From link shut to node shut:

Graceful operations in link-state routing networks

François CLAD, Pascal MERINDOL and Jean-Jacques PANSIOT

Team presentation
December 17th, 2012

1 Introduction

2 Transient loops

3 Link shut

4 Node shut

5 Conclusion

Some context

- Routing in providers' networks
  - Intra-domain routing
  - Link-state protocols : OSPF, IS-IS
- Frequent topological changes
  - Link or node addition, withdrawal or modification
  - . . . and as many convergence periods

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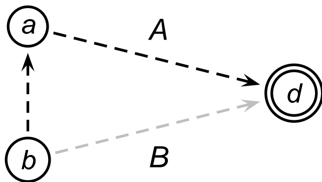
How do transient loops appear ?

Routers' update order is **not controlled.**
It depends on *LSA flooding* and *RIB/FIB update* times.

- Initially, both a and b reach d through a.

Routes towards d :



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  Path through b more interesting, even for a.

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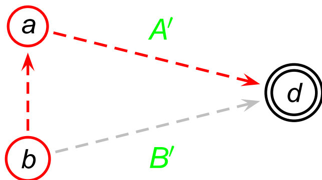

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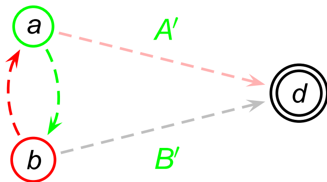

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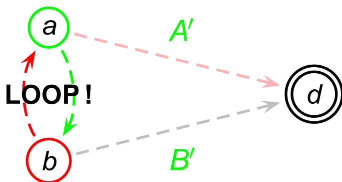

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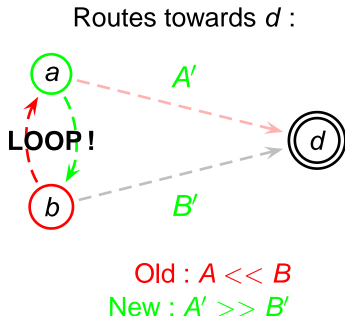
- A **transient loop** appears on link (a, b).
  - Increased latency
  - Packet losses

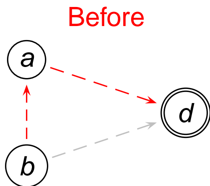


How to detect them ?

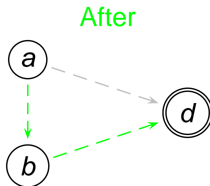
For a given destination (e.g. *d*) :

1. Compute routes before and after the change.

Before



After



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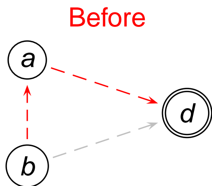

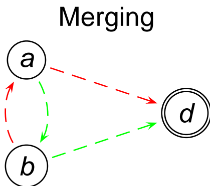

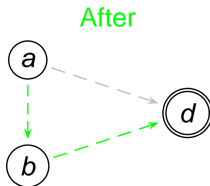

How to detect them ?

For a given destination (e.g. *d*) :

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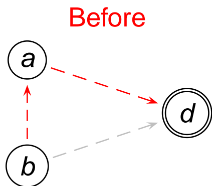
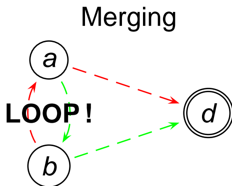
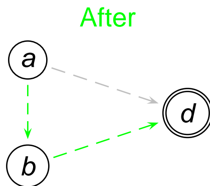
3. Perform a cycle detection on the resulting graph.







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Force the routers to update in the *right* order.

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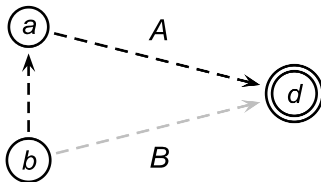

$$A + w(b, a) < B$$

P. Francois and O. Bonaventure, “Avoiding Transient Loops During the Convergence of Link-State Routing Protocols”, *IEEE/ACM Transactions on Networking*, volume 15, pages 1280-1292, December 2007.

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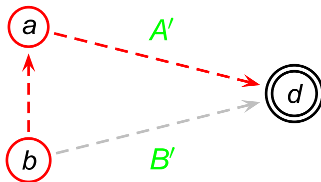

Old : $A + w(b, a) < B$
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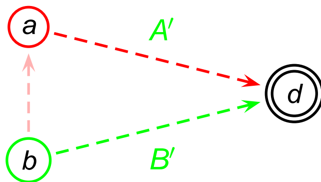

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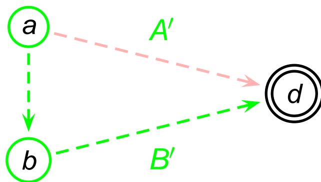

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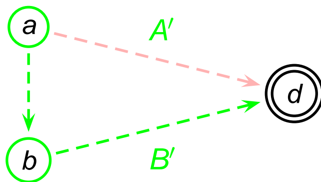

One goal, several approaches.

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Progressive update

Basic idea

Split up the change into a sequence of smaller modifications, such that **each one is loop free.**

Objectives

Compute a sequence of intermediate updates, such that :

- No transient loop may appear during the transition between two consecutive updates.
- Each intermediate update prevents at least one cycle.

Challenge

Minimal operational impact (sequences of minimal size)

Illustration : path increment sequence

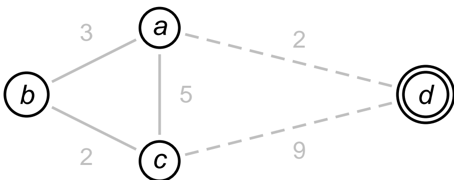
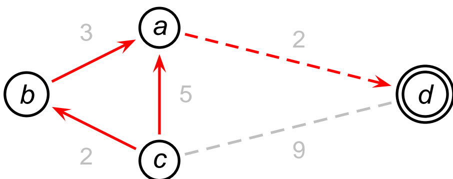


Illustration : path increment sequence

- Initially, a, b and c reach d through node a.



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- Initially, a, b and c reach d through node a.
- If a change occur on path $P(a, d)$ increasing its cost to 50...

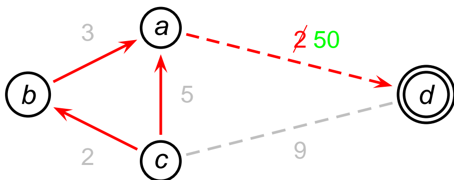

Illustration : path increment sequence

- Initially, a, b and c reach d through node a.
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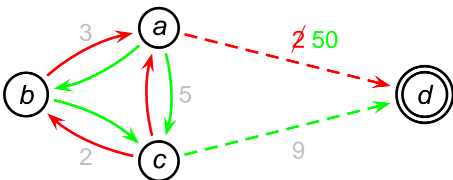

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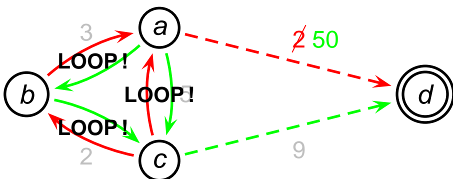

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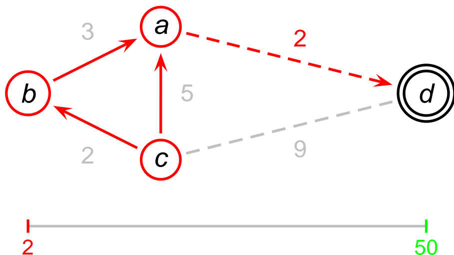

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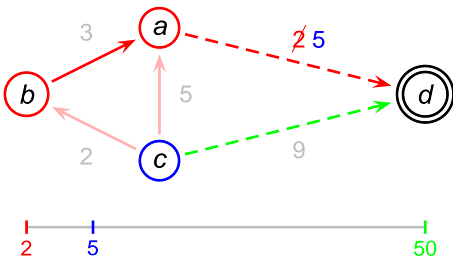
With progressive increments :

- Node c could update first



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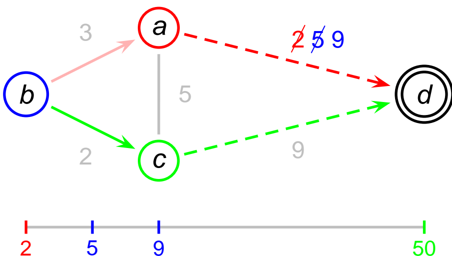
With progressive increments :

- Node *c* could update first
- Then *b*



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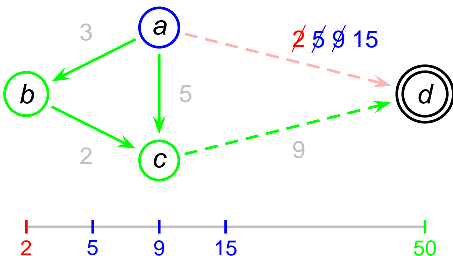

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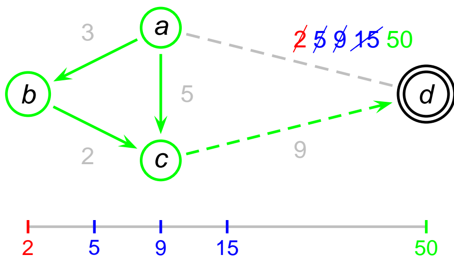
So that the transition to 50 will be loop free.



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Case of a link shut (withdrawal)[1]

1. Compute a list of **affected destinations**
2. Compute *new* paths toward these nodes (after removal)
3. Extract **destination oriented** metric sequences
4. Merge and reduce them to build a **global** sequence

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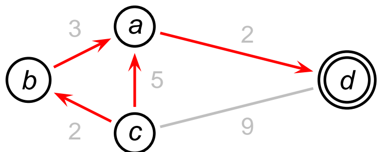
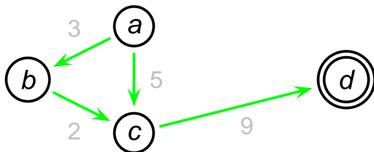
1. The same algorithms may be used for any other kind of modification on a single link (addition, weight increment or decrement).

Destination oriented sequences : Δ values

Current paths



New paths



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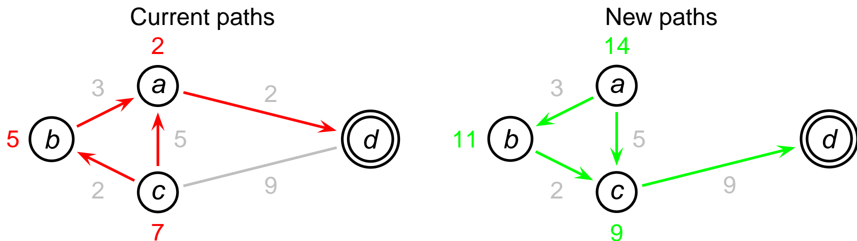

- Retrieve distances from each node to the destination

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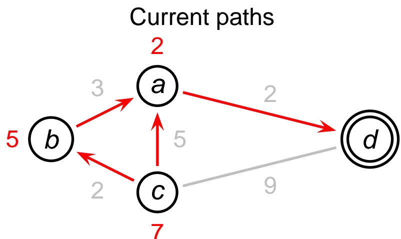

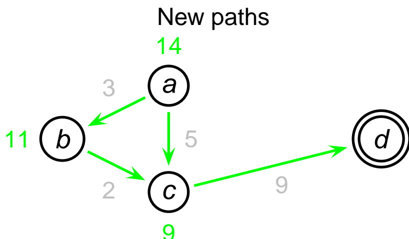

- Retrieve distances from each node to the destination
- Compute the difference (Δ) between new and old distances
  - $\Delta(a) = 14 - 2 = 12$
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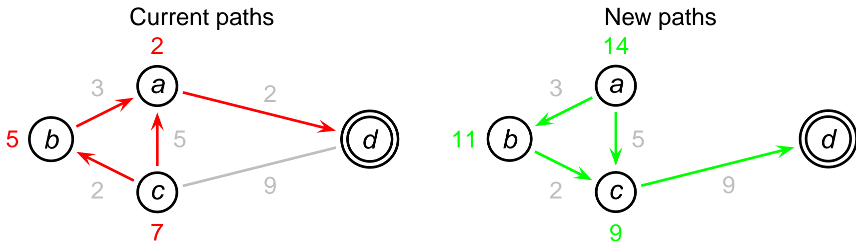
Destination oriented sequences : Δ values



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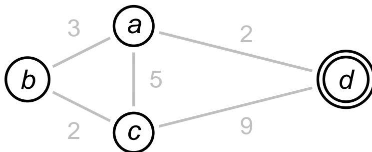
▷ Incrementing the weight of link (a, d) by one of these Δ values would put the corresponding node in an **ECMP transient state**.

Destination oriented sequences : ECMP state

While in **ECMP state**, a node uses both its old and new routes towards the destination.



- Δ sequence : $\{2, 6, 12\}$

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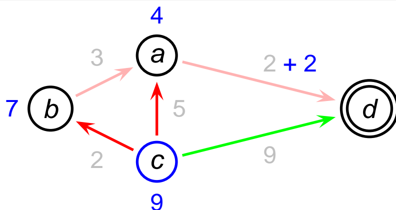

- Δ sequence : $\{2, 6, 12\}$
  - ▷ First values such that the nodes use their new path(s)

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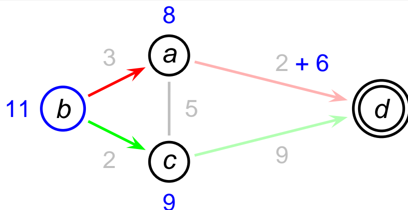

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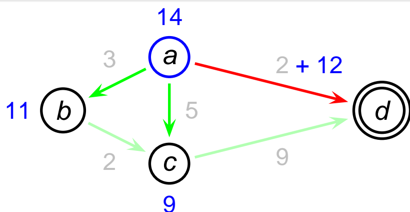

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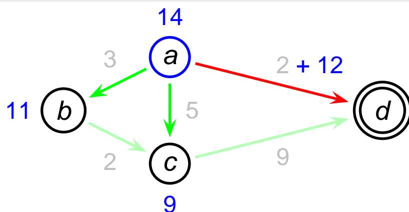

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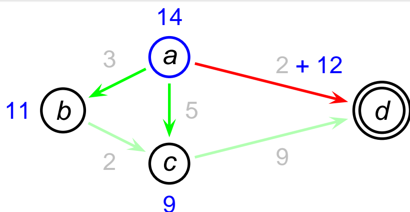

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- Increment sequence $(\Delta + 1)$: $\{3, 7, 13\}$
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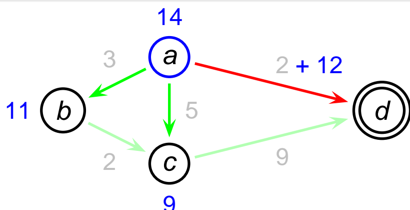

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- Metric sequence $(\Delta + 1 + w(a, d))$: $\{5, 9, 15\}$

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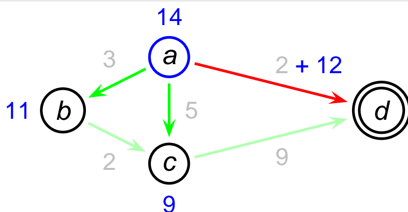

- Δ sequence : $\{2, 6, 12\}$ relative to $w(a, d)$
  - ▷ First values such that the nodes use their new path(s)
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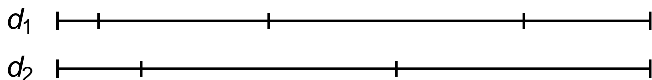
Global metric sequences



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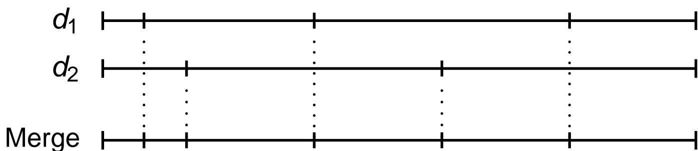

- Merge all destination oriented sequences
  - ▷ Prevent transient loops for all destinations
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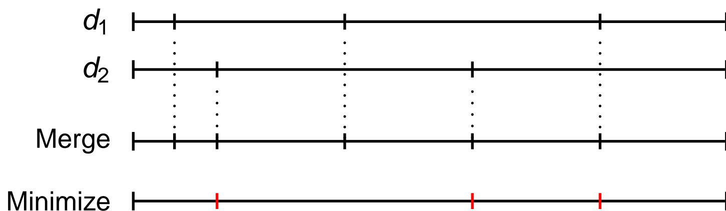
Global metric sequences



- Merge all destination oriented sequences
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  - Ensure the minimality in terms of sequence size

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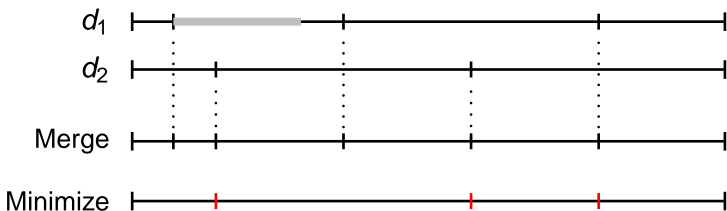

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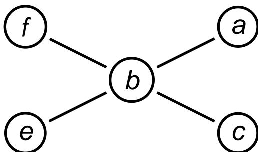
2 Transient loops

3 Link shut

4 Node shut

5 Conclusion

Case of a node shut[2]



- Shut each outgoing link of the node
- Increasing the weight of one link may shift the traffic to an alternate link
  - ▷ Flapping issues
- Several link updates in a single signalisation packet (LSA)
  - ▷ Vectorial increments

2. As for a link, the same procedure may be used for adding a node.

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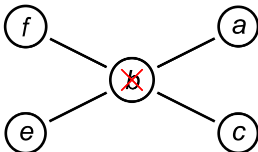

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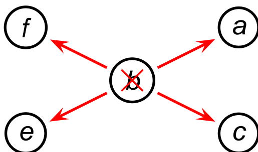

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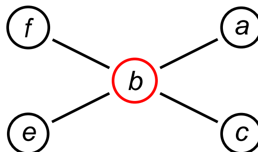
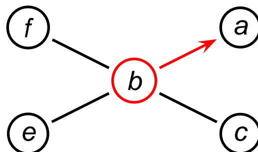


- Proof of existence
- Shut outgoing links one-by-one using the *link shut* approach
- Different orders may produce sequences of different sizes

+ One algorithm for link and node shut
– Multiple traffic shifts (flapping), far from being minimal

A first approach : link-by-link



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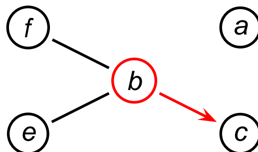

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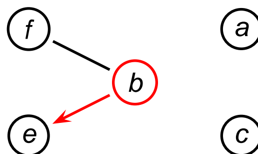

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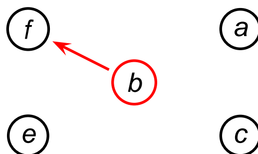

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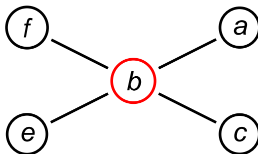
A smarter way : uniform increments



- **Uniform increments** on outgoing links
- Same algorithm as for the link shut

\+ Good computing performances, no traffic shift

– Still not minimal

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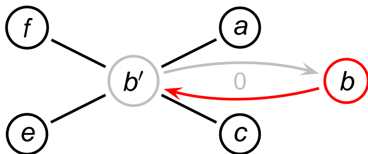

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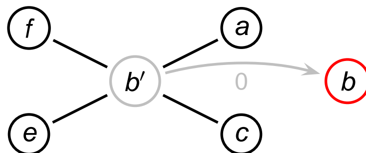

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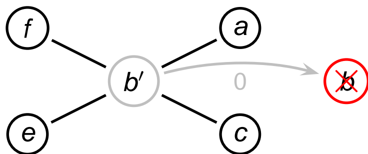

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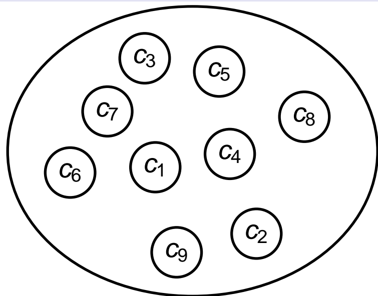
Towards minimality : Greedy Backward Algorithm



- Enumerate every transient cycle

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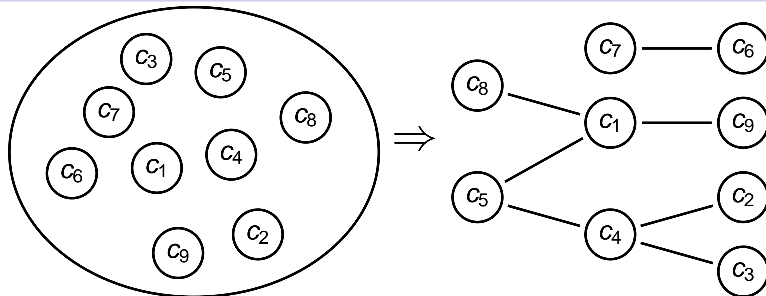

- Enumerate every transient cycle
- Order these cycles in a dependency DAG (partial order)

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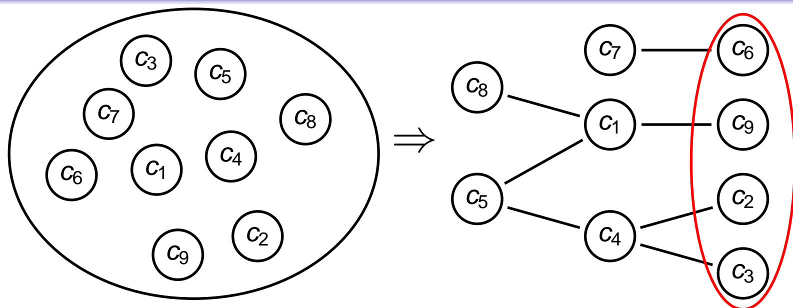

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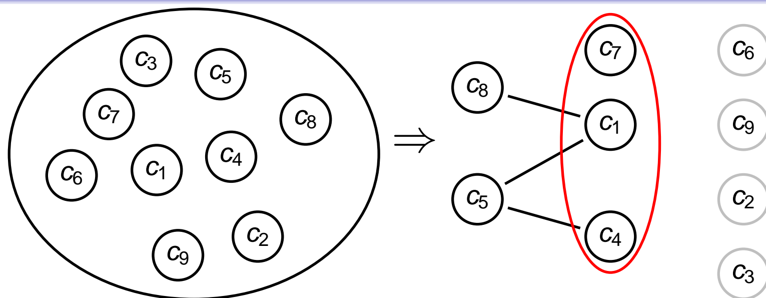

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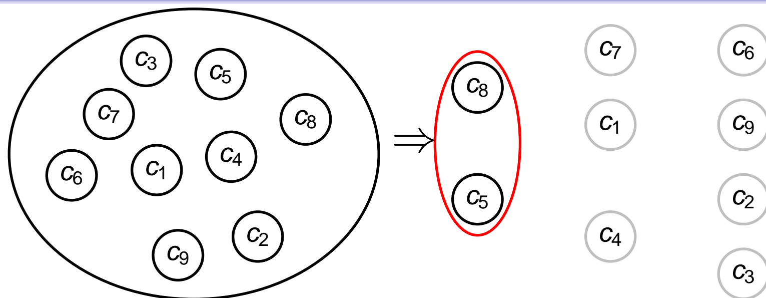

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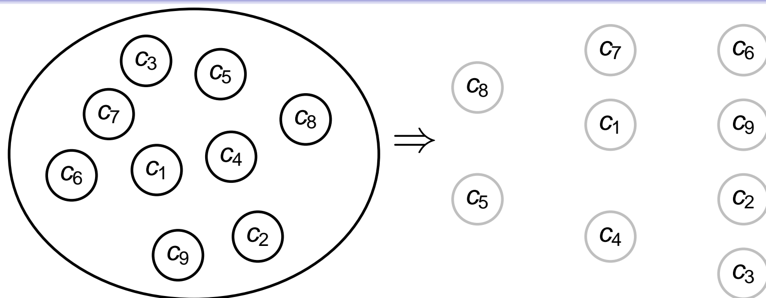

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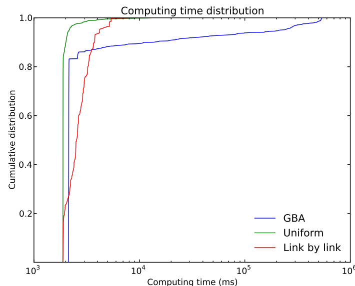
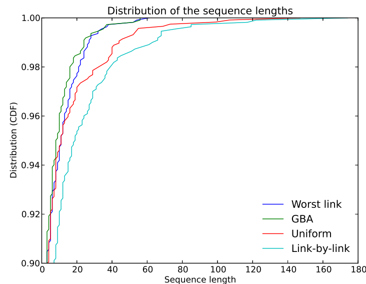
+ Minimal sequence size

− Path flapping, high computing times

Comparative evaluation





- Close results for most nodes
- Differences appear on *worst cases*

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Conclusion

- ✓ Link shut
  - ✓ Minimal solution
  - ✓ Low time complexity

- Node shut – work in progress
  - ✓ Minimal solution
  - ▷ Improve time performances
  - ▷ Avoid flapping

Thank you for your attention.