

Gradual Stabilization under τ -Dynamics

Karine Altisen, Stéphane Devismes, **Anaïs Durand**, and Franck Petit

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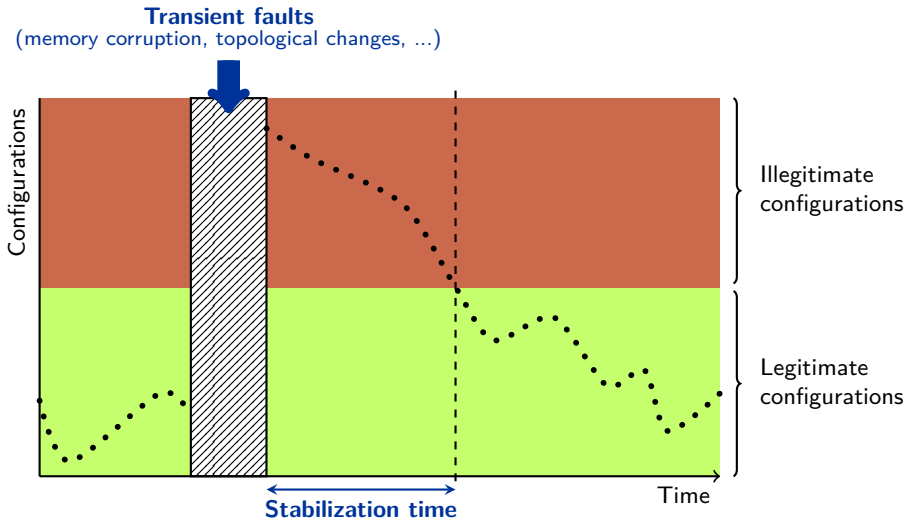


Dynamic asynchronous distributed networks

- Topological changes
- Anonymous network
- Arbitrary topology
- Locally shared memory
- Non-static problems

State of the Art

Self-stabilization [Dijkstra, 74]



- **Lower bounds on stabilization time in arbitrary networks:**
 - ▶ Synchronization problems: $\Omega(\mathcal{D})$ rounds¹ [Awerbuch *et al.*, 93]
 - ▶ Non-static problems: $\Omega(\mathcal{D})$ rounds [Genolini, Tixeuil, 02]
- ⇒ **Depending on global parameters**

¹Time measure according to the speed of the slowest process

■ Lower bounds on stabilization time in arbitrary networks:

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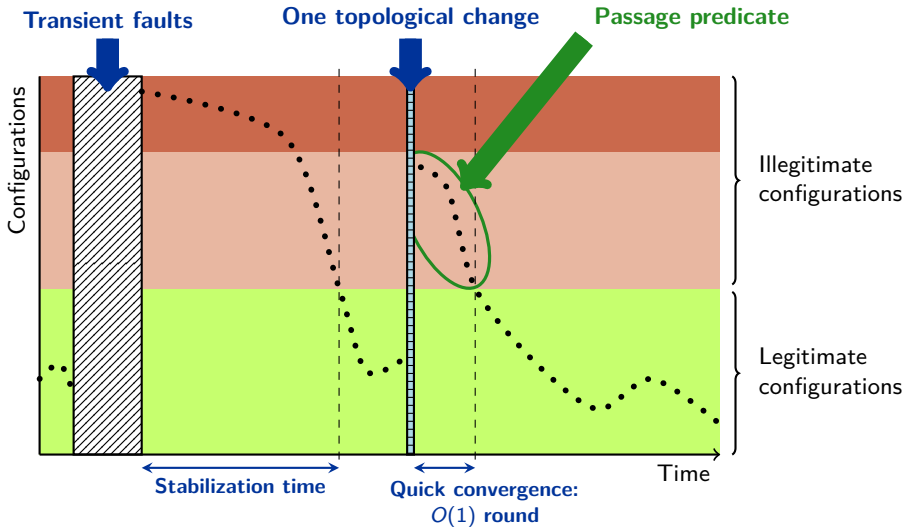
⇒ **Depending on global parameters**

■ Variants of self-stabilization when few faults occur:

- ▶ Time-adaptative self-stabilization [Kutten, Patt-Shamir, 99]
- ▶ Fault-containment [Ghosh *et al.*, 07]
- ▶ Superstabilization [Dolev, Herman, 97]

¹Time measure according to the speed of the slowest process

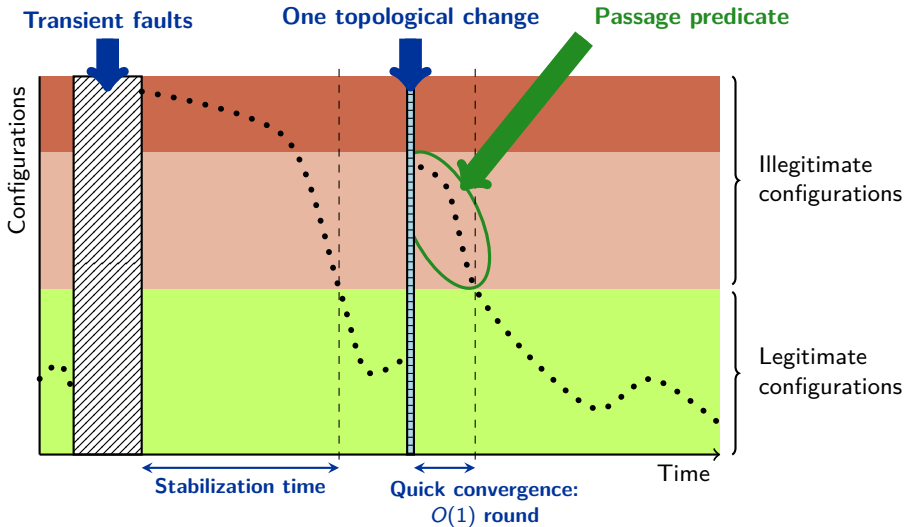
Superstabilization [Dolev, Herman, 97]



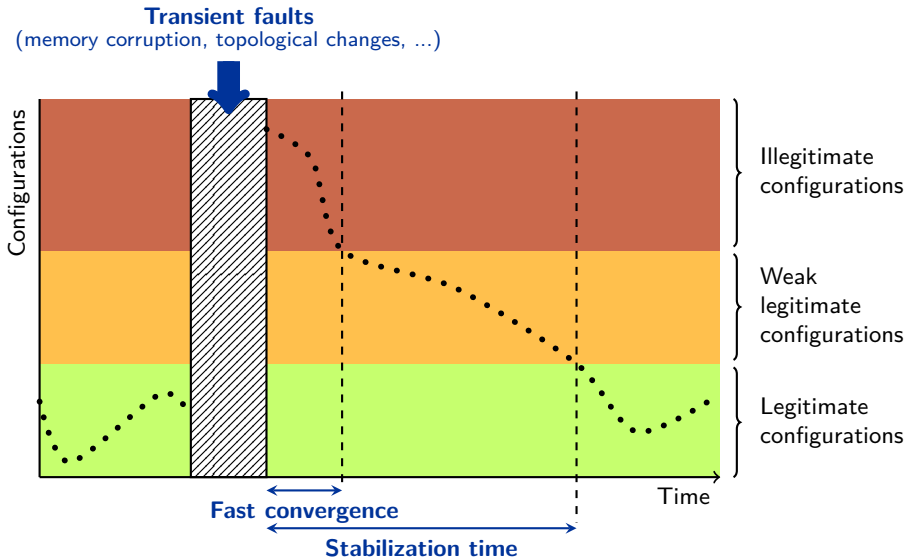
Superstabilization State of the Art

- [Dolev, Herman, 97] Superstabilizing protocols for dynamic distributed systems
 - [Blin *et al.*, 10] Loop-free super-stabilizing spanning tree construction
 - [Blin *et al.*, 13] A super-stabilizing $\log(n)\log(n)$ -approximation for dynamic steiner trees
 - [Herman, 00] Superstabilizing mutual exclusion
 - [Katayama *et al.*, 02] A latency optimal superstabilizing mutual exclusion protocol in unidirectional rings
- } Static problems
- } Particular networks

Superstabilization [Dolev, Herman, 97]



Safe Convergence [Kakugawa, Masuzawa, 06]

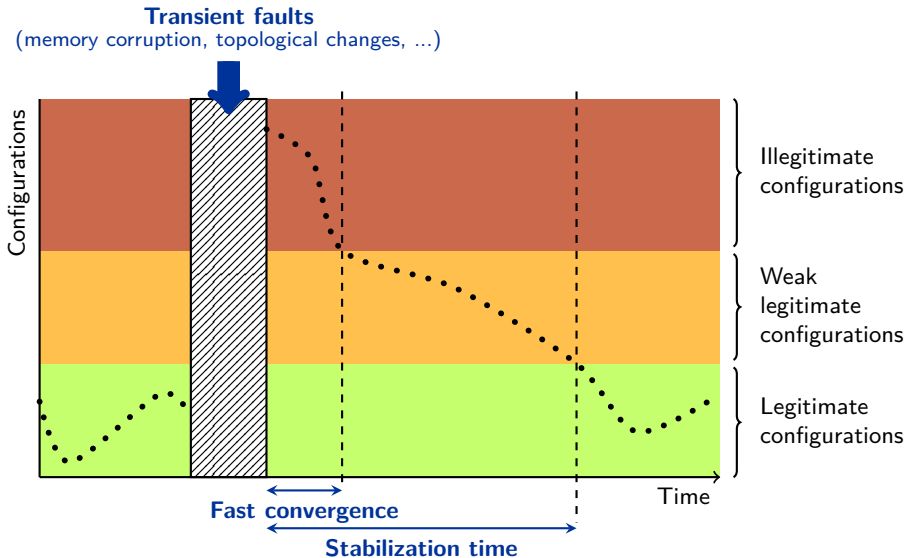


Safe Convergence State of the Art

- **[Kakugawa, Masuzawa, 06]** A self-stabilizing minimal dominating set algorithm with safe convergence
- **[Kamei *et al.*, 13]** An asynchronous self-stabilizing approximation for the minimum connected dominating set with safe convergence in unit disk graphs
- **[Kamei, Kakugawa, 12]** A self-stabilizing δ -approximation for the minimum connected dominating set with safe convergence in unit disk graphs
- **[Carrier *et al.*, 15]** Self-stabilizing (f, g) -alliances with safe convergence

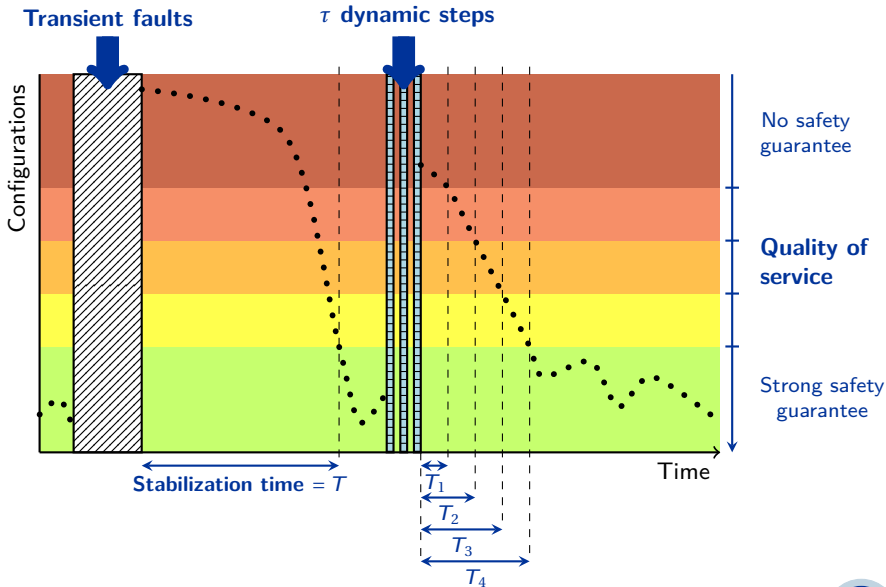
} Static
problems

Safe Convergence [Kakugawa, Masuzawa, 06]



Gradual Stabilization under τ -dynamics

Gradual Stabilization under τ -dynamics [Altisen *et al.*, 16]



Case Study: Unison

$$clock \in \{0, \dots, \alpha - 1\}$$

Liveness:

Clocks incremented infinitely often

Safety:

Case Study: Unison

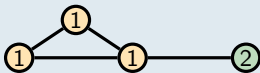
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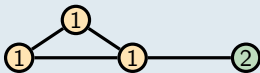
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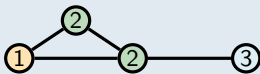
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■ **Strong unison:**



■ **(Weak) unison:**



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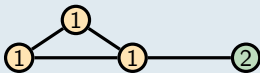
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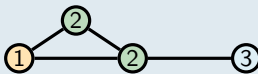
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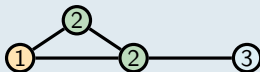
■ **Strong unison:**



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■ **Partial unison:**



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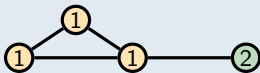
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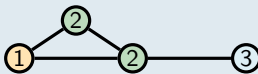
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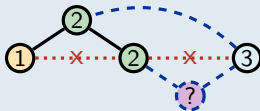
■ Strong unison:



■ (Weak) unison:



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Case Study: Unison

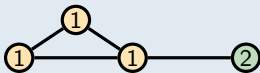
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Liveness:

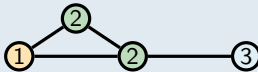
Clocks incremented infinitely often

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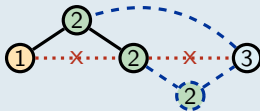
■ Strong unison:



■ (Weak) unison:

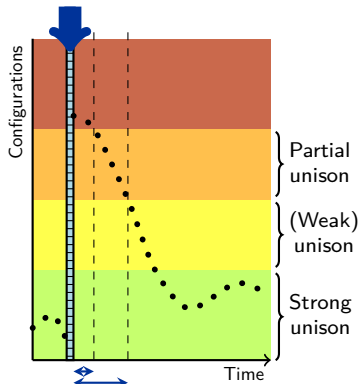


■ Partial unison:



Objectives:

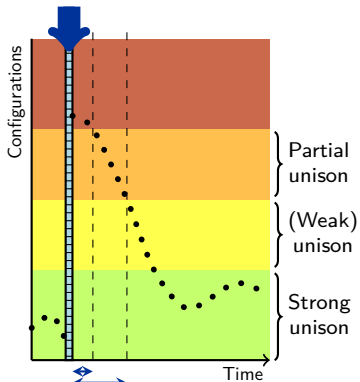
1 (atomic) dynamic step: $\tau = 1$



Fastest convergences

Objectives:

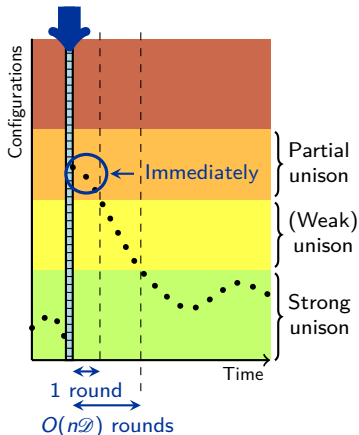
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Fastest convergences

Our algorithm:

1 (atomic) dynamic step: $\tau = 1$



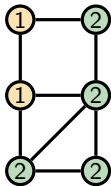
Dynamic Step Hypotheses

- 1 Network remains **connected**
- 2 If $\alpha > 4$, new processes are **under local control**:

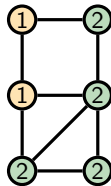
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Under Local Control



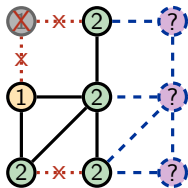
~~**Under Local Control**~~



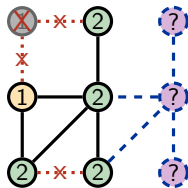
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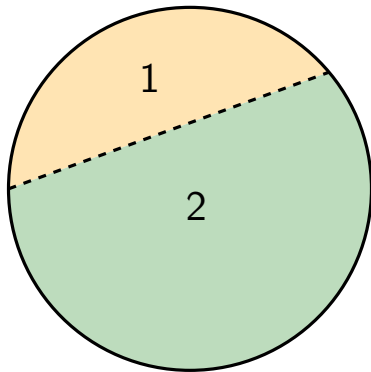
To ensure gradual stabilization under 1-dynamics

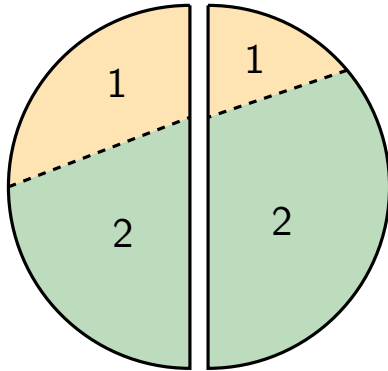
Immediately: Partial unison

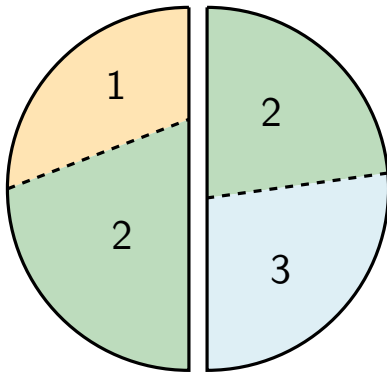
1 round 
(Weak) unison

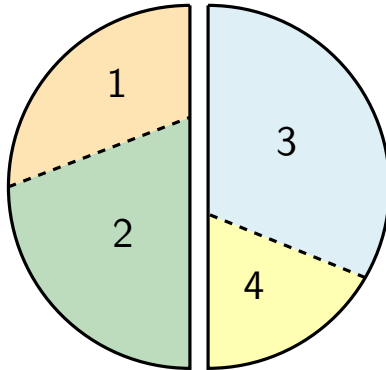

Strong unison

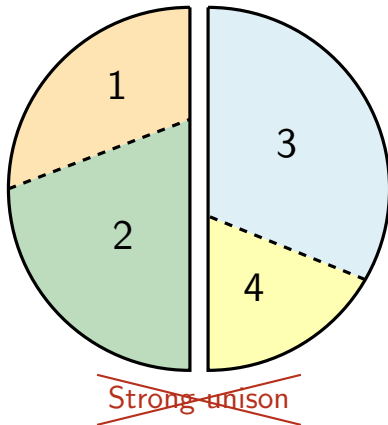
is it necessary that the dynamic step ensures
Connected and **Under Local Control** ?



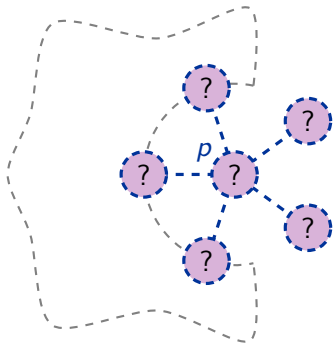




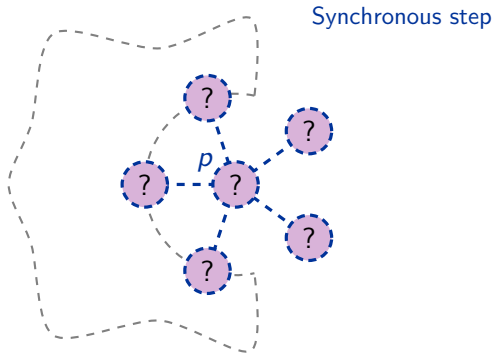




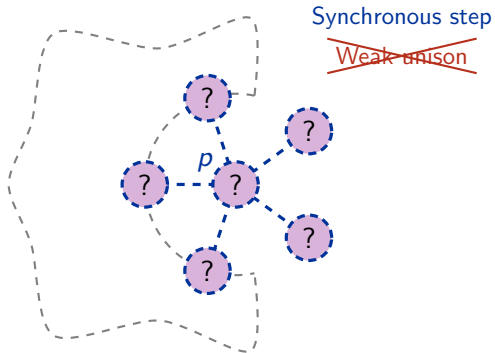
Under Local Control



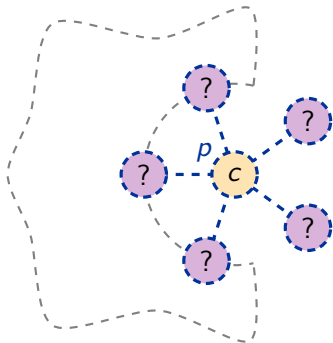
Under Local Control

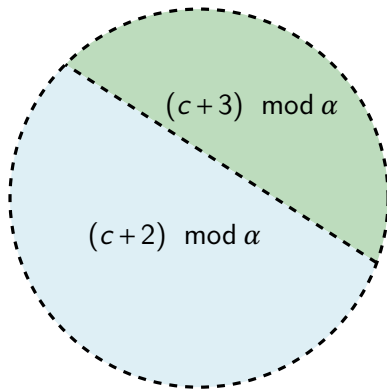


Under Local Control

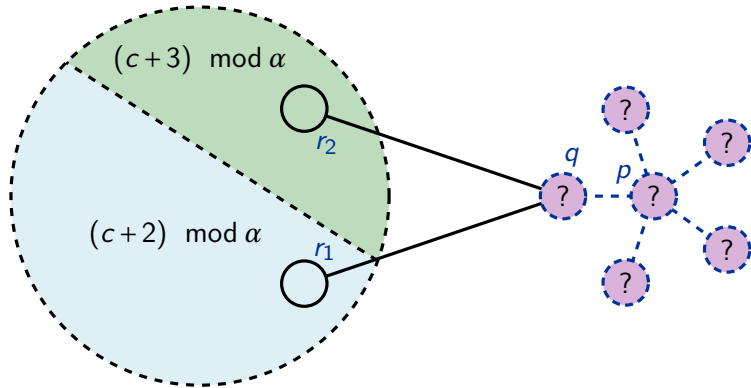


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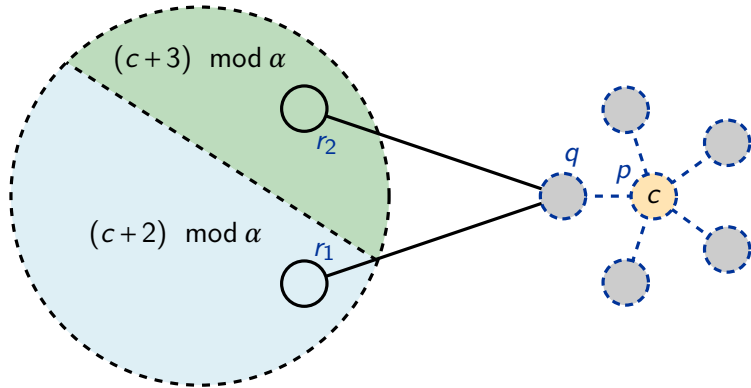




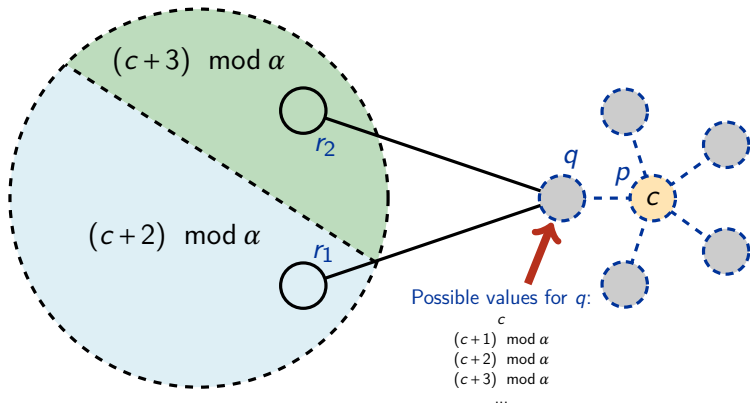
Under Local Control



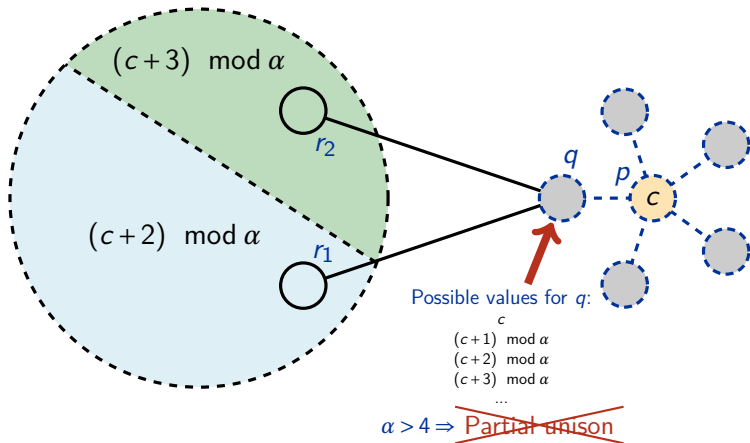
Under Local Control



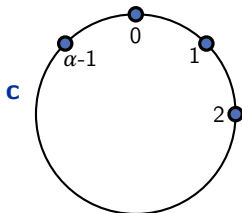
Under Local Control



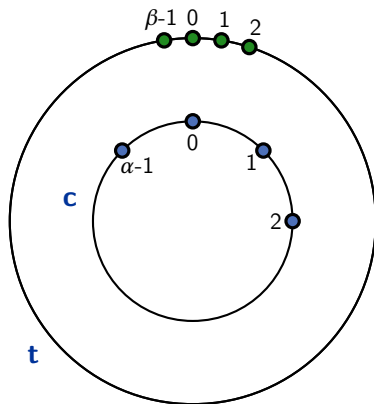
Under Local Control



Algorithm

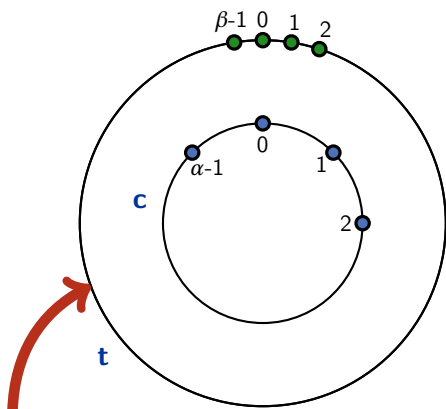


Algorithm [Altisen *et al.*, 16]



t computed using [Boulinier, 07] (Generalization of [Couvreur *et al.*, 92])

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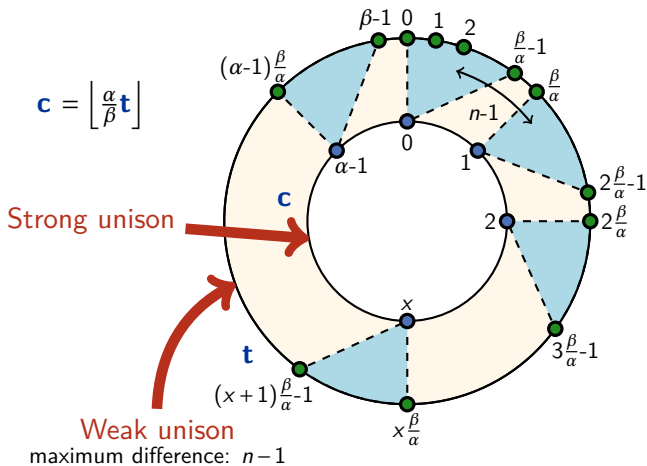


Weak unison

maximum difference: $n-1$

t computed using [Boulinier, 07] (Generalization of [Couvreur *et al.*, 92])

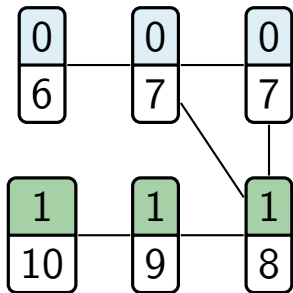
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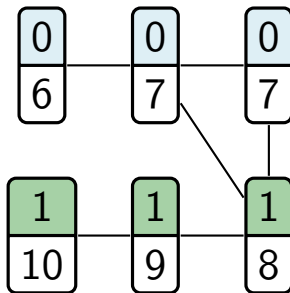
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Management of Topological Changes (1/3)

Removal of Links or Nodes

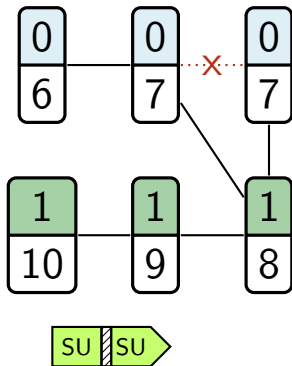


Addition of Links

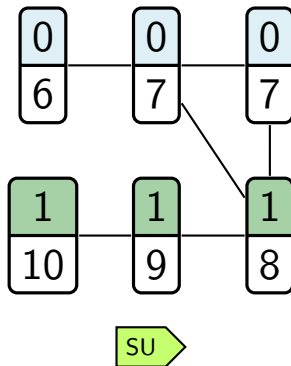


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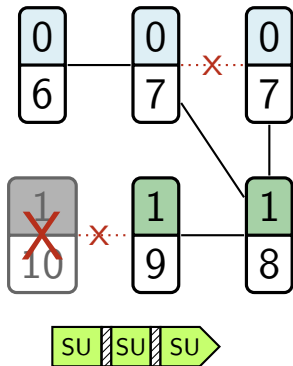


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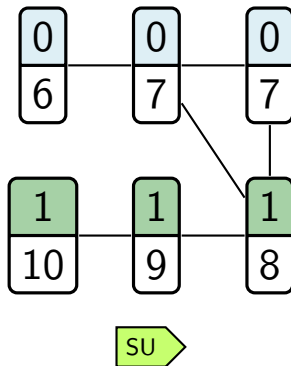


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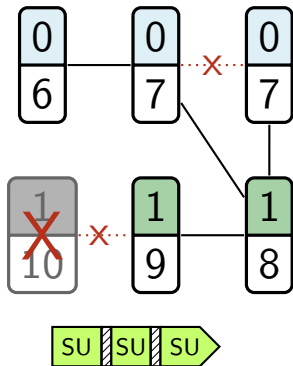


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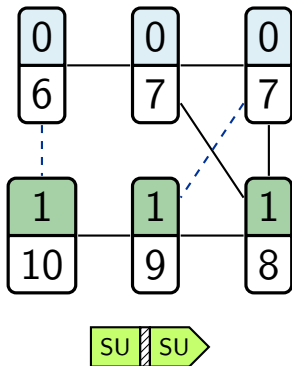


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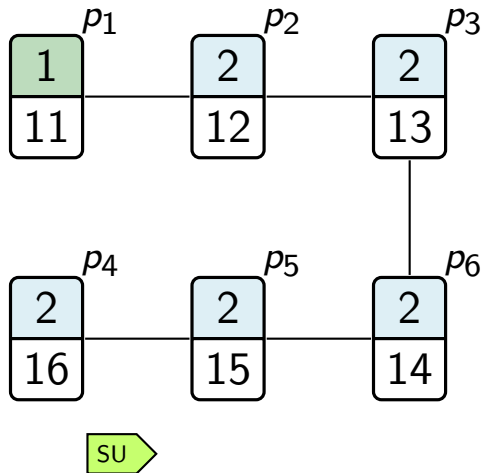


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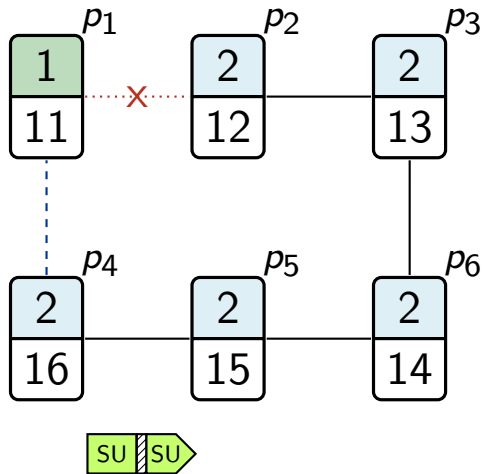
Management of Topological Changes (2/3)

Addition and Removal of Links



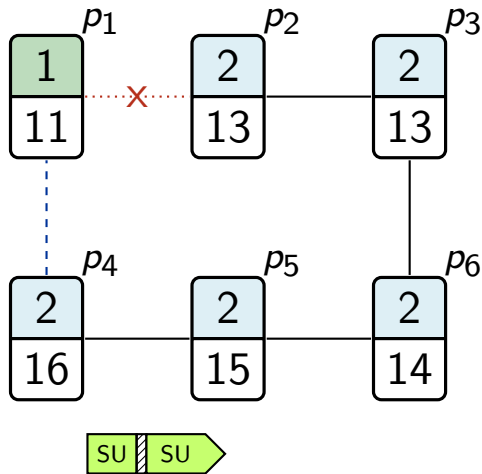
Management of Topological Changes (2/3)

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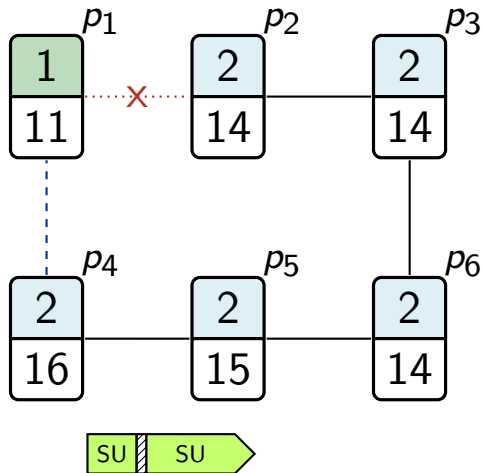
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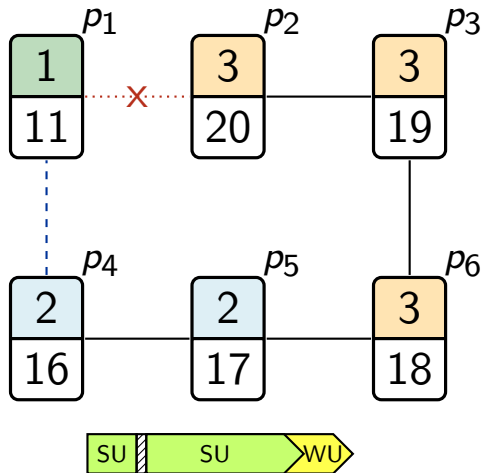
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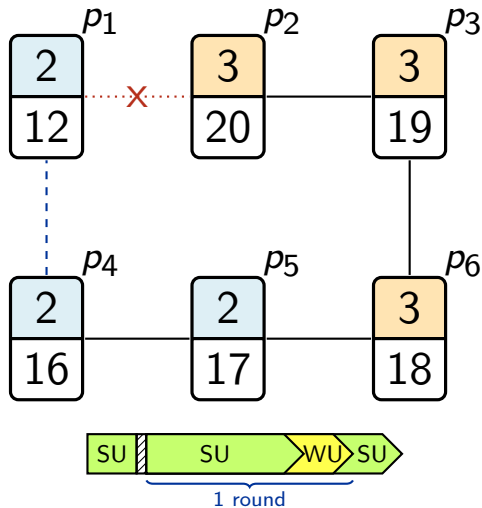
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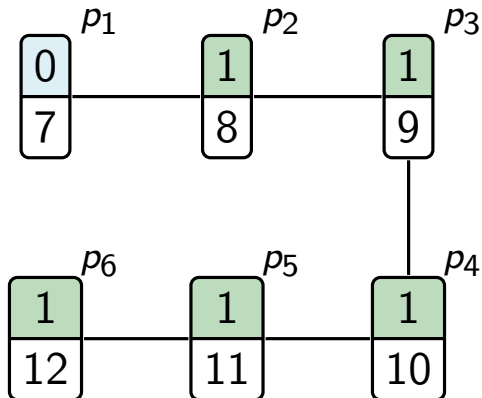
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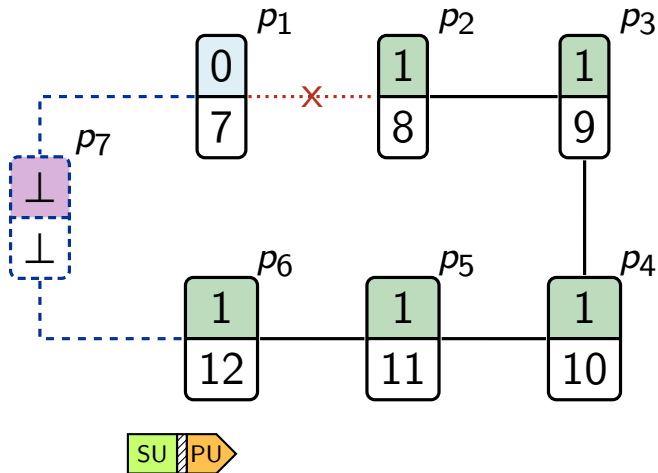
Management of Topological Changes (3/3)

Addition of Nodes



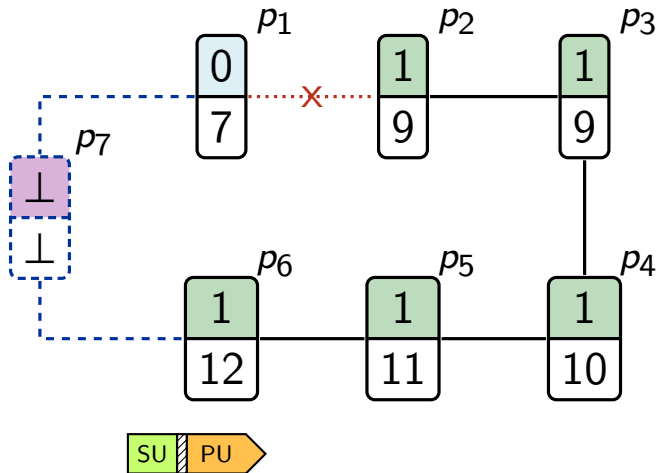
Management of Topological Changes (3/3)

Addition of Nodes



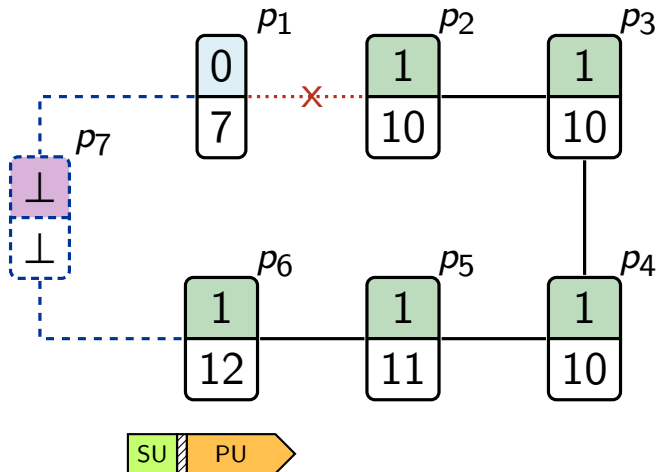
Management of Topological Changes (3/3)

Addition of Nodes



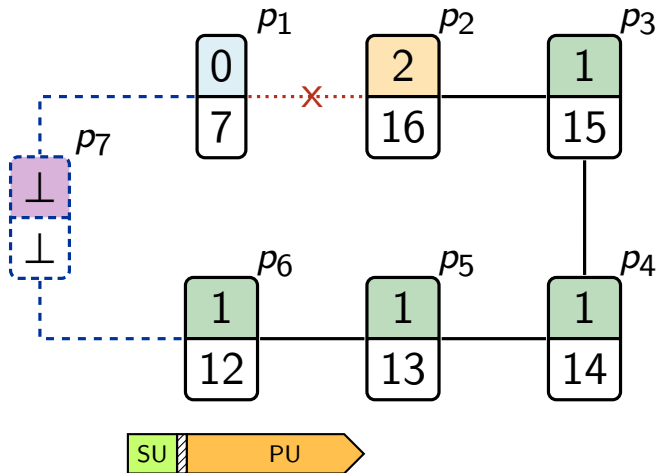
Management of Topological Changes (3/3)

Addition of Nodes



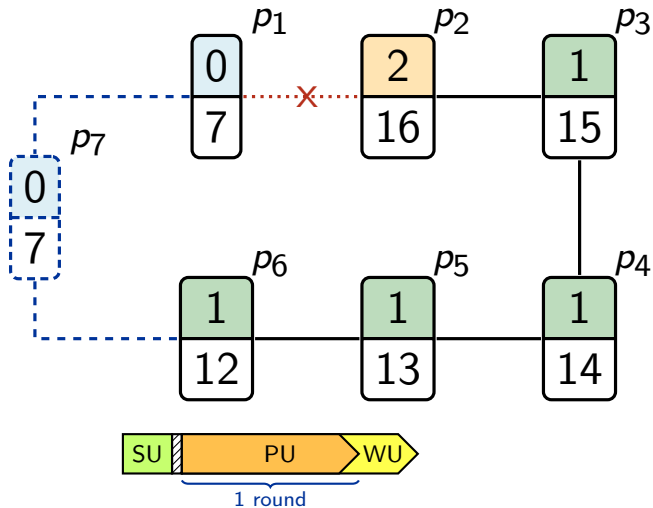
Management of Topological Changes (3/3)

Addition of Nodes



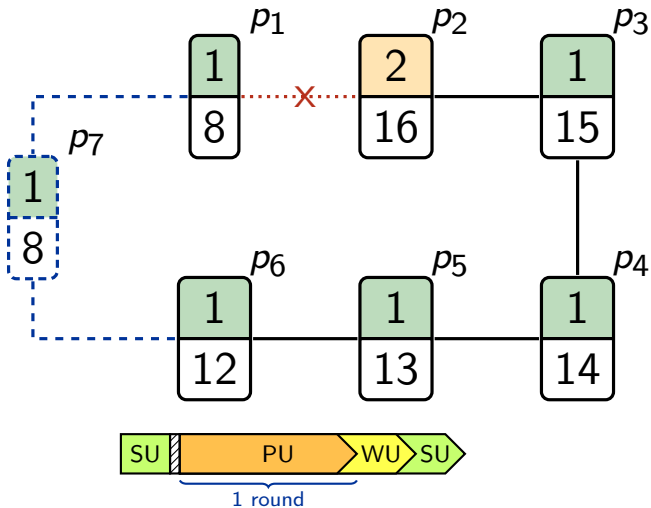
Management of Topological Changes (3/3)

Addition of Nodes



Management of Topological Changes (3/3)

Addition of Nodes



Contributions

- Definition of **gradual stabilization under τ -dynamics**
- Gradually stabilizing algorithm under 1-dynamics for unison:
If connected and under local control (**necessary condition**):
 - ▶ **Immediately**: partial unison
 - ▶ **1 round**: weak unison
 - ▶ **$O(n\mathcal{D})$ rounds**: strong unison

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Future Work

- Gradually stabilizing algorithm under τ -dynamics for unison with $\tau > 1$
- Other non-static problems

Thank you for your attention.



Do you have any questions ?