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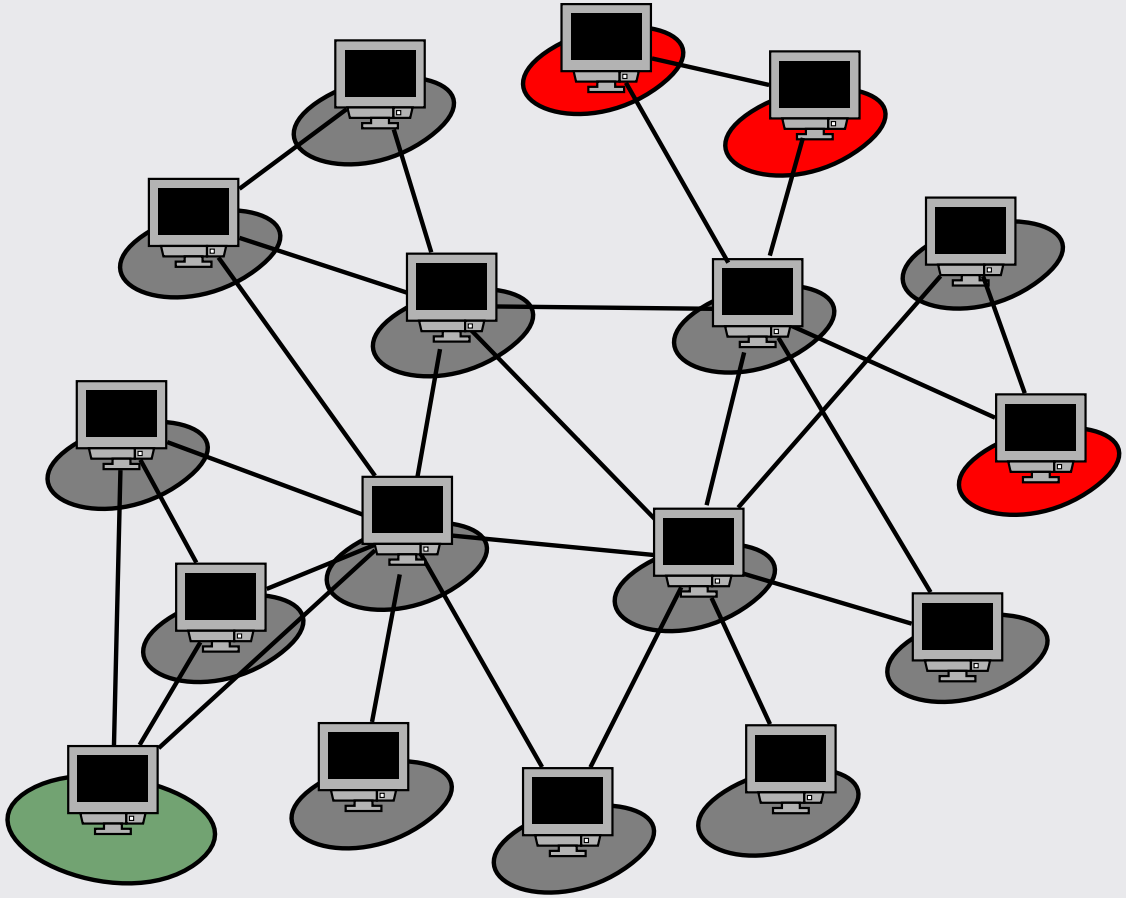
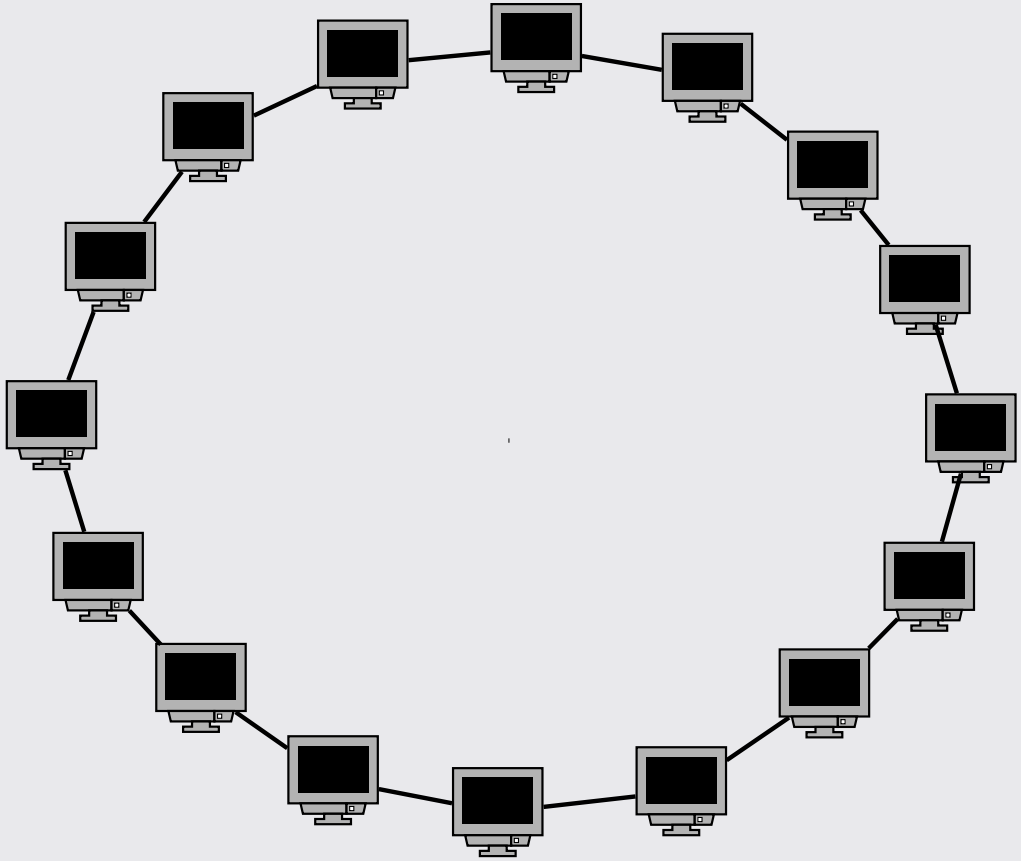


One ring to rule them all



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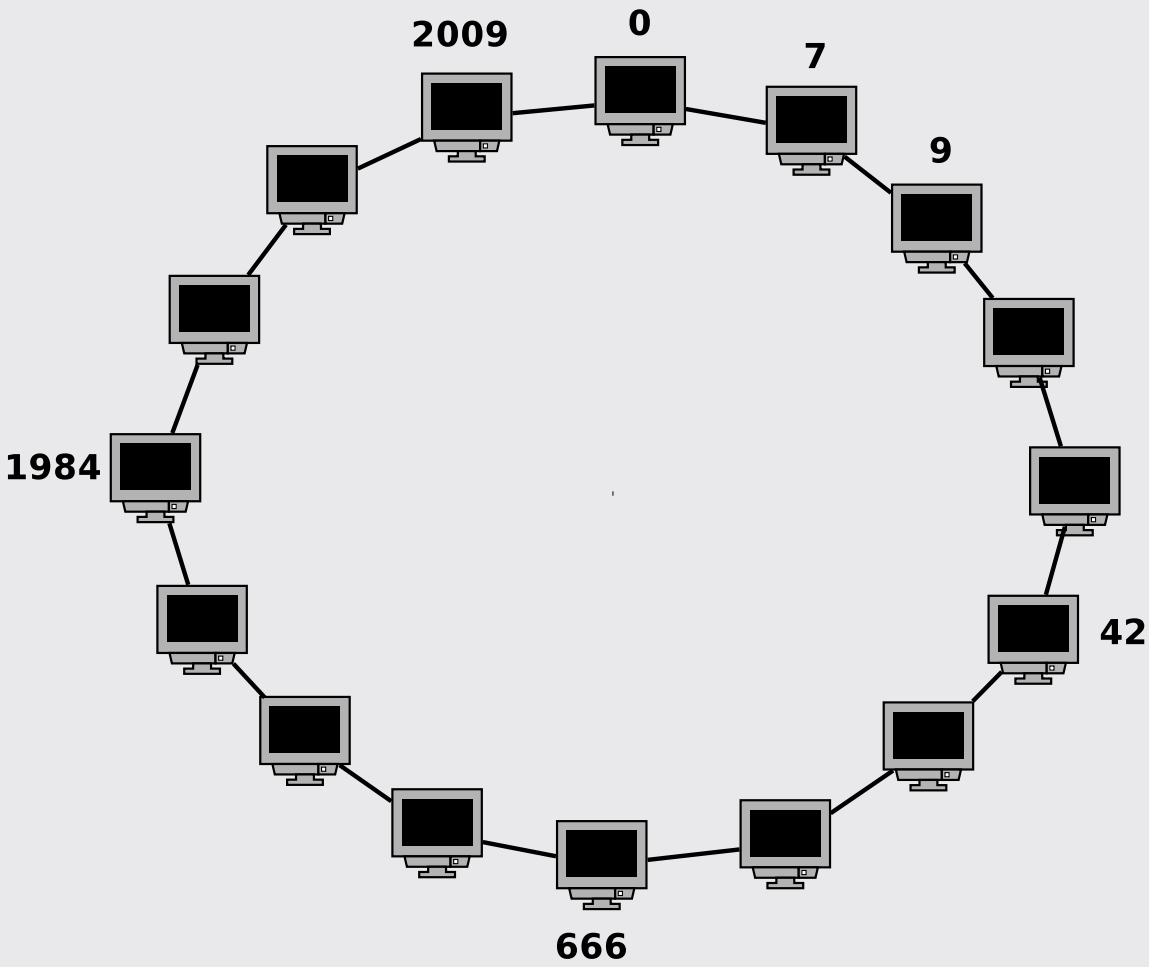

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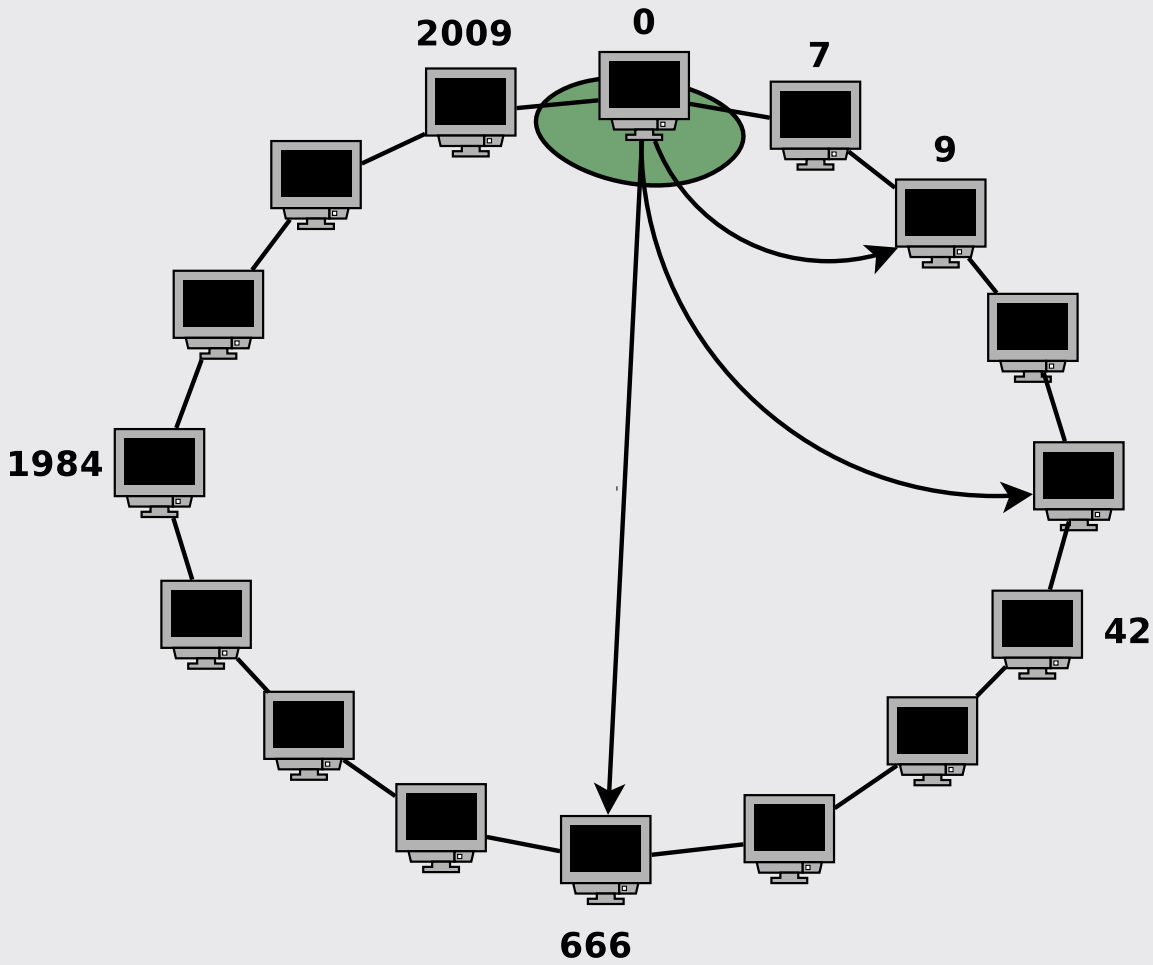

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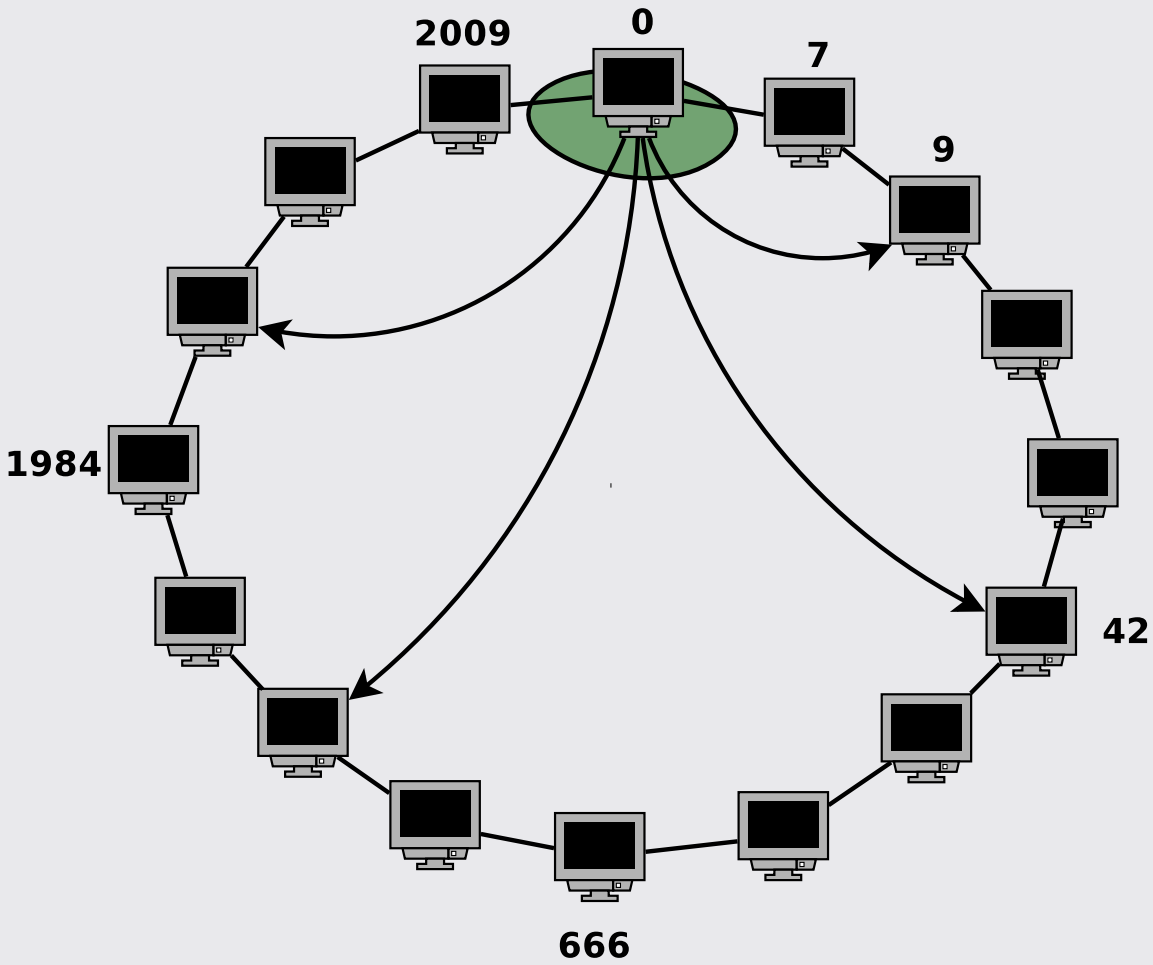
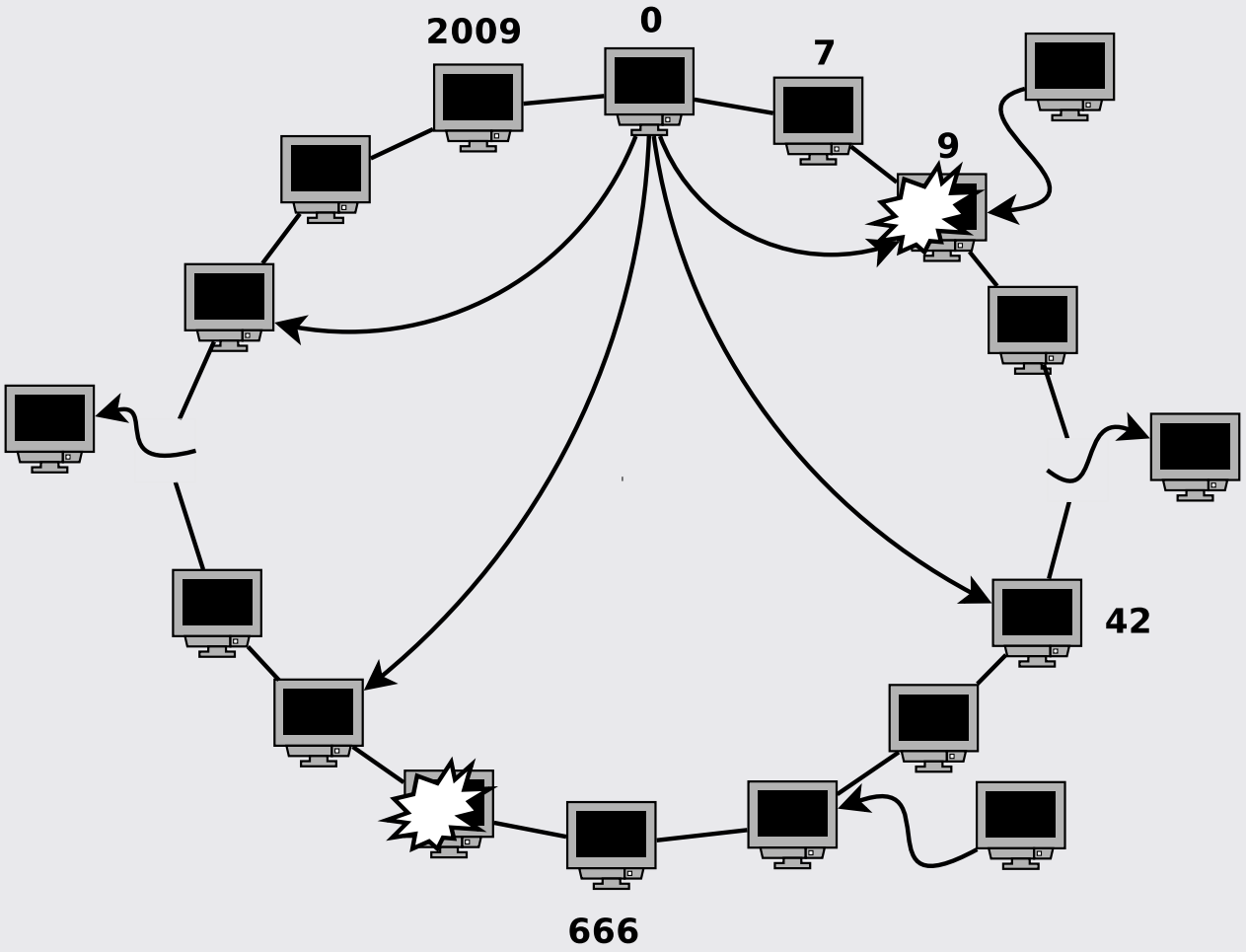


Need for self management



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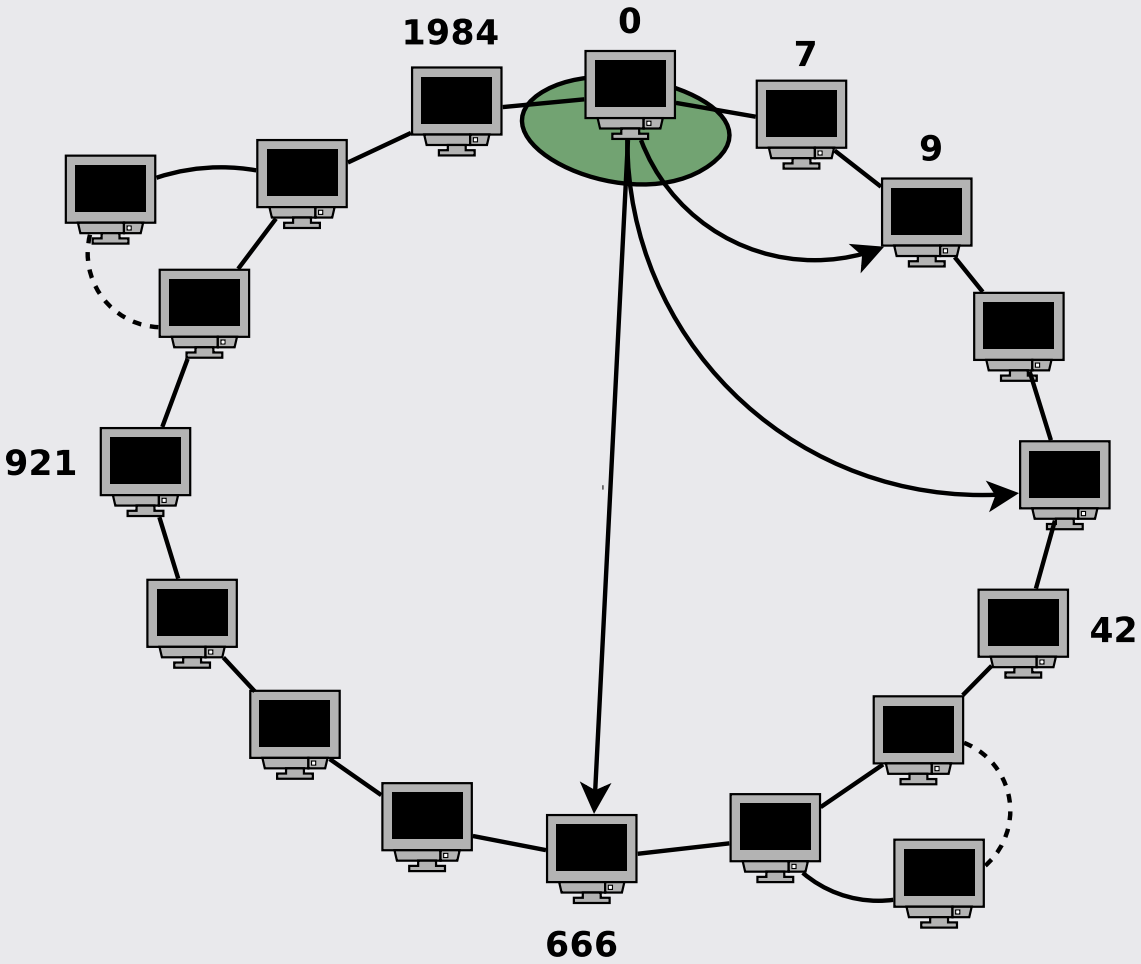
2. Analyse the cost and feasibility of such requirements. If the requirements are too hard to meet, relax them to fit the inherent properties of the system.
3. Analyse the cost of the relaxation to avoid relaxing too much.

The rest of the presentation

- The relaxed ring - overlay network
- Trappist - transactional storage
- Building applications

The Relaxed Ring

The relaxed ring



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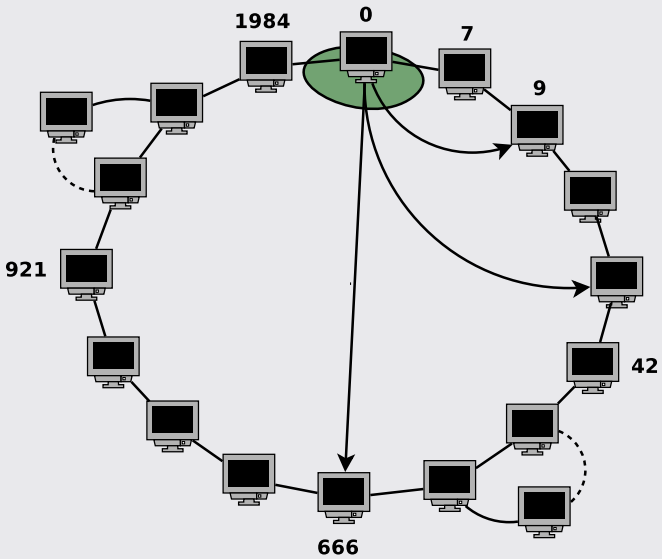

Distributed Hash Table

- `put(key, value)`
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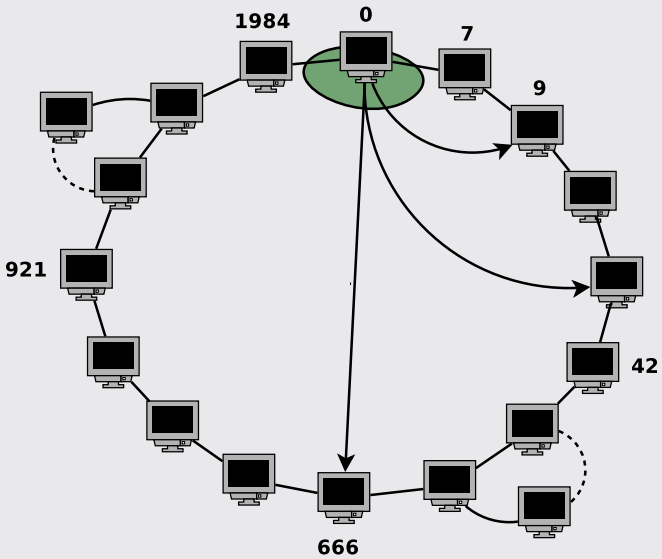

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- Lookup consistency: at any given time, **only one peer is responsible** for a given key, or it is temporary unavailable.
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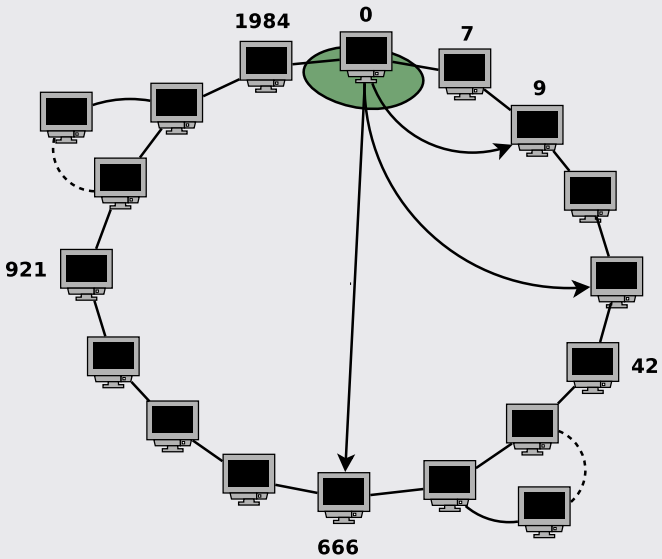

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- Fingers provide efficient routing $O(log_k(N) + b)$

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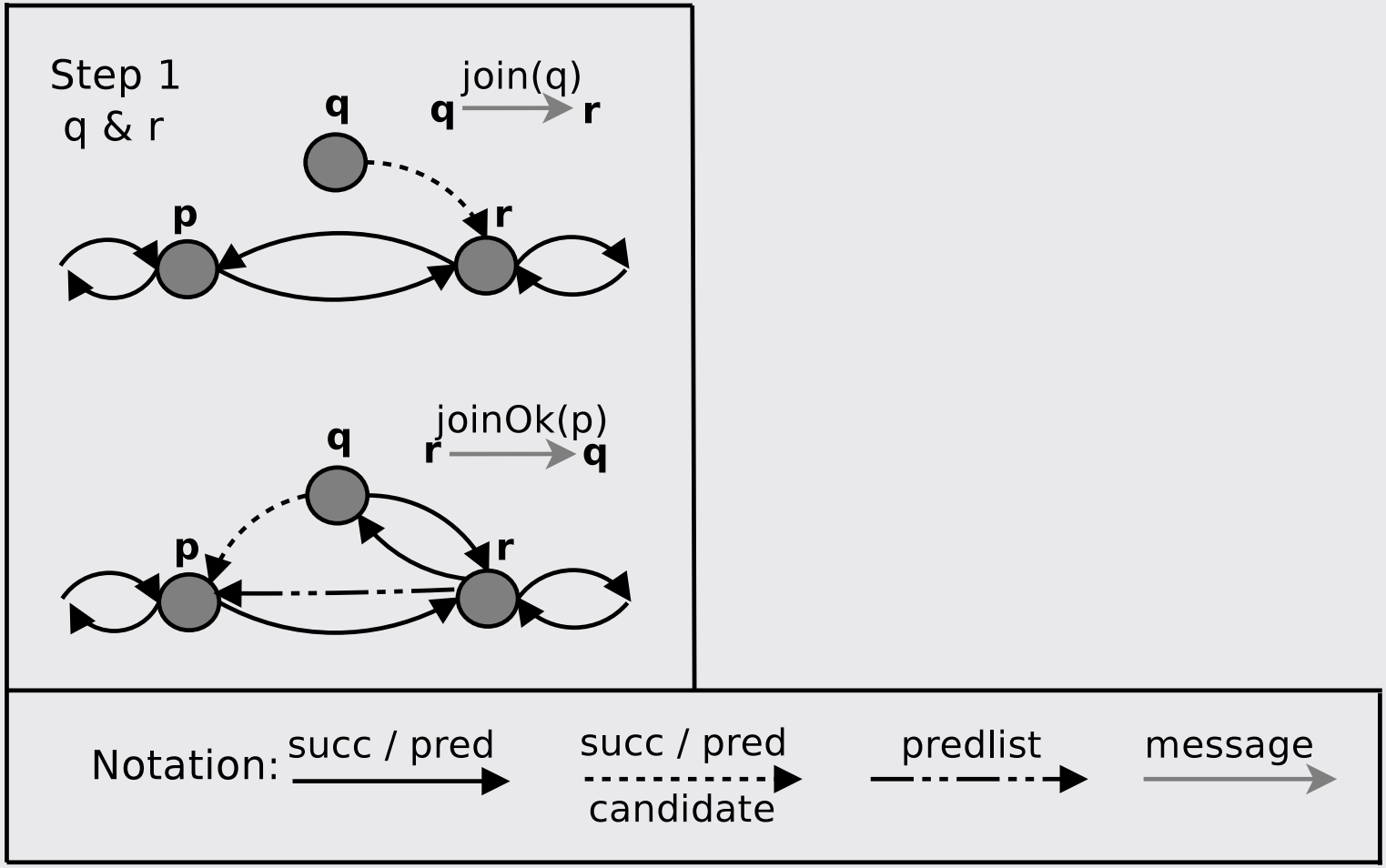
3. **Cost of relaxation**:
   - Beernet: Extra routing to branches if any. Skewed distribution of address space in branches. Cost efficient ring-maintenance
   - Chord: Periodic stabilization is too expensive

The join algorithm



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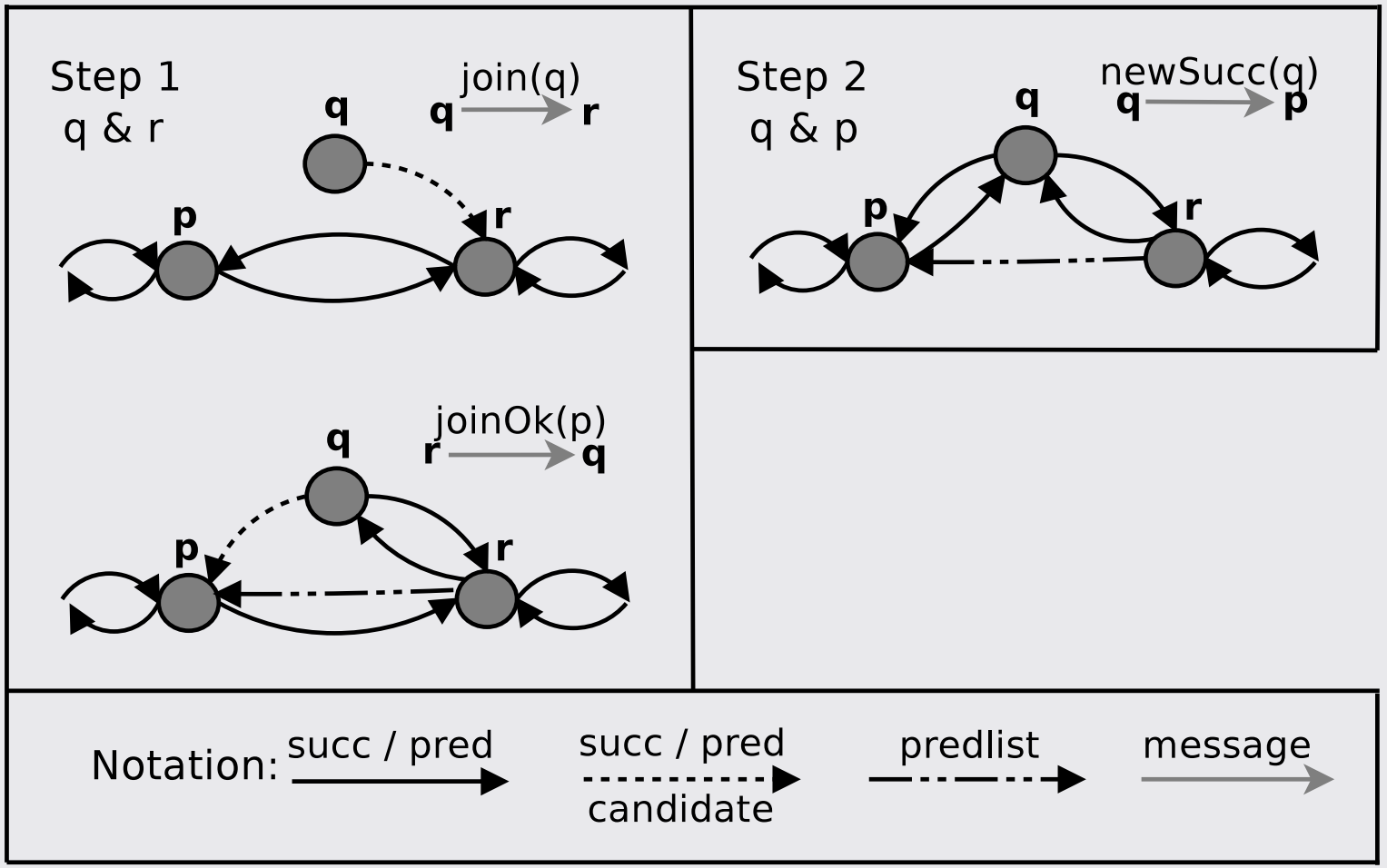

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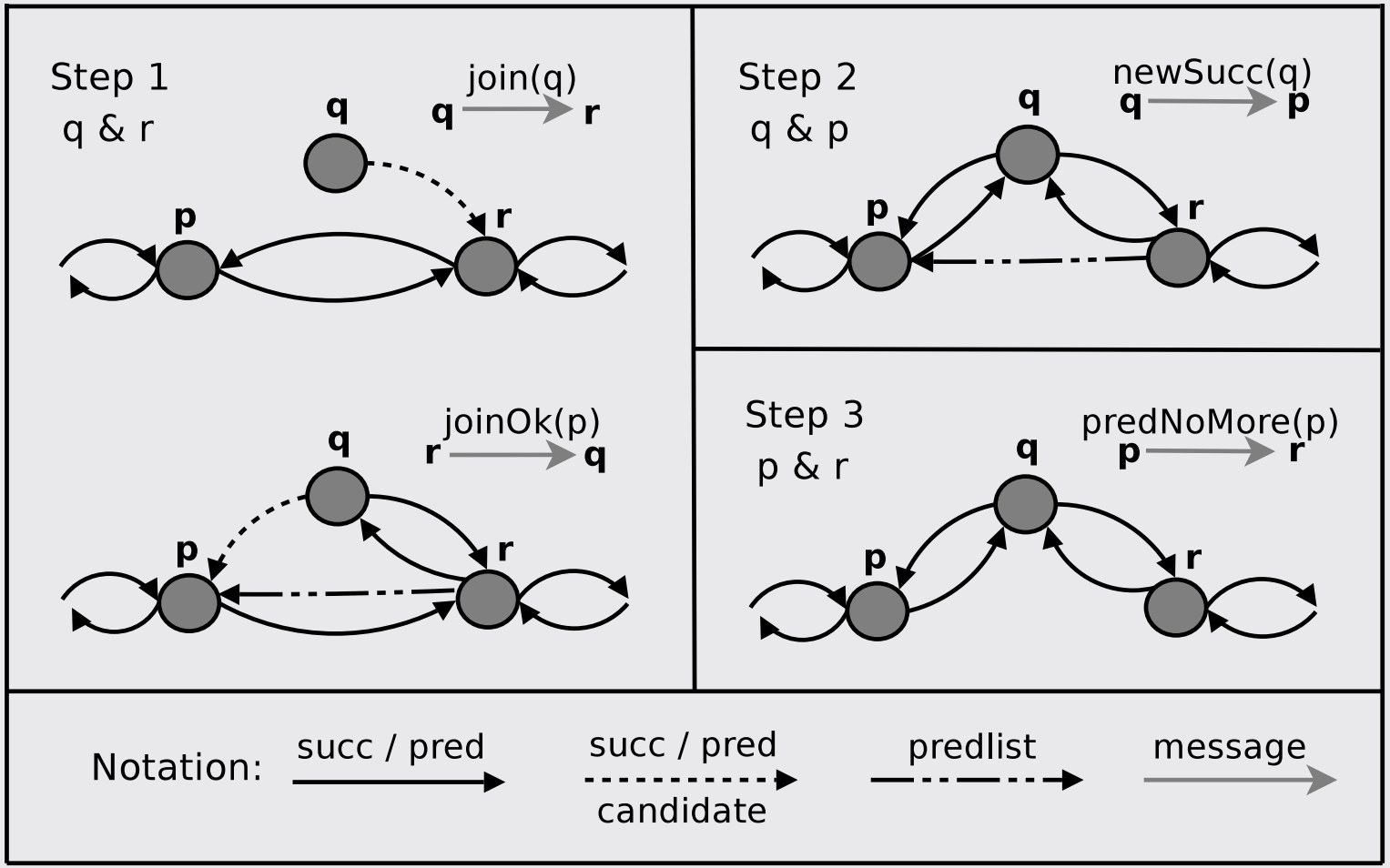

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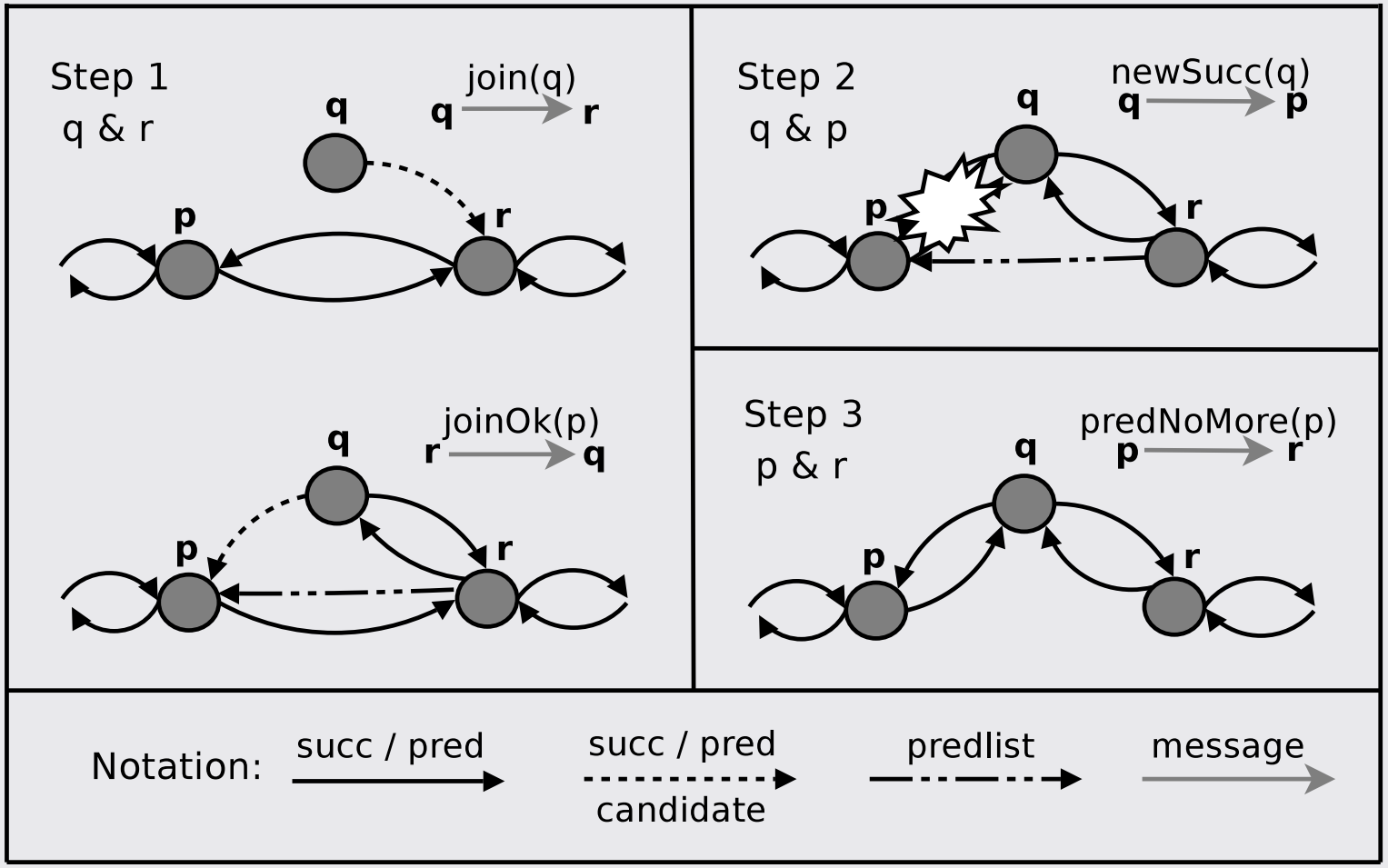

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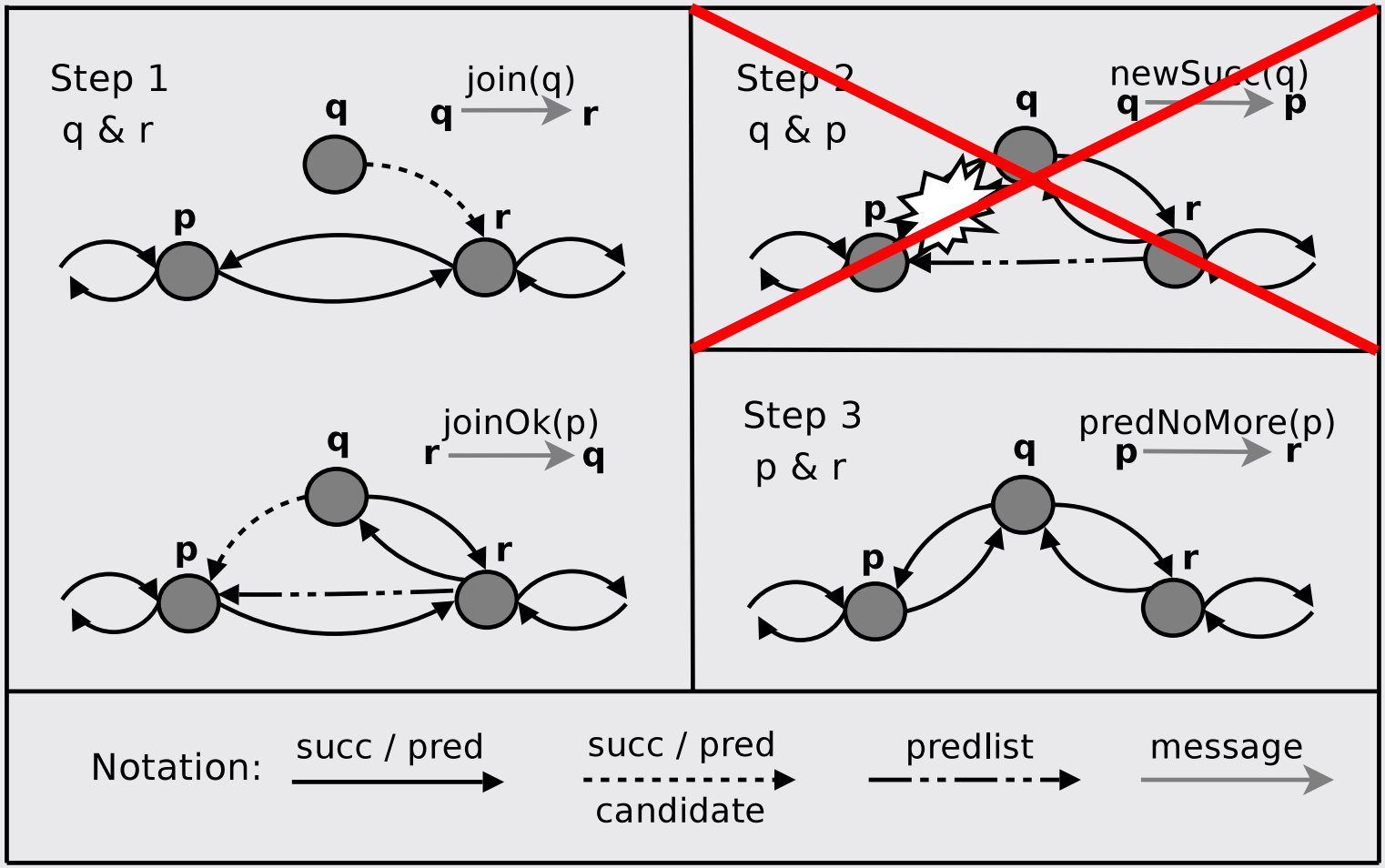

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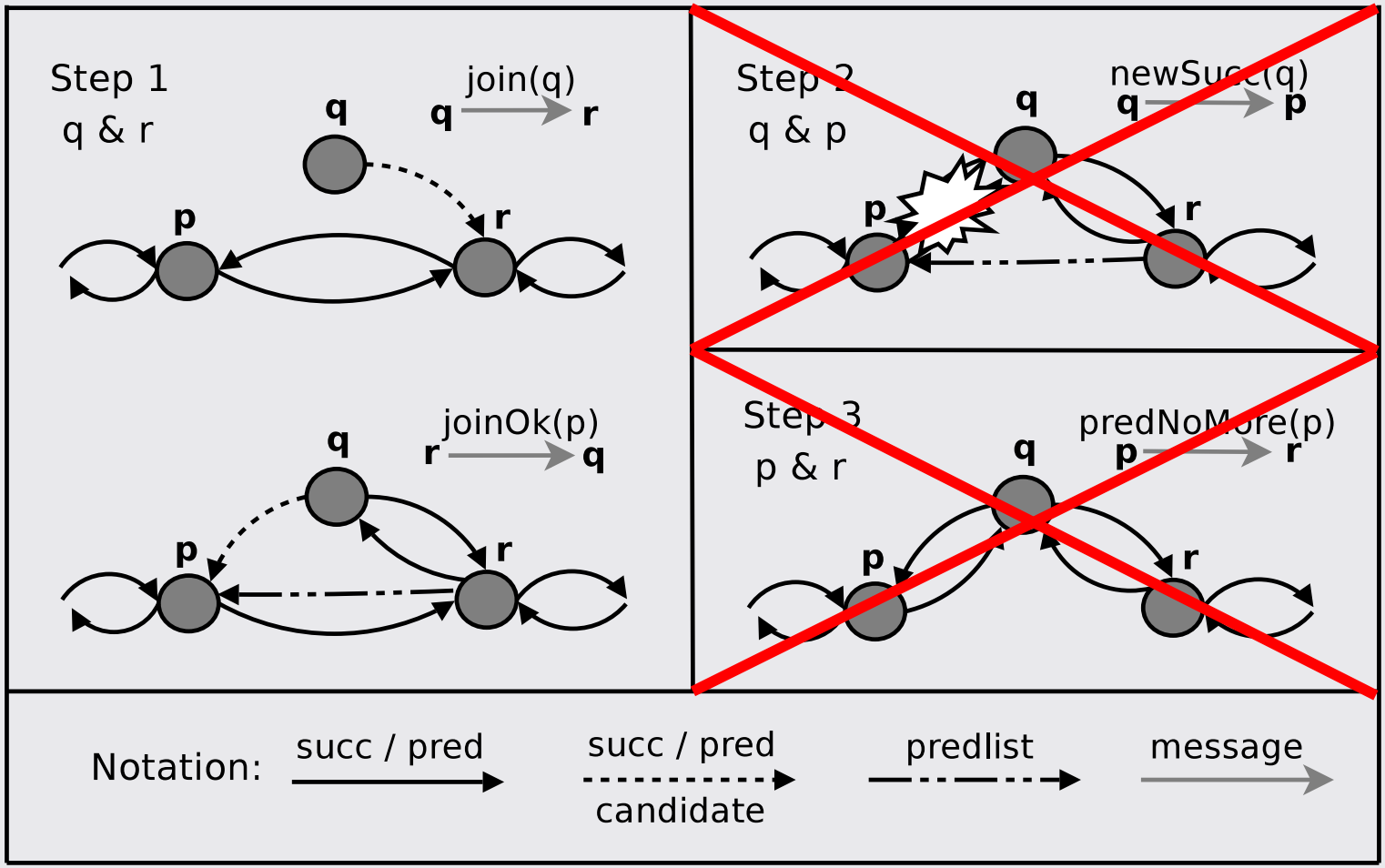

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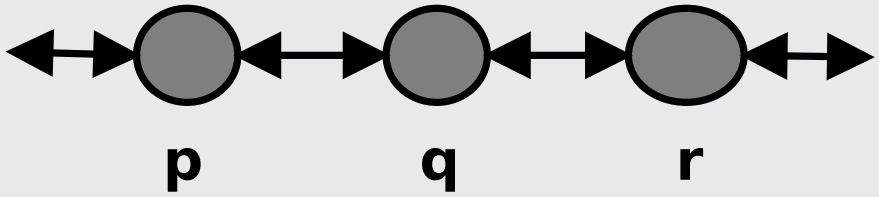

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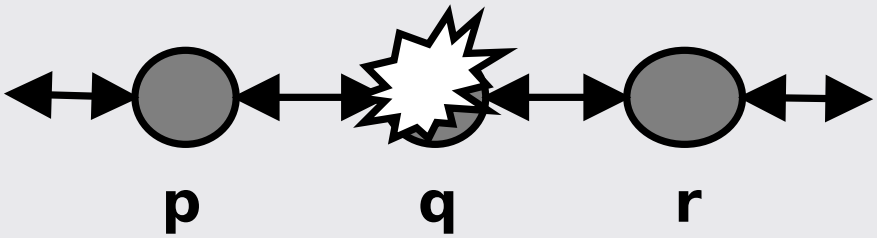

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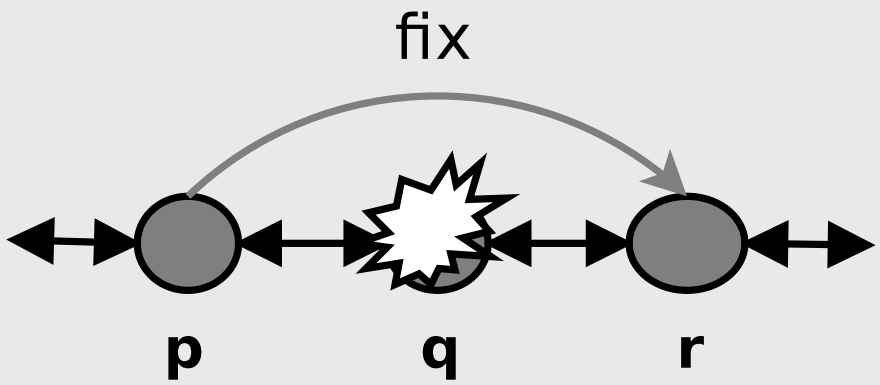

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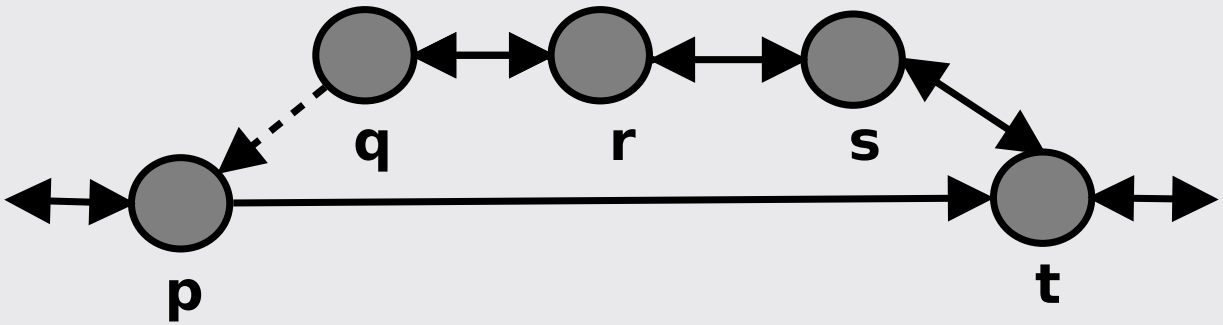

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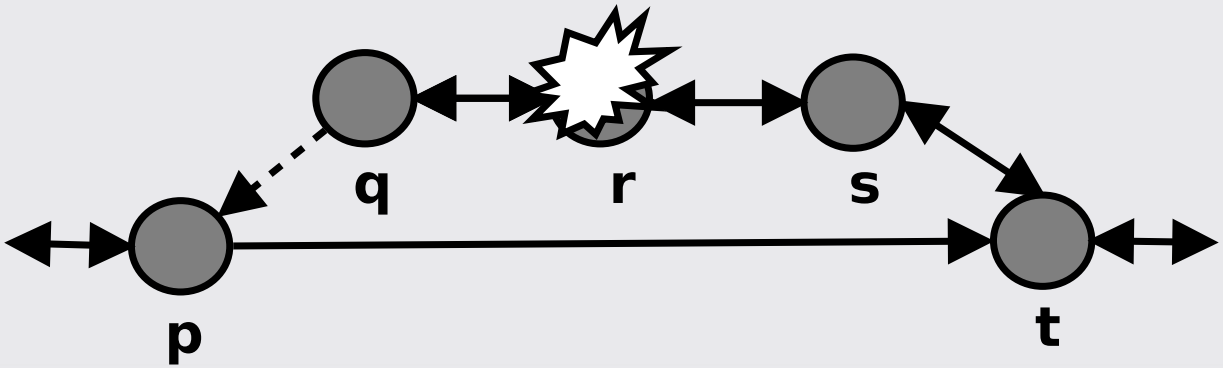

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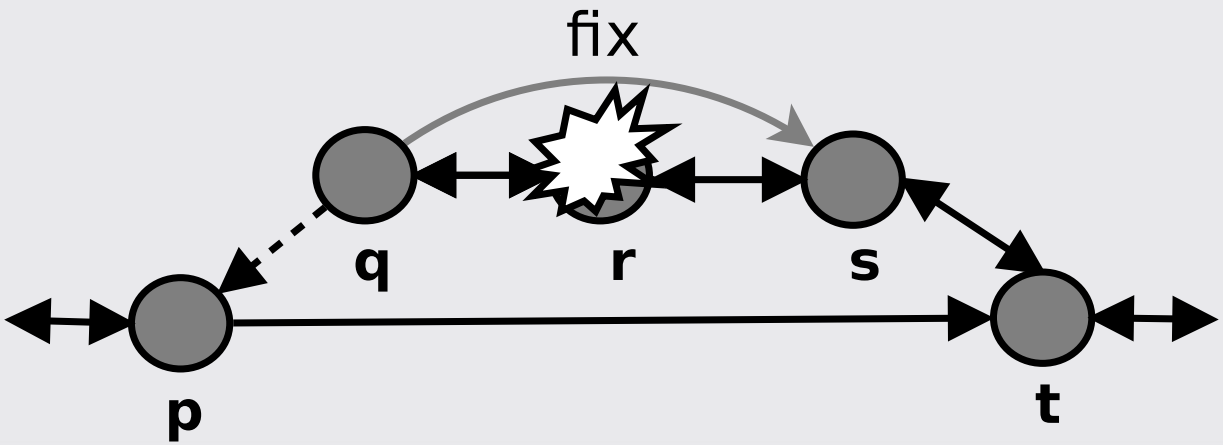

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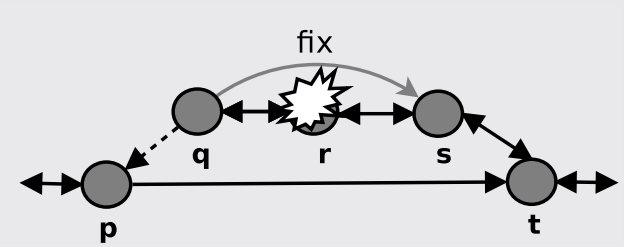

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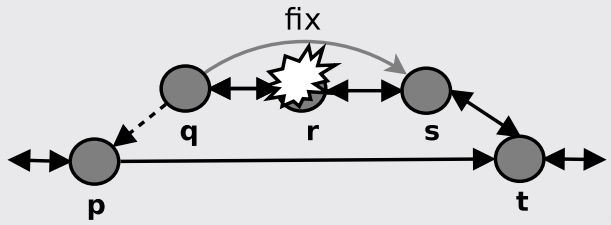

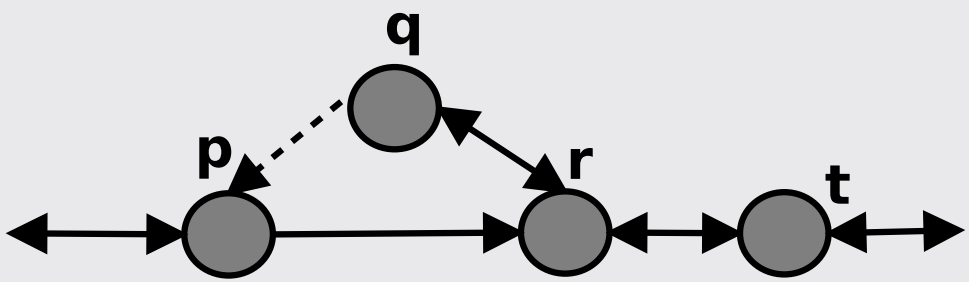

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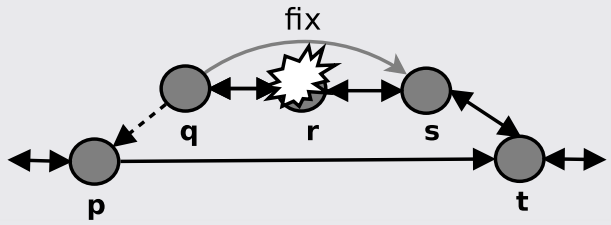

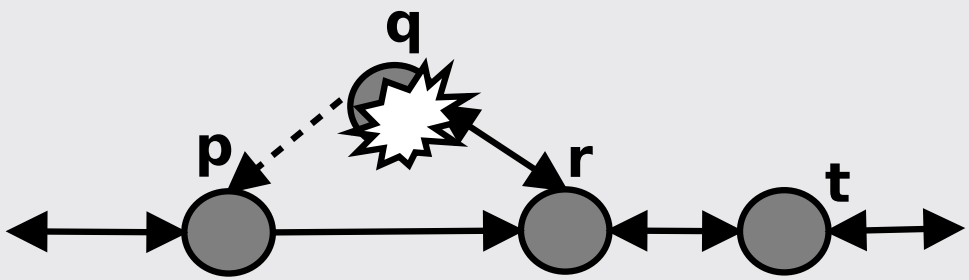

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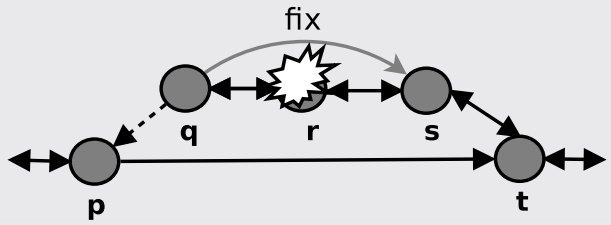

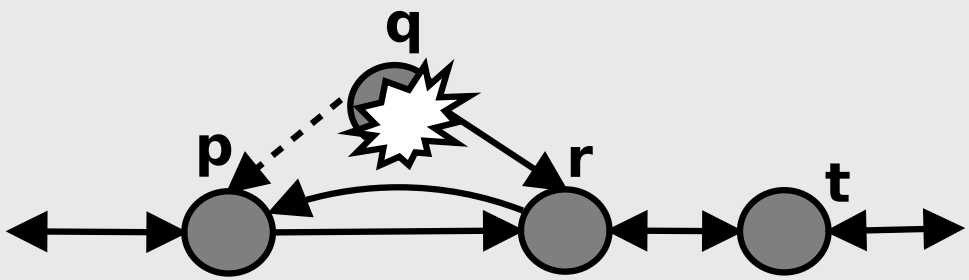

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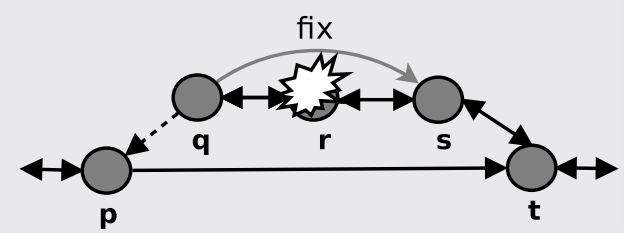

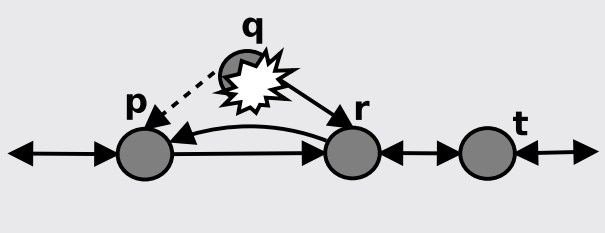

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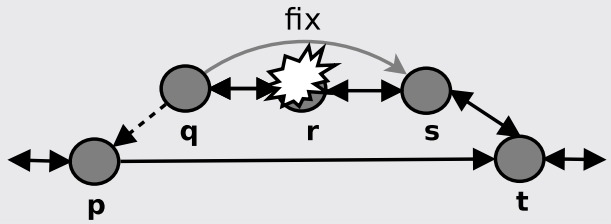
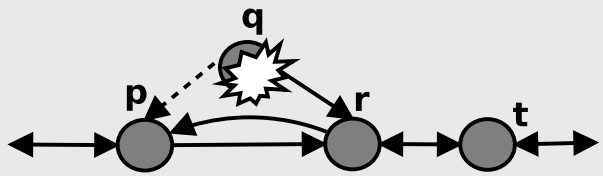
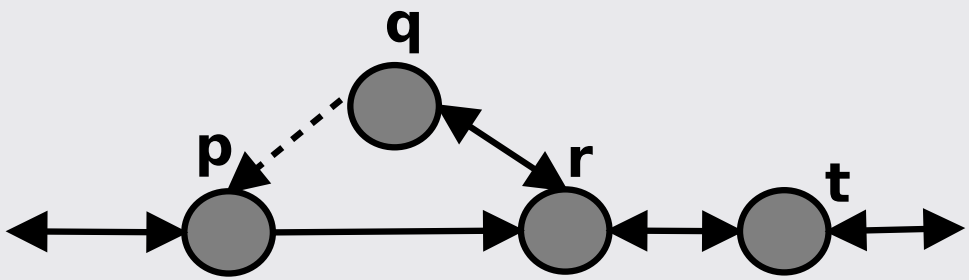
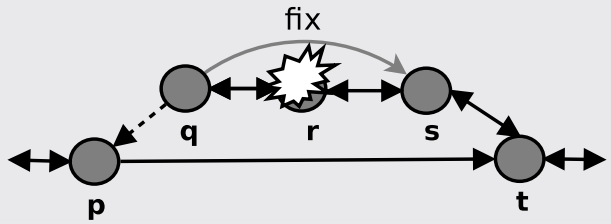
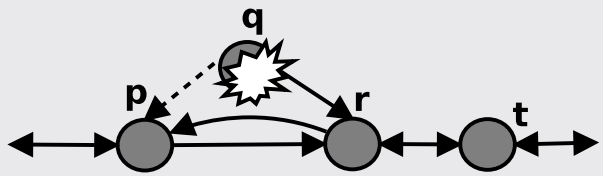


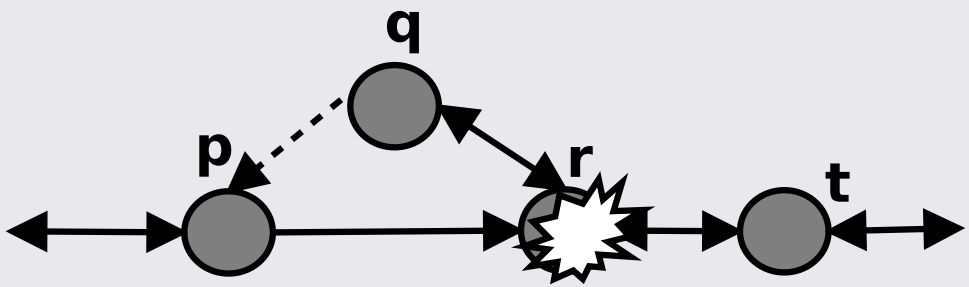




Failure recovery







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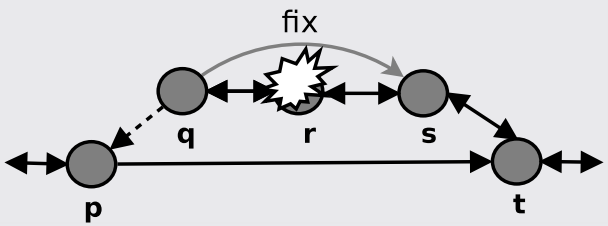
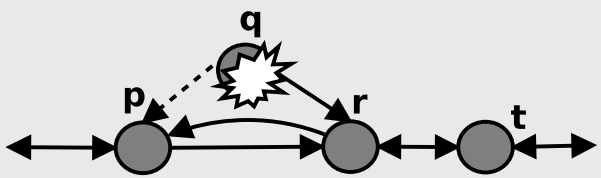
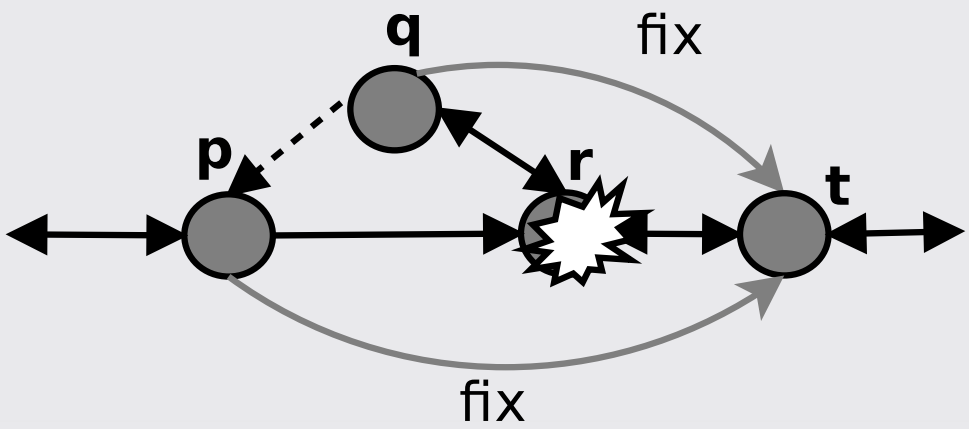
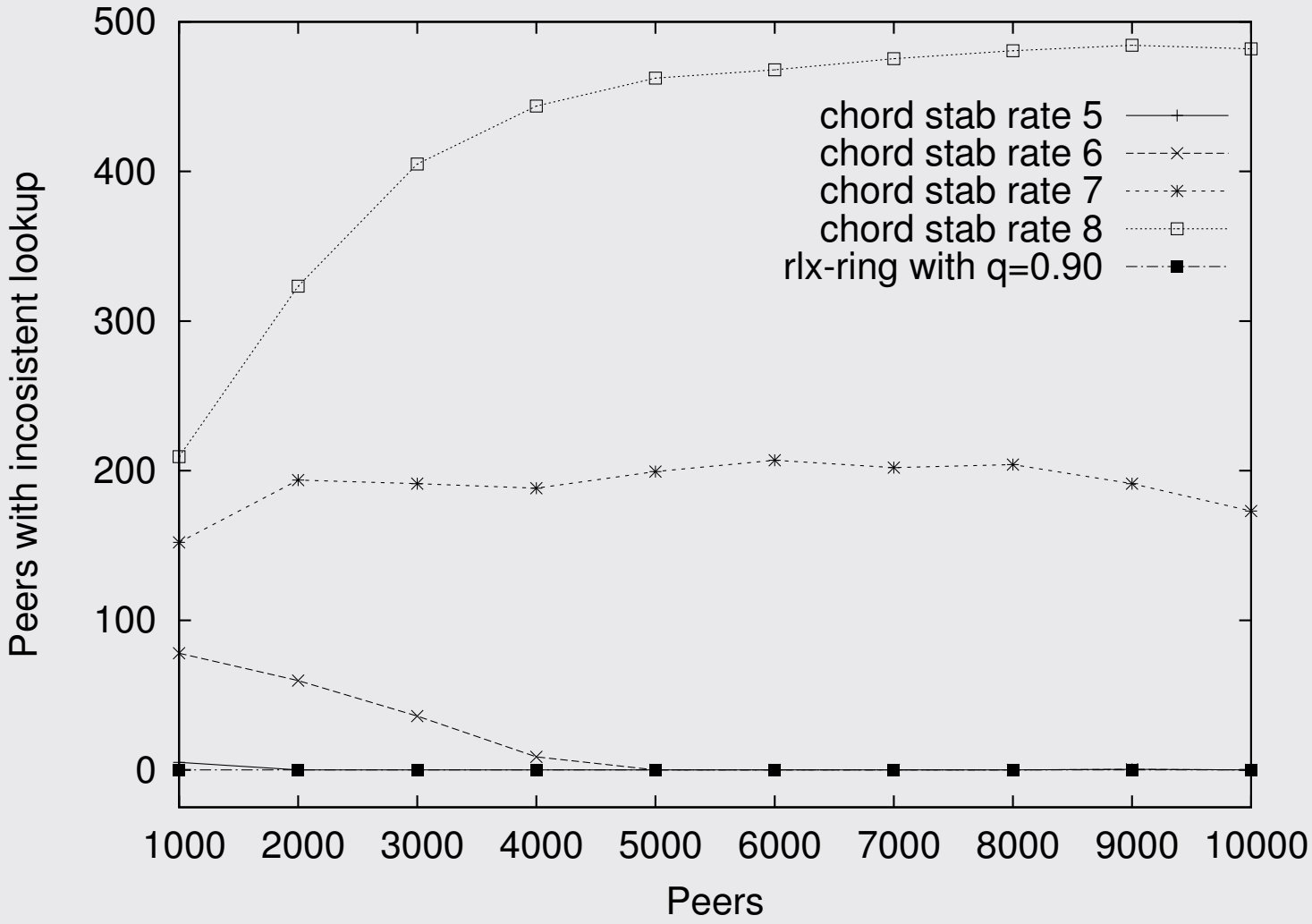


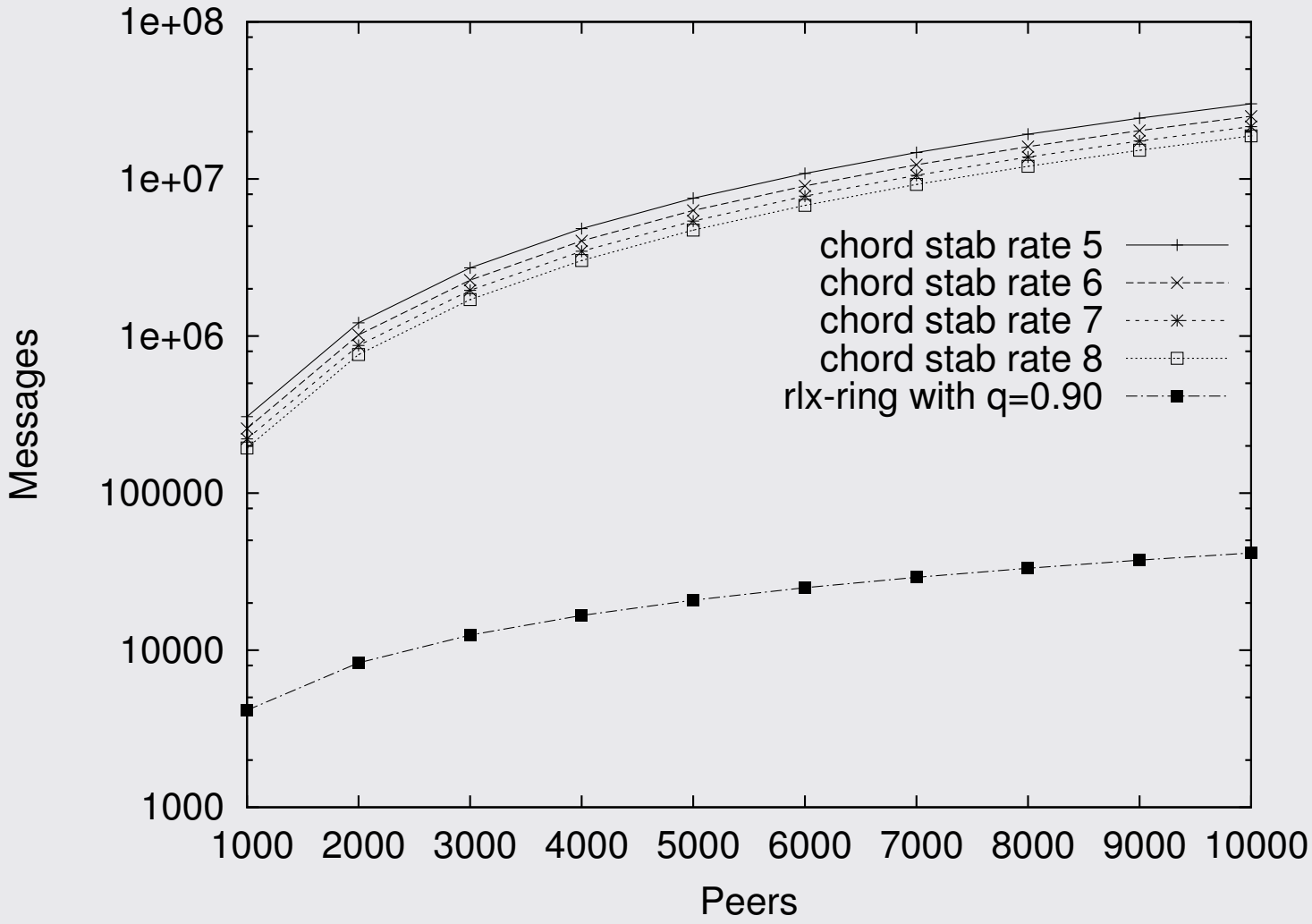




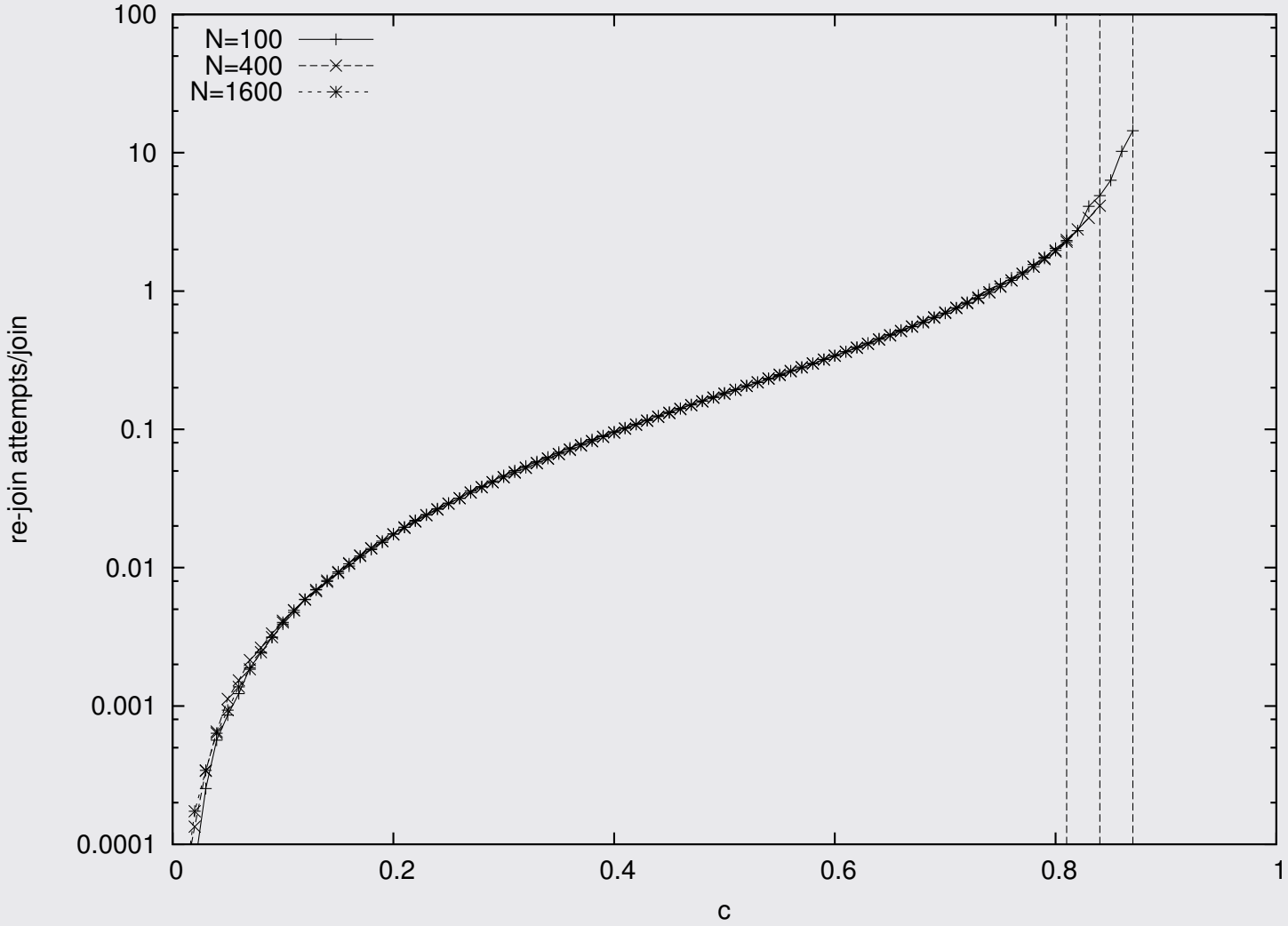
Lookup consistency



Cost efficient ring maintenance



In presence of NATed peers



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- No lookup inconsistency introduced by join events
- Cost-efficient ring maintenance (no periodic stabilization)
- Efficient routing $O(\log(N) + b)$

Related work

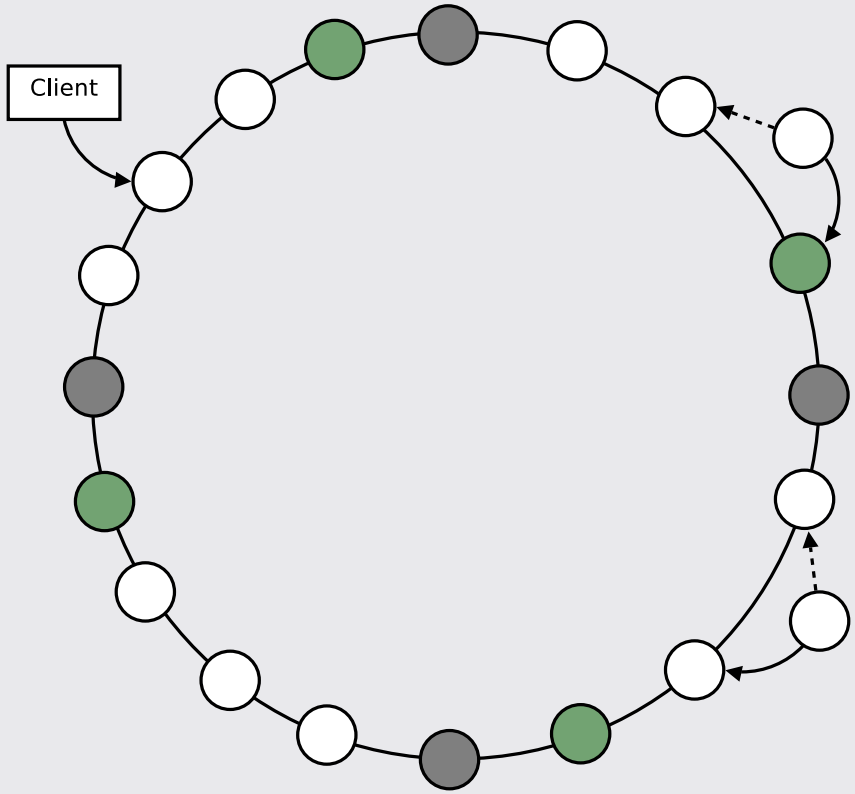
- **Chord**: Too much relaxation. Good idea to just let peers join or leave, but fixing pointers by doing *periodic stabilization* is too costly.
- **DKS atomic join/leave**: Requirements too hard to meet. By locking too nodes it achieves agreement of three nodes. Problems with non-transitive networks, latency and failures.

Trappist

Transactions over **p**eer-to-**p**eer with **is**ola**t**ion

Symmetric replication and transactions

- Every item is symmetrically replicated



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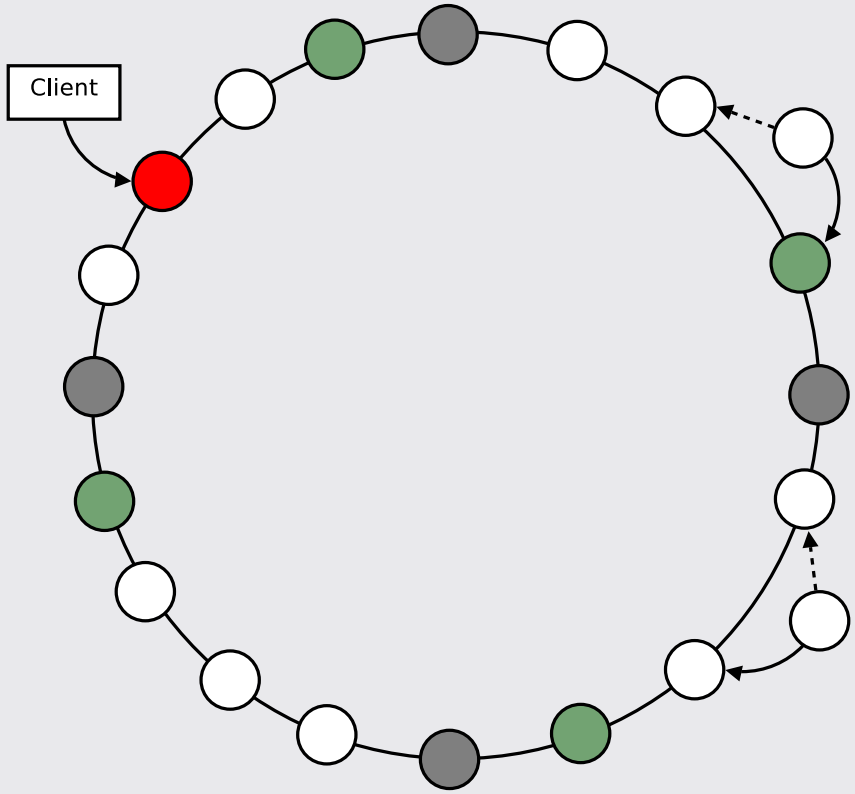

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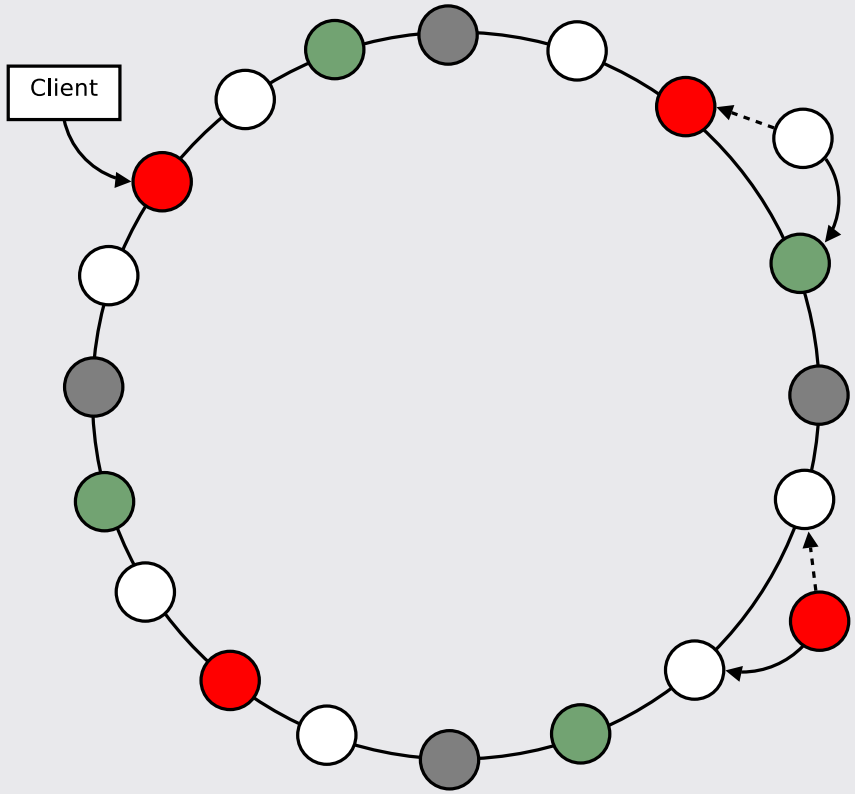

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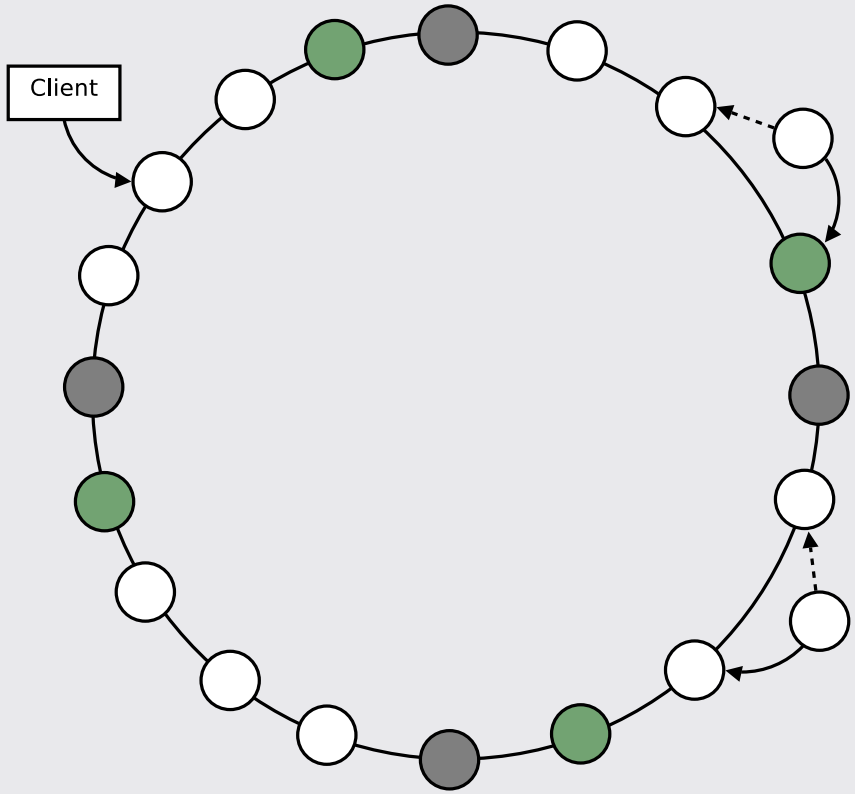
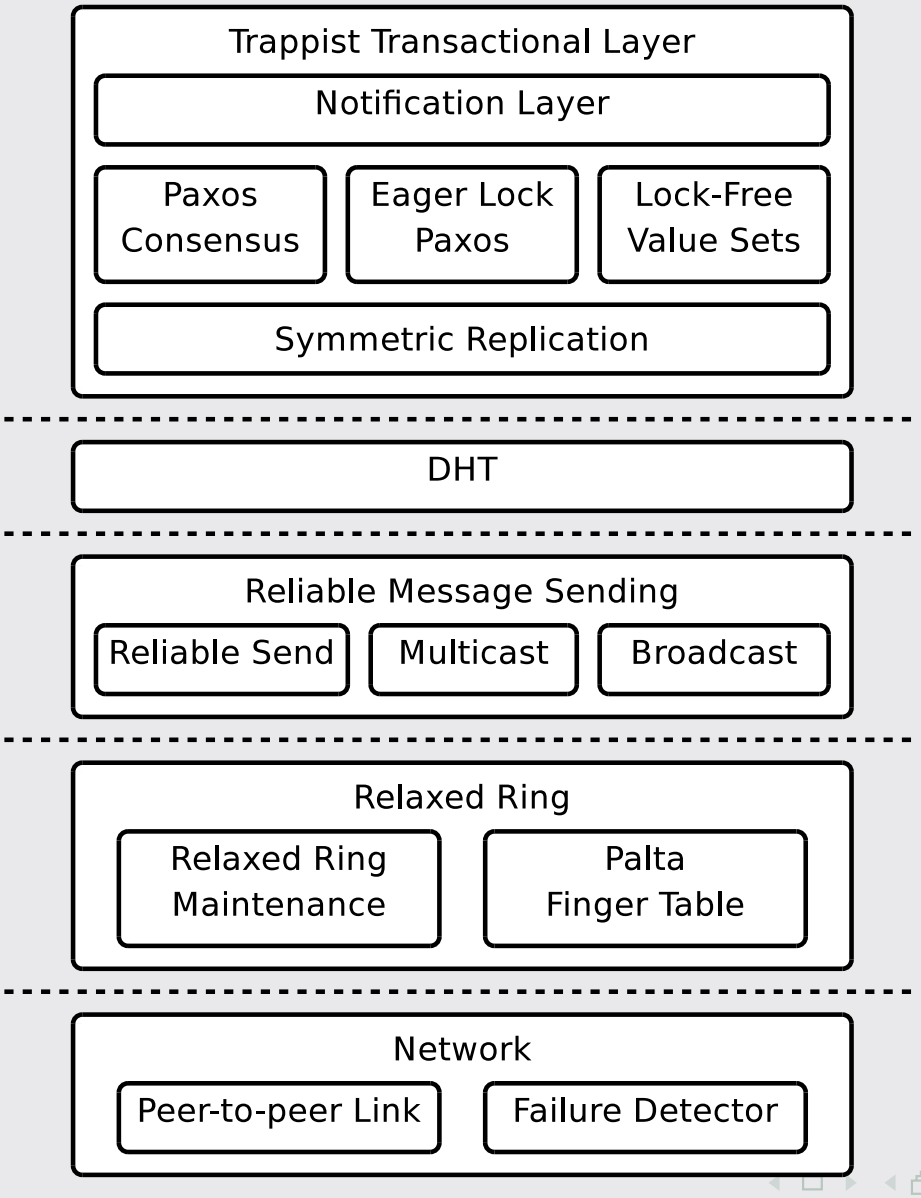


Beernet's architecture



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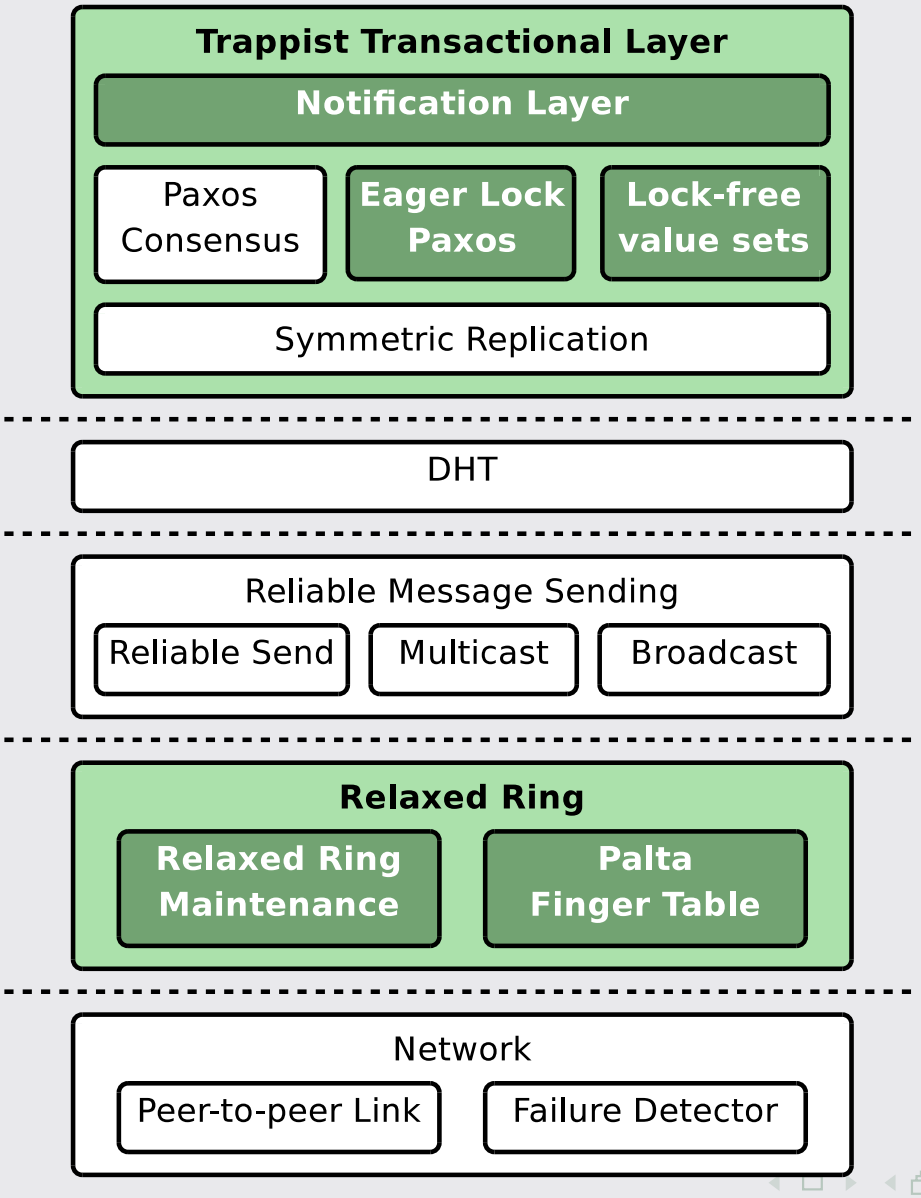

Trappist protocols with strong consistency

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- Eager locking
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  - Still works with majority but it is more fragile
- Lock-free key/value-sets
  - More fault-tolerant
  - Better performance
  - No versioning and no total order (no queues, no stacks)

Trappist's operations

- `write(foo, bar)`
  - Writes an item on the majority of the replicas where value *bar* is associated with key *foo*
- `read(foo)`
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- `readSet(key)`
  - Reads the value-set associated to *key*

Deducing the set

Time	Operation	Majority	p	q	r
t_0	add(k, a)	{p, q}	{a}	{a}	ϕ

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t_3	add(k, c)	{p, q, r}	{a, b, c}	{a, c}	{b, c}

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t_3	add(k, c)	{p, q, r}	{a, b, c}	{a, c}	{b, c}
t_4	remove(k, c)	{p, q}	{a, b}	{a}	{b, c}

Deducing the set

Time	Operation	Majority	p	q	r
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t_4	remove(k, c)	{p, q}	{a, b}	{a}	{b, c}
t_5	readSet(k)	{q, r}	$\rightarrow$ {a, b} or {a, b, c}?		

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Identifying every operation

t	Operation	Majority	p	q	r
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t_0	*i*: add(k, a)	{p, q}	(*i*)	(*i*)	ϕ
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t	Operation	Majority	p	q	r
t_0	i: add(k, a)	{p, q}	(i)	(i)	ϕ
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t_2	ii': remove(k, c)	{p, q}	(i, ii, ii')	(i, ii, ii')	(ii)

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t_3	readSet(k)	{q, r}	$\rightarrow$ {a}		

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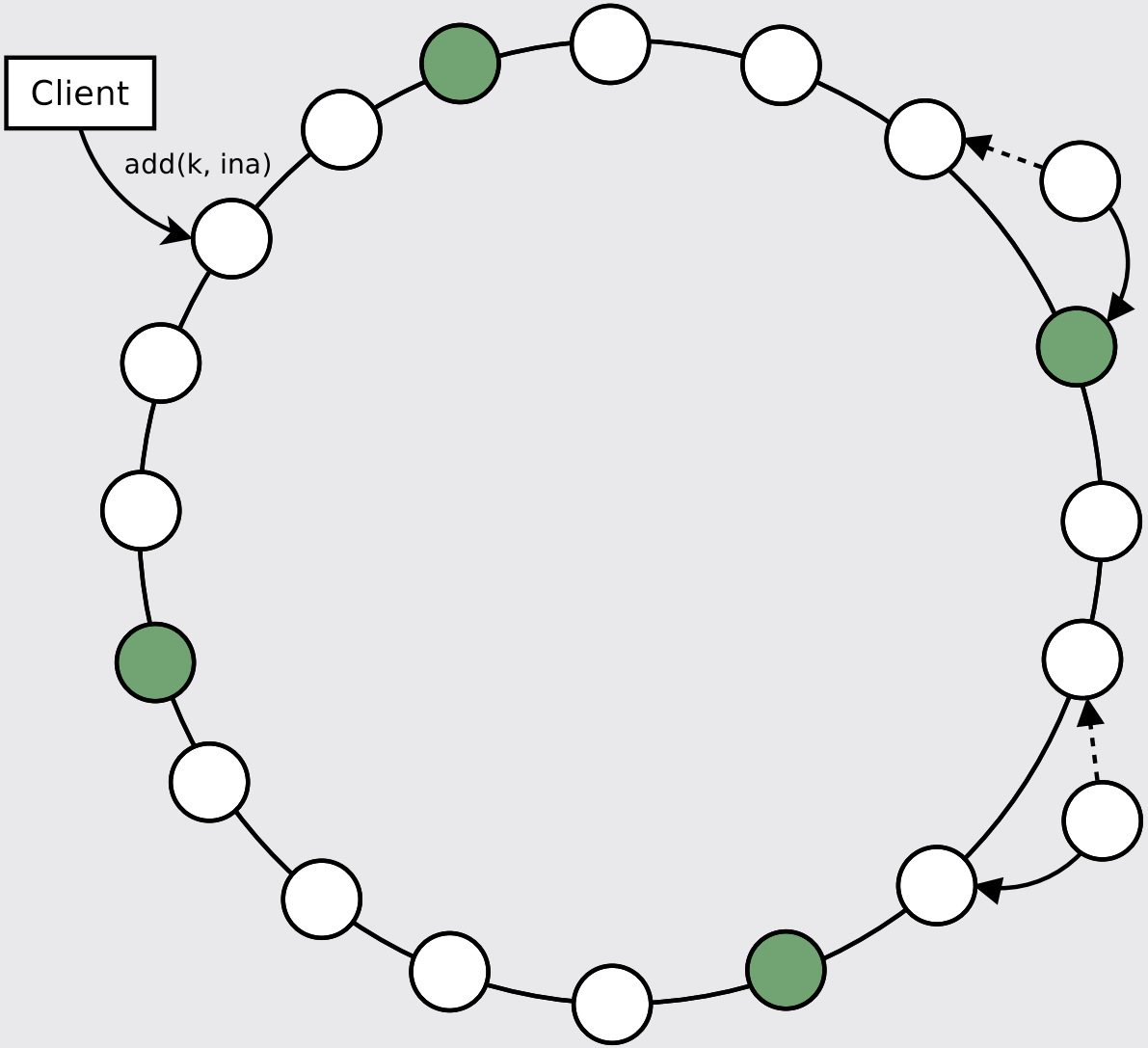
Lock-free key/value-sets



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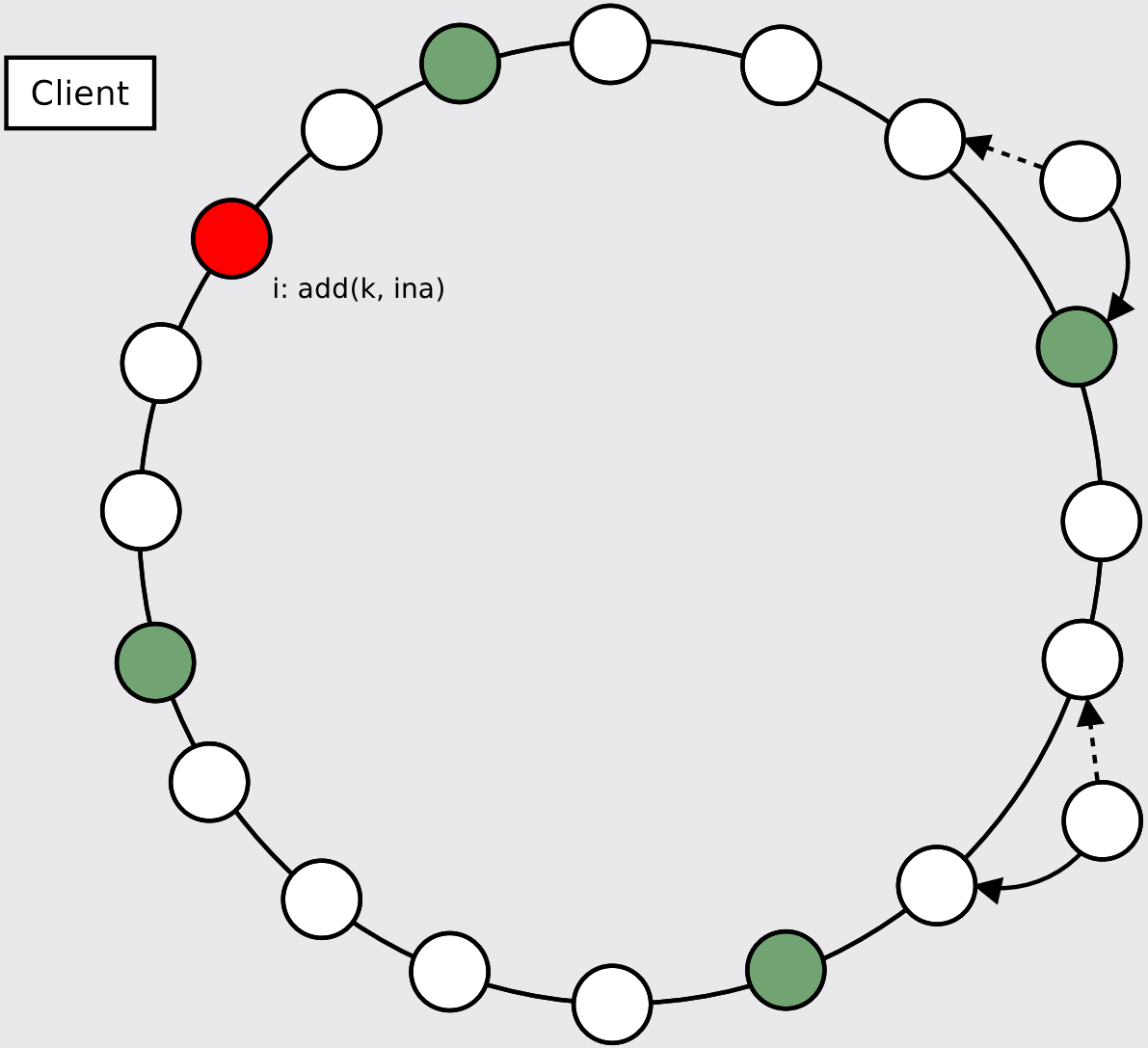

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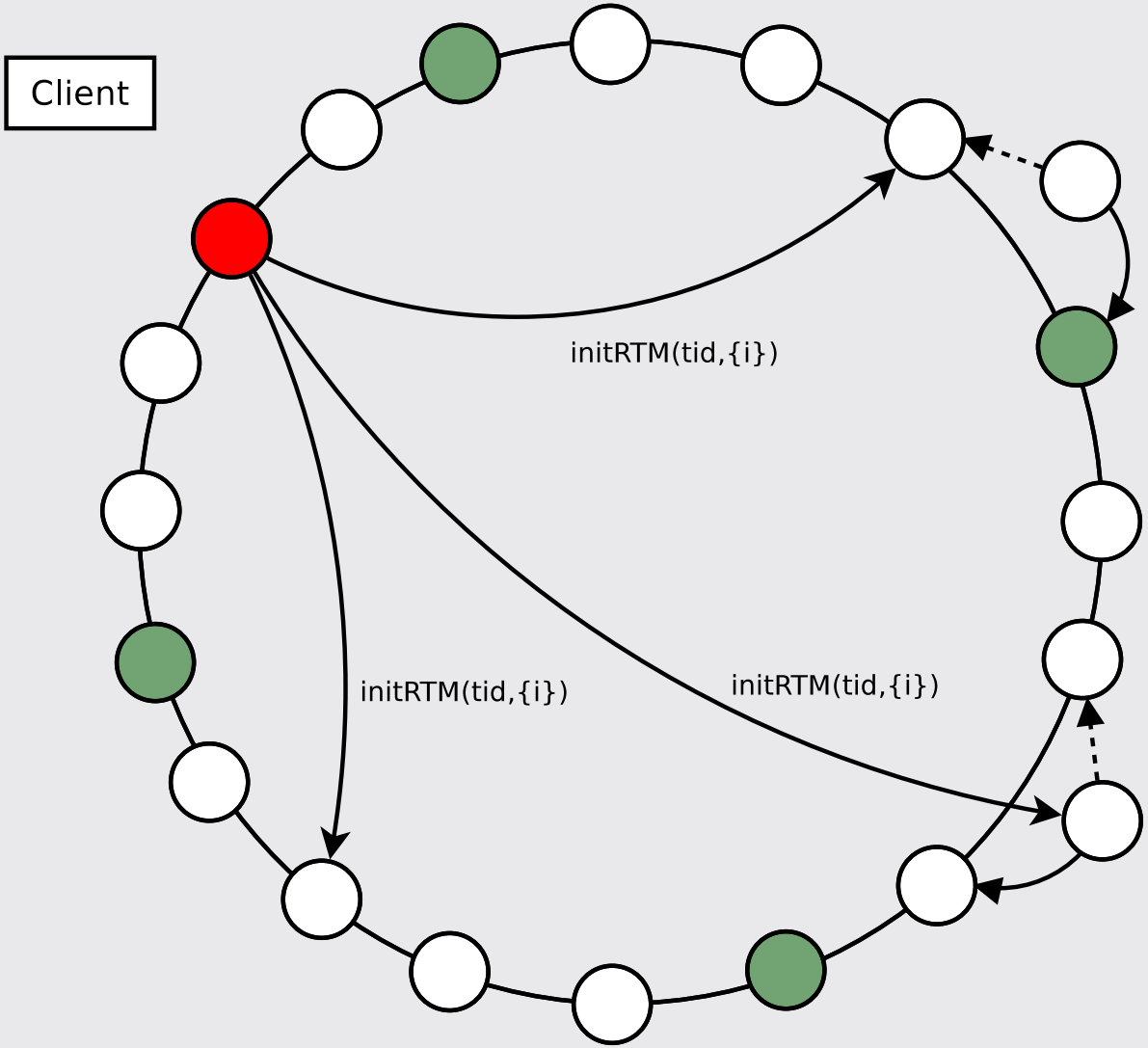

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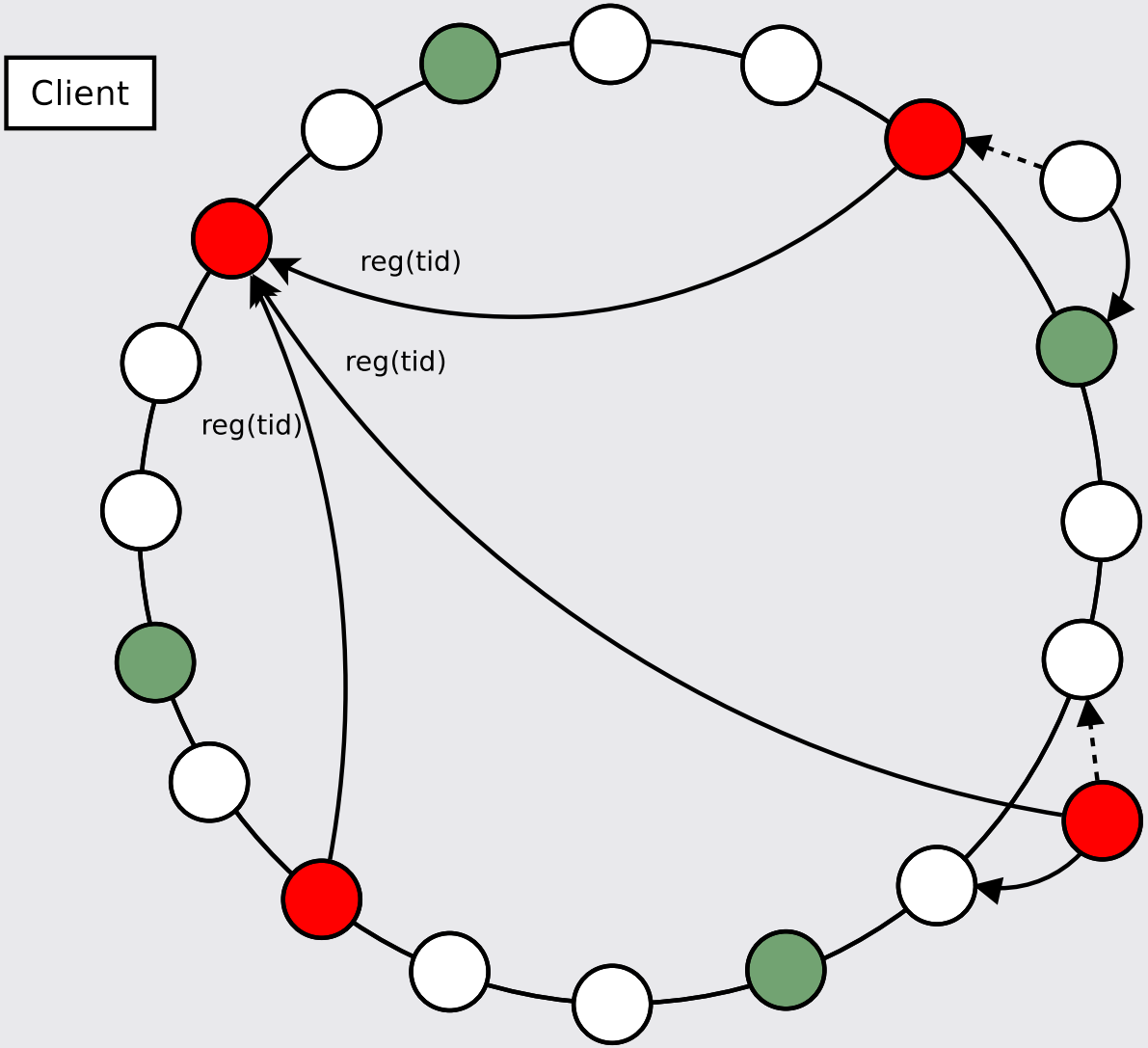

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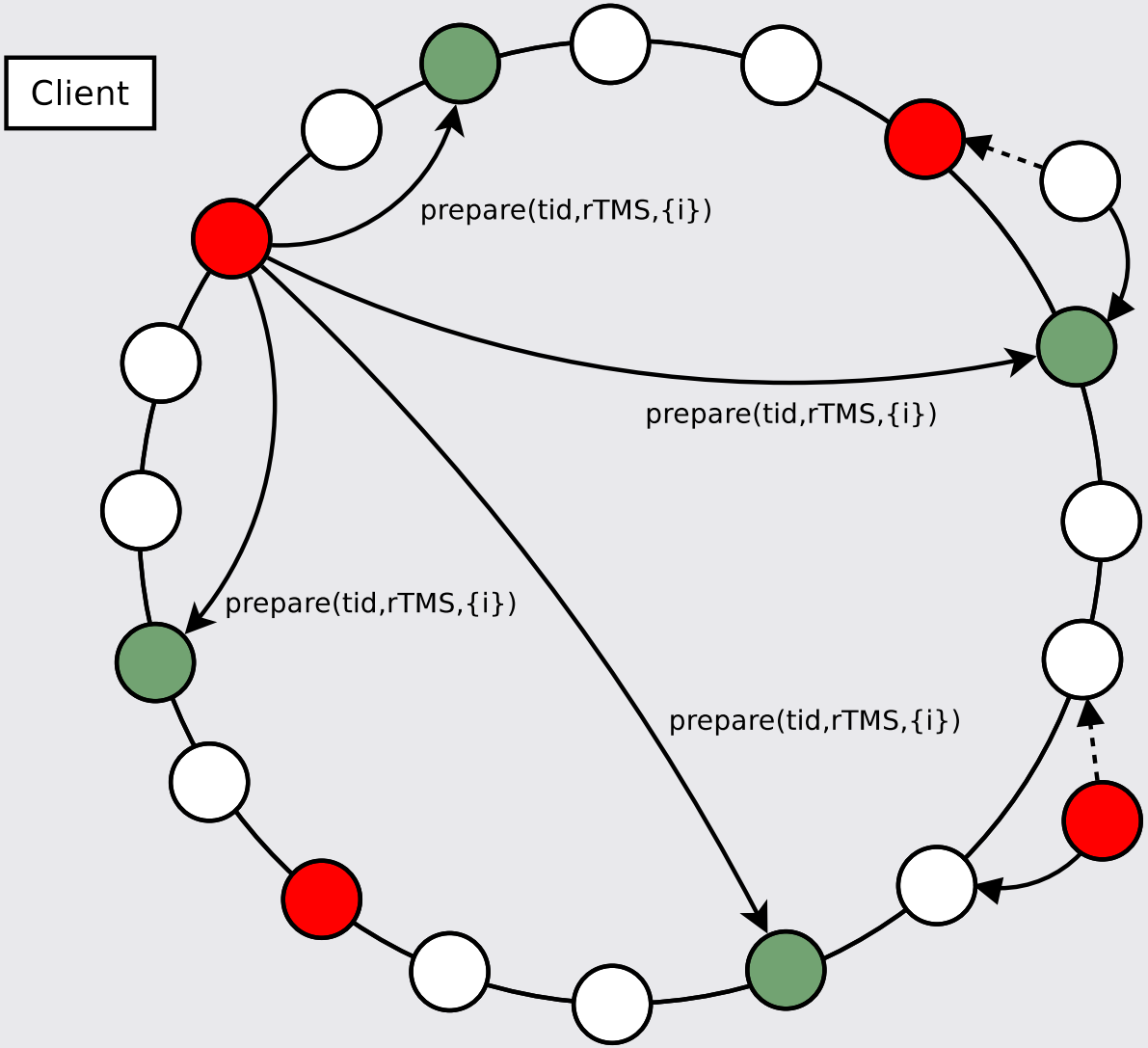

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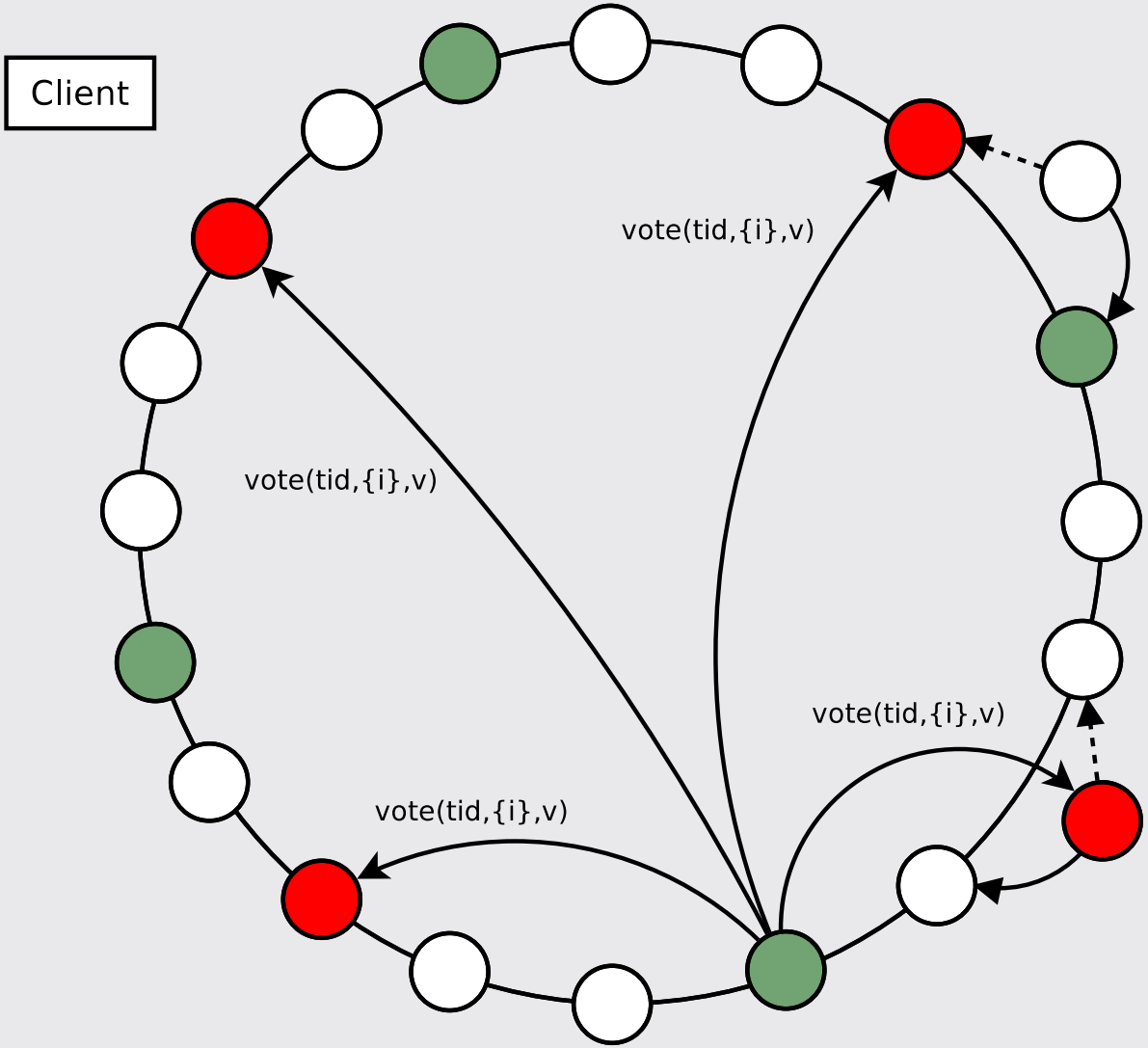

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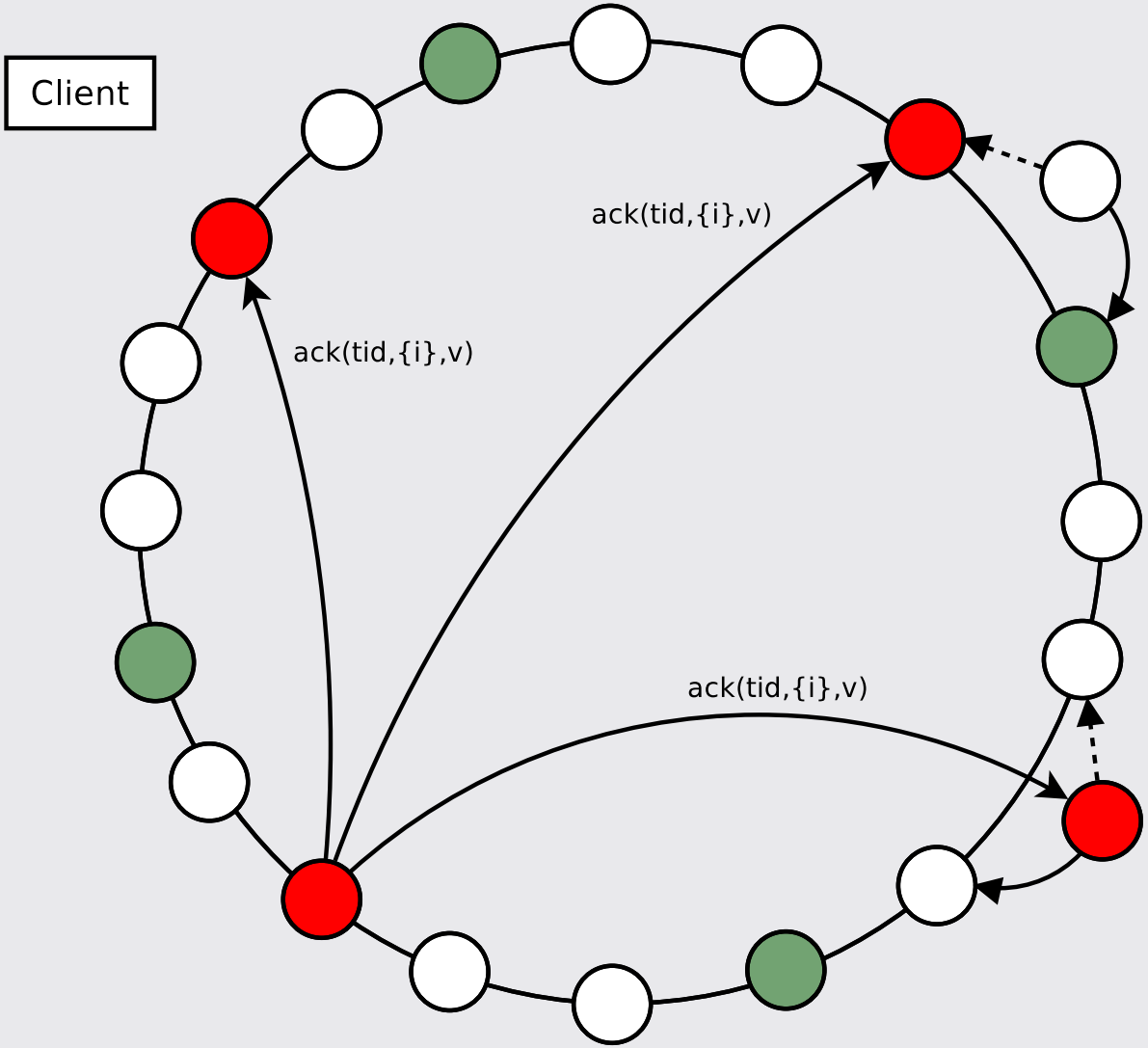

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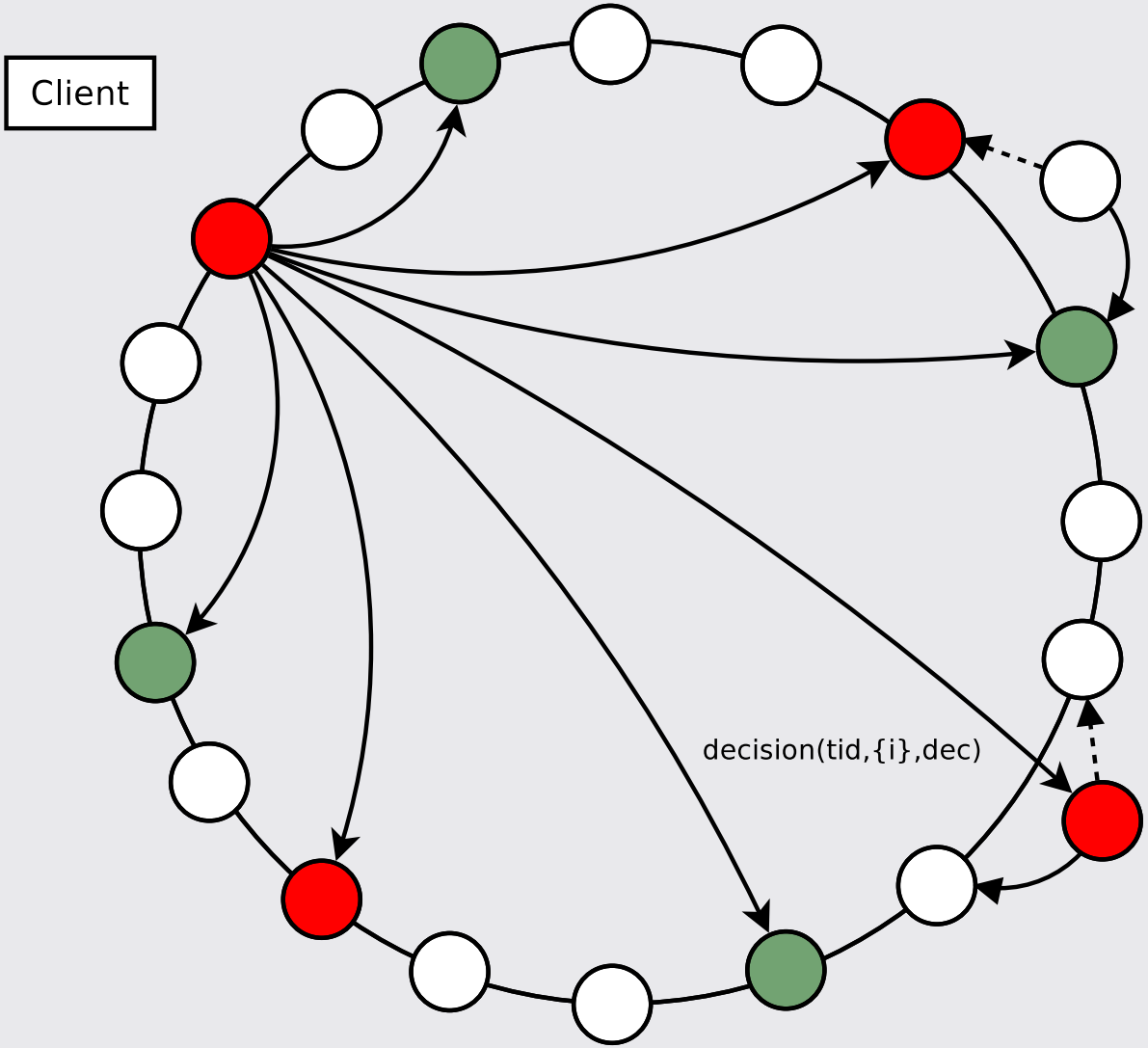

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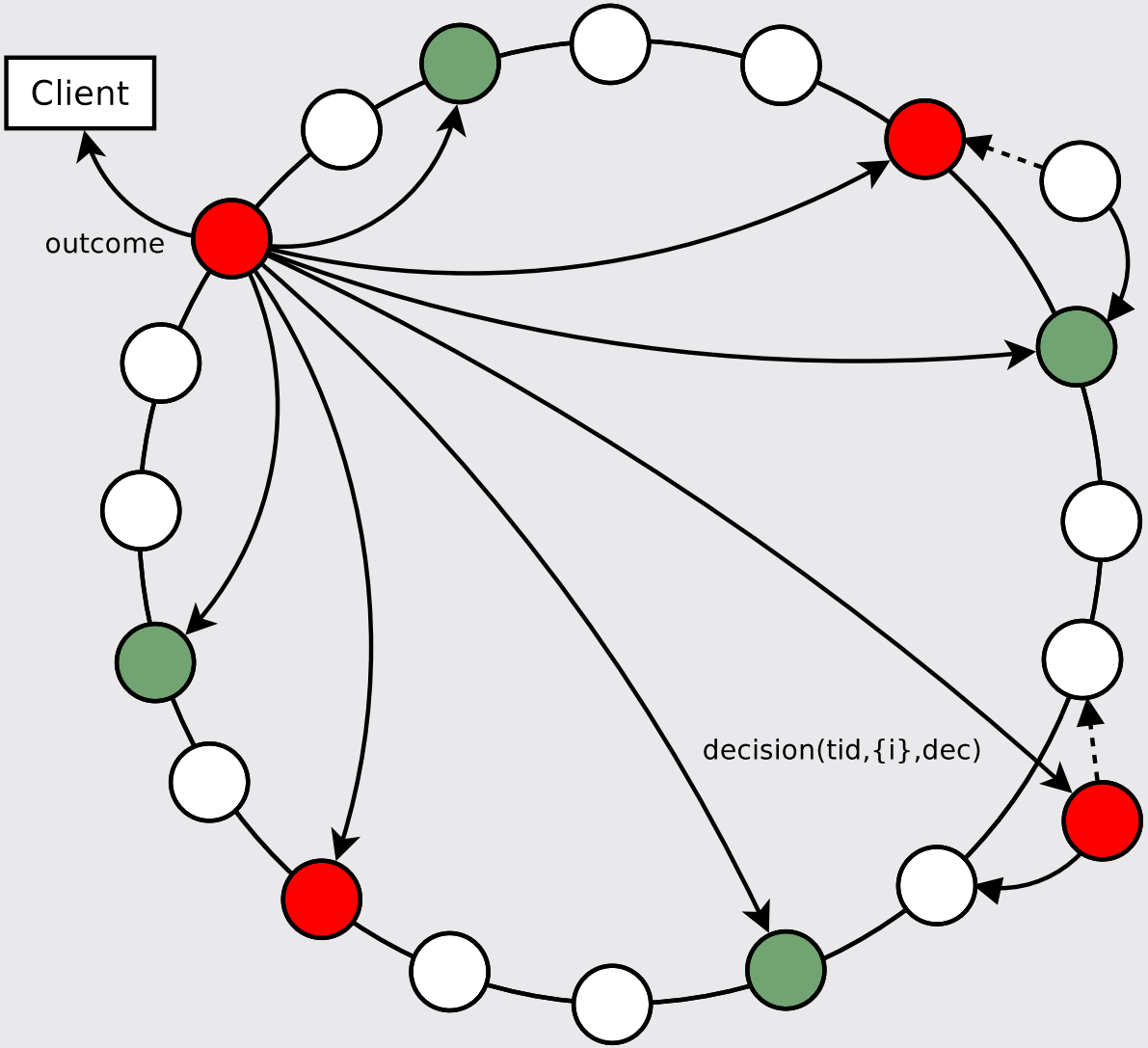

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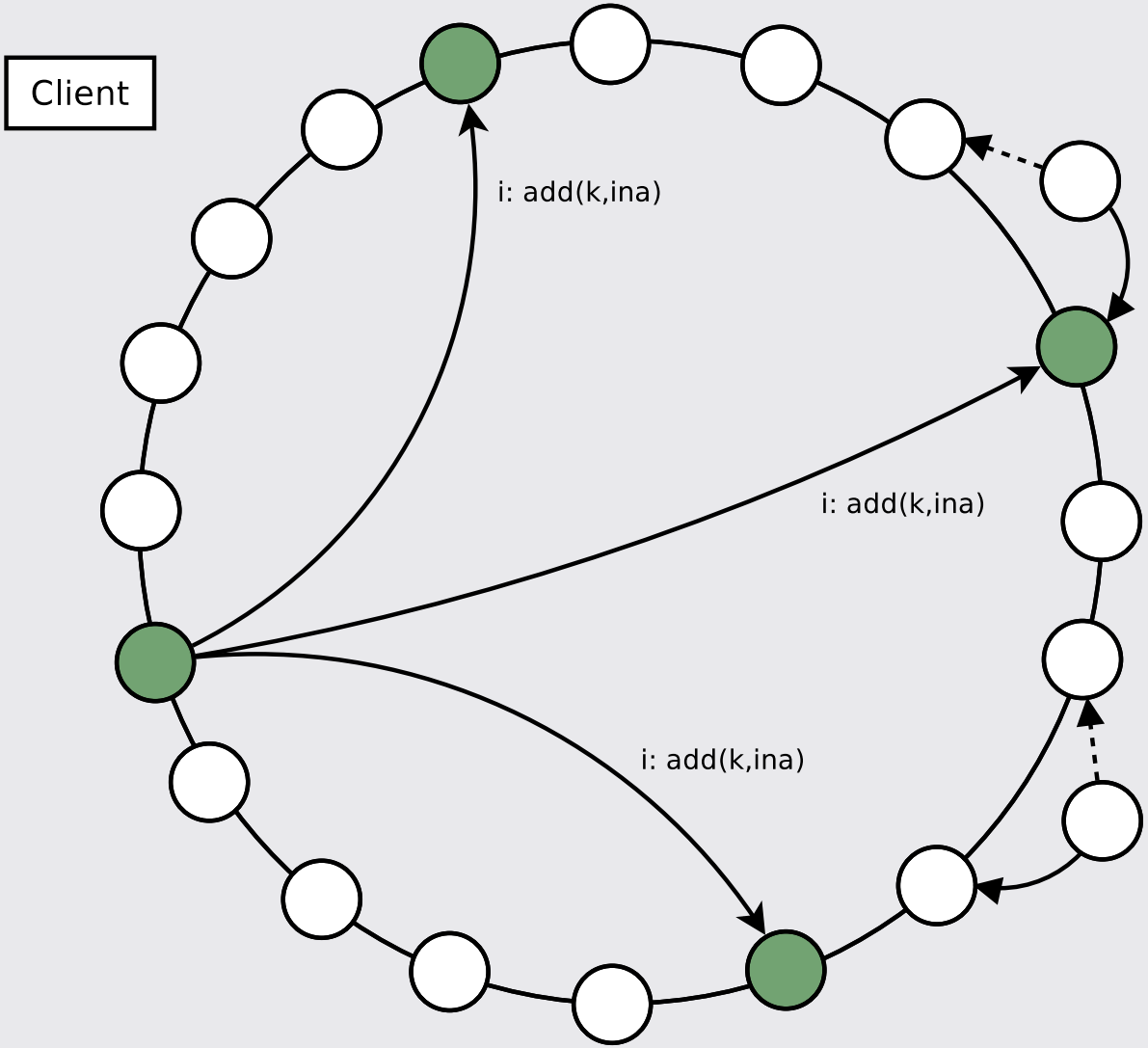

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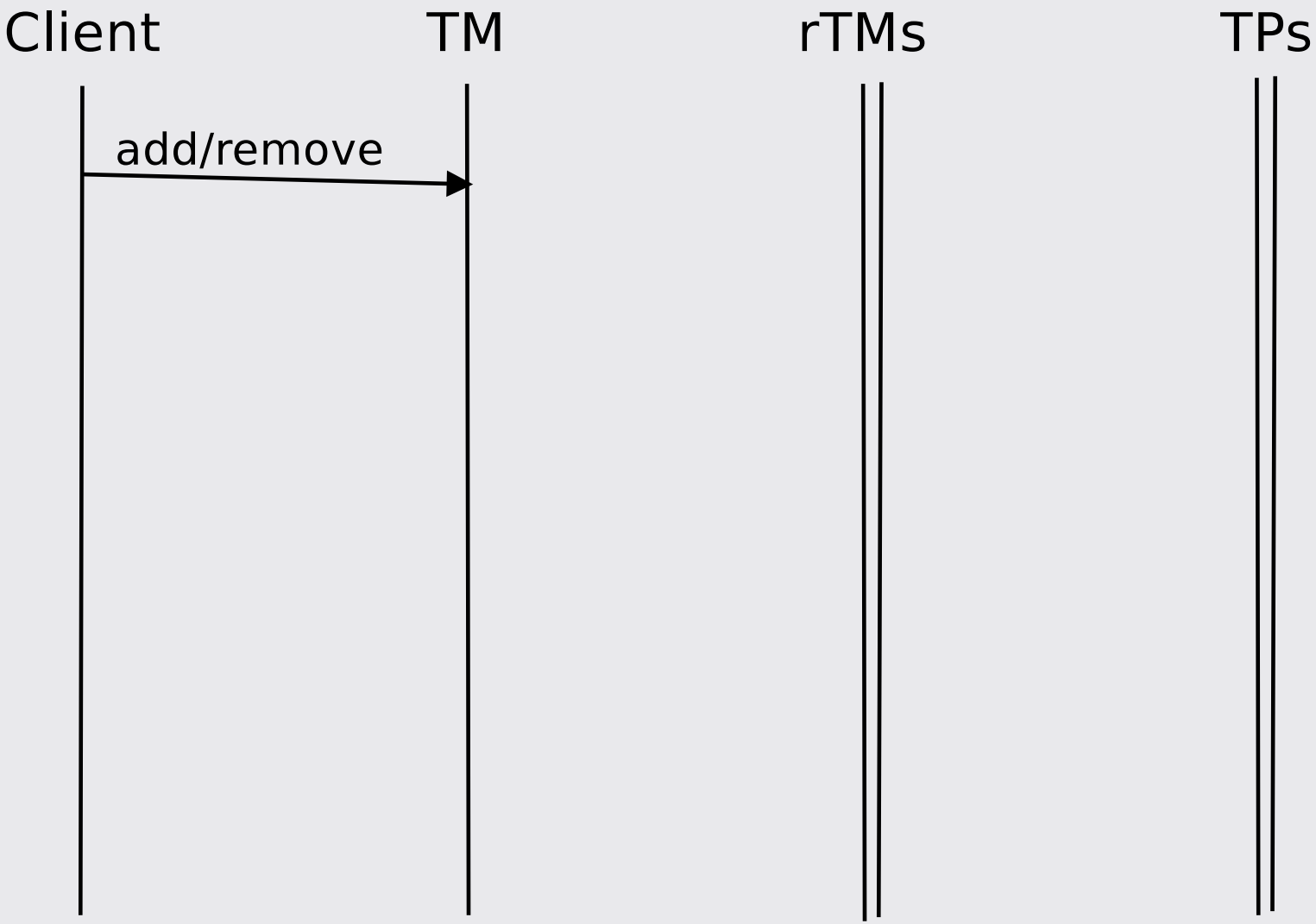

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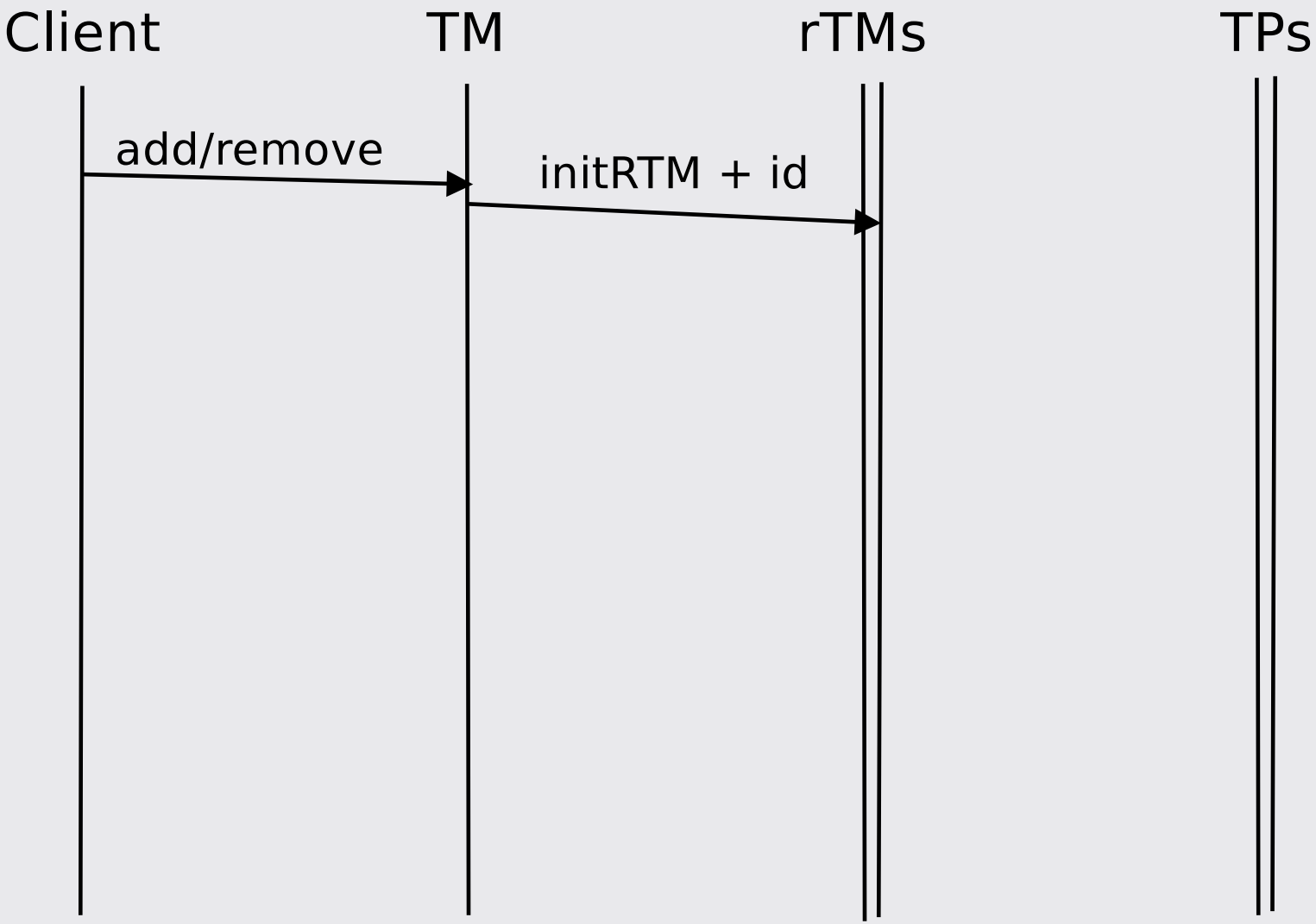

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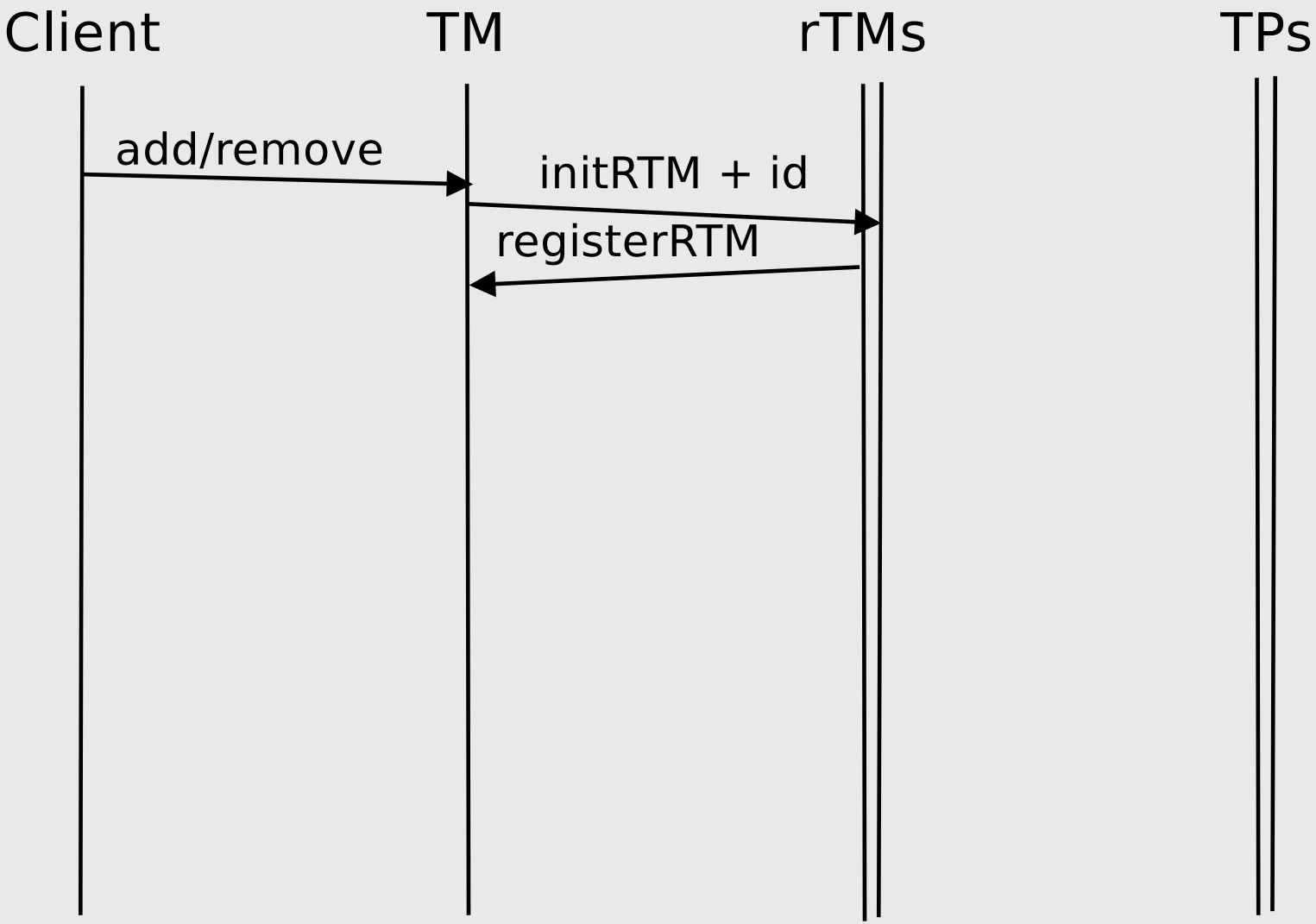

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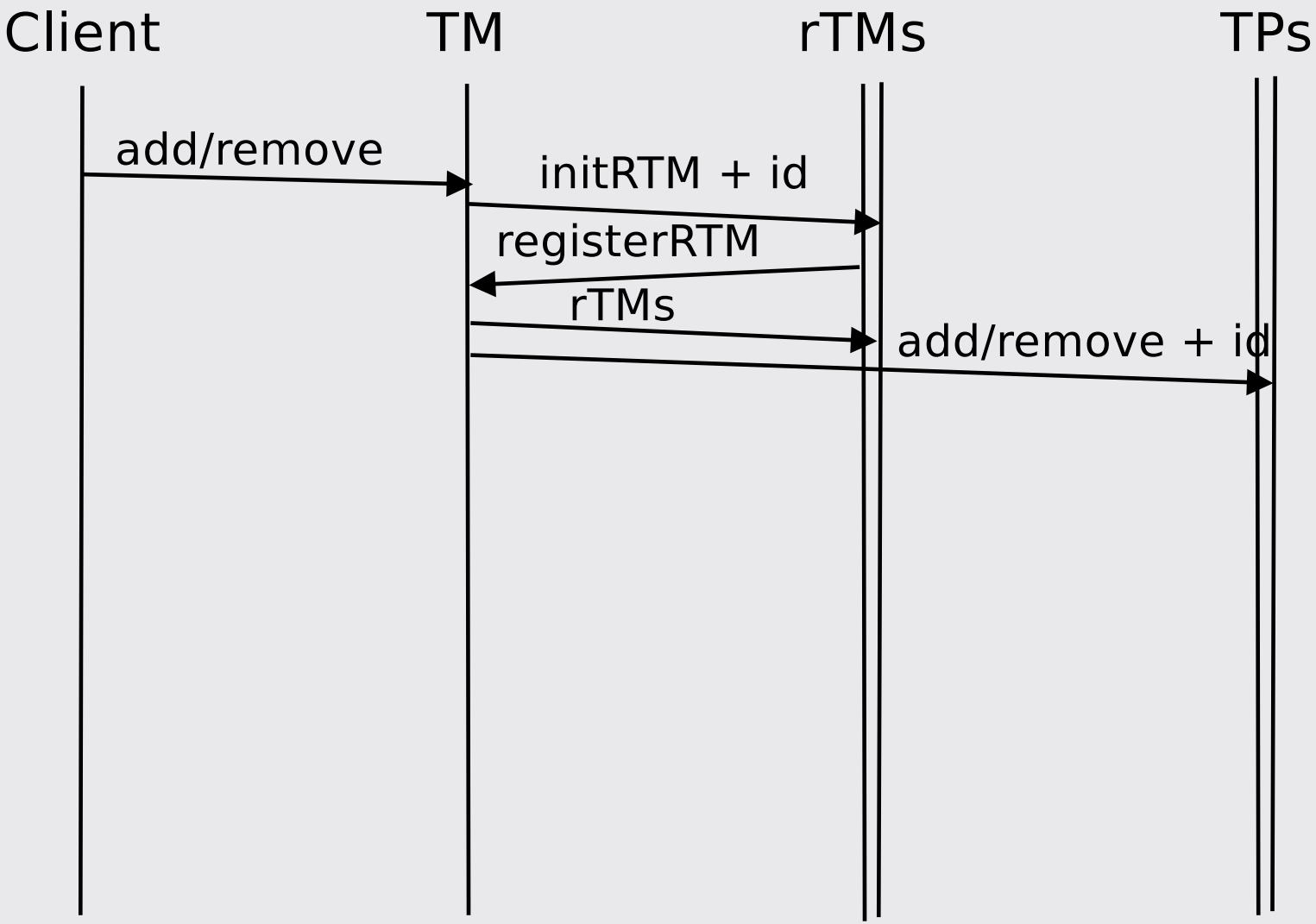

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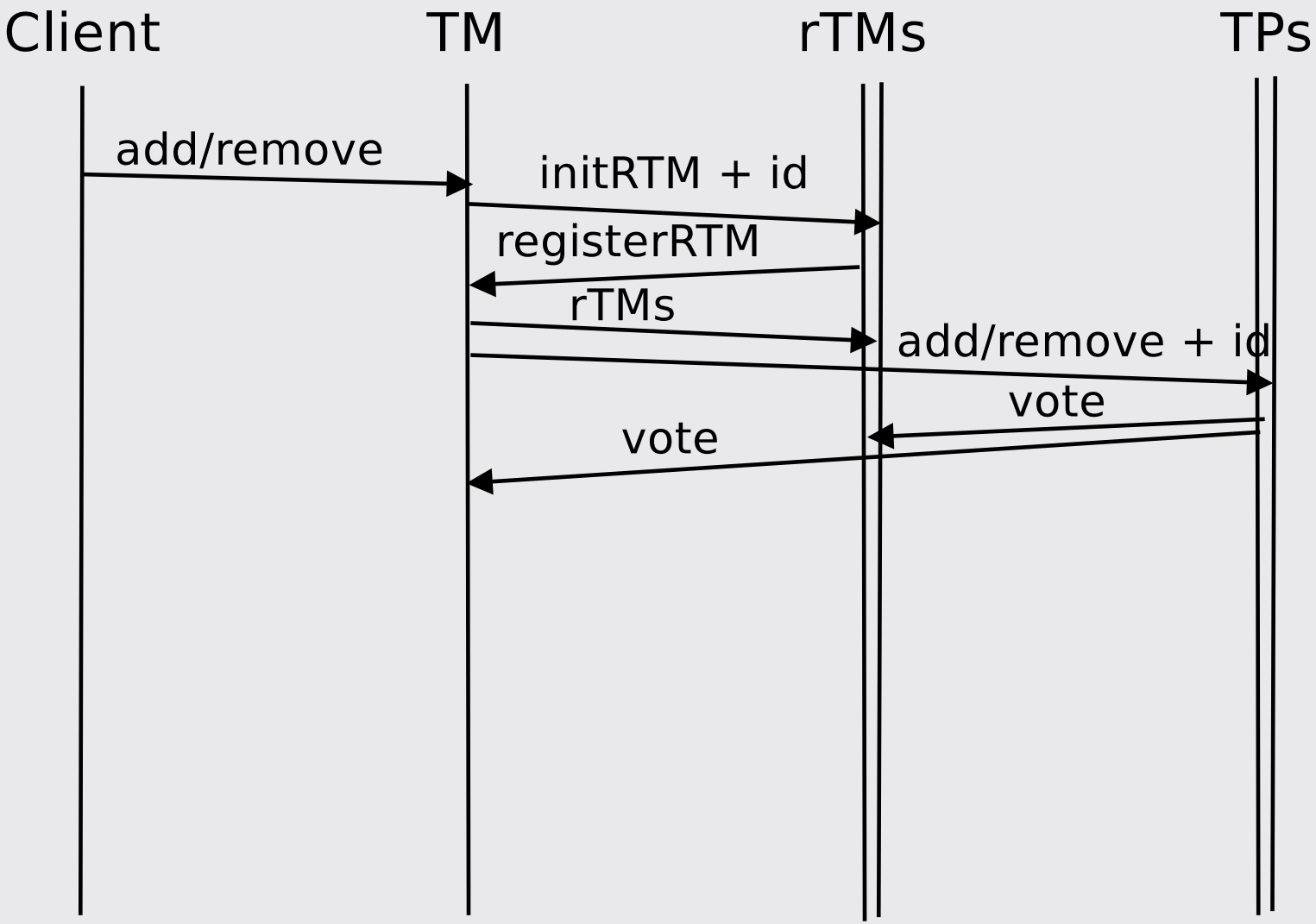

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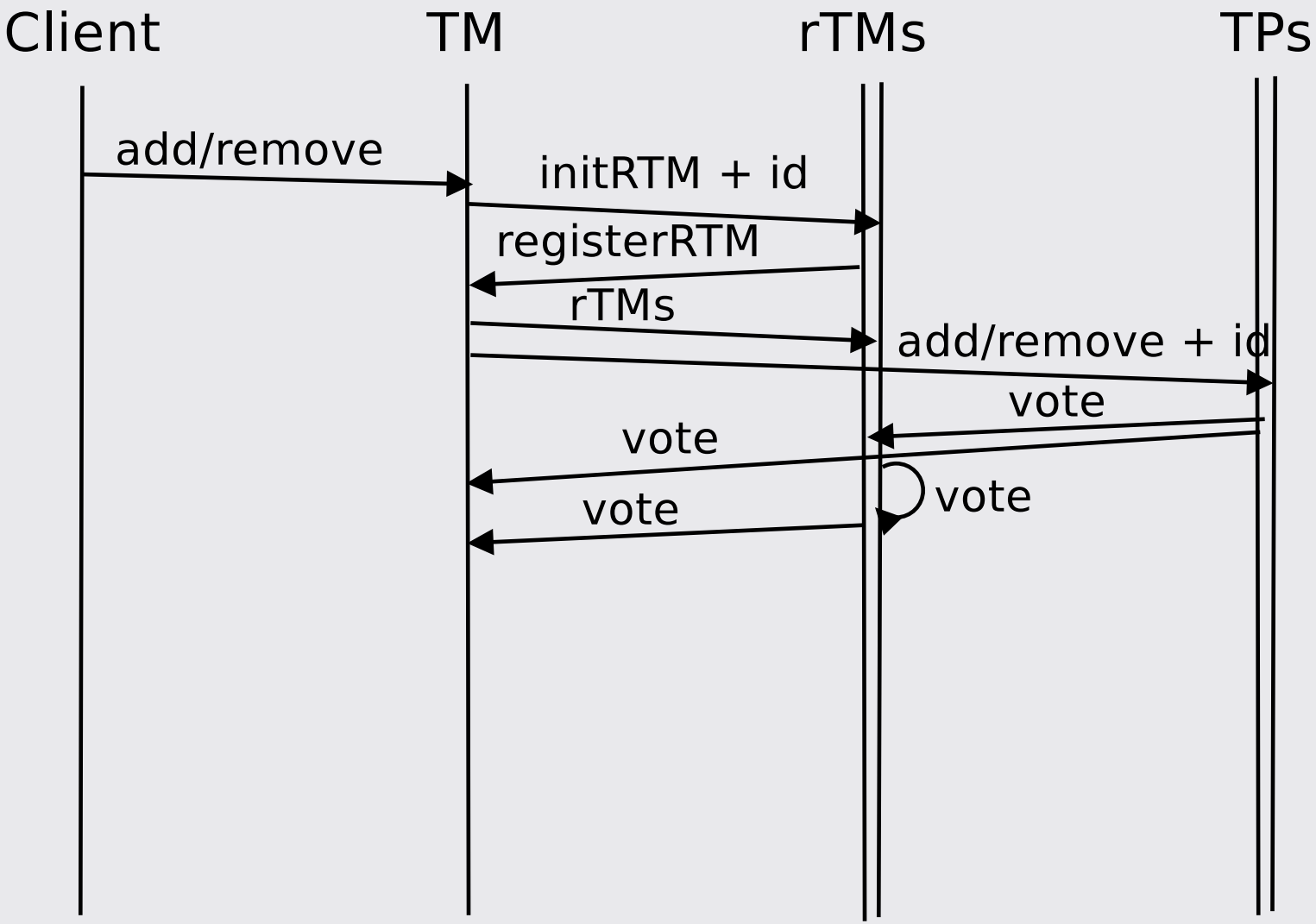

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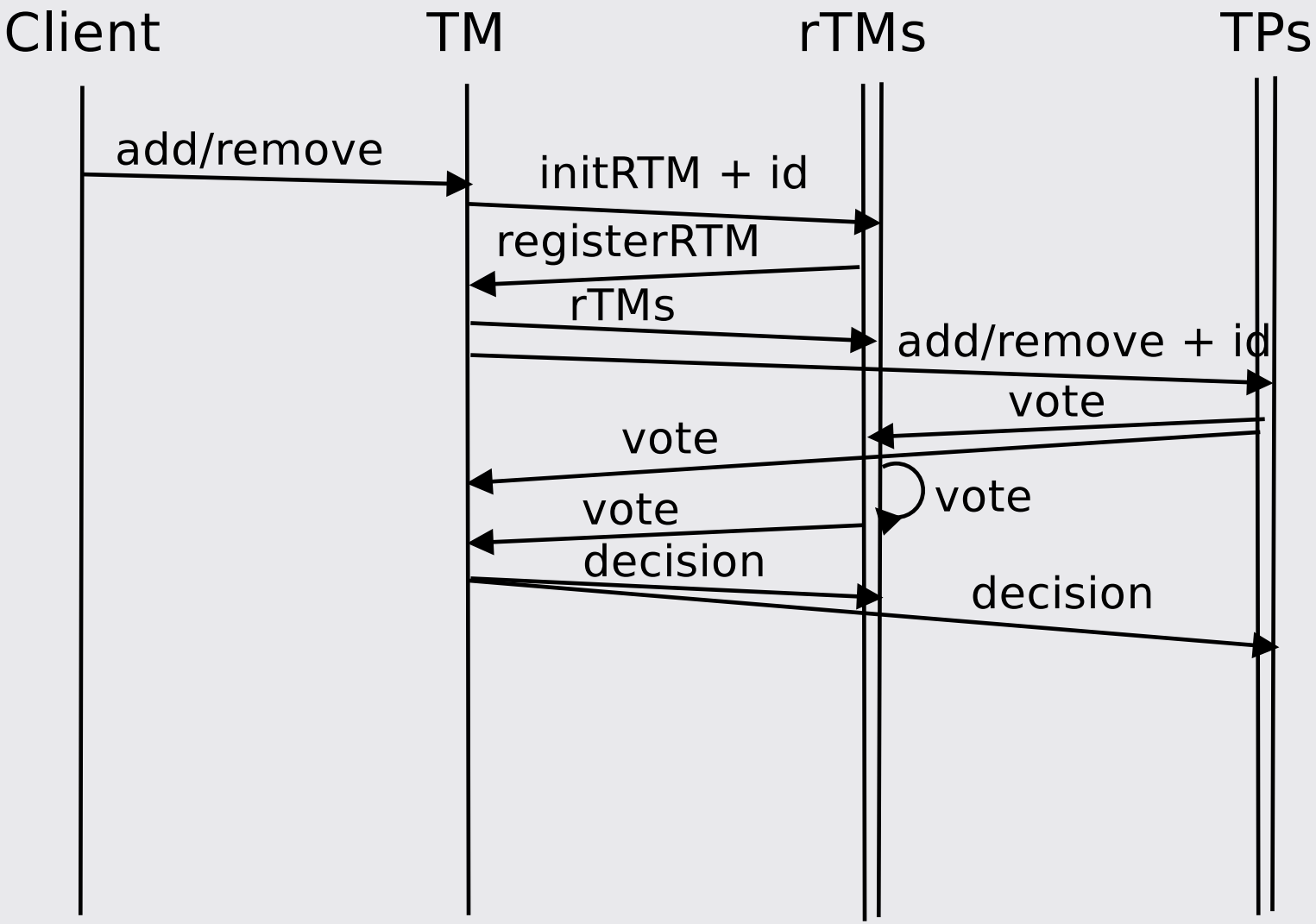

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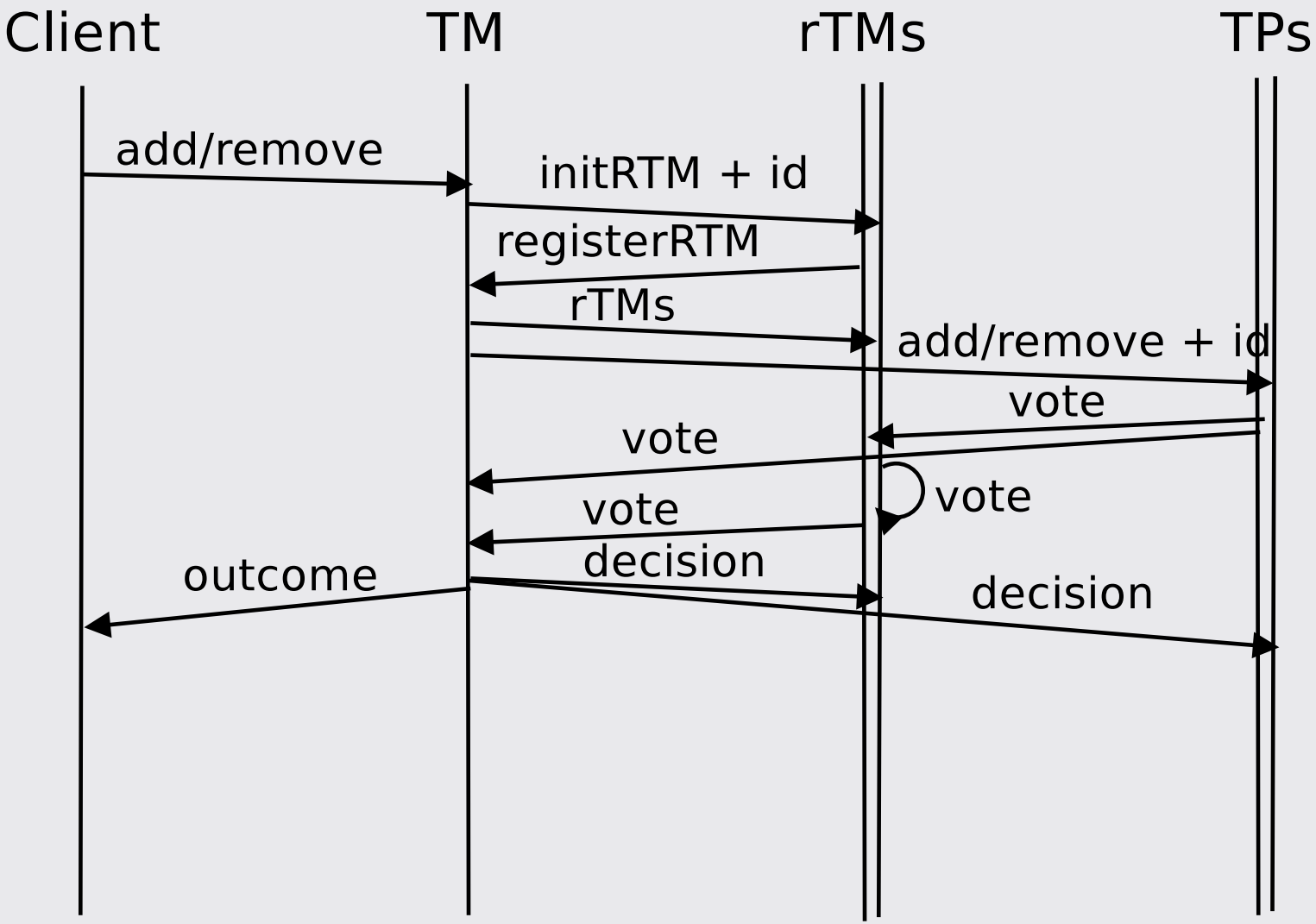

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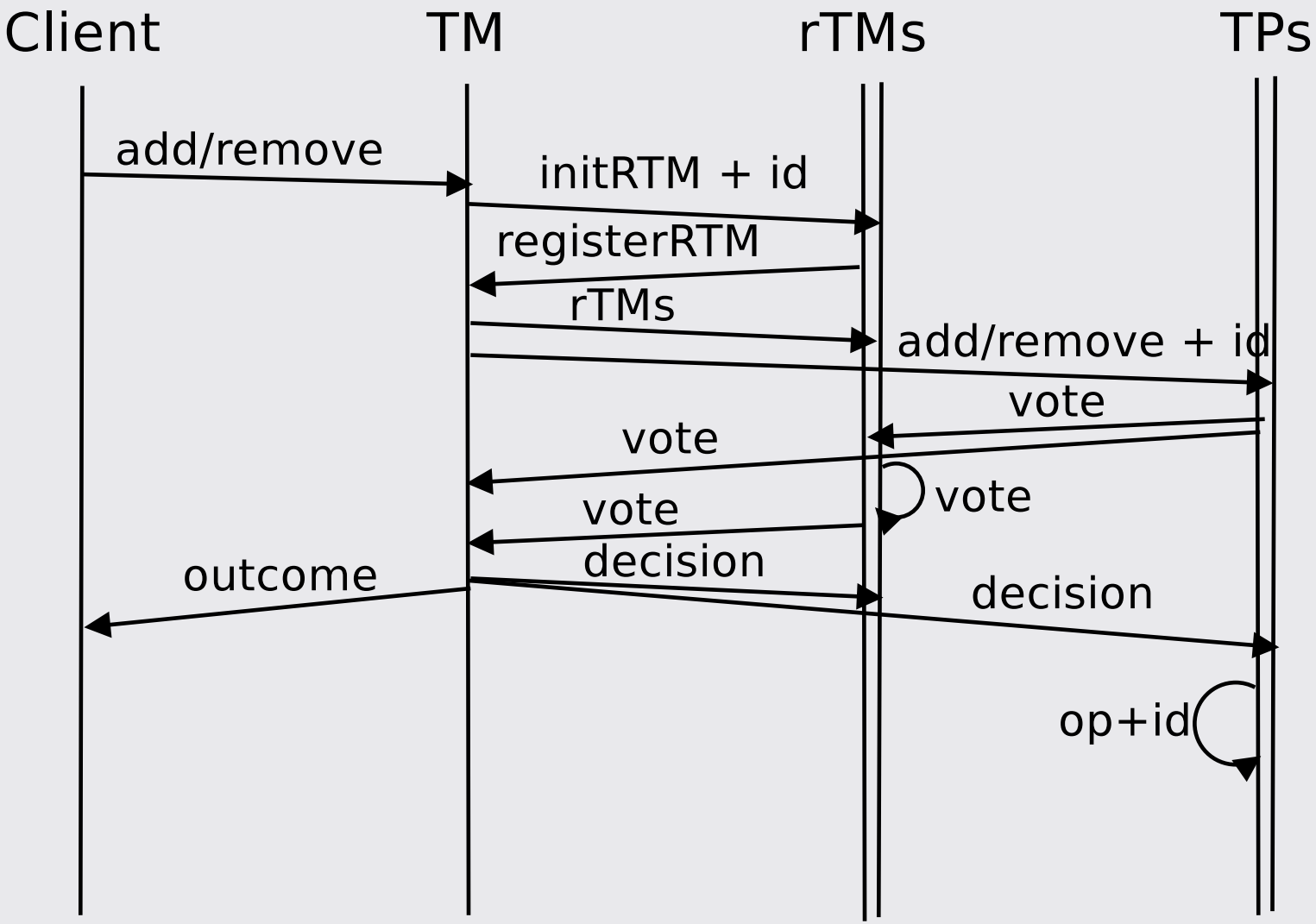

Taking the decision

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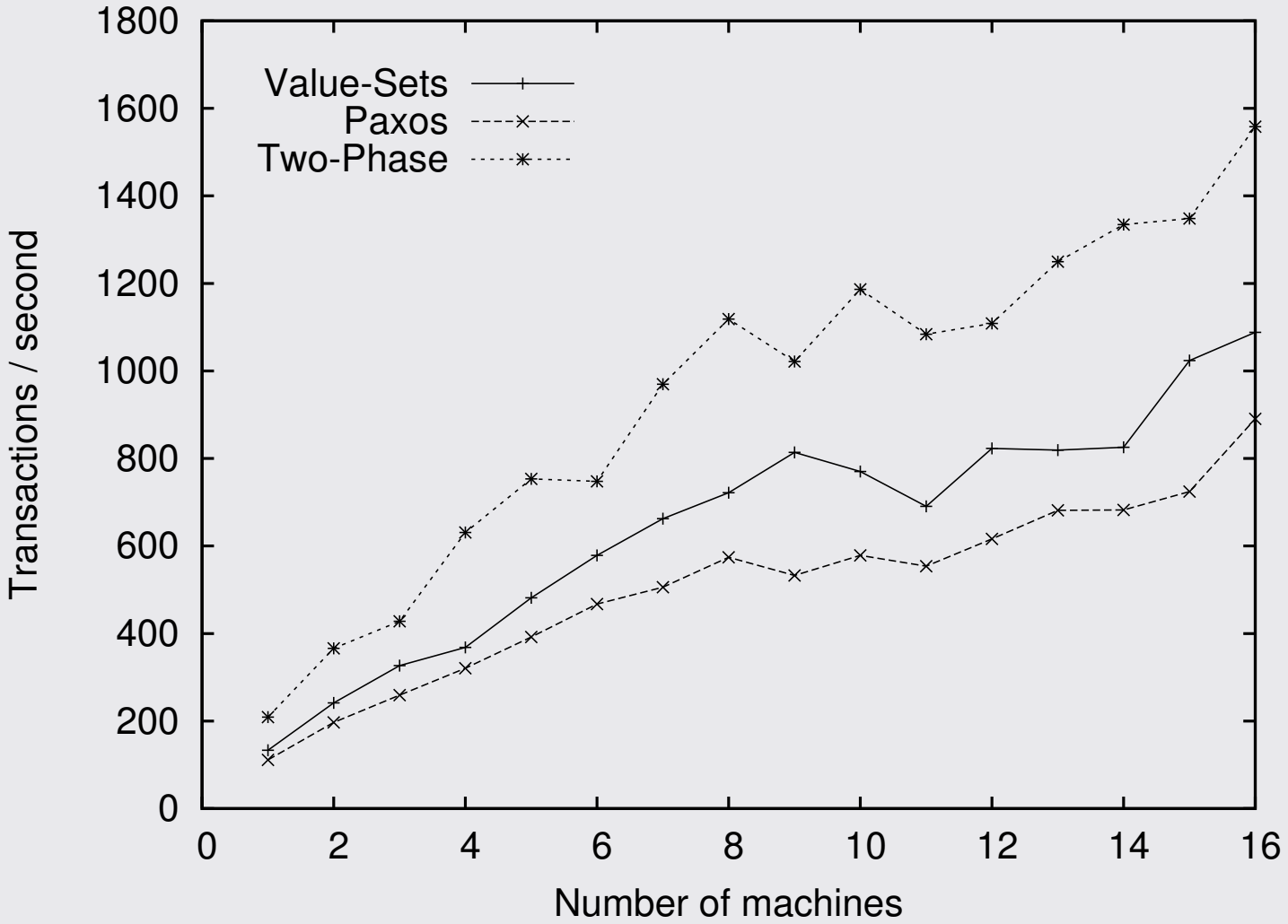
concurrent	*retry*	*no outcome*
no majority	abort	abort

Trappist's Evaluation - Average Performance



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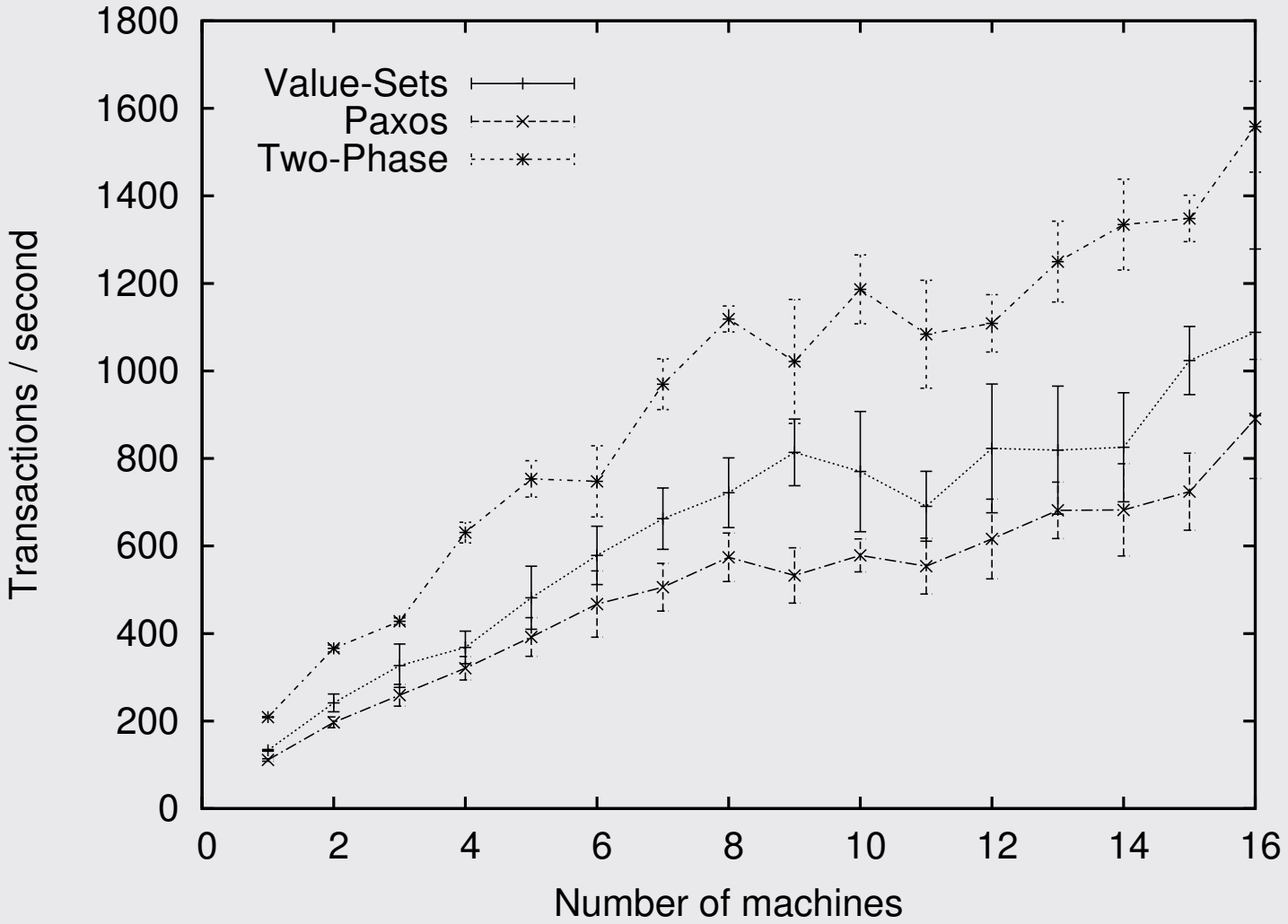

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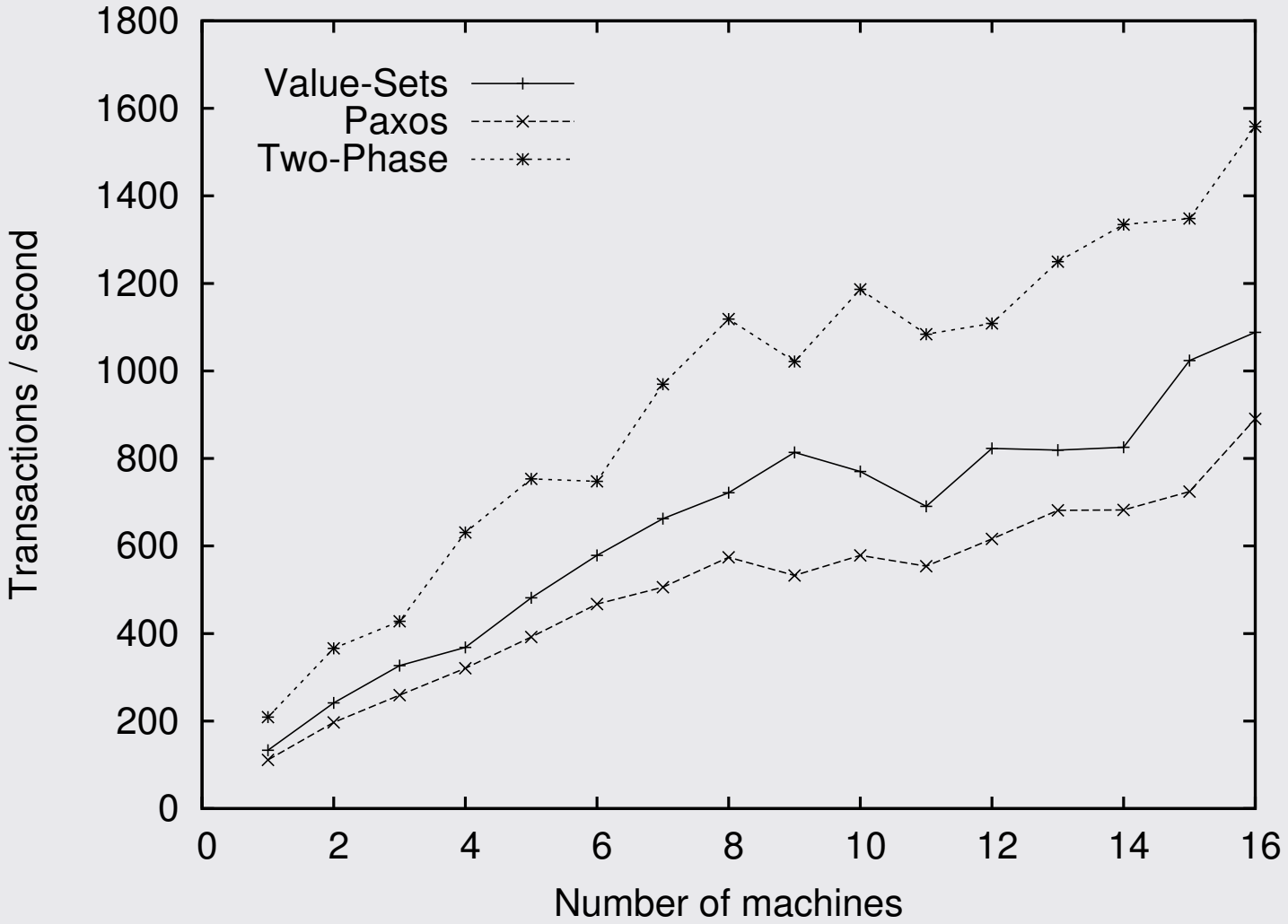

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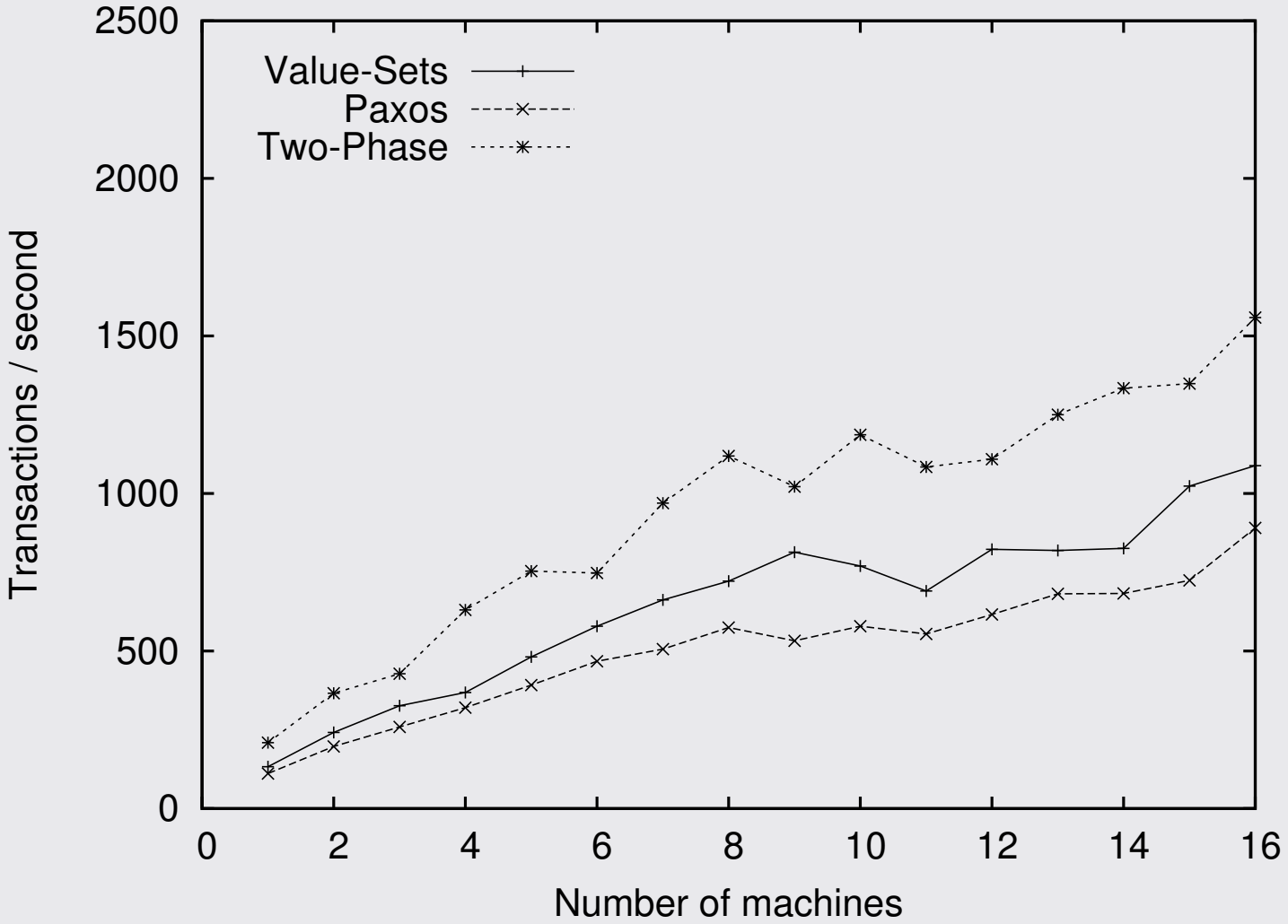
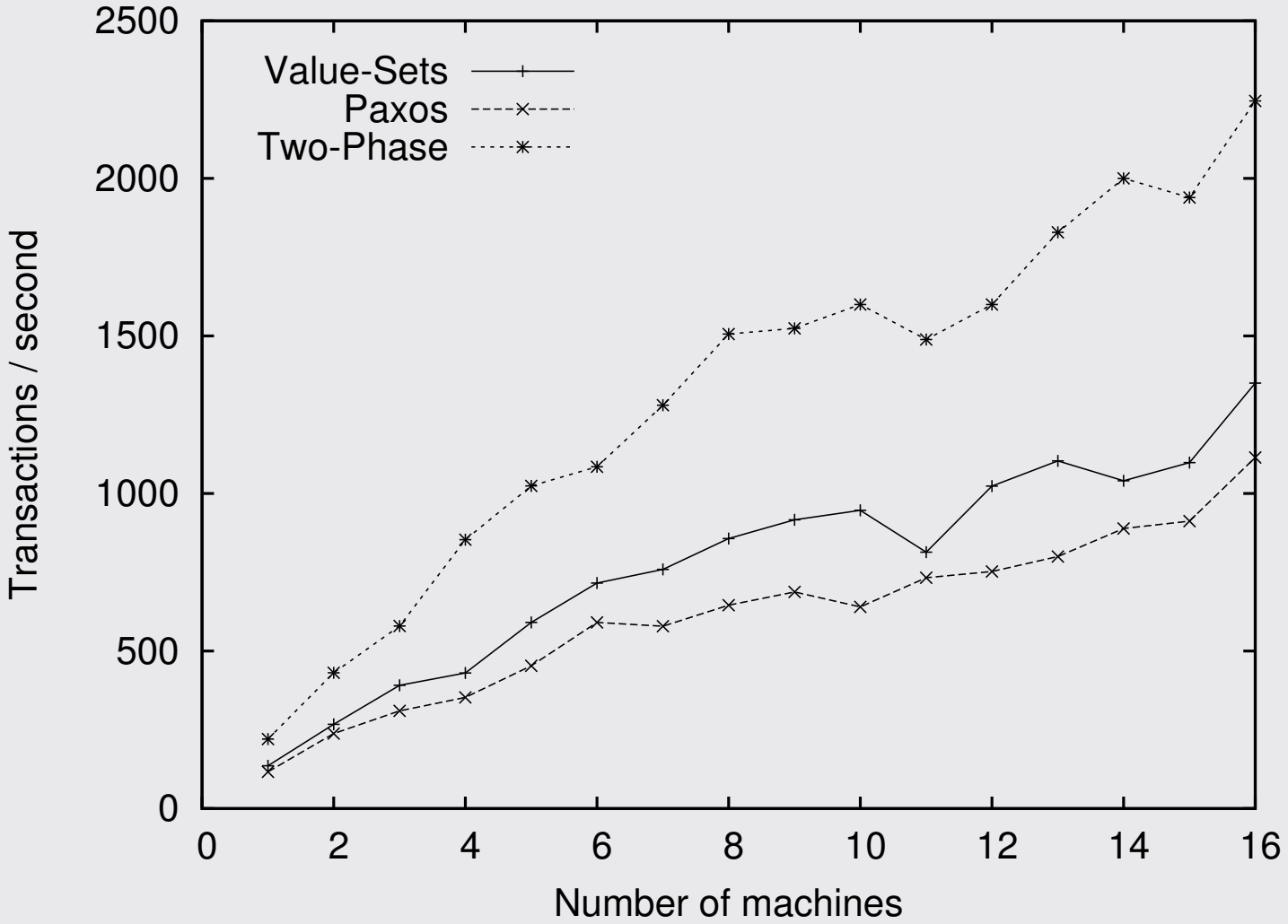
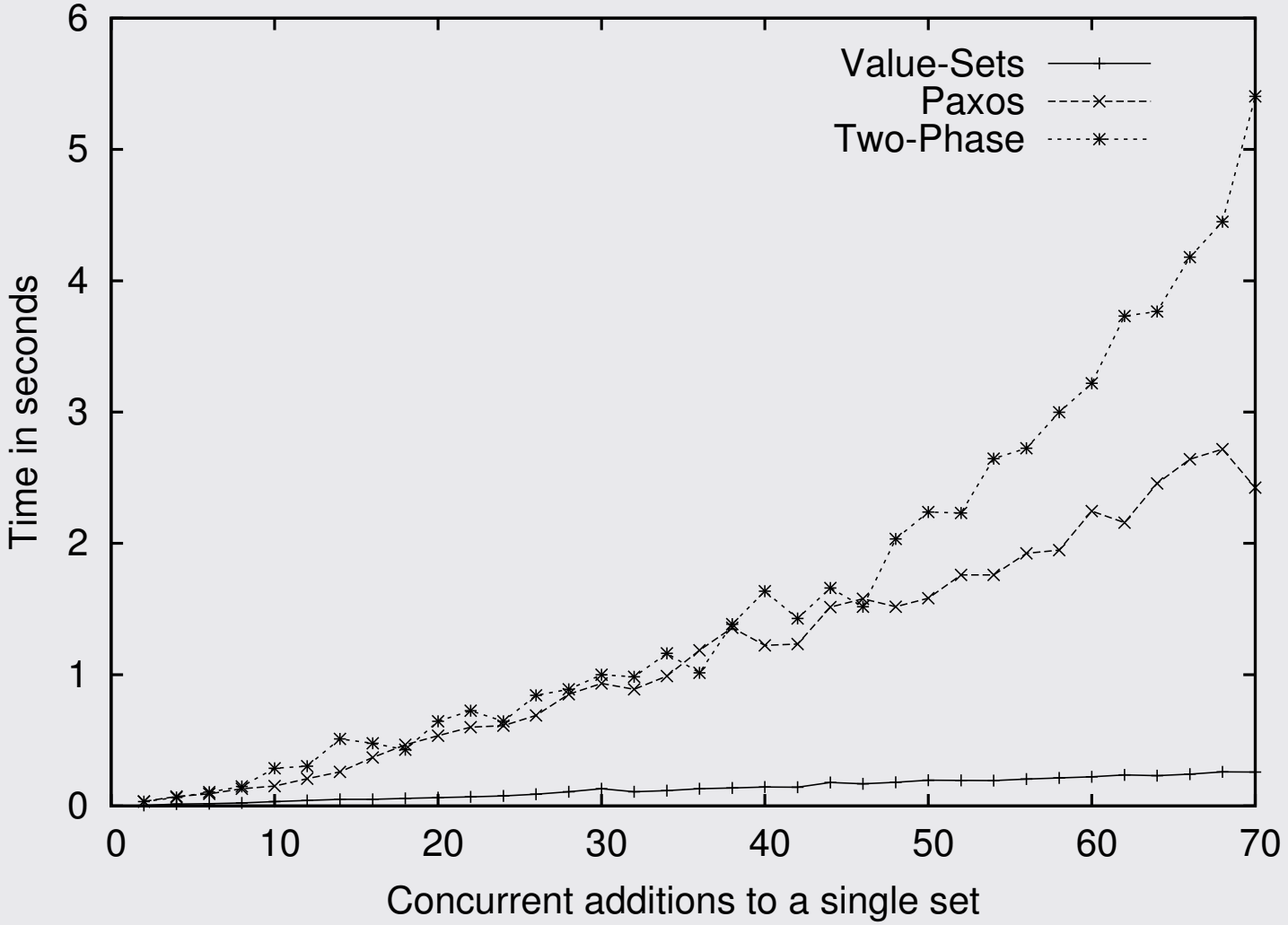


Trappist's Evaluation - Maximal Performance



Trappist's Evaluation - Race Conditions



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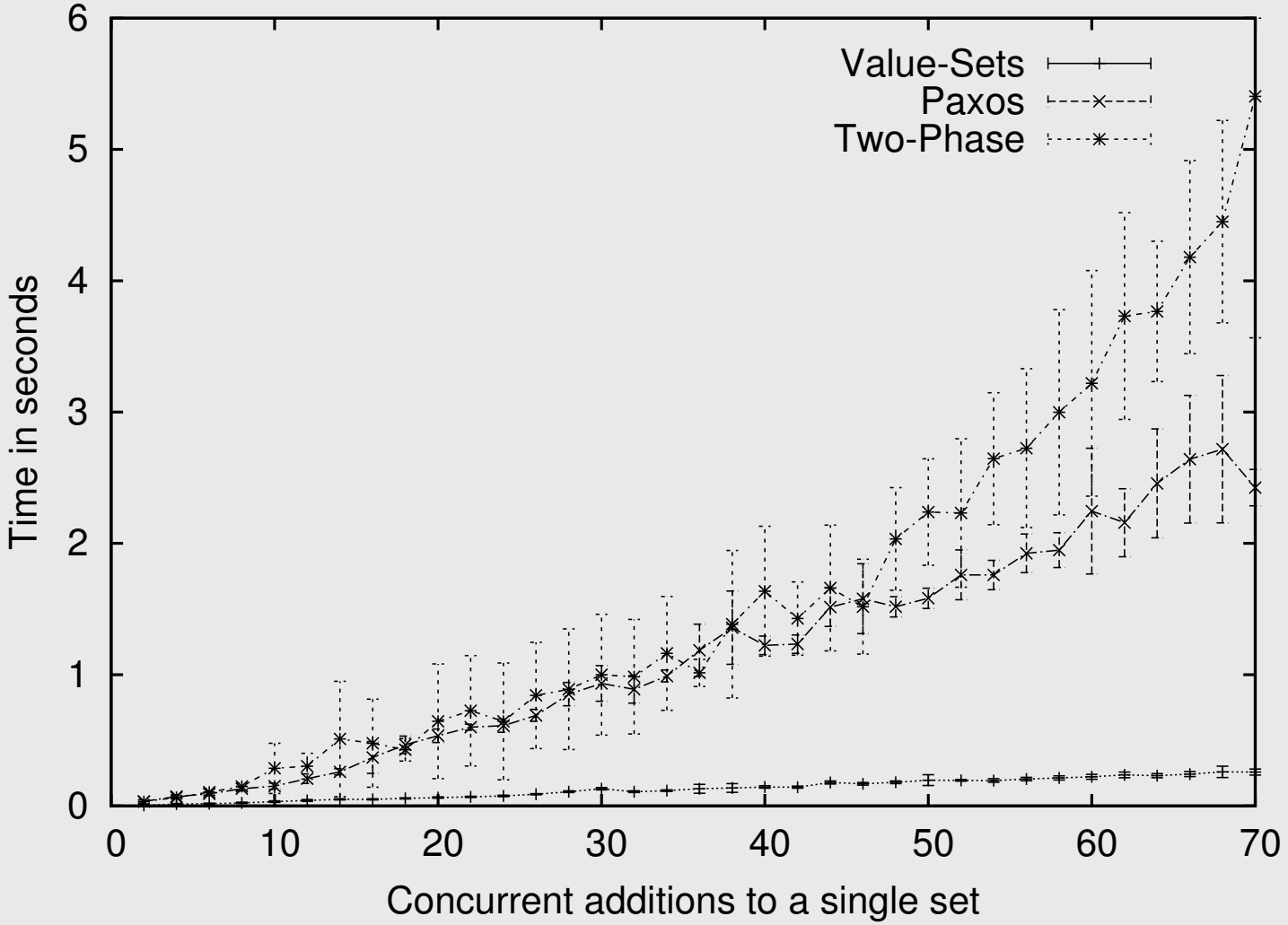
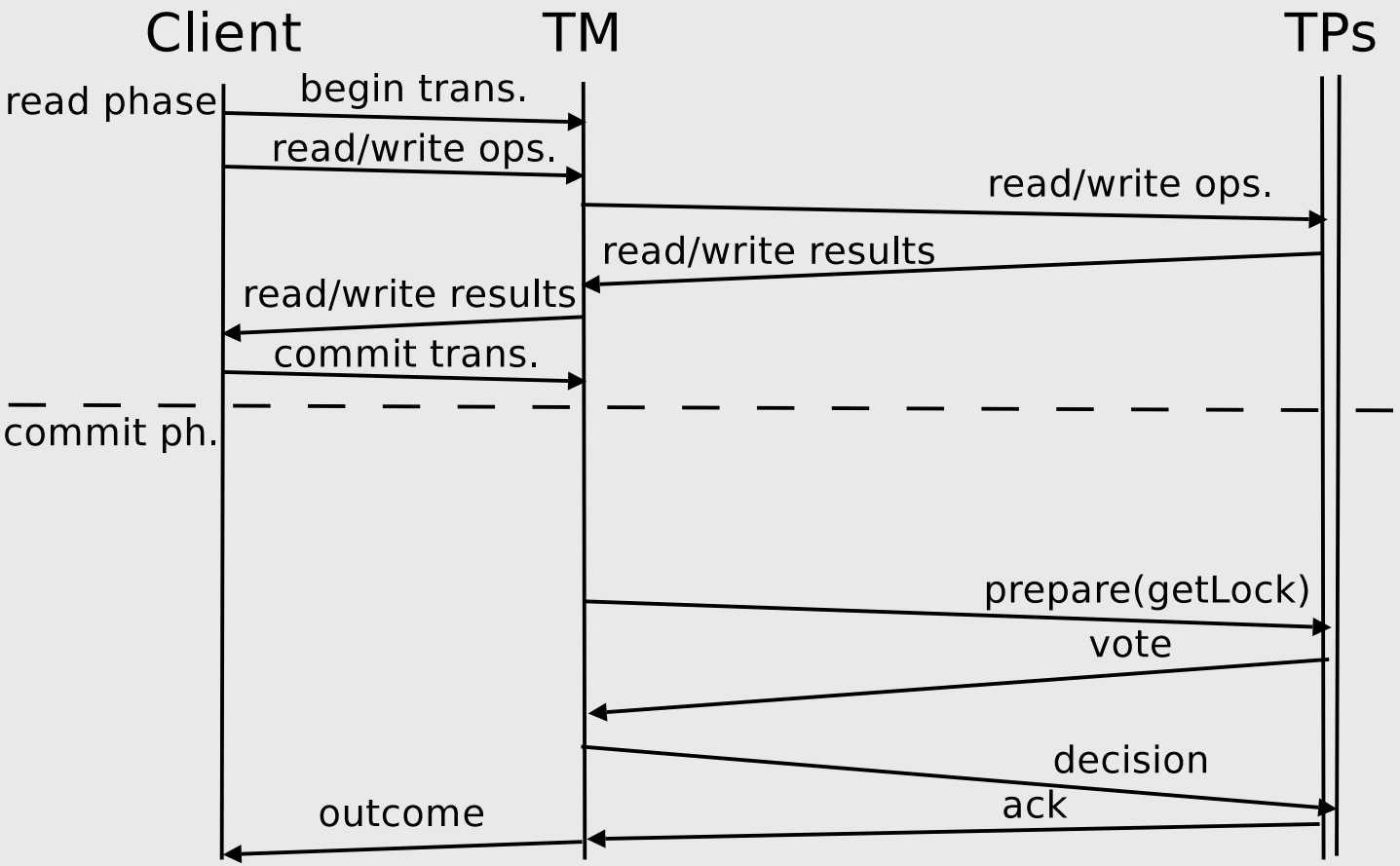
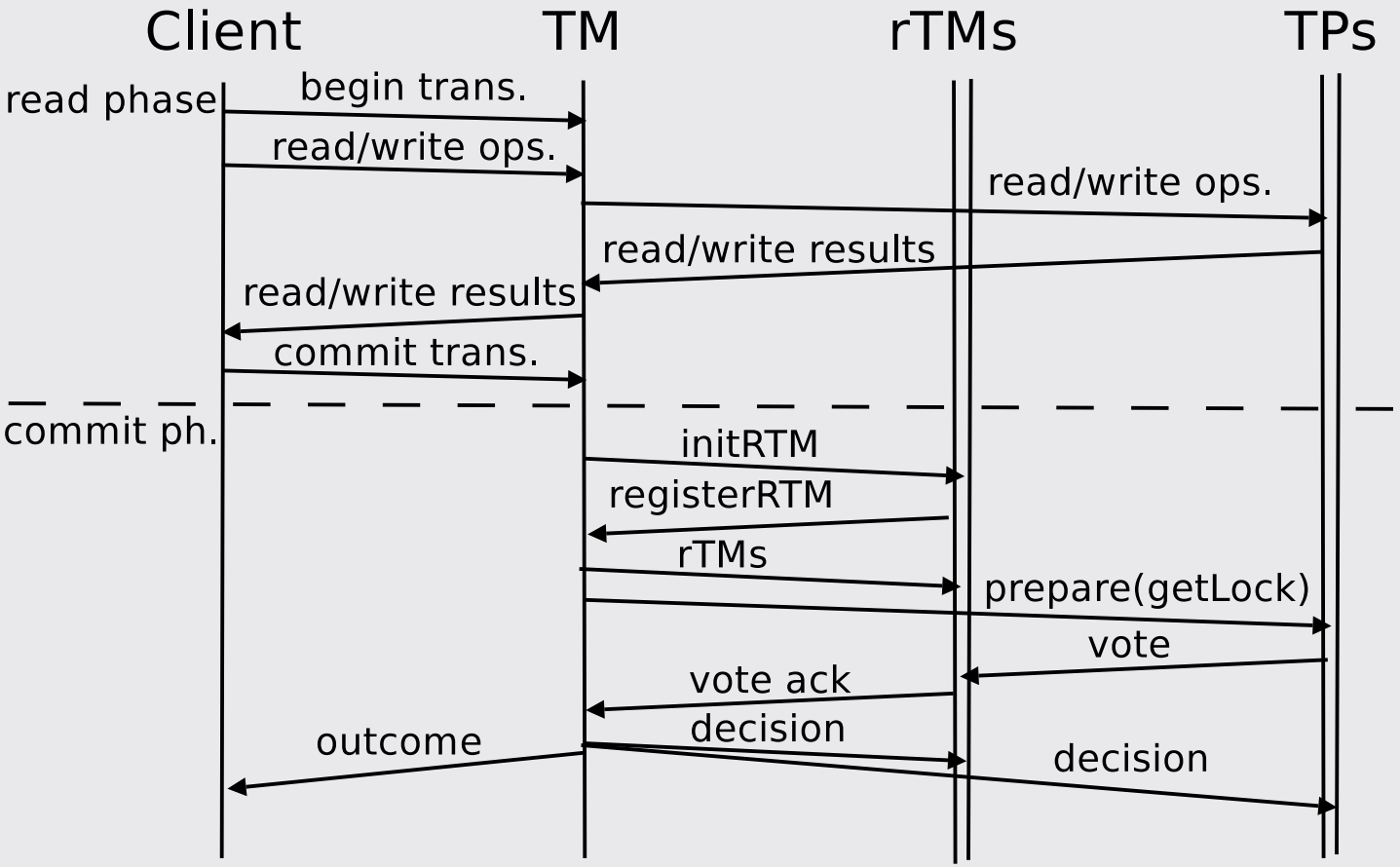


Two-Phase Commit



Atomic Paxos Commit



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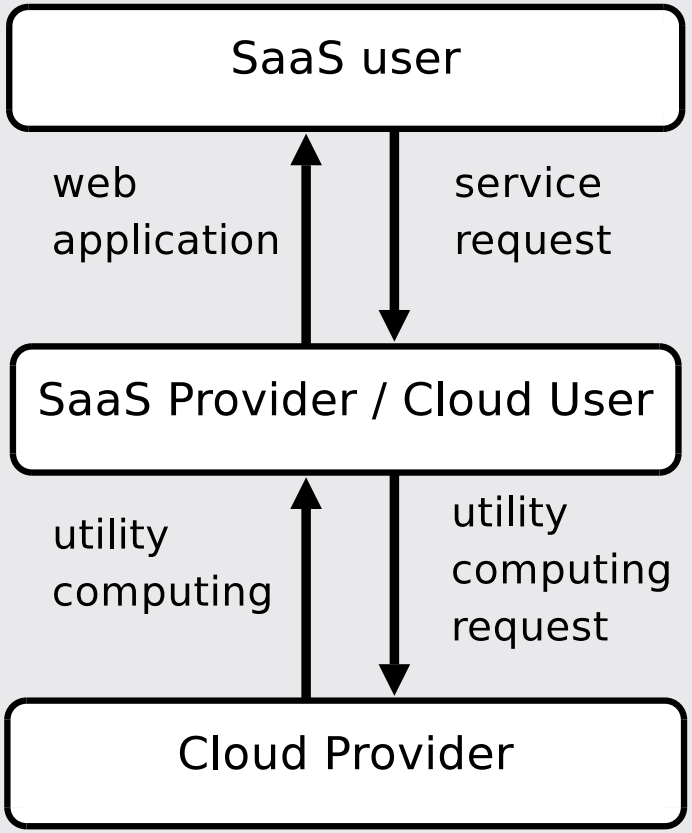
- **Key/value-sets**
  - Relaxes versioning and ordering of elements
    $\Rightarrow$ get rid of locks, better performance and less race conditions.

Applications

A Note on Cloud Computing and Elasticity



Berkeley's view of cloud computing

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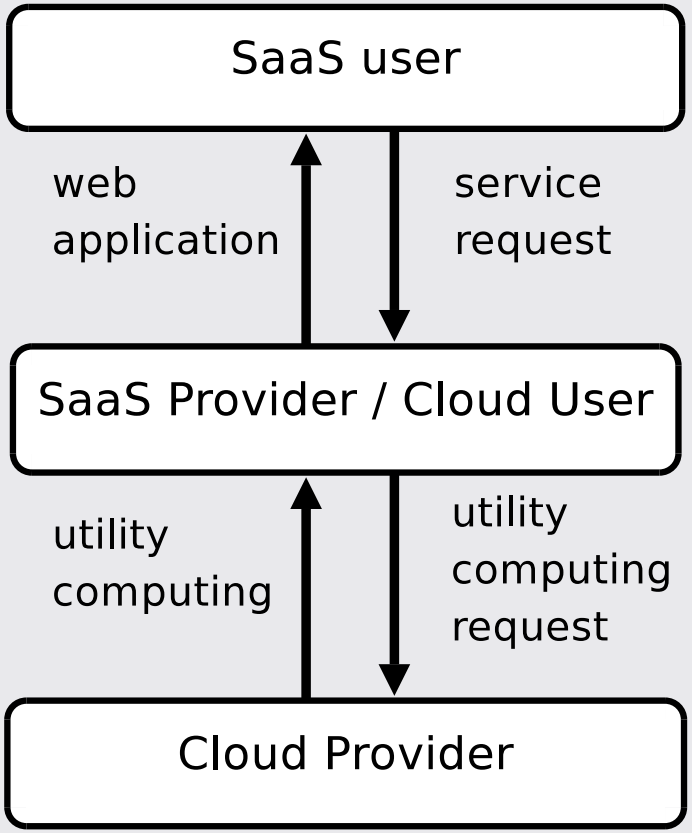

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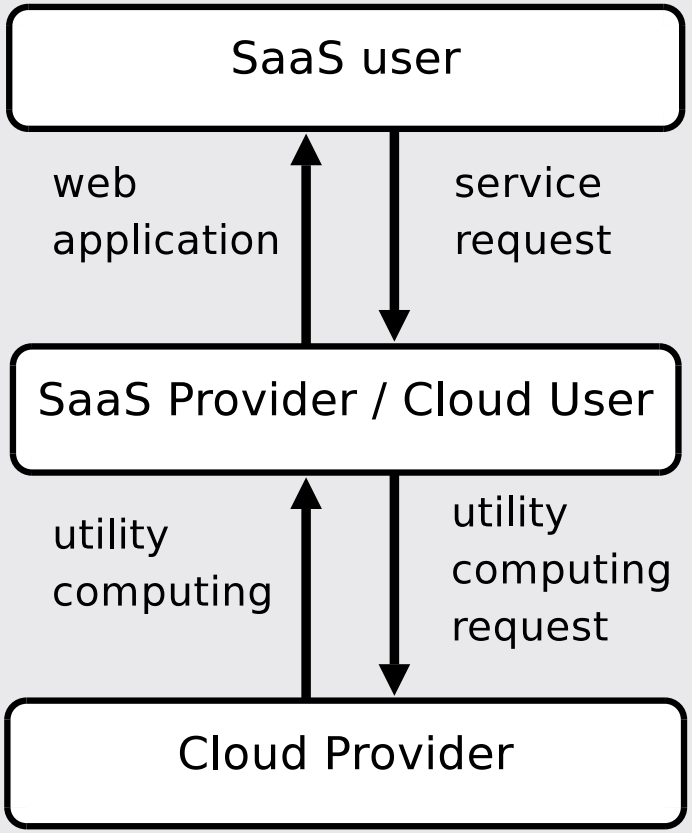
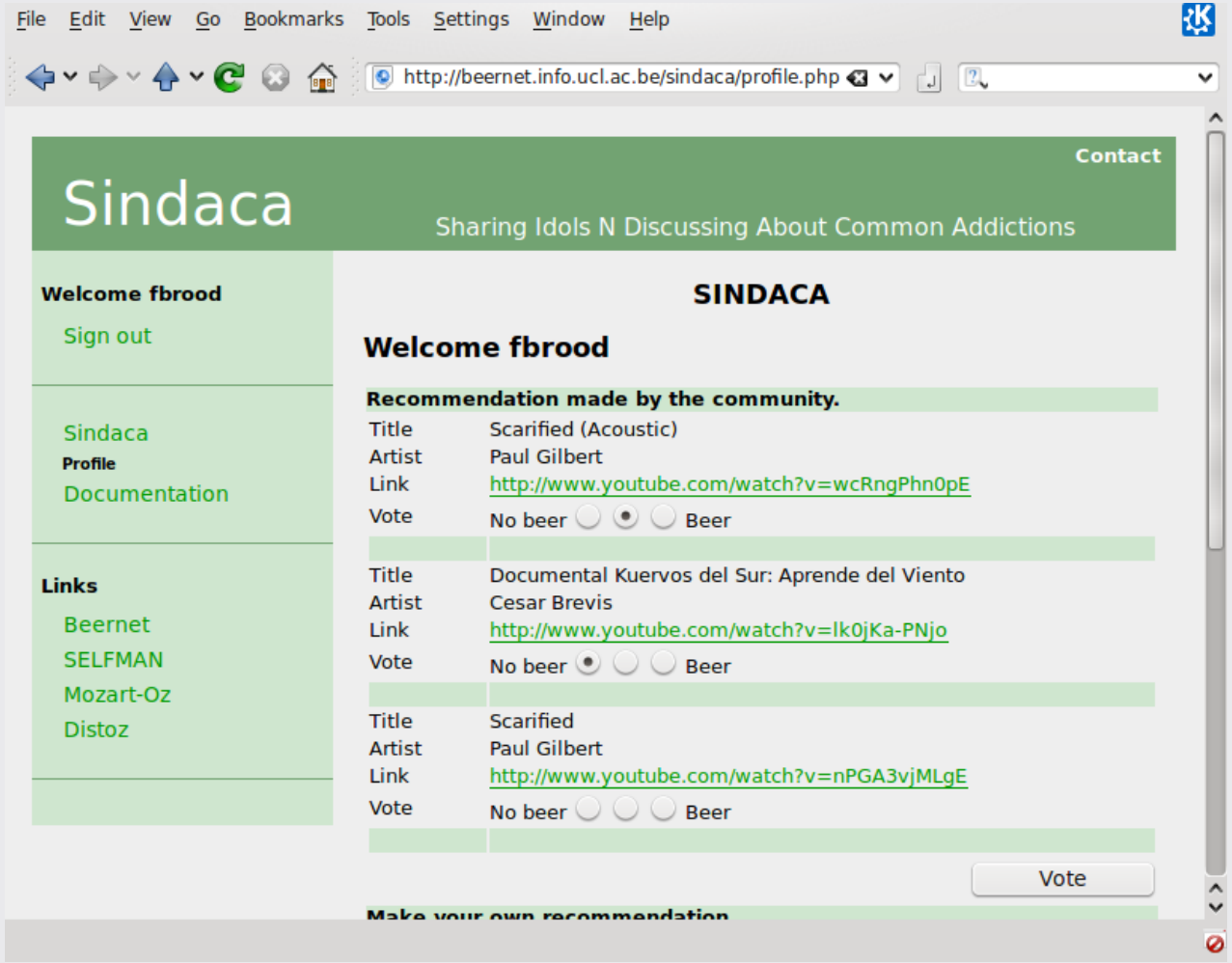


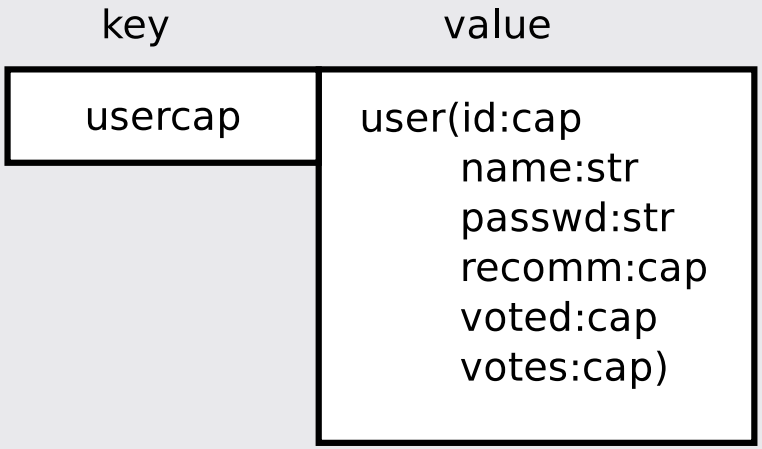
Berkeley's view of cloud computing

- **Elasticity** helps to take advantage of the cloud
- **Scale up** to provide good performance if service request increases (no Twitter's "fail whale")
- **Scale down** to minimize utility computing request

Sindaca - Community driven recommendation system



Sindaca's key/value store



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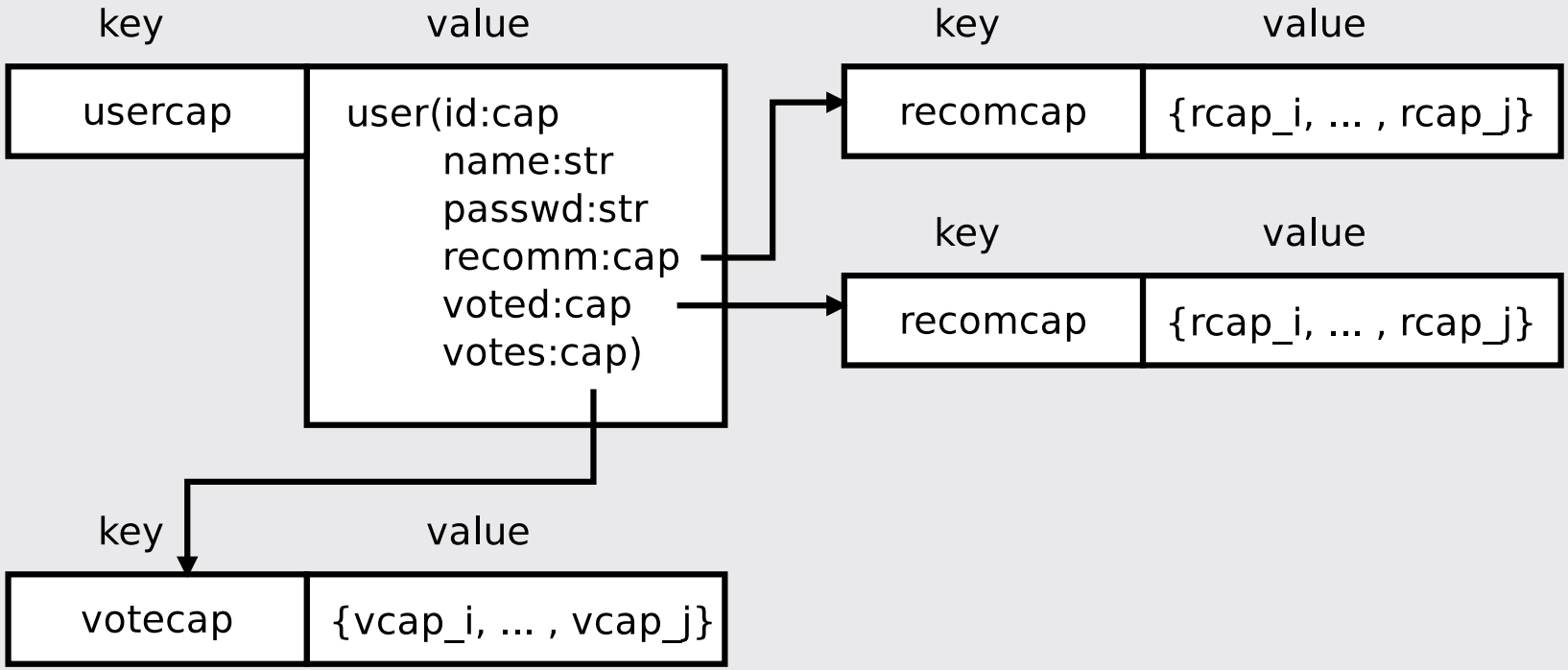

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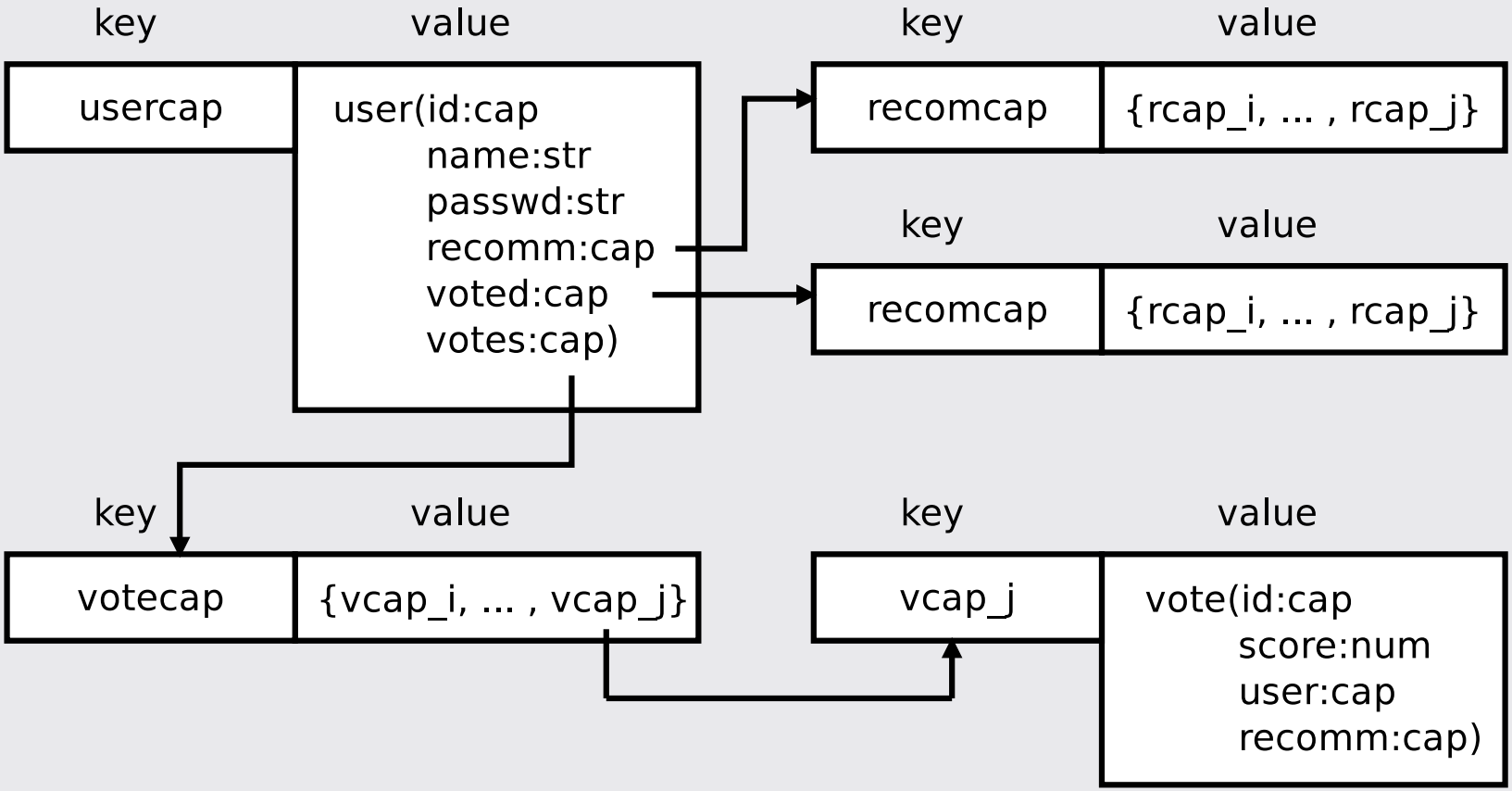


WikipediOz

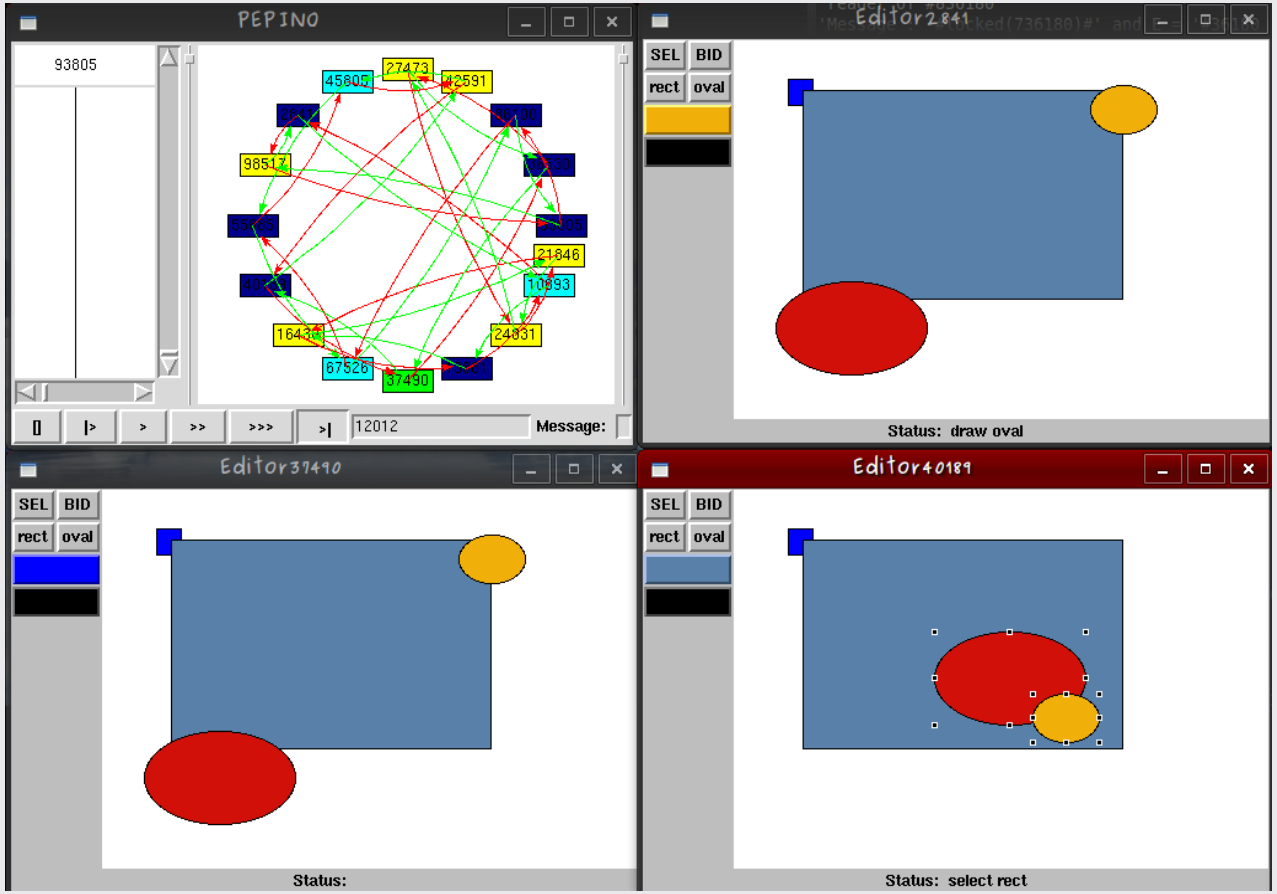
Thanks to Quentin Pirmez and Laurent Pierson

Programming with transactions

```
proc {UpdateArticle ToUpdate ToDelete}
   proc {Trans TM}
      for UpdPar in ToUpdate do
         {TM write(UpdPar.id UpdPar.text)}
      end
      for DelPar in ToDelete do
         {TM remove(DelPar.id)}
      end
      {TM commit}
   end
in
   {PBeer executeTransaction(Trans Client paxos)}
end
```

Thanks to Alexandre Bultot and Laurent Herbin

DeTransDraw - Decentralized Transactional Drawing



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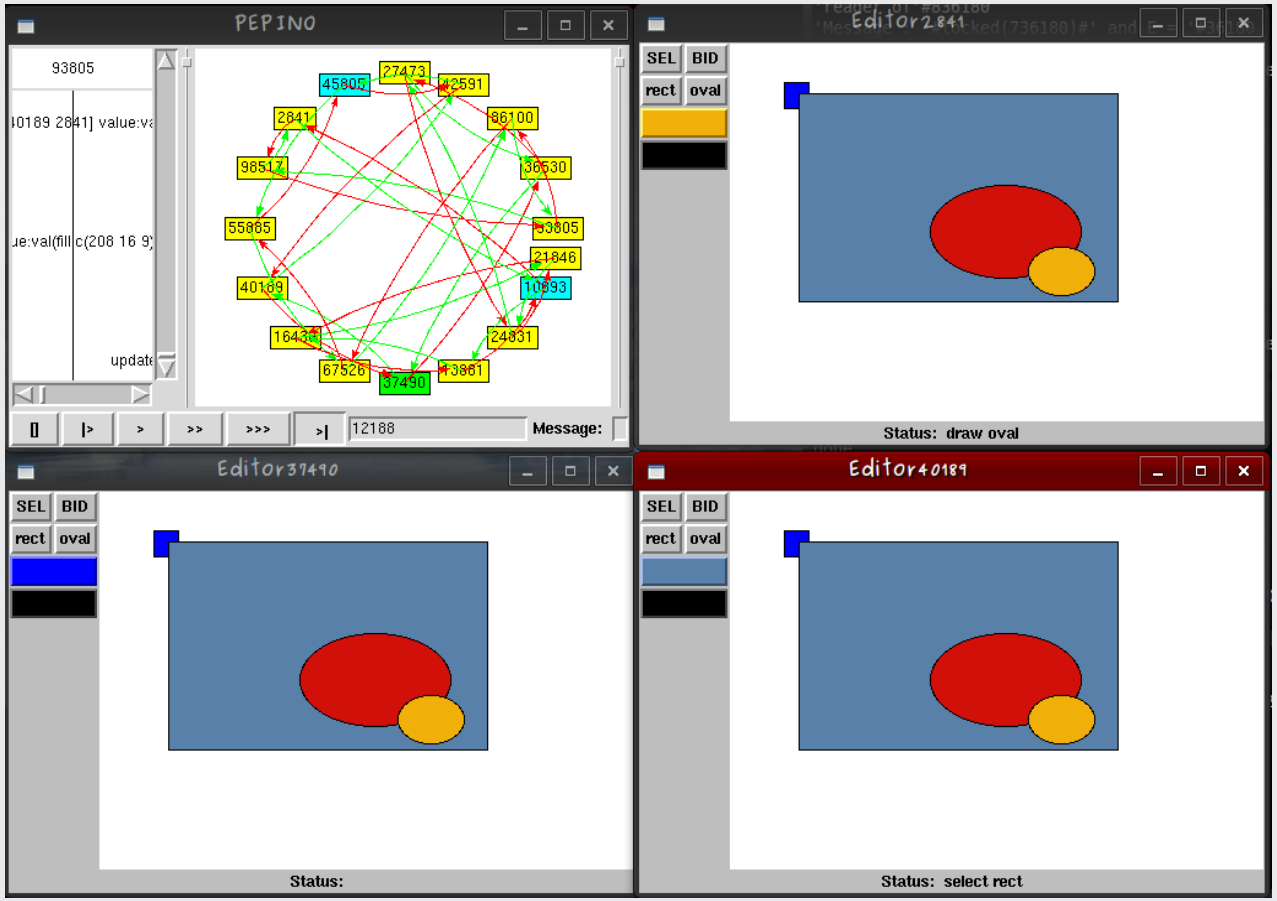

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- **Software**
  - Free/open source software release: Beernet-0.8
  - Several applications

Future Work

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  - Improve semantics and API of storage operations to allow several applications running on the same net
- Further study how peer-to-peer systems can provide elasticity in cloud computing
  - Beer in the Clouds
  - Social Interactions based on Beer(net)

That's it. . .

A beer a day keeps the doctor away

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Relaxing a bit can help to find the way

http://beernet.info.ucl.ac.be