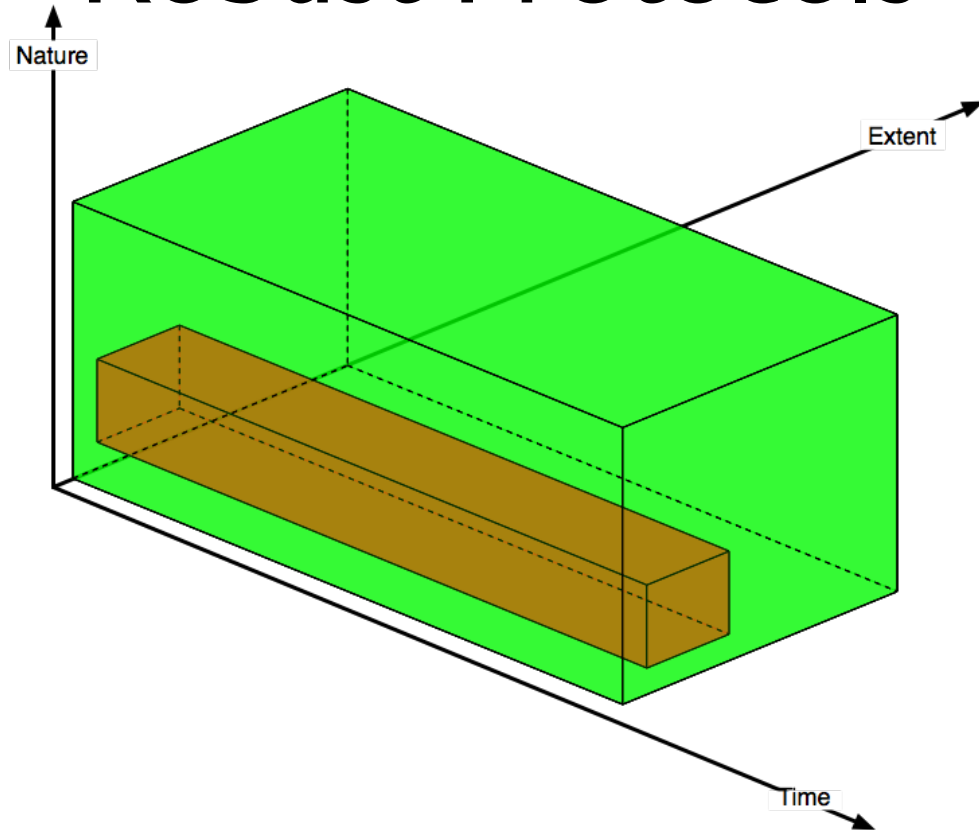


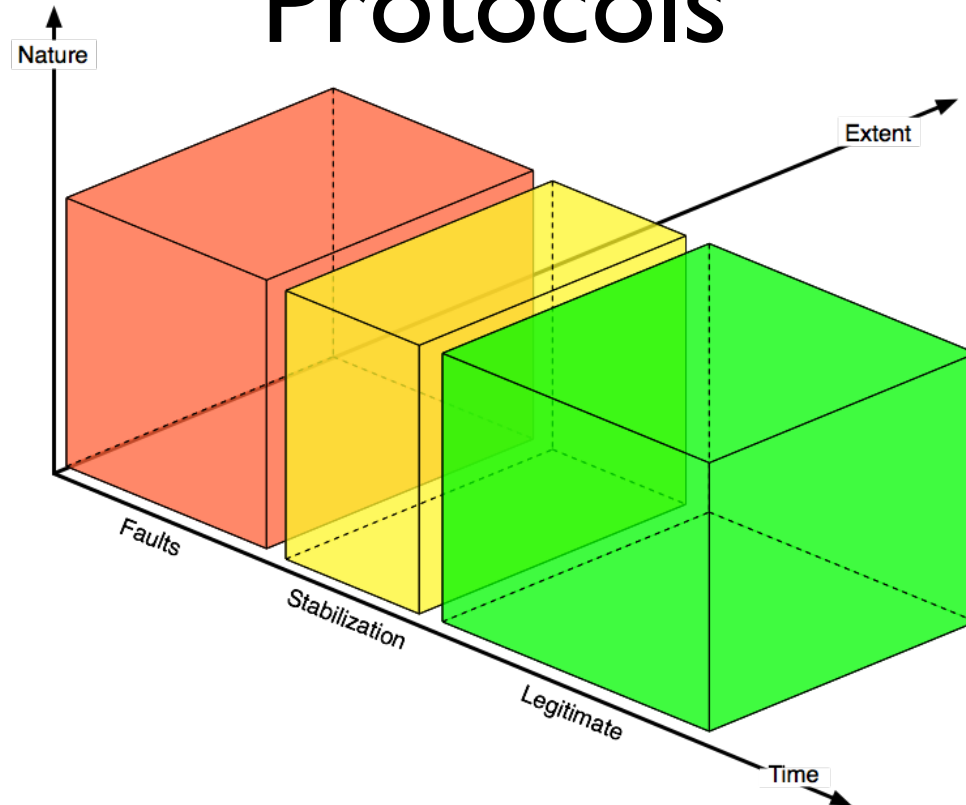
Snap-stabilization

Franck Petit

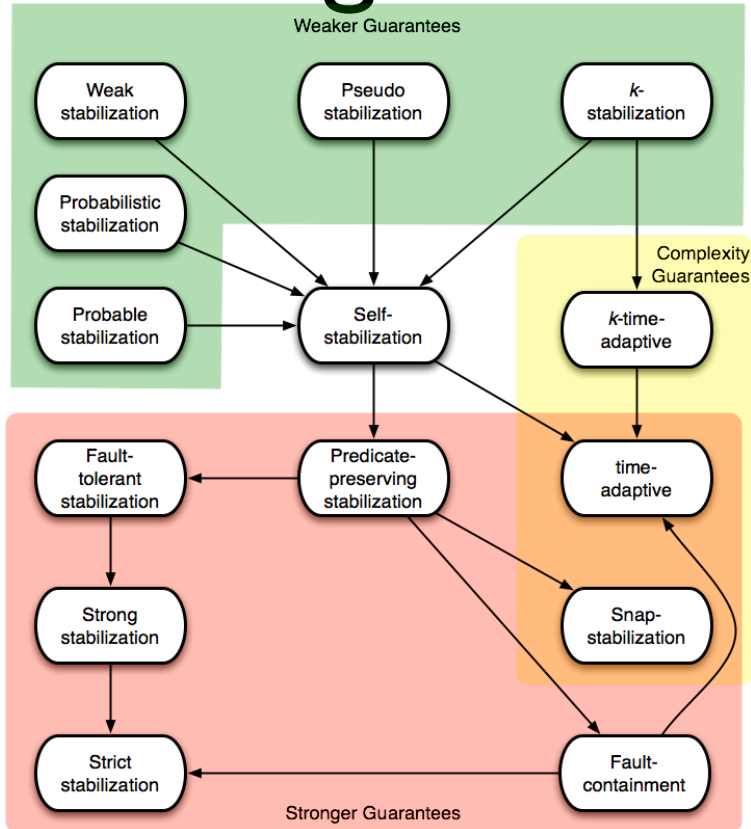
Robust Protocols



Self-stabilizing Protocols



The Big Picture

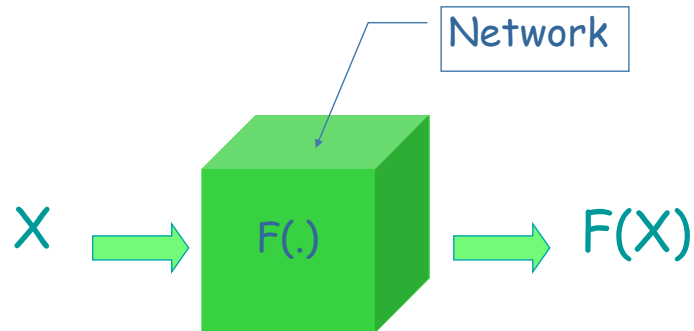


Snap-Stabilization

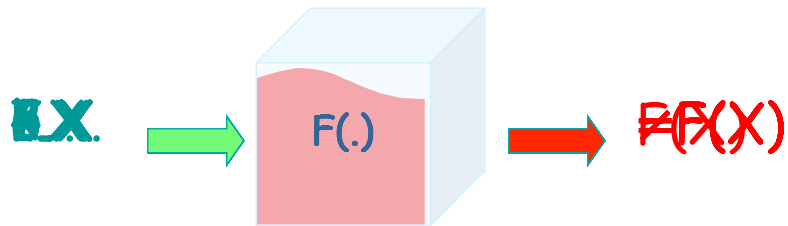
Snap-Stabilization

- **Specification**
- **Self-stabilization:** Starting from **any** initial configuration, the system **eventually** reaches a configuration from which its behavior is correct
- **Snap-stabilization:** Starting from **any** initial configuration, the system **always** behaves as its specification

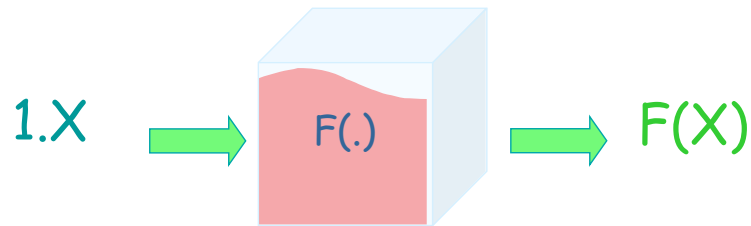
Non Self-*



Self-stabilization



Snap-stabilization



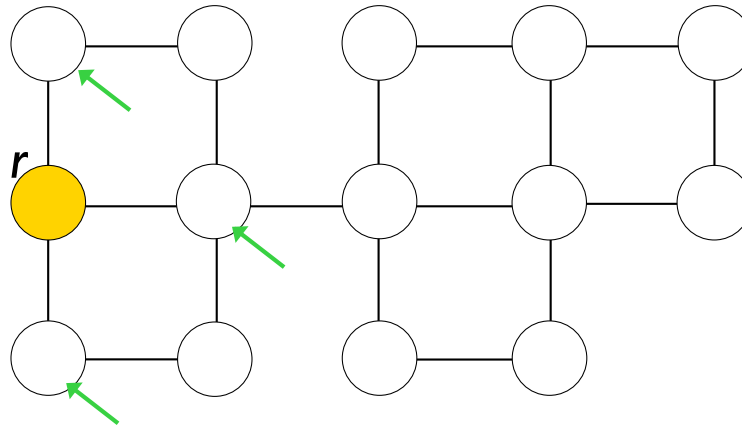
Related Works

- *Bui, Datta, Petit, Villain. State-optimal snap-stabilizing PIF in tree networks. WSS 1999.*
- *Cournier, Datta, Petit, Villain. Enabling snap-stabilization. SSS 2003.*
- *Cournier, Devismes, Villain. From Self- to Snap- Stabilization. SSS 2006.*
- *Bui, Datta, Petit, Villain. Snap-stabilization and PIF in tree networks. Distributed Computing 2007.*

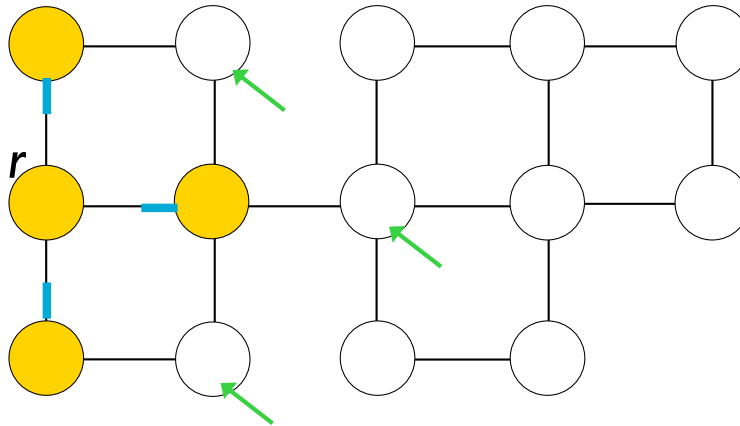
PIF

- Propagation of Information with Feedback
- **Distributed-Control Problems**
- Broadcast, Routing, Synchronization, Protocol, Leader Election, Resource Sharing and Allocation, Graph Algorithms, Termination Detection, Deadlock Detection, Reset, Distributed Ranking, Distributed Sorting...

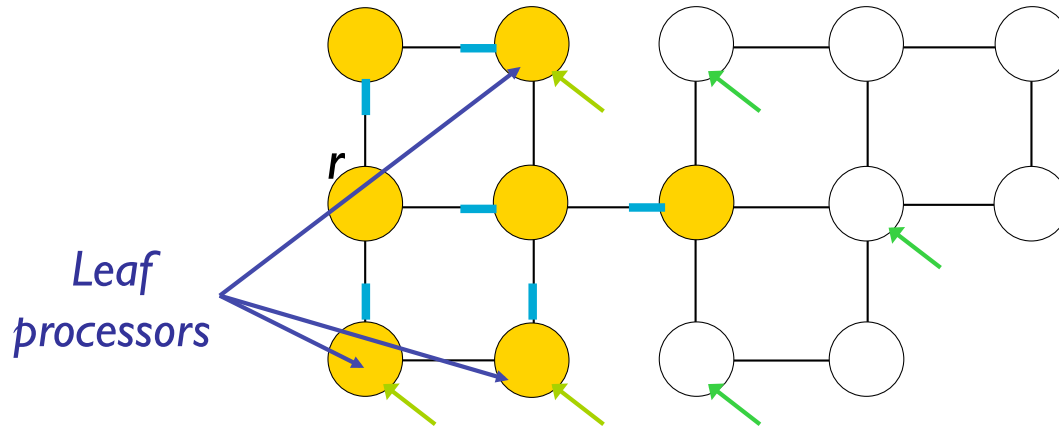
Propagation of Information with Feedback



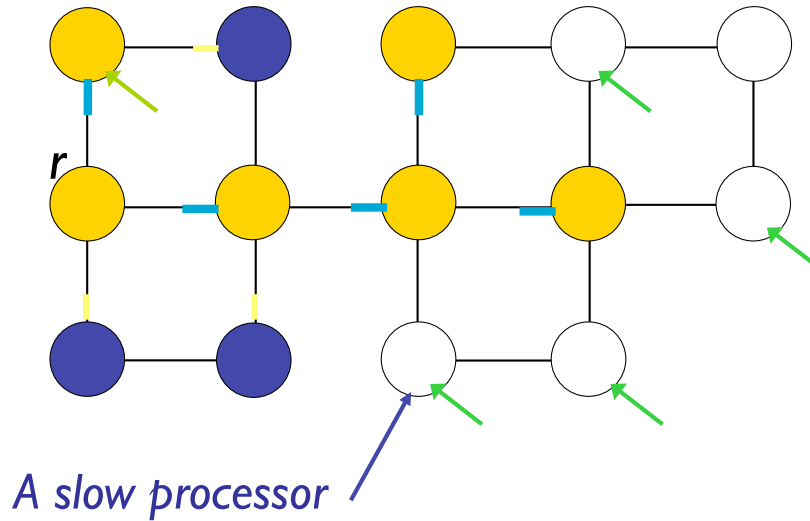
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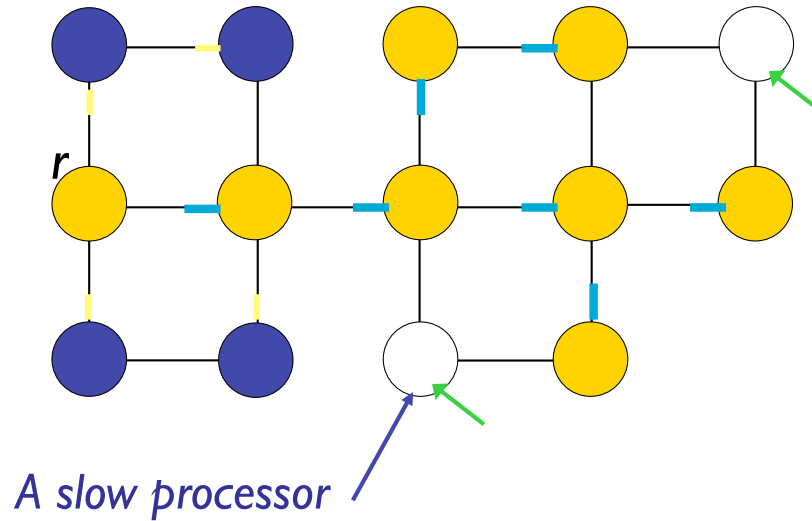
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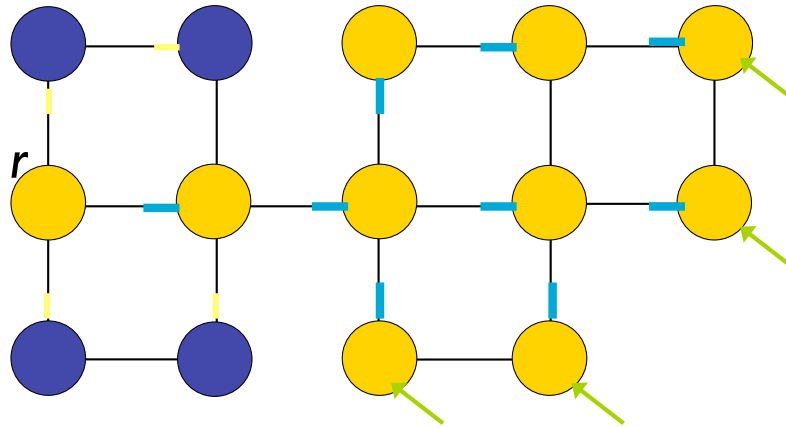
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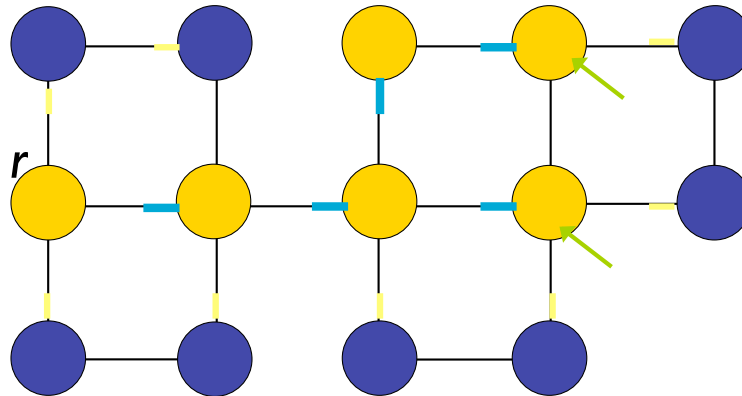
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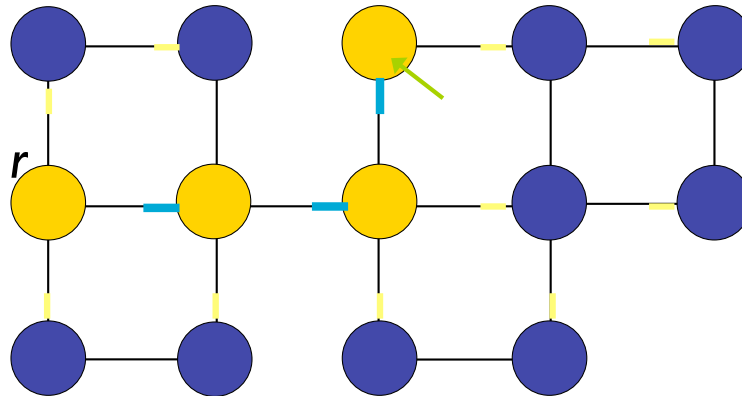
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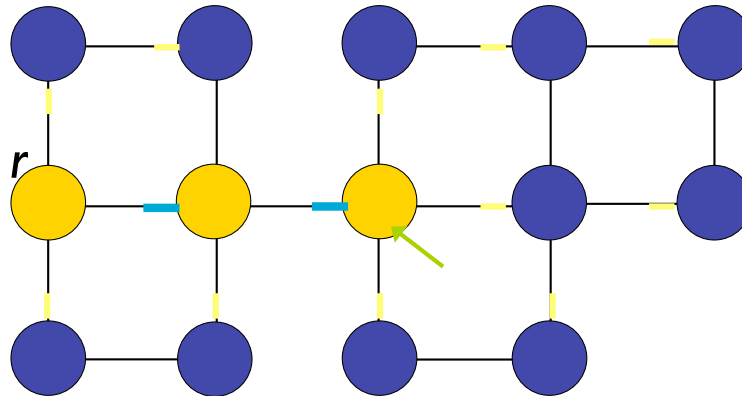
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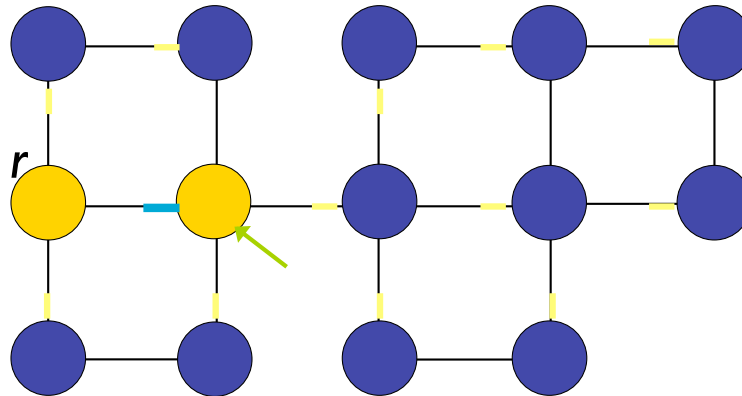
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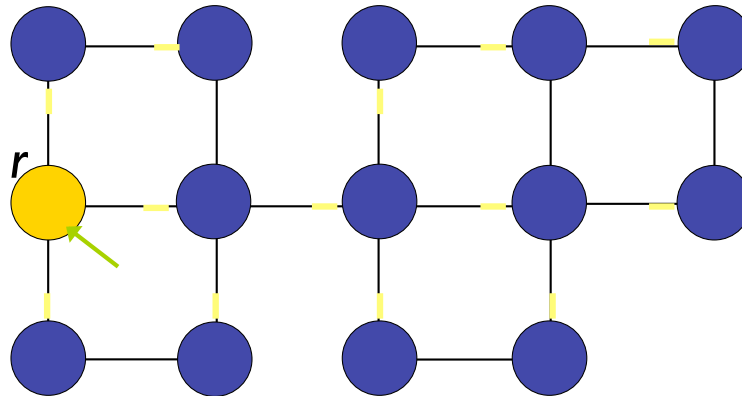
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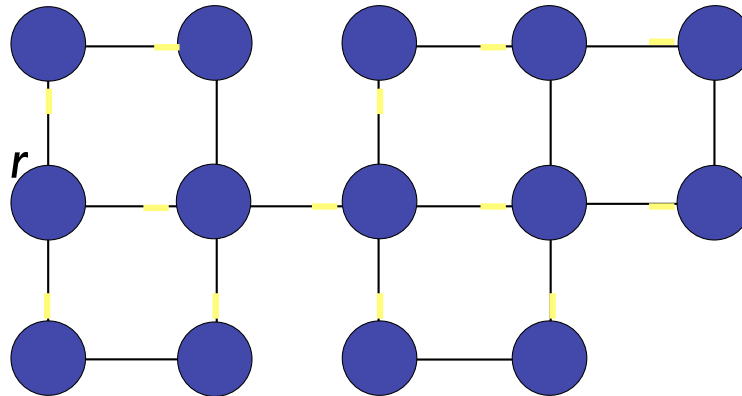
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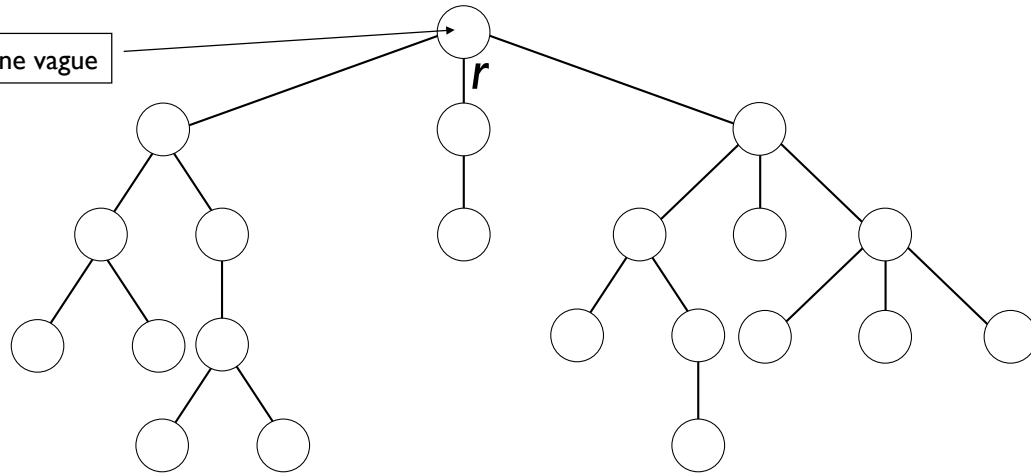


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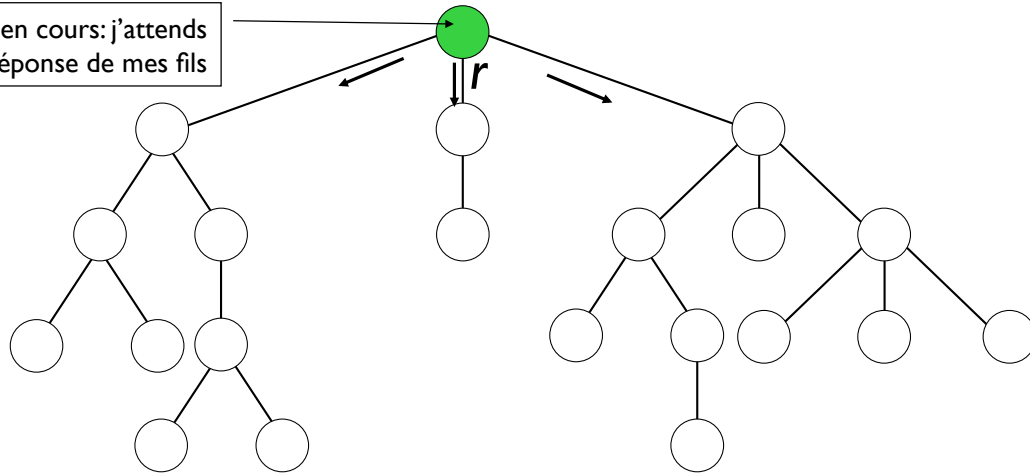
PIF sur l'arbre

Je lance une vague

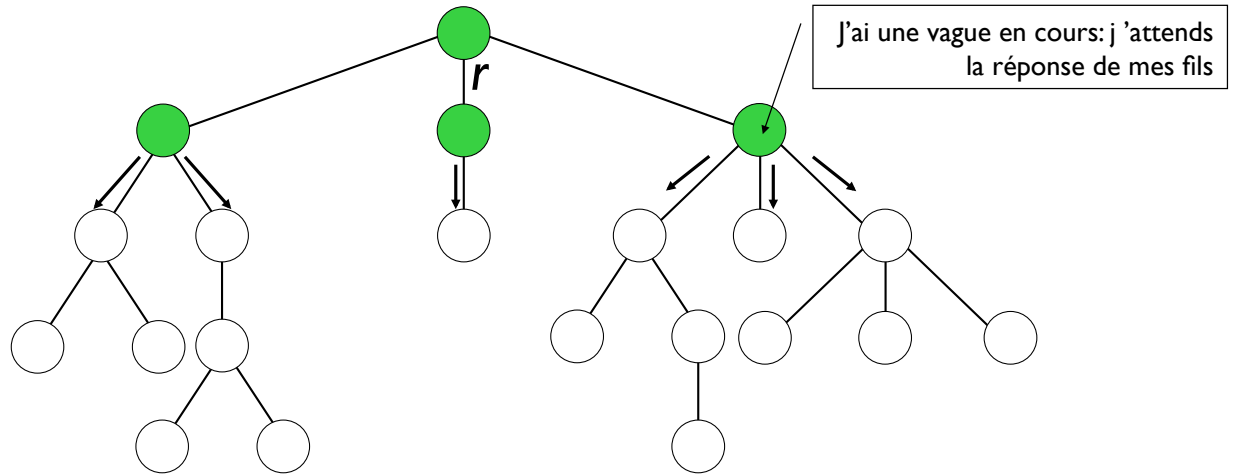


PIF sur l'arbre

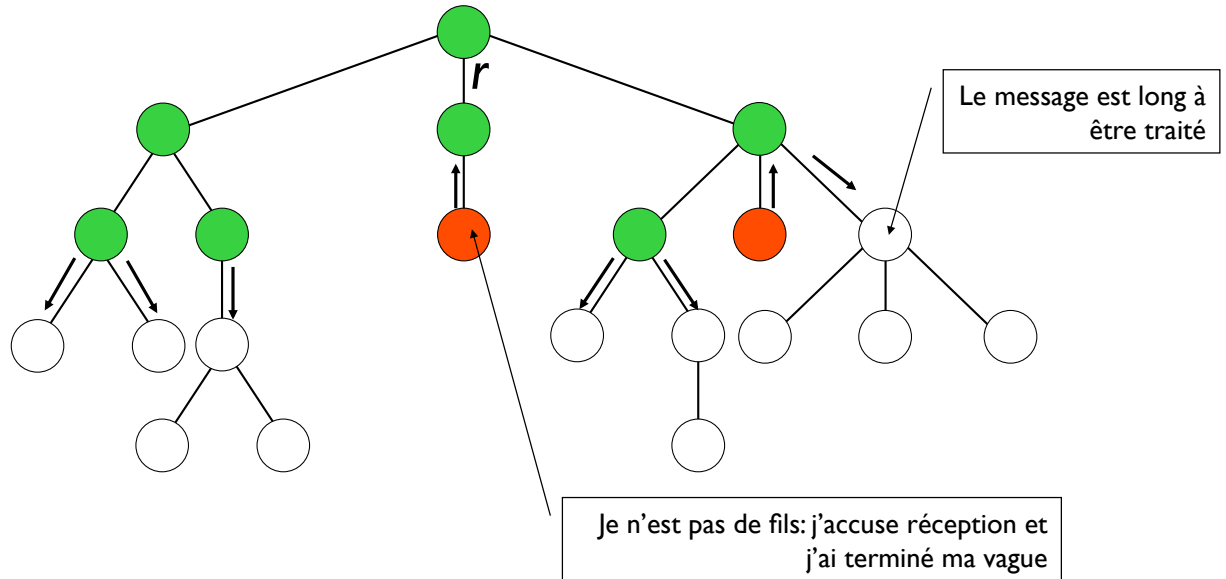
J'ai une vague en cours: j'attends la réponse de mes fils



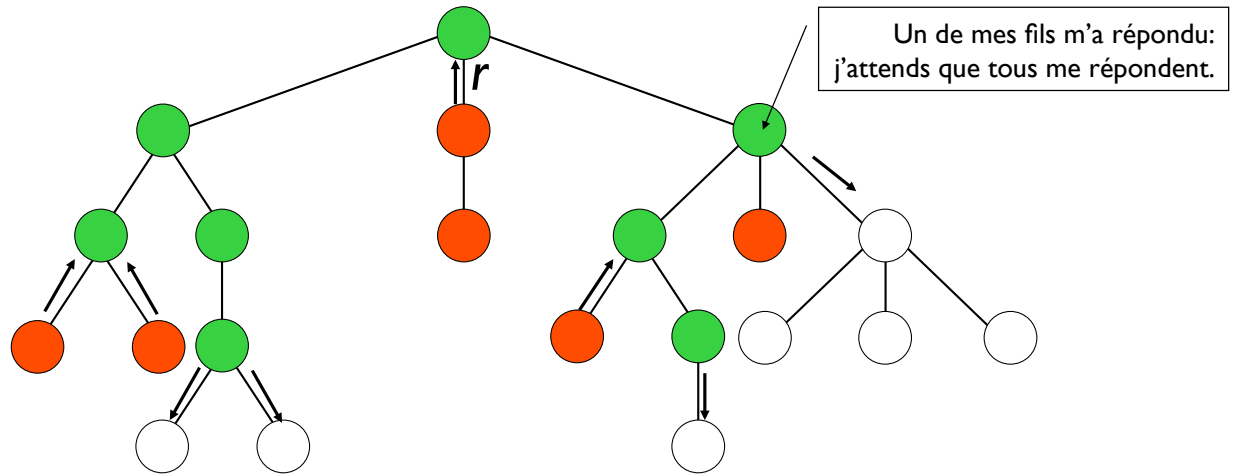
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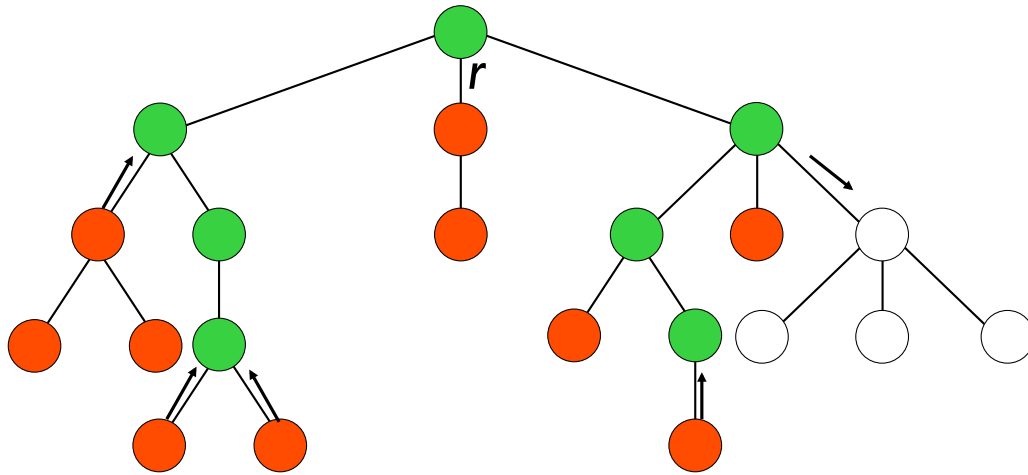


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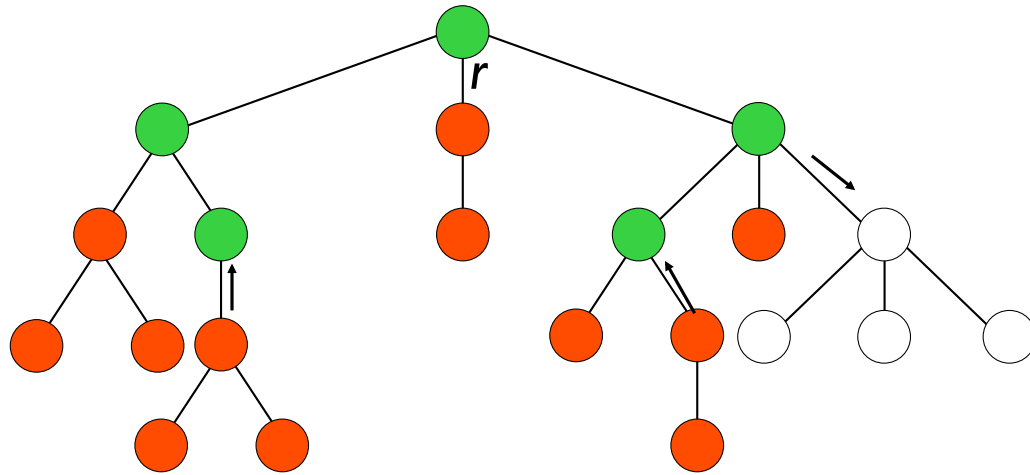


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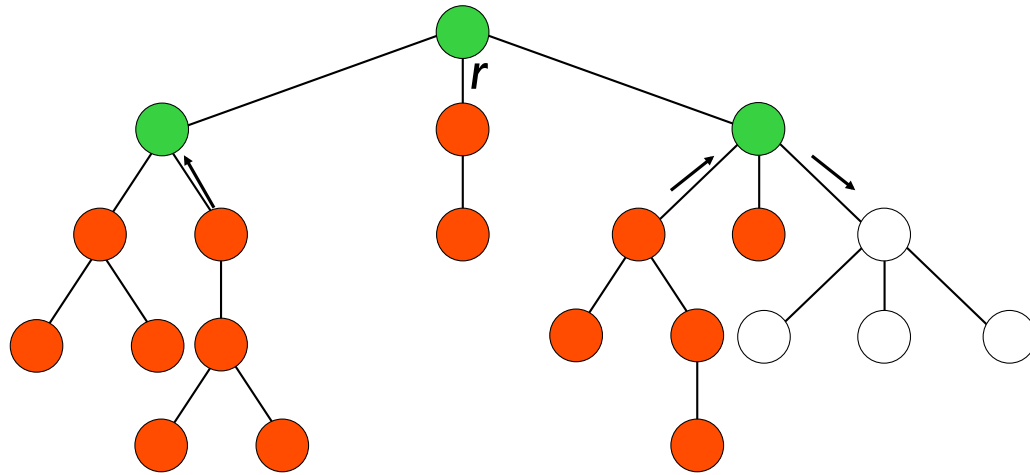




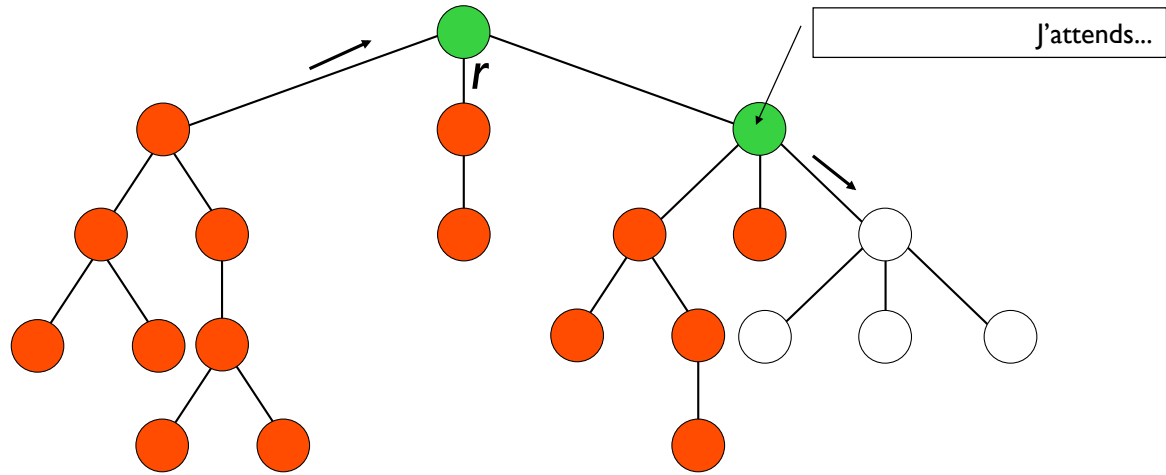
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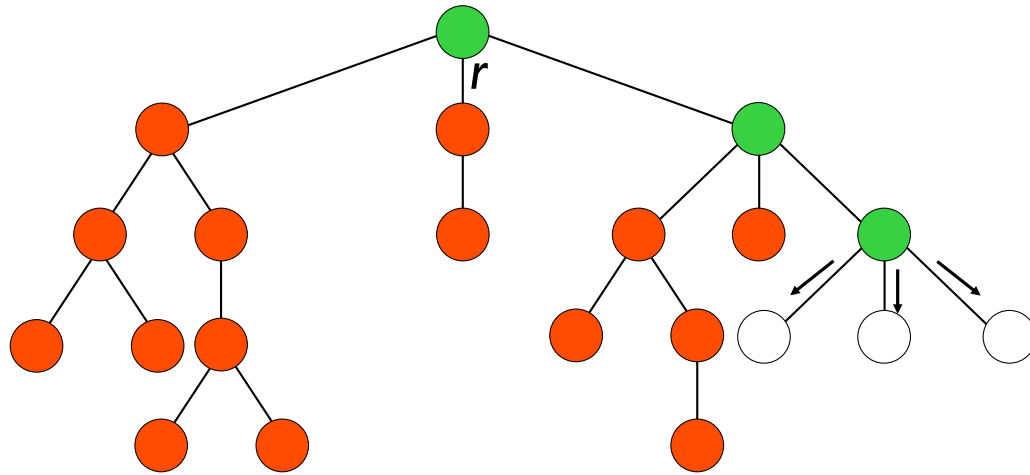


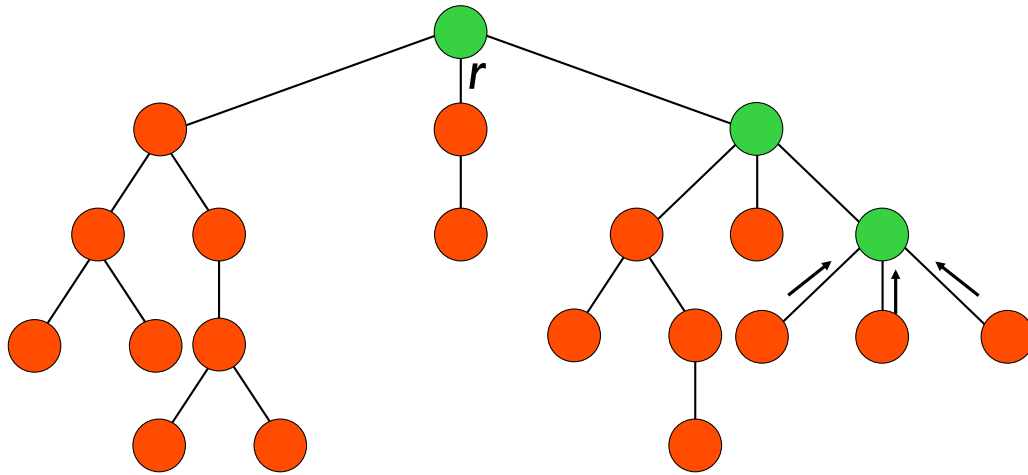
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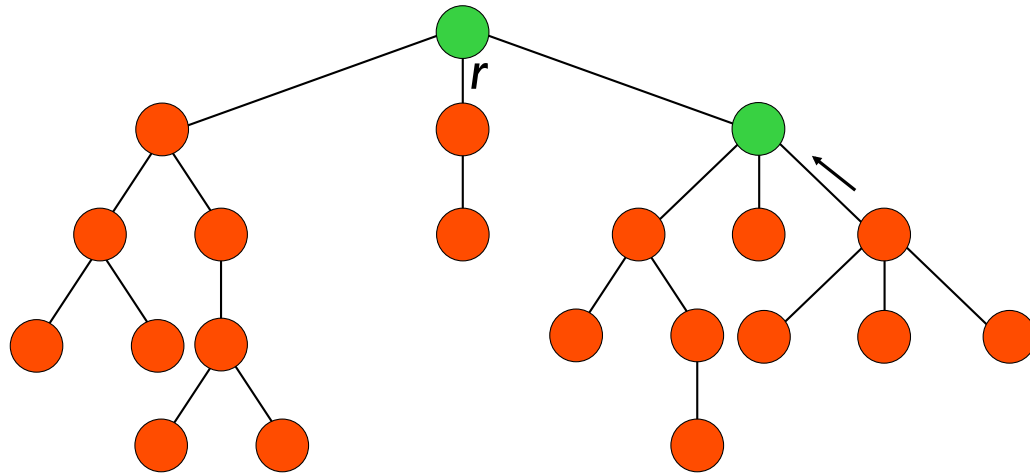
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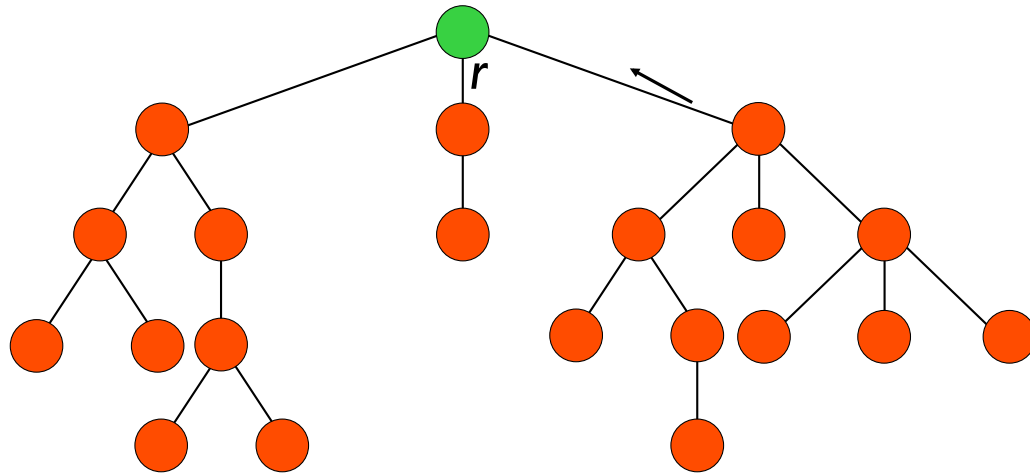




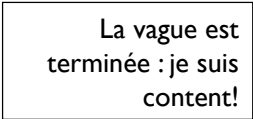
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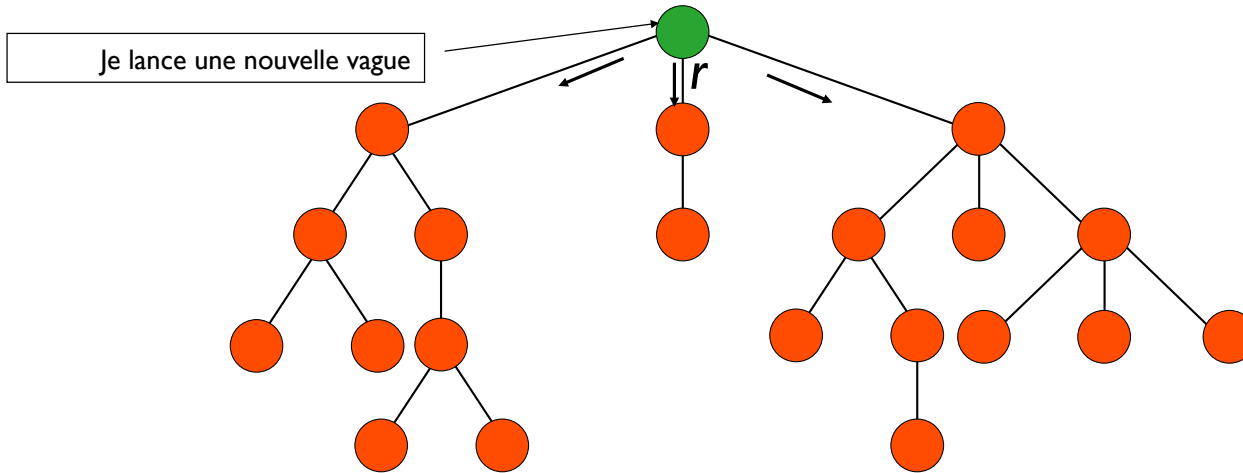
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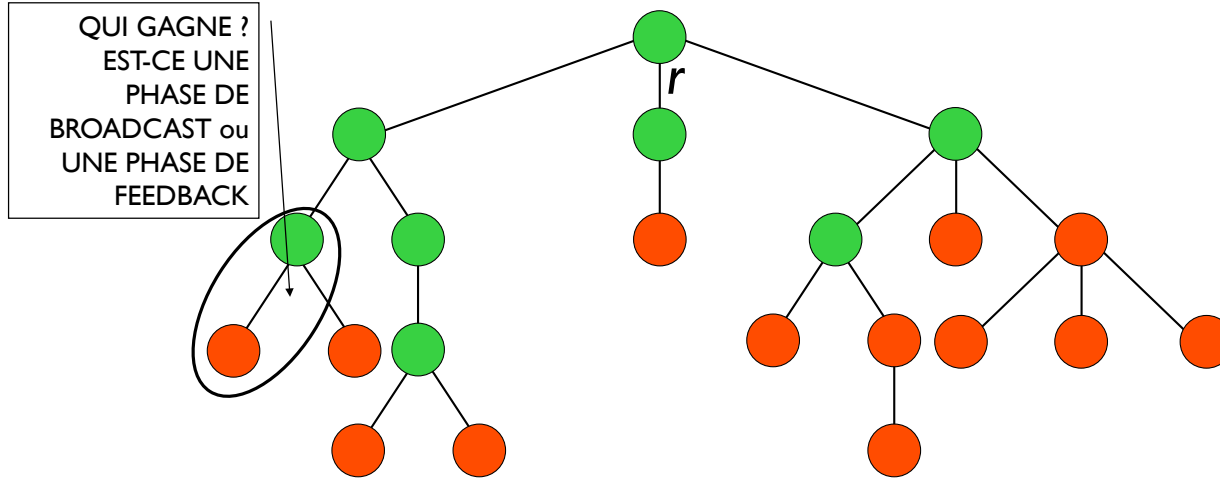
PIF sur l'arbre



Nombre d'états par processeur = 4

QUESTION : Est-il possible d'implémenter le PIF avec seulement 2 états ?

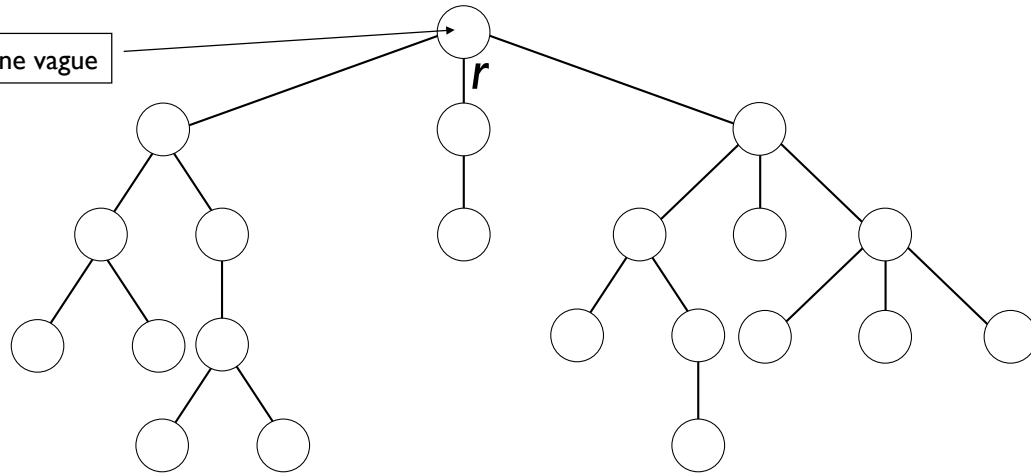
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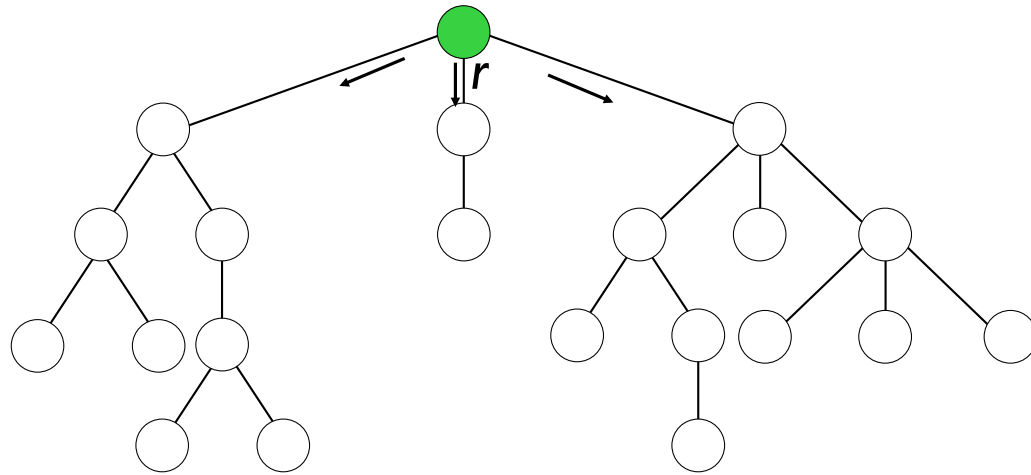
REPONSE : Non. Intuitivement, les états « *J'attends les réponses de mes fils* » poussent les états « *J'ai terminé ma vague* » de la vague précédente (ou état initial), et les états « *J'ai terminé ma vague* » de la vague précédente poussent les états « *J'attends les réponses de mes fils* ».

PIF sur l'arbre

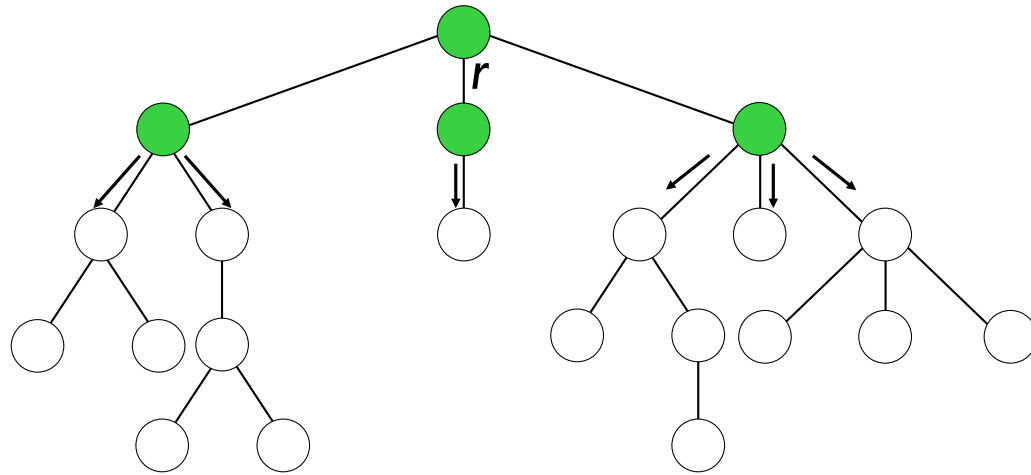
Je lance une vague



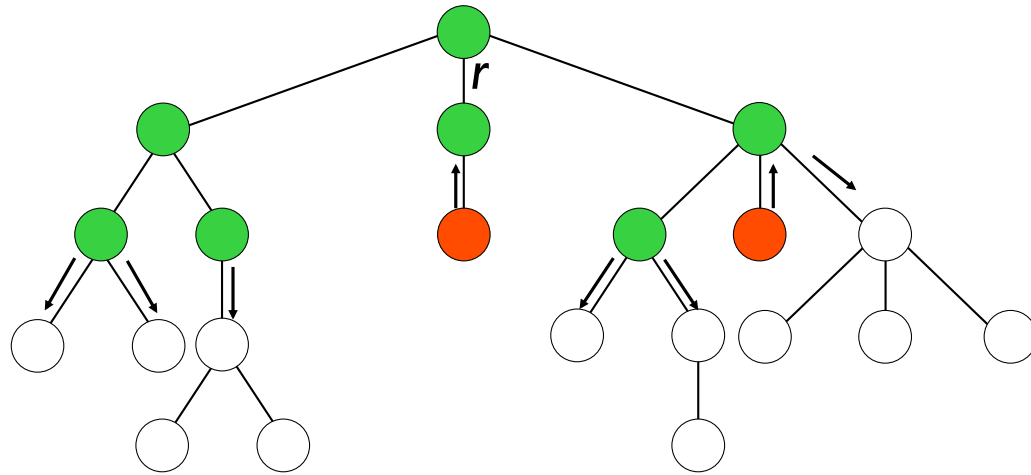
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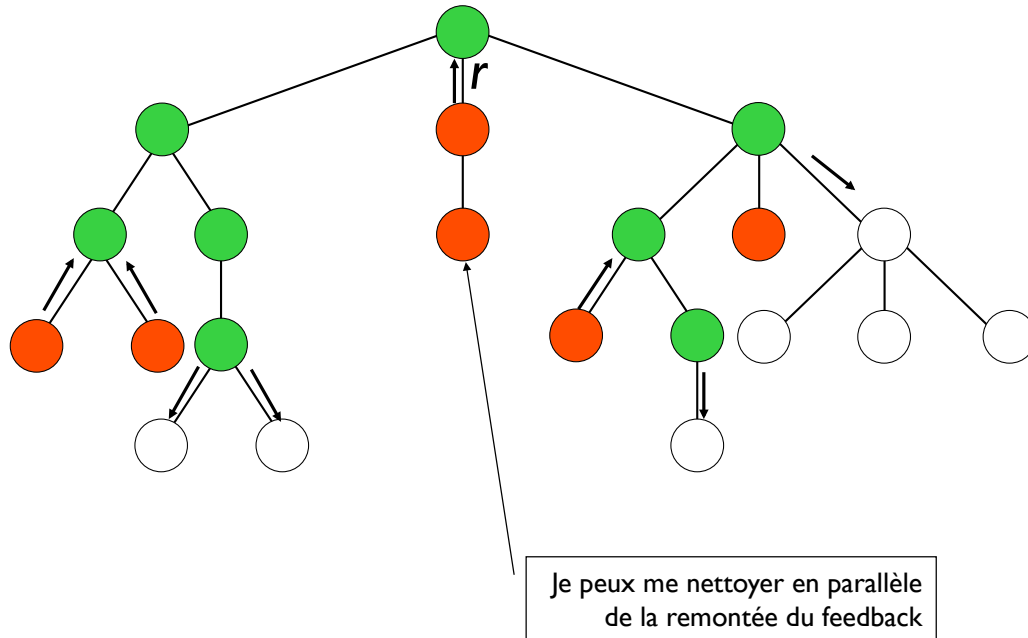
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PIF sur l'arbre

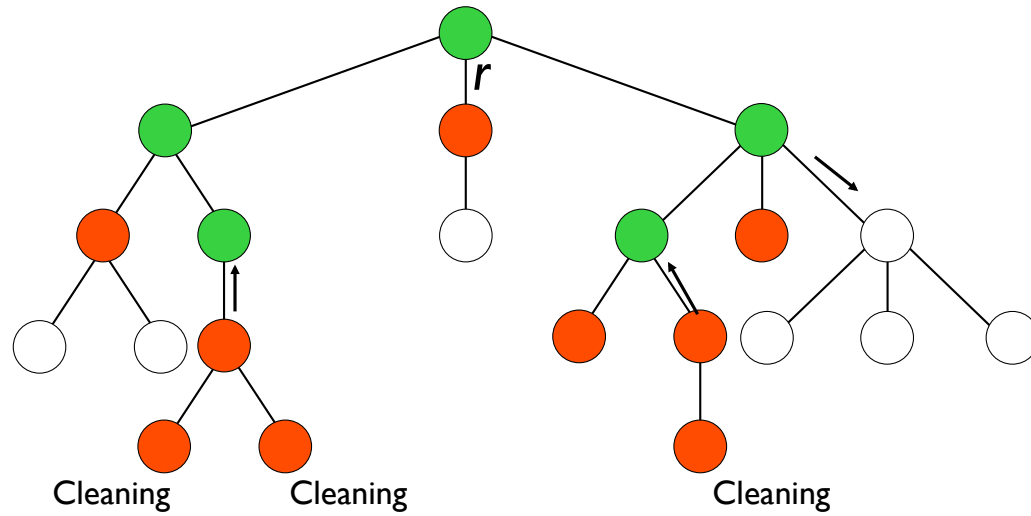


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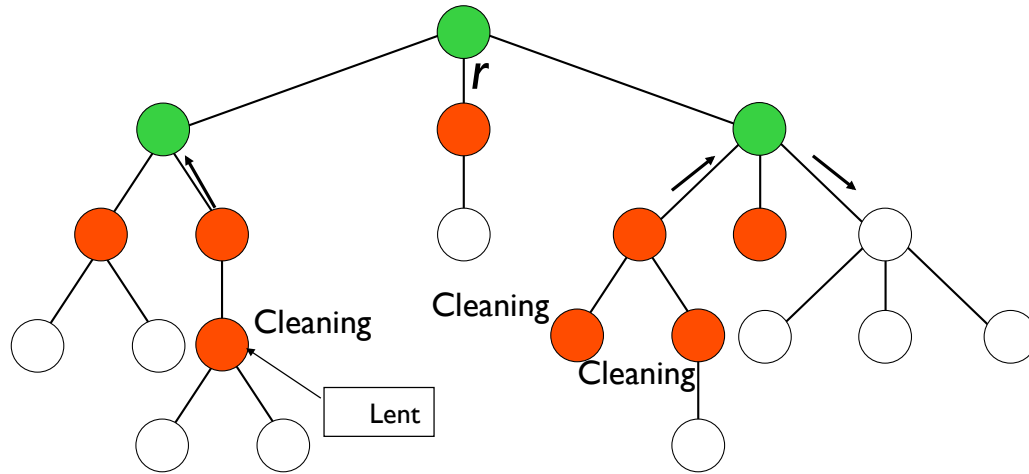




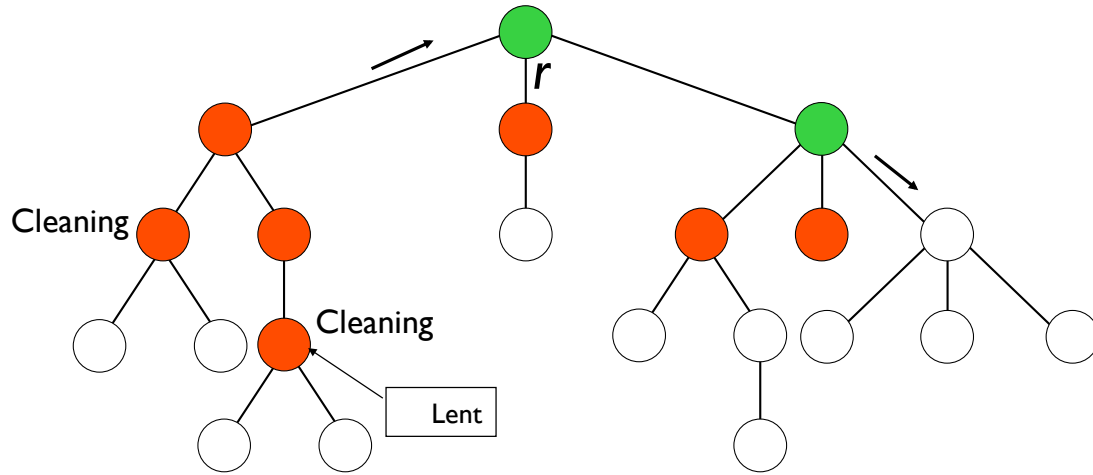
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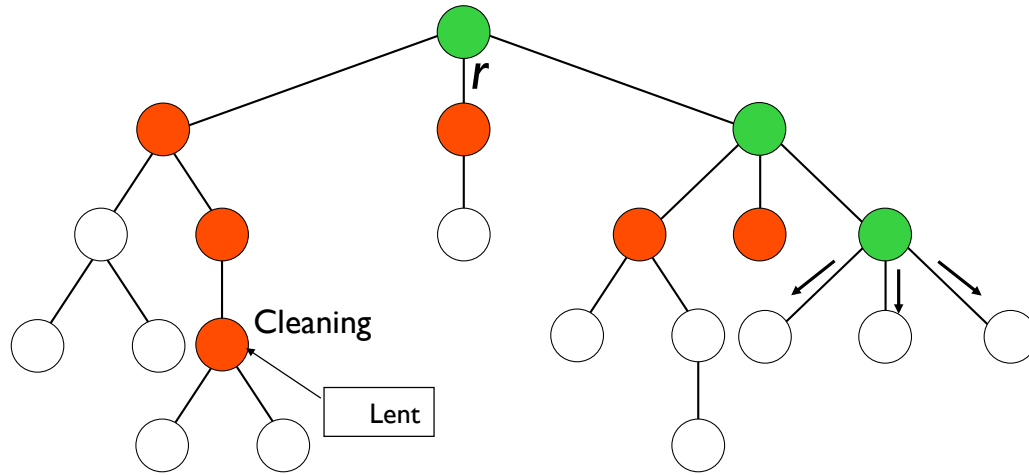
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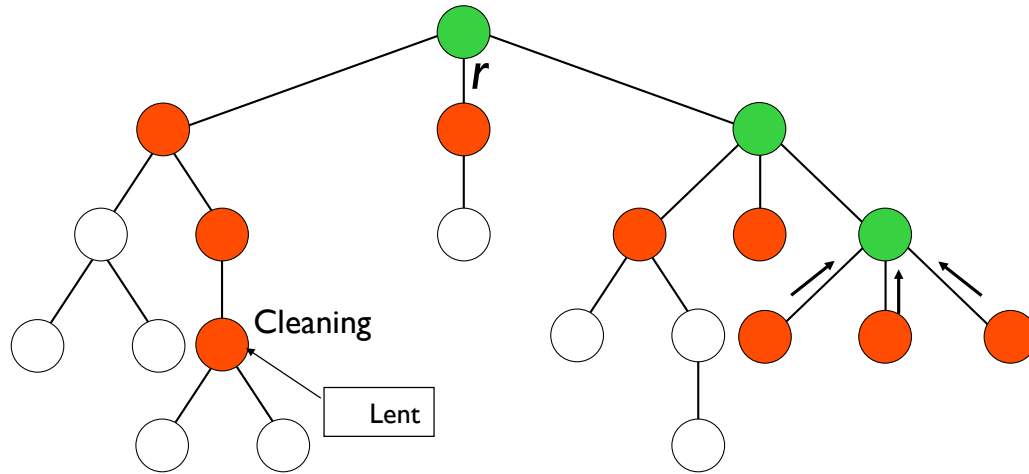


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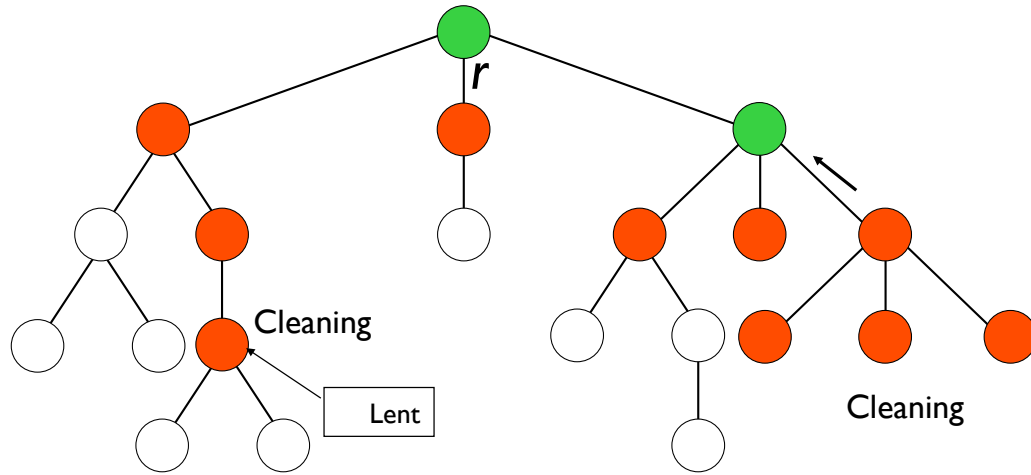


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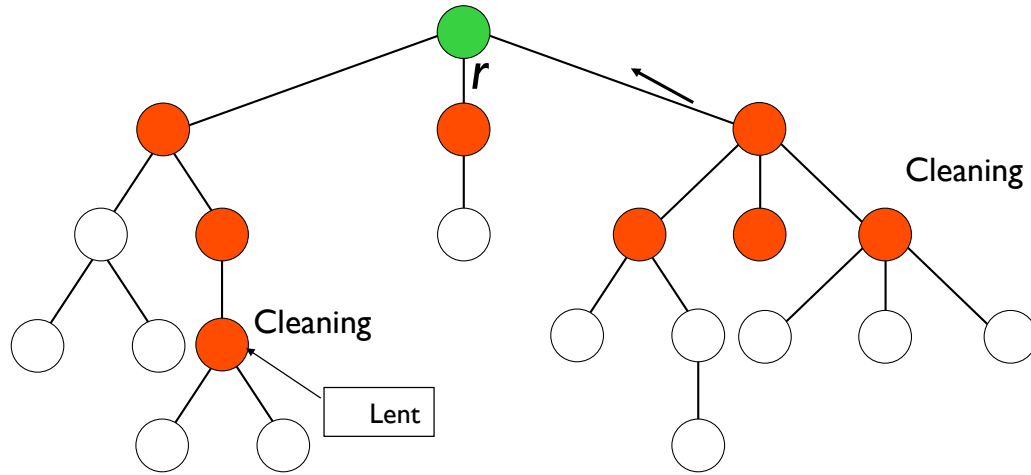


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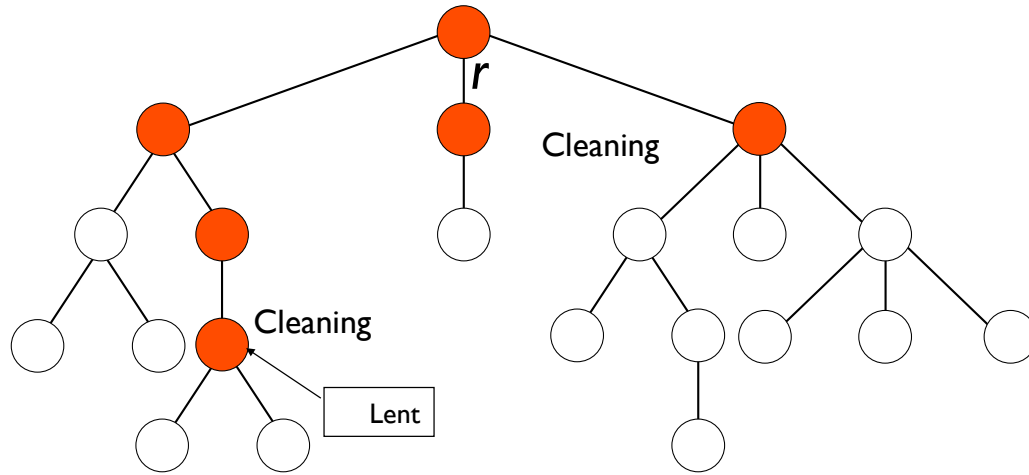
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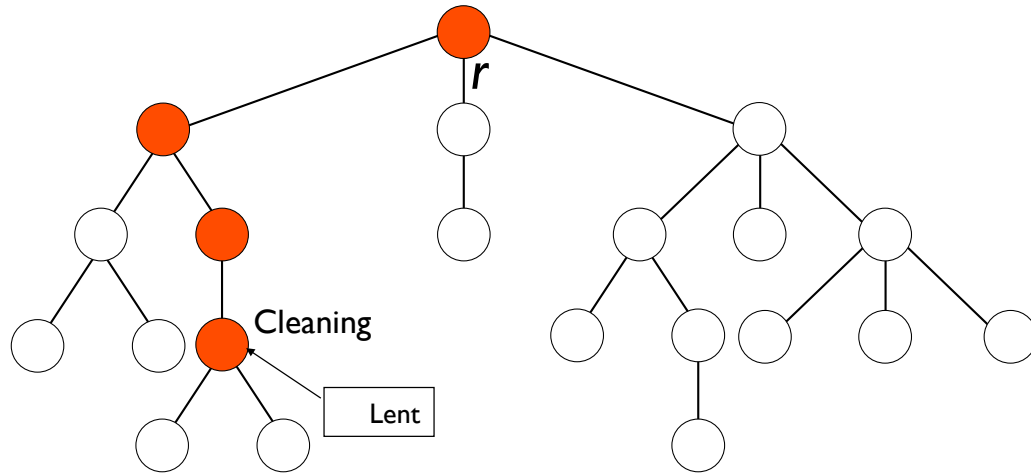
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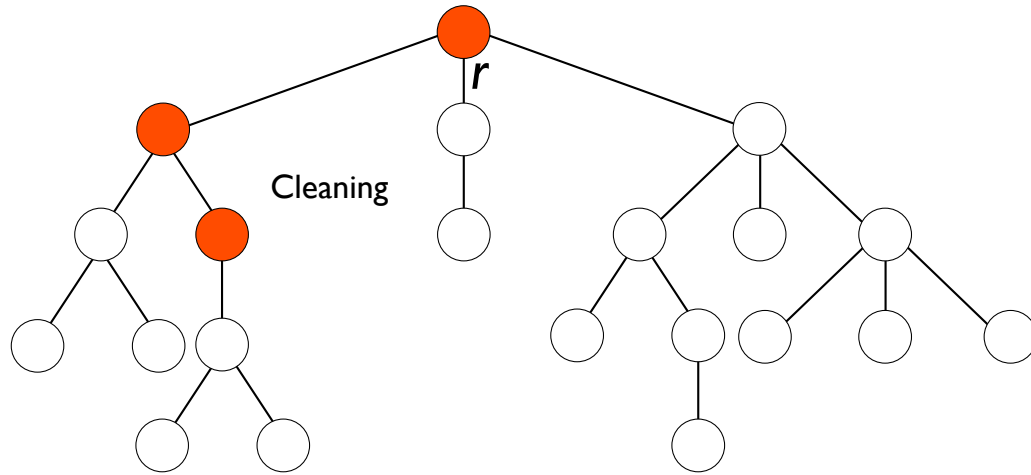
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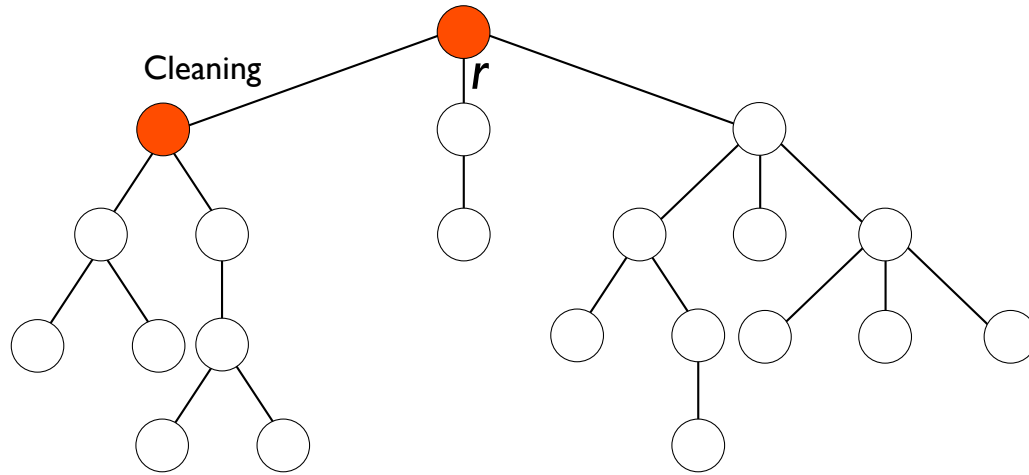
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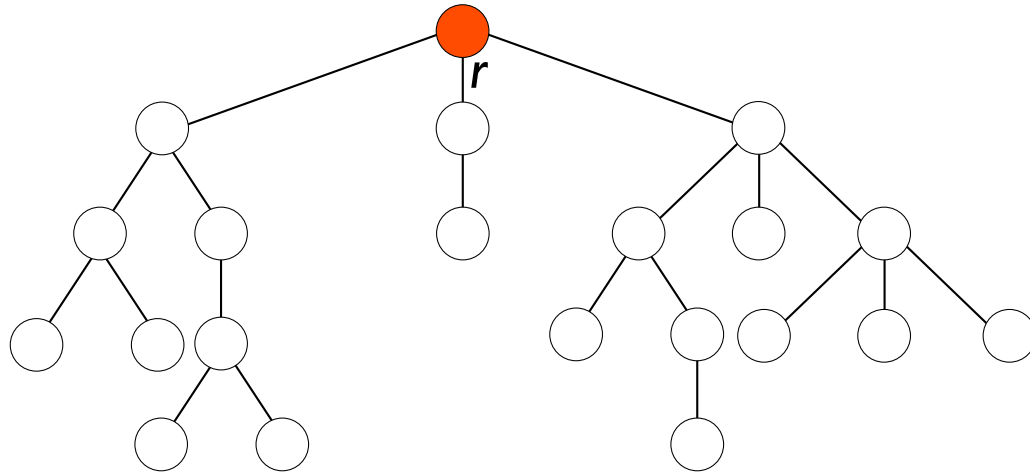
PIF sur l'arbre



PIF sur l'arbre



PIF sur l'arbre



Algorithm 1.1 (*PFCS*) PIF in Rooted Tree Networks.

Variable: S_p

$S_p \in \{B, F, C\}$ if p is an internal processor ($p \in I$).

$S_p \in \{B, C\}$ if p is the initiator ($p = \mathbf{root}$).

$S_p \in \{F, C\}$ if p is a leaf processor ($p \in L$).

Notations:

P_p is the parent of p ($p \neq \mathbf{root}$).

d is a descendant of p , i.e., $d \in D_p$.

q is a neighbor of p , i.e., $q \in N_p$.

Actions:

{For the internal processors}

IB-action :: $S_p = C \wedge S_{P_p} = B \wedge (\forall d \in D_p :: S_d = C) \longrightarrow S_p := B;$

IF-action :: $S_p = B \wedge (\forall d \in D_p :: S_d = F) \longrightarrow S_p := F;$

IC-action :: $S_p = F \wedge (\forall q \in N_p :: S_q \in \{F, C\}) \longrightarrow S_p := C;$

{For root}

rTB-action :: $S_p = C \wedge (\forall q \in N_p :: S_q = C) \longrightarrow S_p := B;$

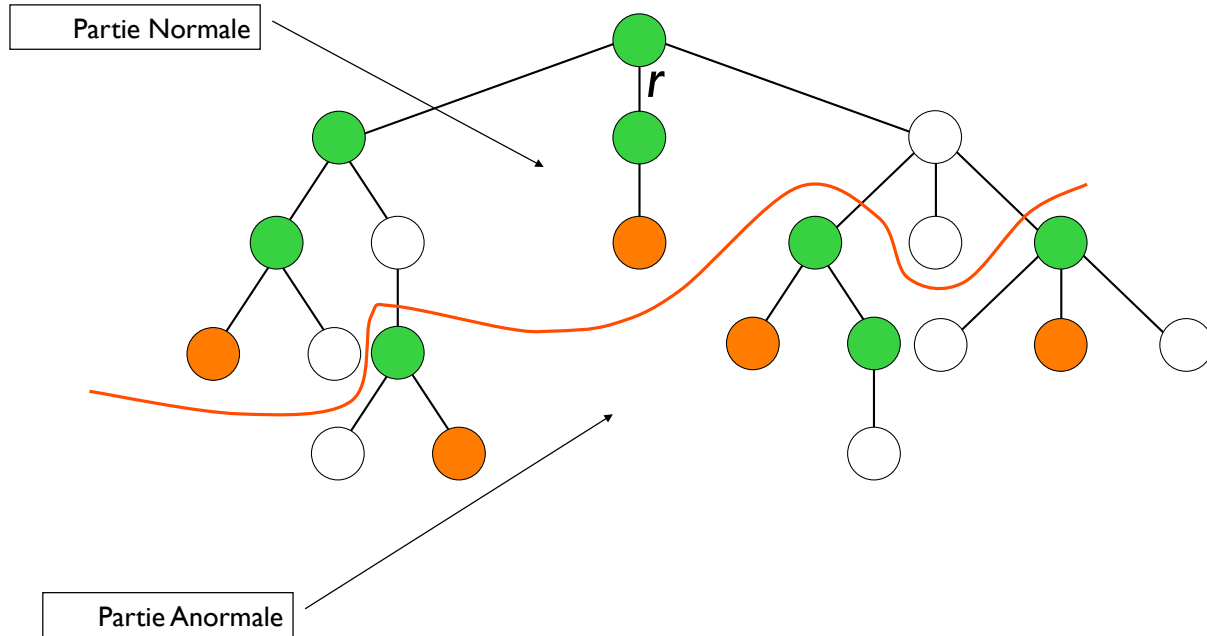
rC-action :: $S_p = B \wedge (\forall q \in N_p :: S_q = F) \longrightarrow S_p := C;$

{For the leaf processors}

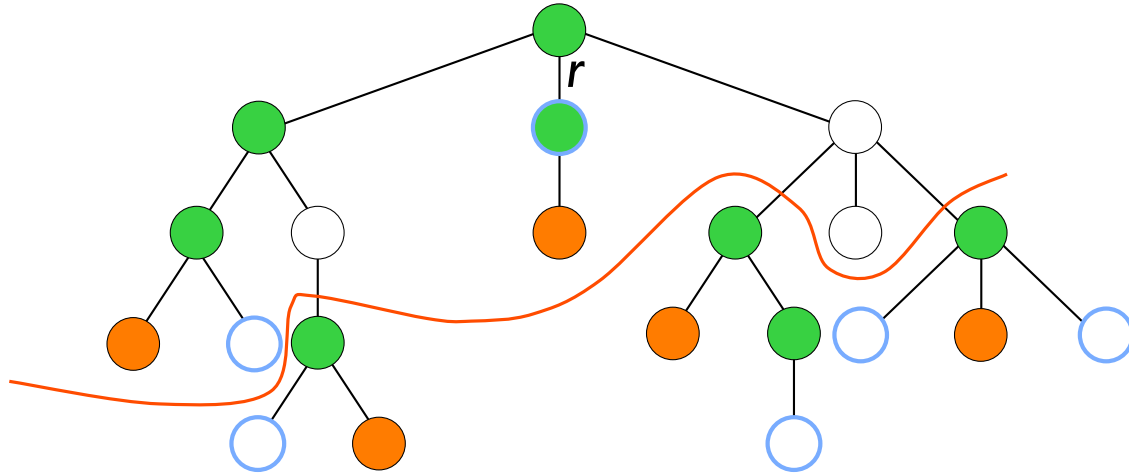
LF-action :: $S_p = C \wedge S_{P_p} = B \longrightarrow S_p := F$

LC-action :: $S_p = F \wedge S_{P_p} \in \{F, C\} \longrightarrow S_p := C;$

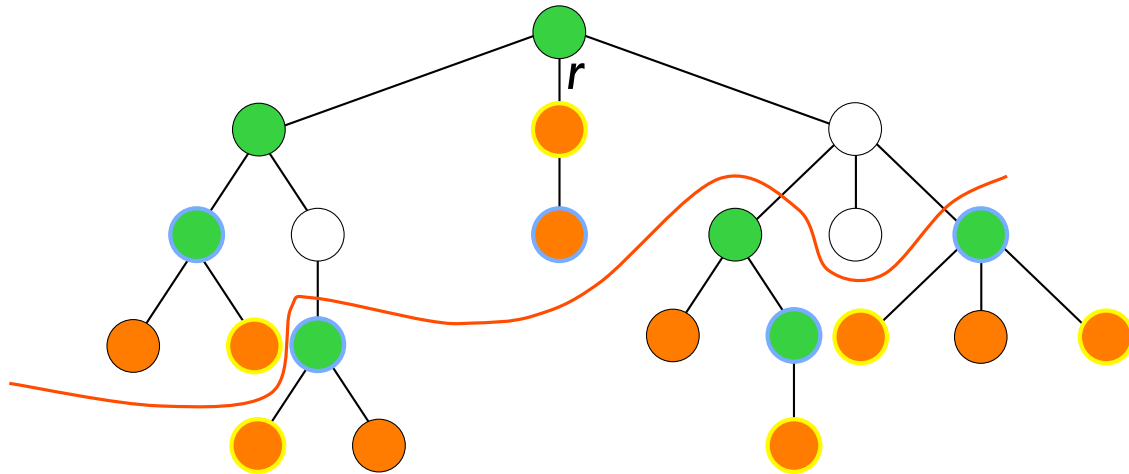
Temps de Stabilisation



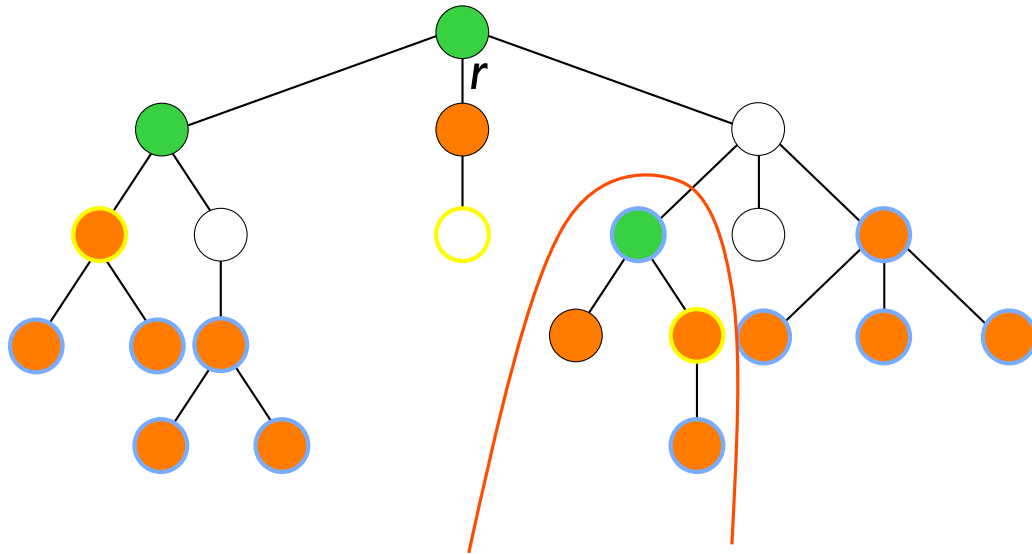
Temps de Stabilisation



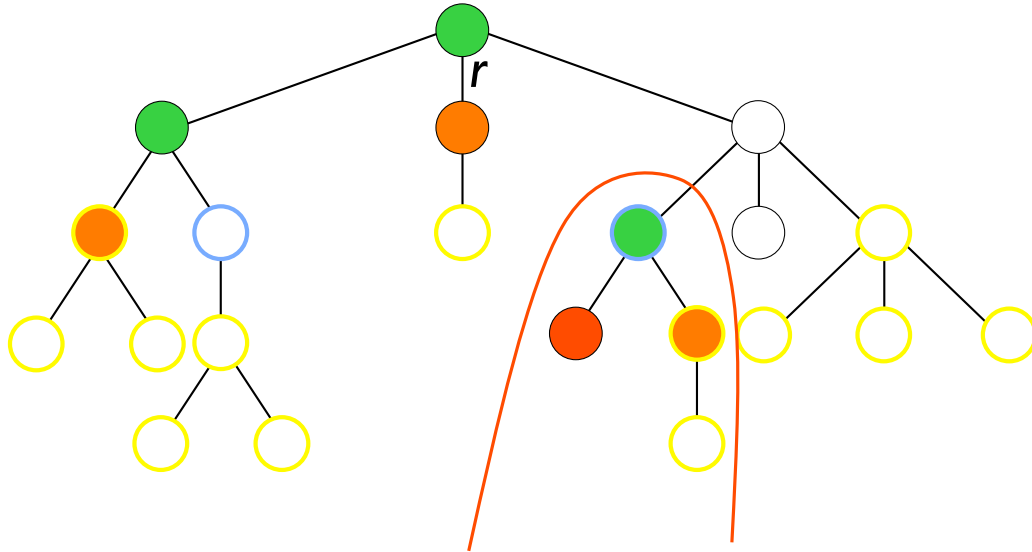
Temps de Stabilisation



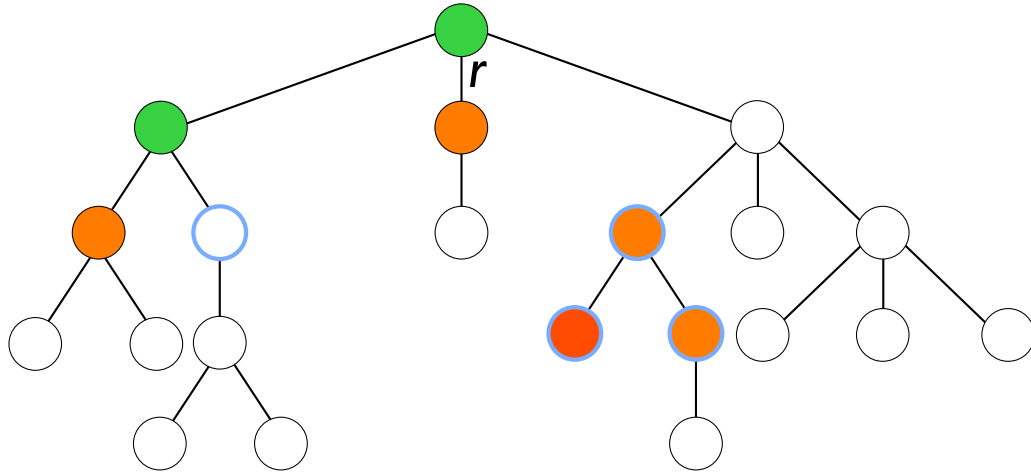
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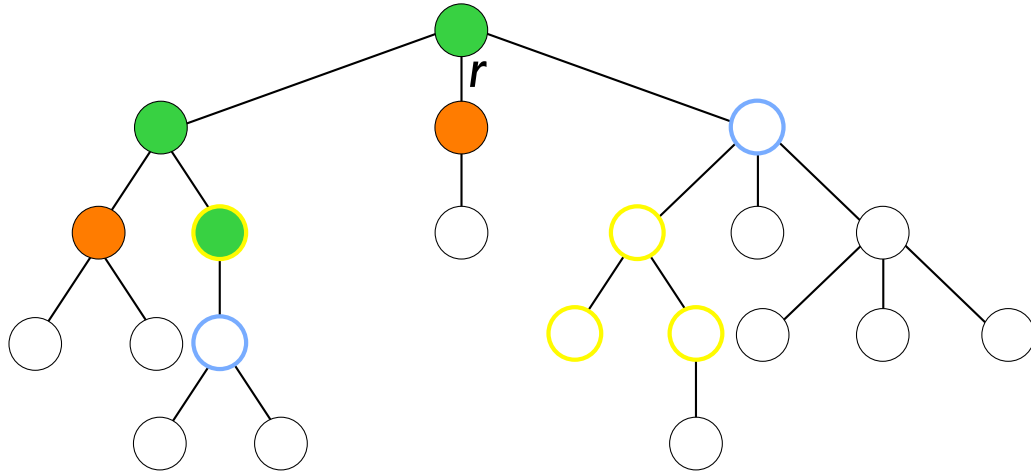
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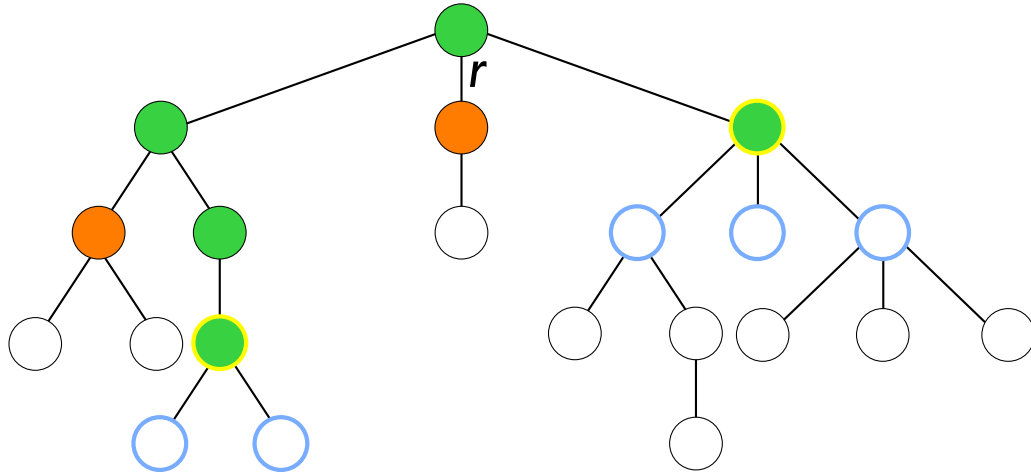
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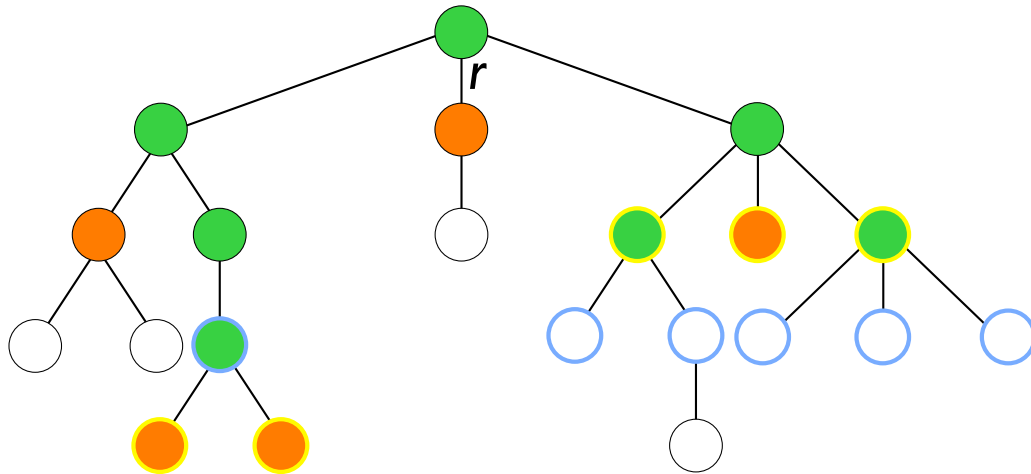
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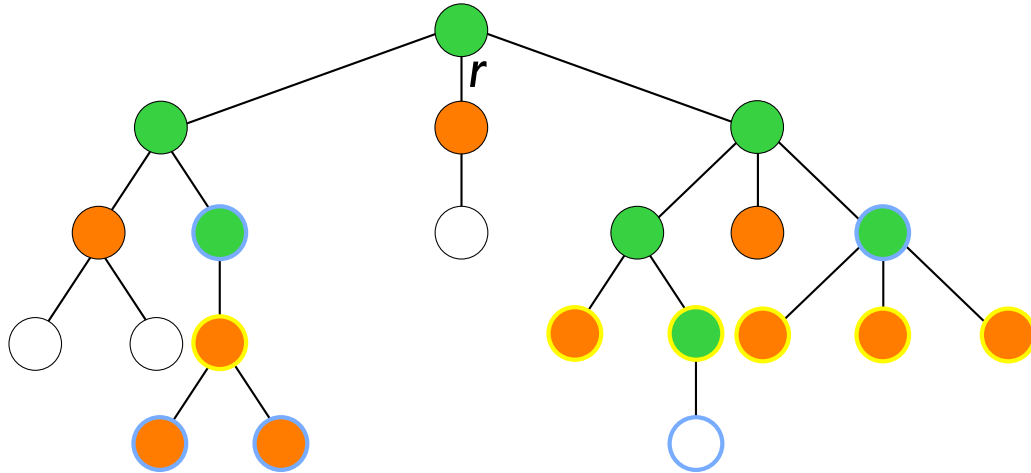
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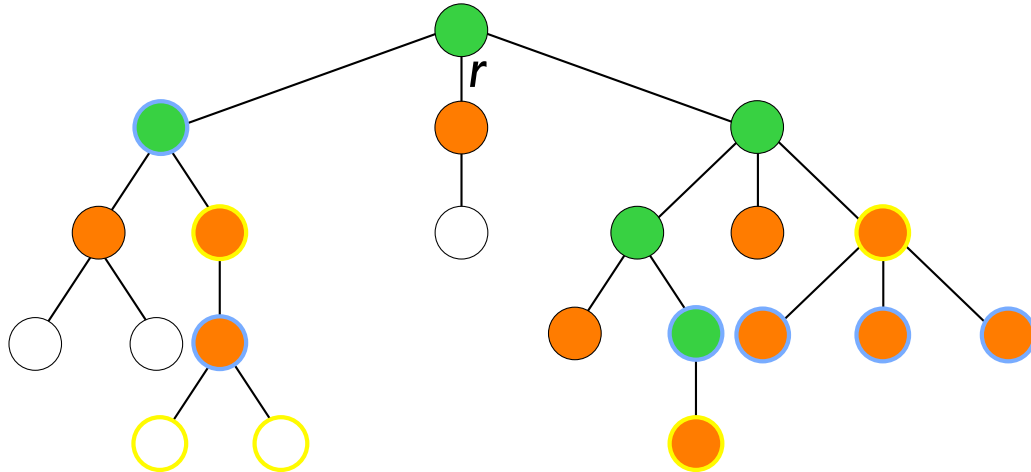
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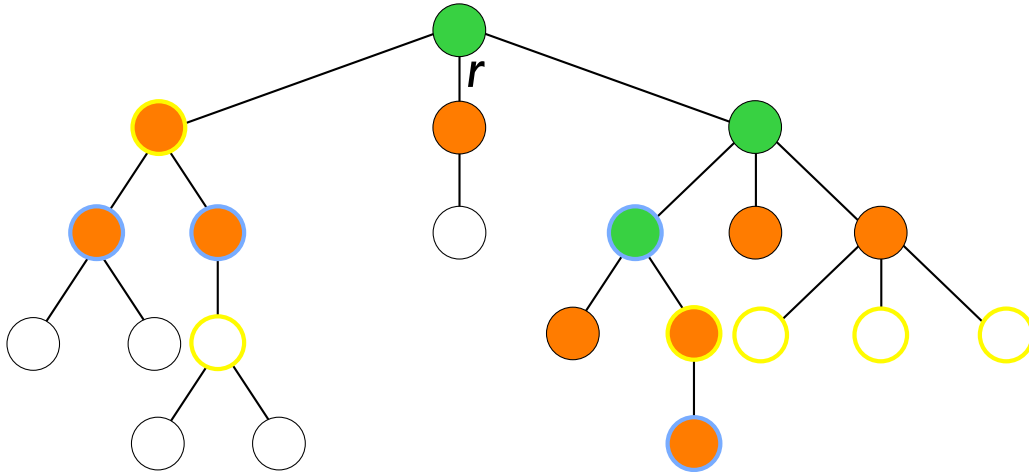
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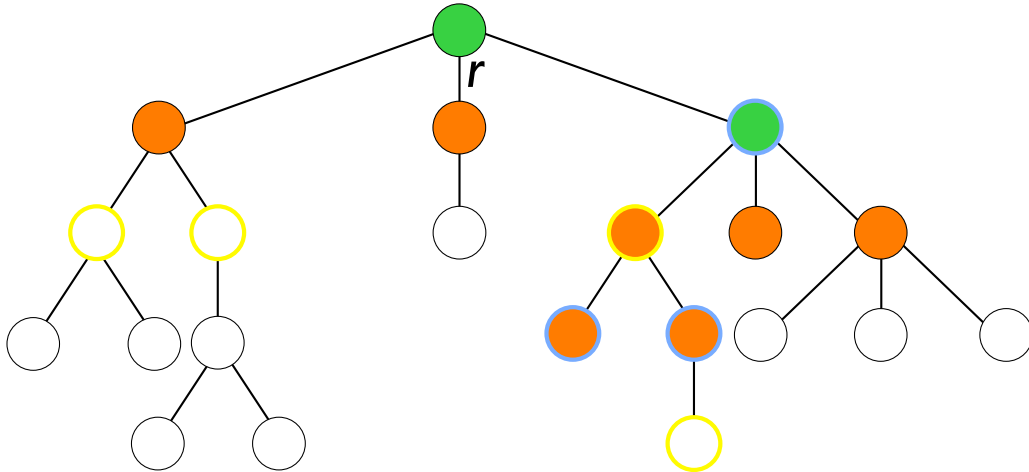
Temps de Stabilisation



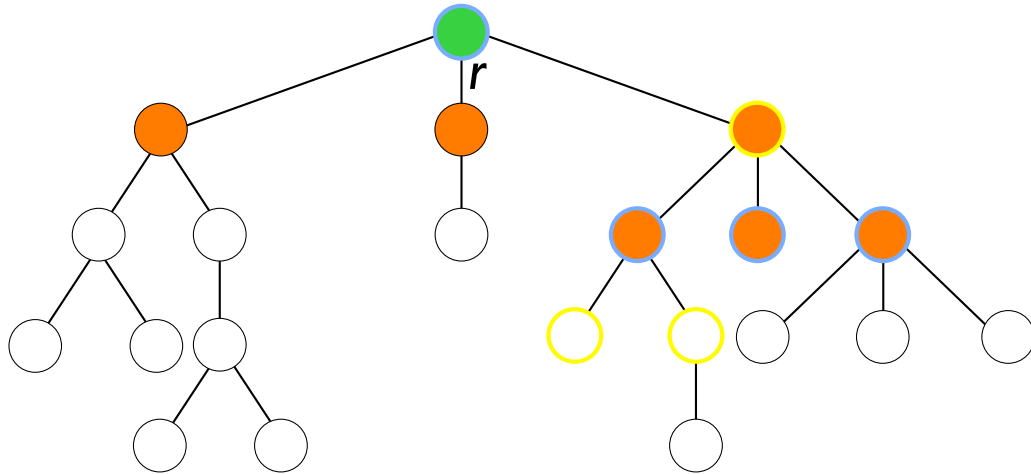
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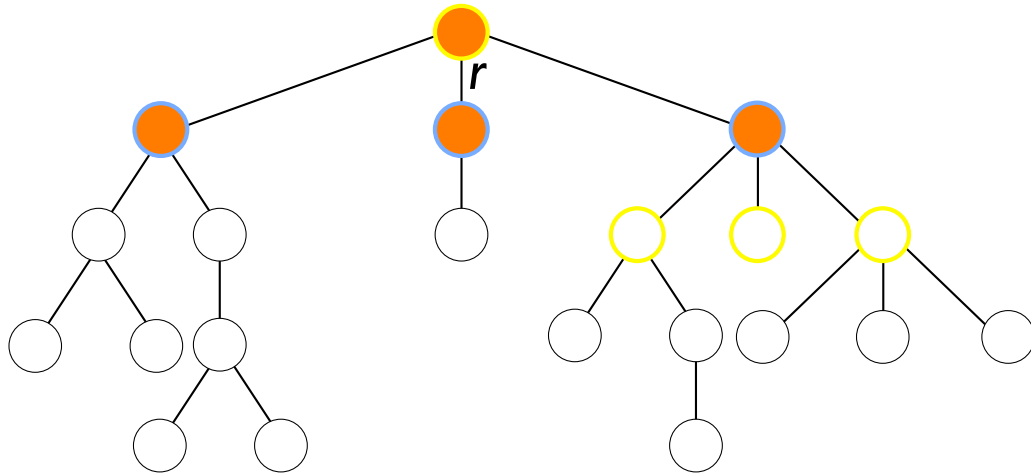
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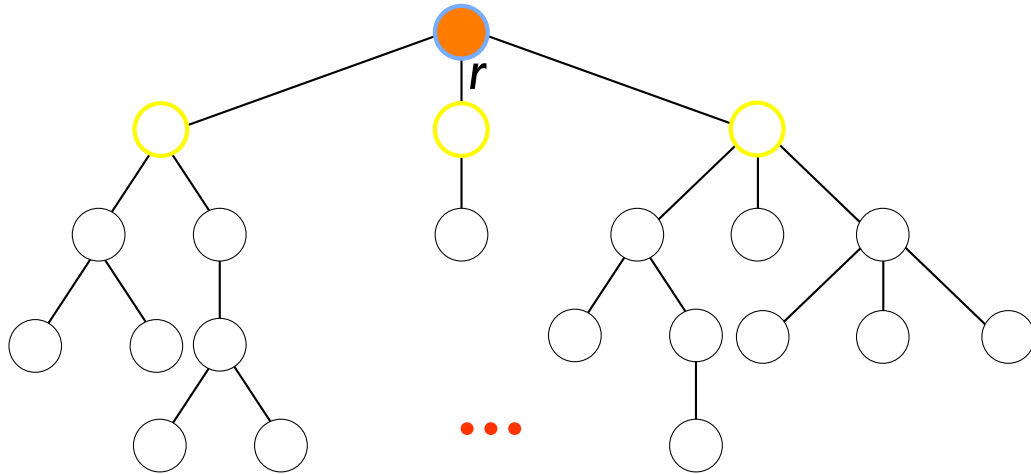
Temps de Stabilisation



Temps de Stabilisation



Temps de Stabilisation



Algorithm 1.2 (*fastPFCSD*) Fast Snap-Stabilizing PIF in Rooted Tree Networks.

Variable: S_p

$S_p \in \{B, F, C\}$ if p is an internal processor ($p \in I$).

$S_p \in \{B, C\}$ if p is the initiator ($p = \text{root}$).

$S_p \in \{F, C\}$ if p is a leaf processor ($p \in L$).

Notations:

P_p is the parent of p ($p \neq \text{root}$).

d is a descendant of p , i.e., $d \in D_p$.

q is a neighbor of p , i.e., $q \in N_p$.

Actions:

{For the internal processors}

IB-action :: $S_p = C \wedge S_{P_p} = B \wedge (\forall d \in D_p :: S_d = C) \longrightarrow S_p := B;$

IF-action :: $S_p = B \wedge S_{P_p} = B \wedge (\forall d \in D_p :: S_d = F) \longrightarrow S_p := F;$

IC-action :: $S_p = F \wedge (\forall q \in N_p :: S_q \in \{F, C\}) \longrightarrow S_p := C;$

ICorrection :: $S_p = B \wedge S_{P_p} \in \{F, C\} \longrightarrow S_p := C;$

{For root}

rTB-action :: $S_p = C \wedge (\forall q \in N_p :: S_q = C) \longrightarrow S_p := B;$

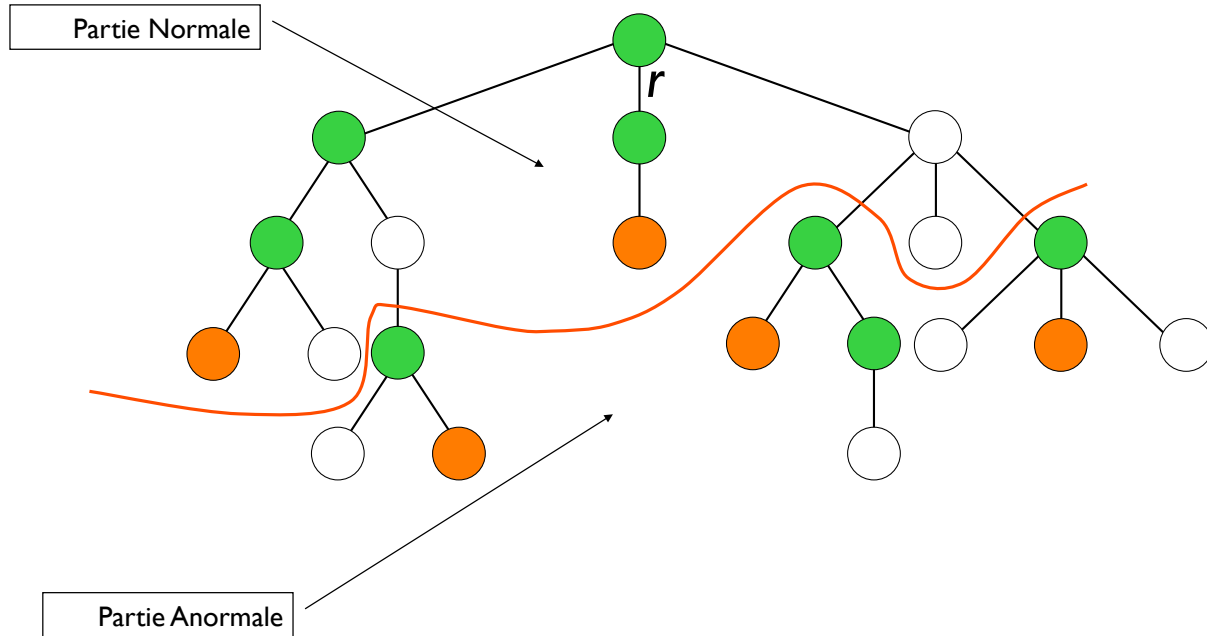
rC-action :: $S_p = B \wedge (\forall q \in N_p :: S_q = F) \longrightarrow S_p := C;$

{For the leaf processors}

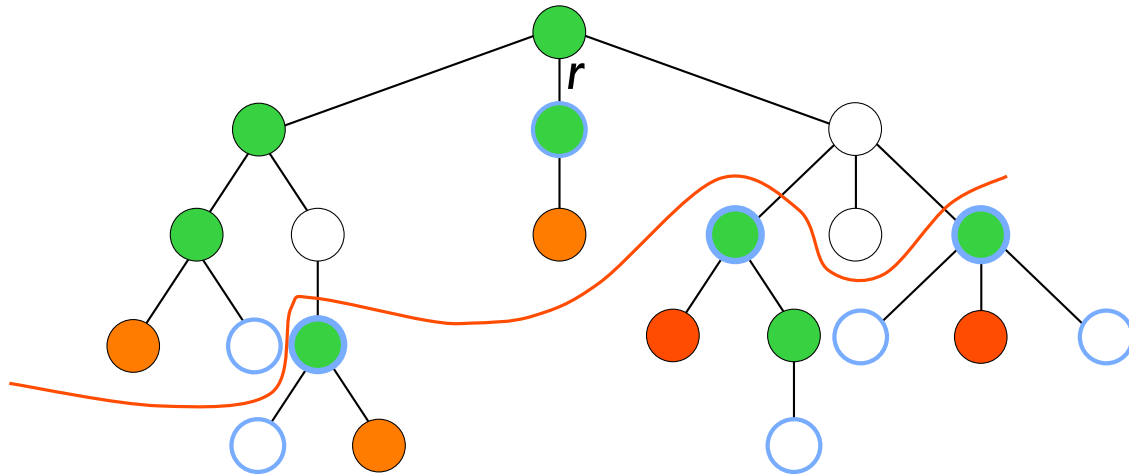
LF-action :: $S_p = C \wedge S_{P_p} = B \longrightarrow S_p := F$

LC-action :: $S_p = F \wedge S_{P_p} \in \{F, C\} \longrightarrow S_p := C;$

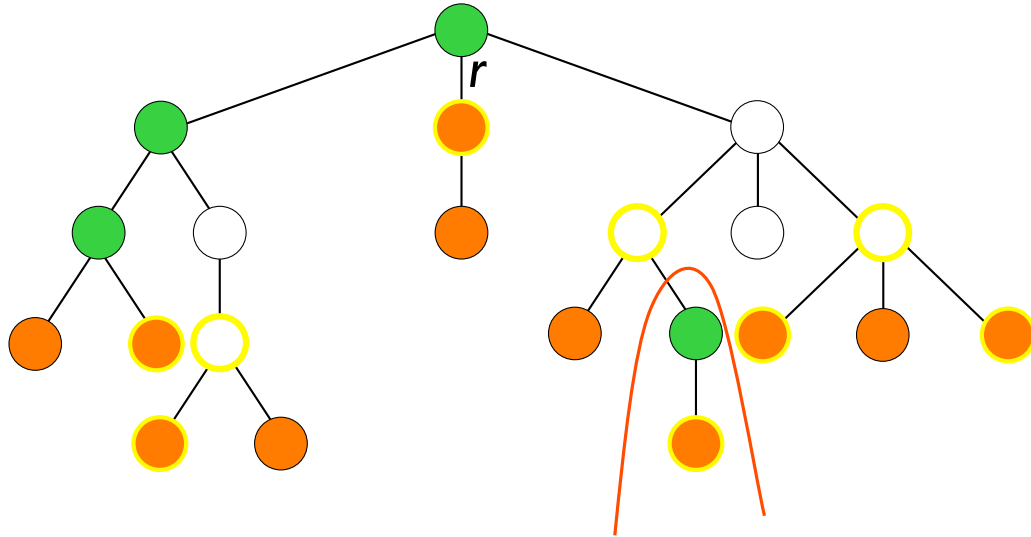
Temps de Stabilisation



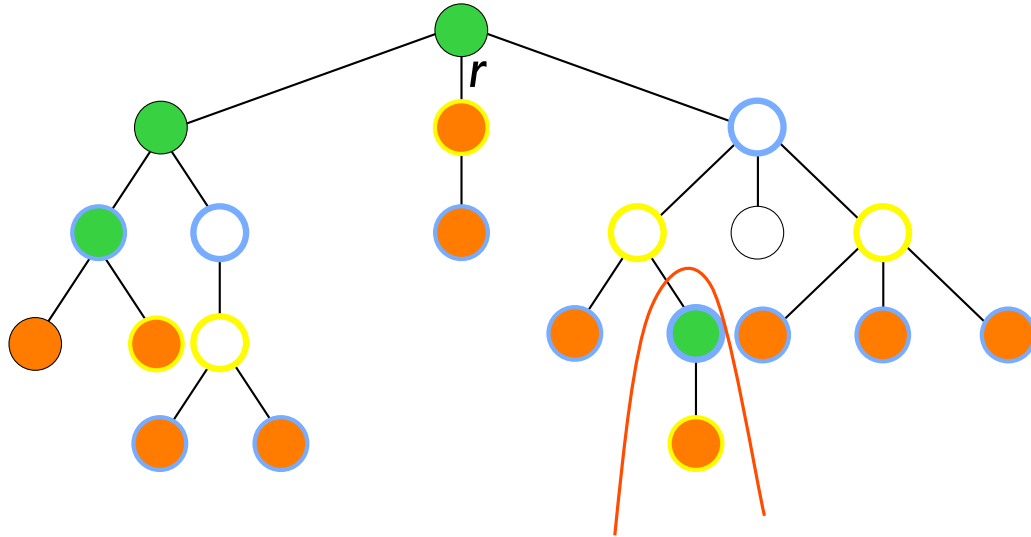
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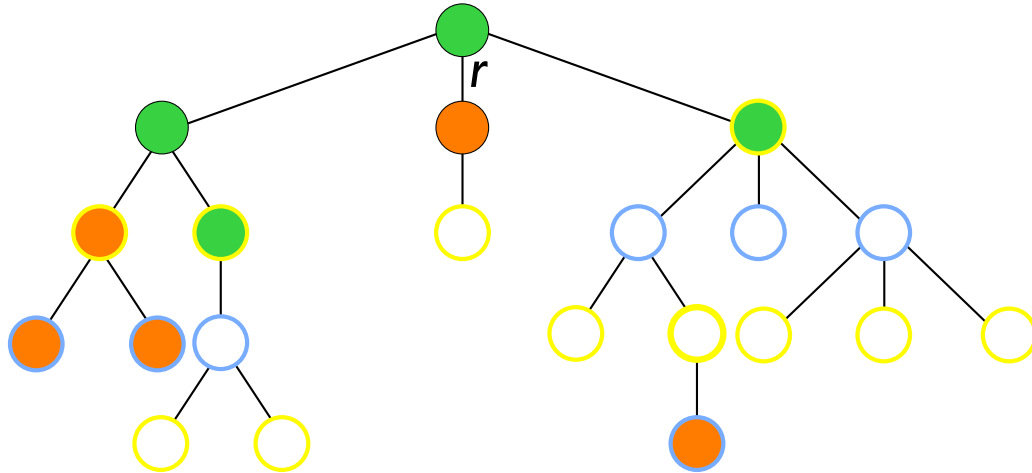
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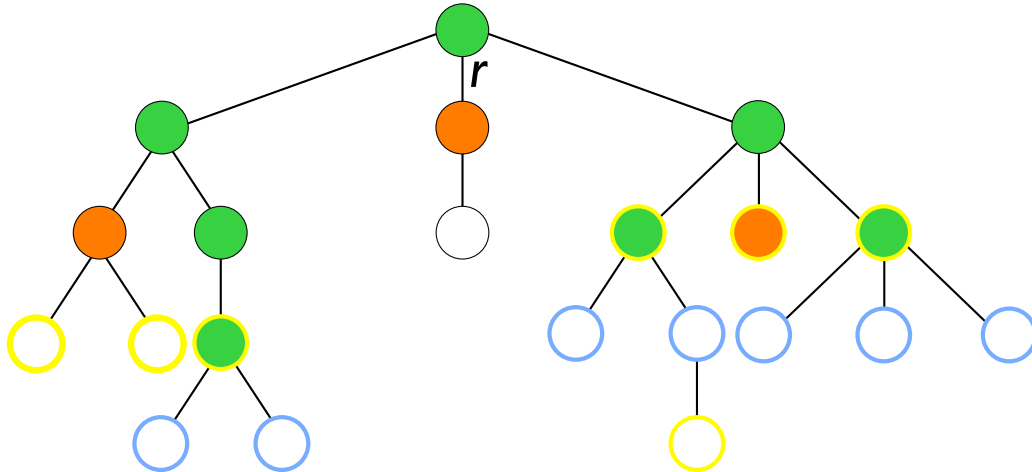
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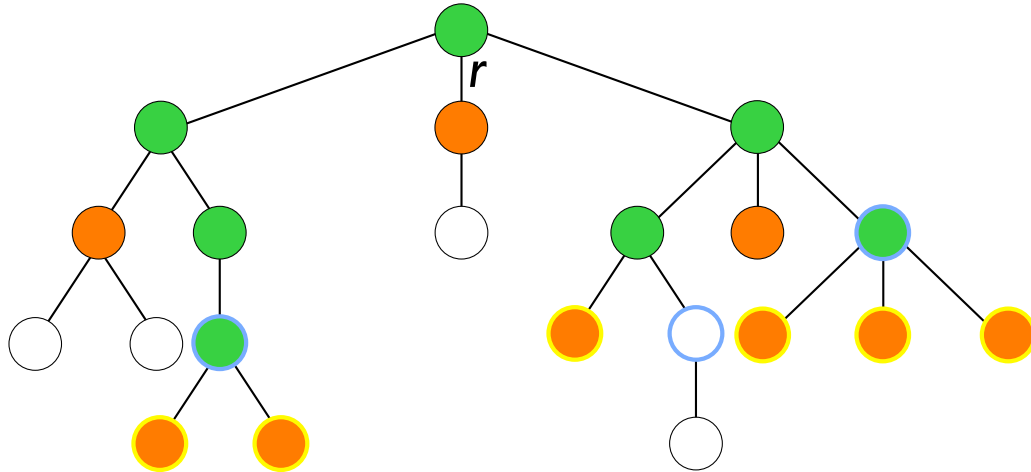
Temps de Stabilisation



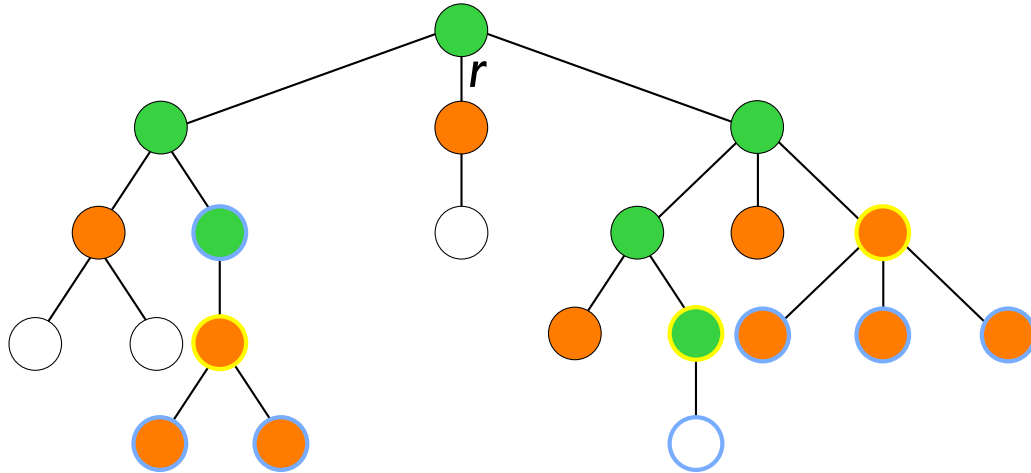
Temps de Stabilisation



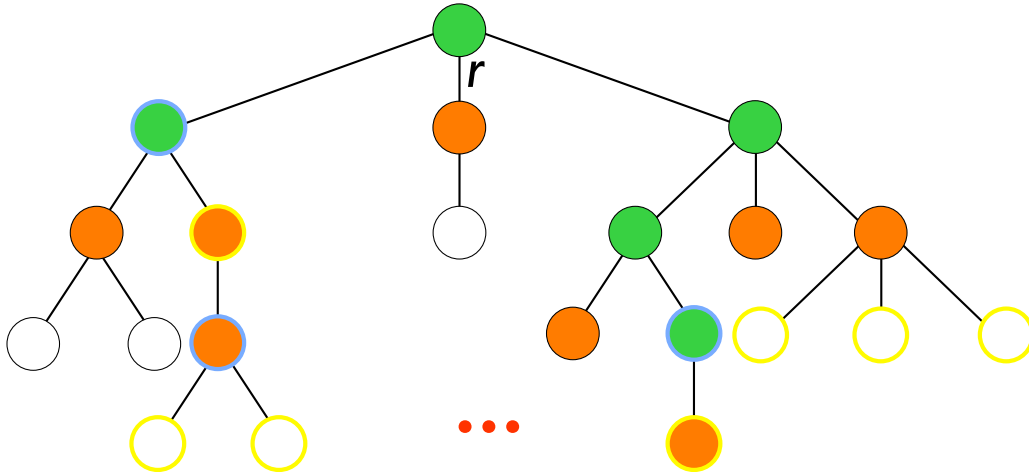
Temps de Stabilisation



Temps de Stabilisation



Temps de Stabilisation



Algorithme amélioré instantanément stabilisé

Peut être retardé d'au plus / étape !

Self-Stabilizing Compiler

- GOAL
- «Universal» Tool to Transform (Compile) **any non self-stabilizing** distributed algorithm into a **self-stabilizing one**
[Katz and Perry 1993]



Snap-Stabilizing Compiler

- GOAL
- «Universal» Tool to Transform (Compile) **any non self-stabilizing** distributed algorithm into a **snap-stabilizing one**
[Cournier, Datta, Petit, Villain 2003]

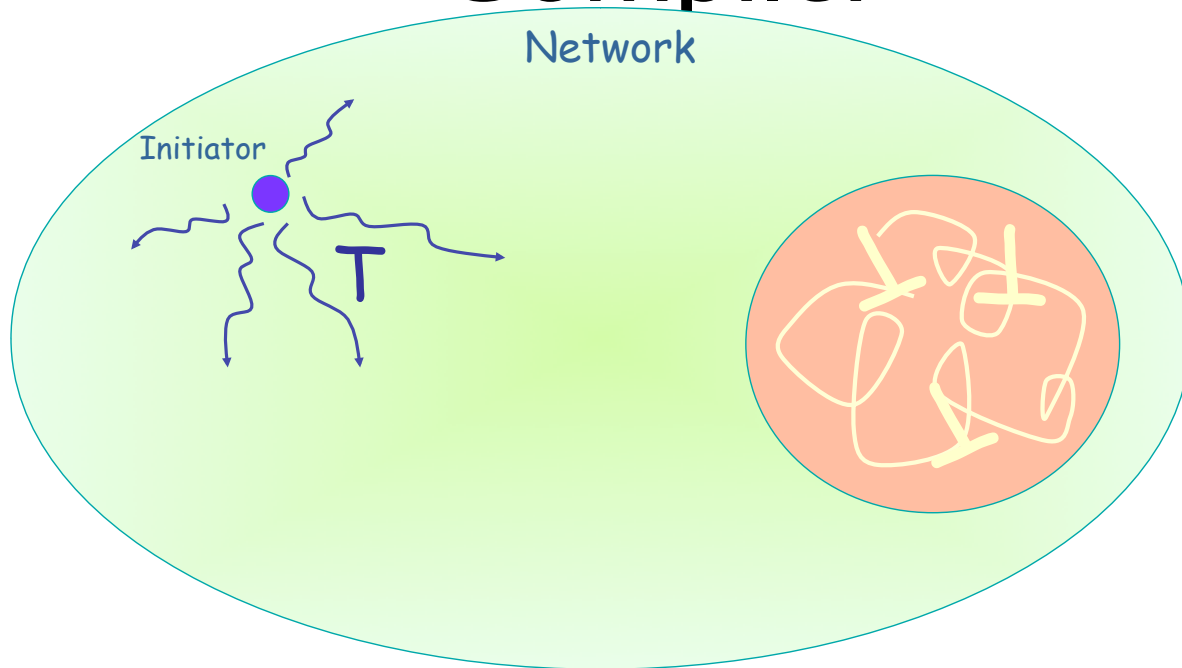


Snap-Stabilizing Compiler

- IDEA
- Snap-stabilizing leader test
- Snap-stabilizing reset
- Snap-stabilizing snapshot
- Snap-stabilizing termination detection

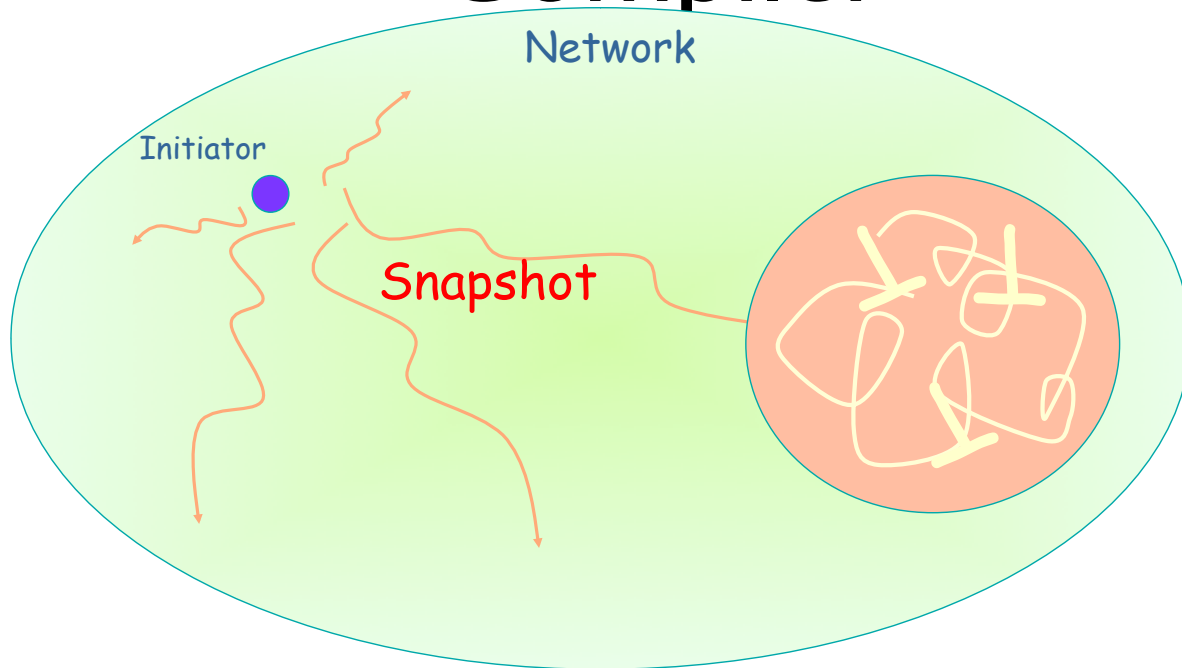
Snap-stabilizing
PIF

Snap-Stabilizing Compiler



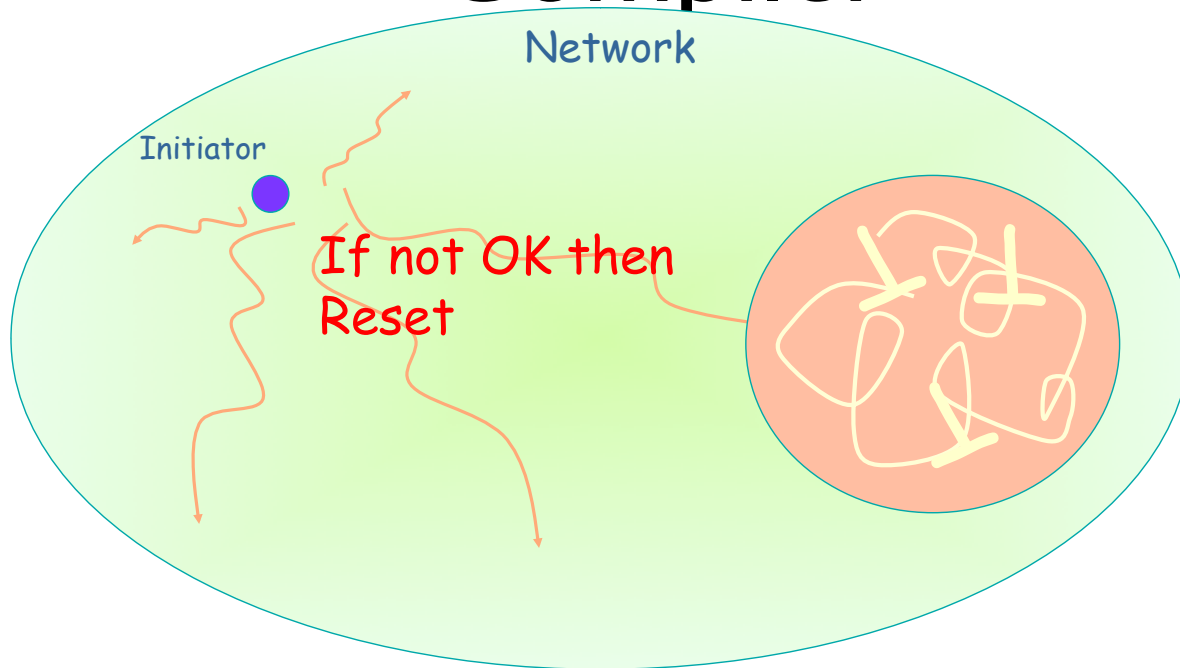
With a Single Initiator

Snap-Stabilizing Compiler



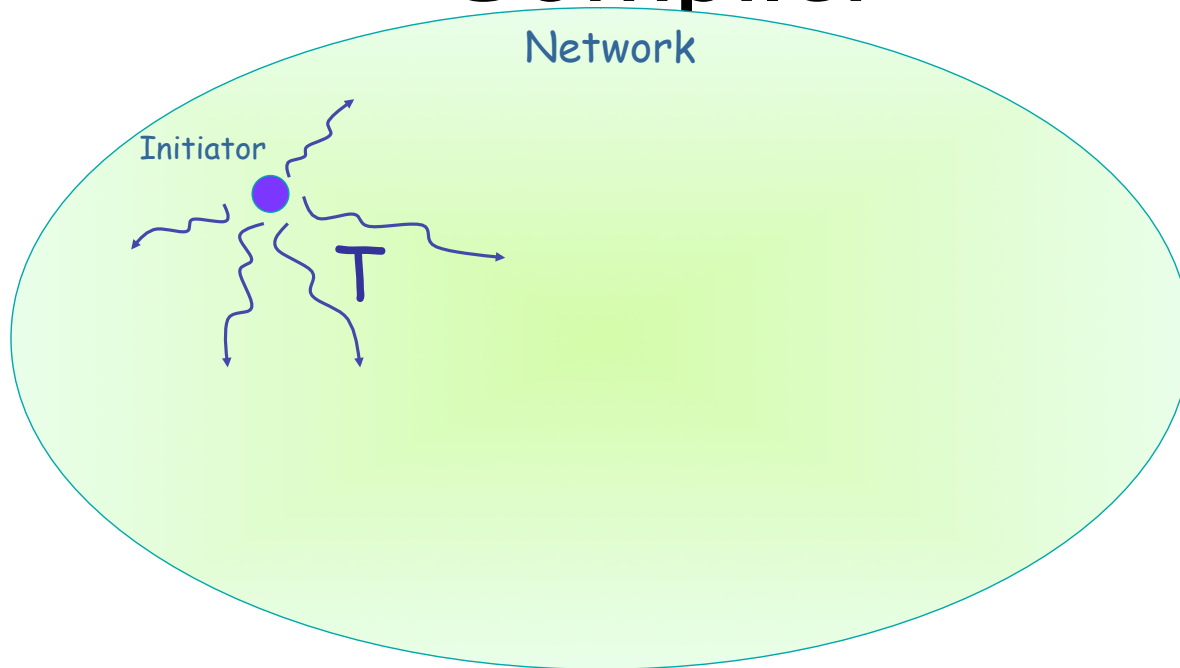
With a Single Initiator

Snap-Stabilizing Compiler



With a Single Initiator

Snap-Stabilizing Compiler



With a Single Initiator

Snap-Stabilizing Compiler

With a Multiple Initiators

- Same principle
- Snap-stabilizing leader test
- Snap-stabilizing leader election
- Snap-stabilizing reset
- Snap-stabilizing snapshot
- Snap-stabilizing termination detection