Safe Routing Reconfiguration with Route Redistribution

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Routing configuration matters

- It controls traffic paths
  - impacts QoE, business goals, SLAs, …
  - enables resource optimization
- It is optimized wrt changing factors
  - traffic demands, working links, …

Live reconfigurations are important

- For traffic engineering
  - fine-tune how traffic flows in the network
- To keep devices up-to-date
  - e.g., new security patches, OS release, equipment renovation, …
- For evolvability
  - new requirements or services
  - introduction of new protocols
    - e.g., OpenFlow?

Reconfiguration techniques exists

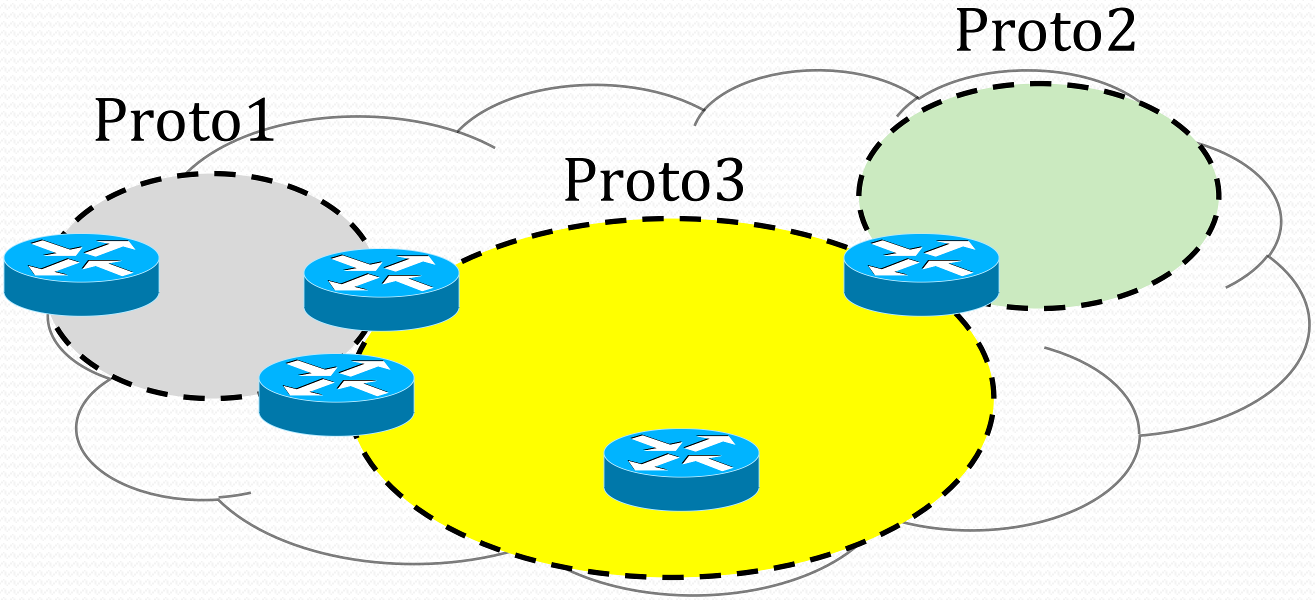
- Industrial guidelines
  - e.g., vendor-based [Herrero10]
- Research proposals
  - case specific, e.g., [Francois07]
  - more general, e.g., Ships-In-The-Night (SITN) [Vanbever11]

Existing techniques oversimplifies

- Industrial guidelines provide no guarantees on service continuity
  - only rules of thumb [Herrero10]
- Research proposals for networks with a single routing instance
  - case specific, e.g., [Francois07]
  - more general, e.g., Ships-In-The-Night (SITN) [Vanbever11]

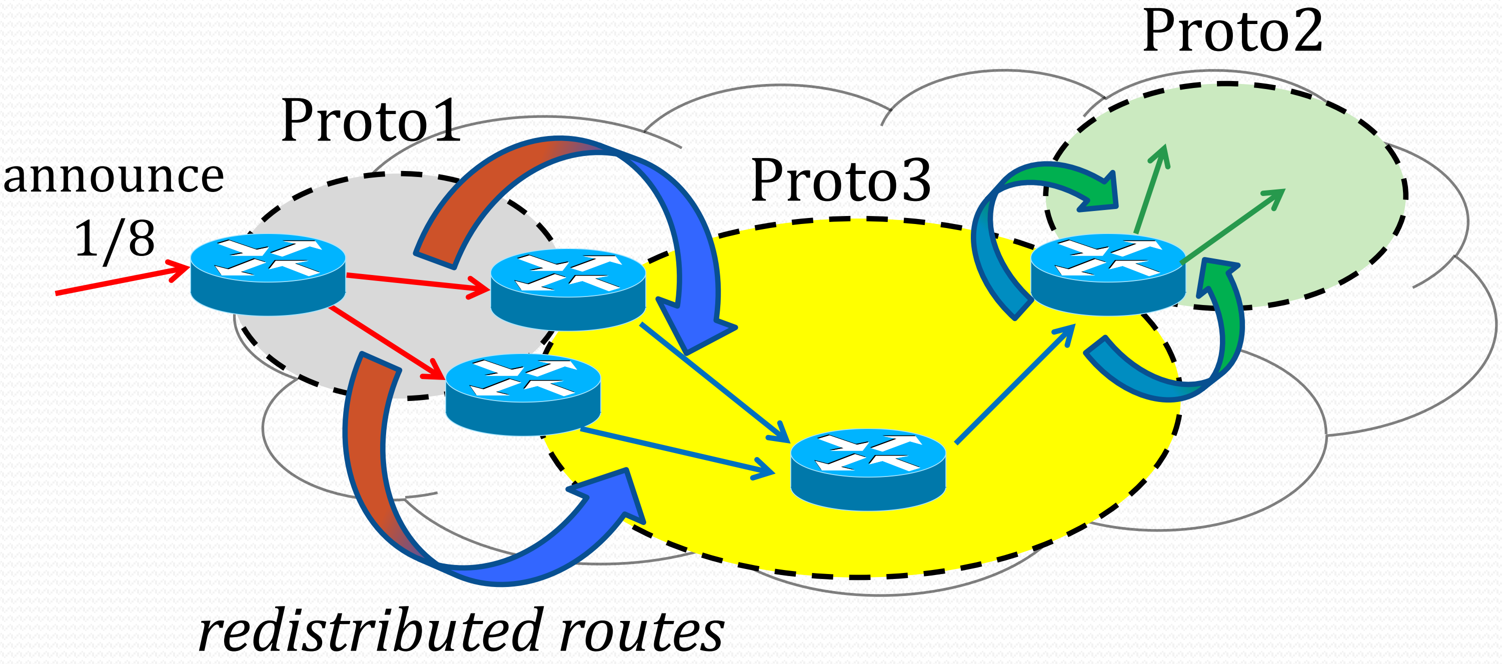
Real networks are complex

- Multiple ***Routing Domains (RD)***
  - each running a different *routing instance* ProtoX



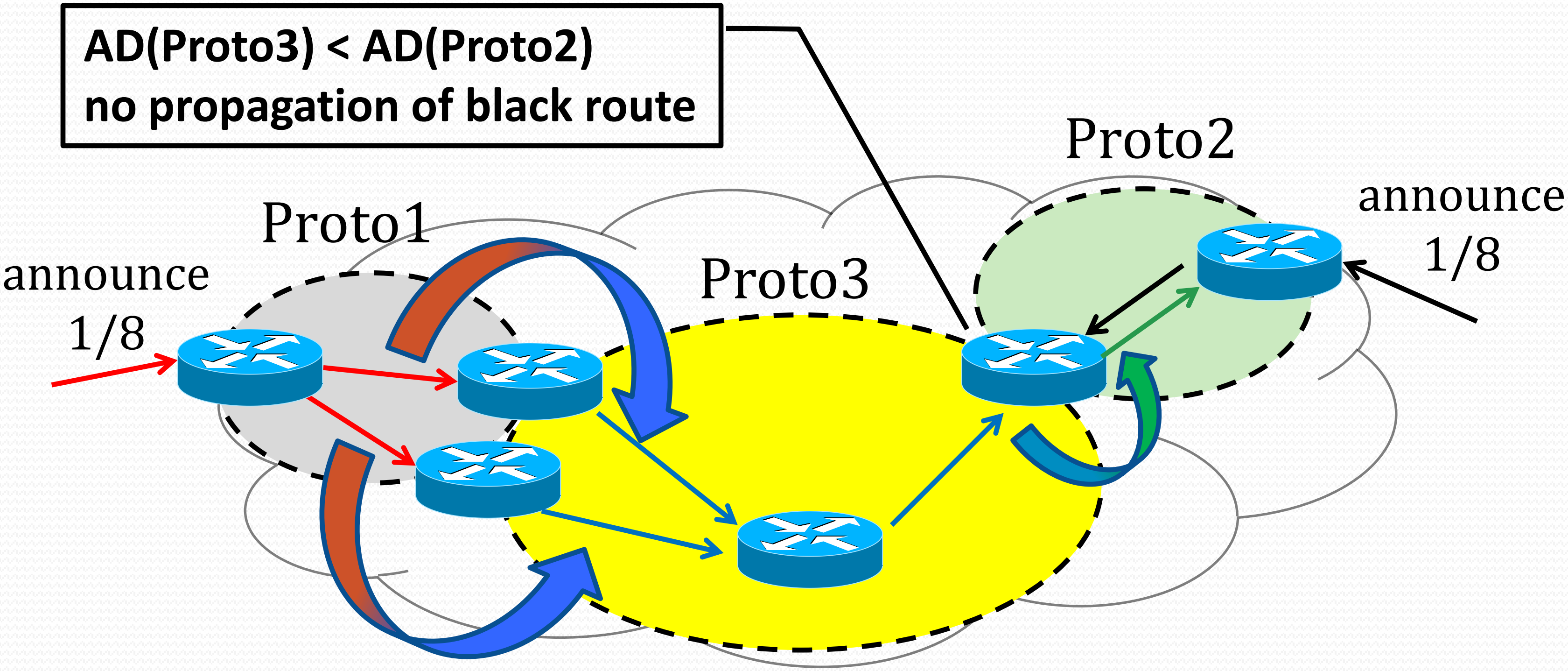
Real networks are complex

- ***Route redistribution (RR)*** glues RDs together
  - propagating used routes across RDs



Real networks are complex

- ***Administrative Distance (AD)*** encodes instance preferences



AD(Proto3) < AD(Proto2)
no propagation of black route

We study practical reconfigurations

- On running networks
  - focus on large enterprises
- Incremental
  - for process control and debug/rollback
- No service disruptions
  - preventing possible routing/fwd anomalies
- No changes to router internals
  - working today

Contribution overview

- Insight on the general problem
  - single-RD and multi-RD reconfigurations
  - anomalies can and do occur
  - RR affects prior work
- Practical solutions
  - new sufficient conditions for RR
  - provably safe procedures
  - prototype implementation and validation

Contribution overview

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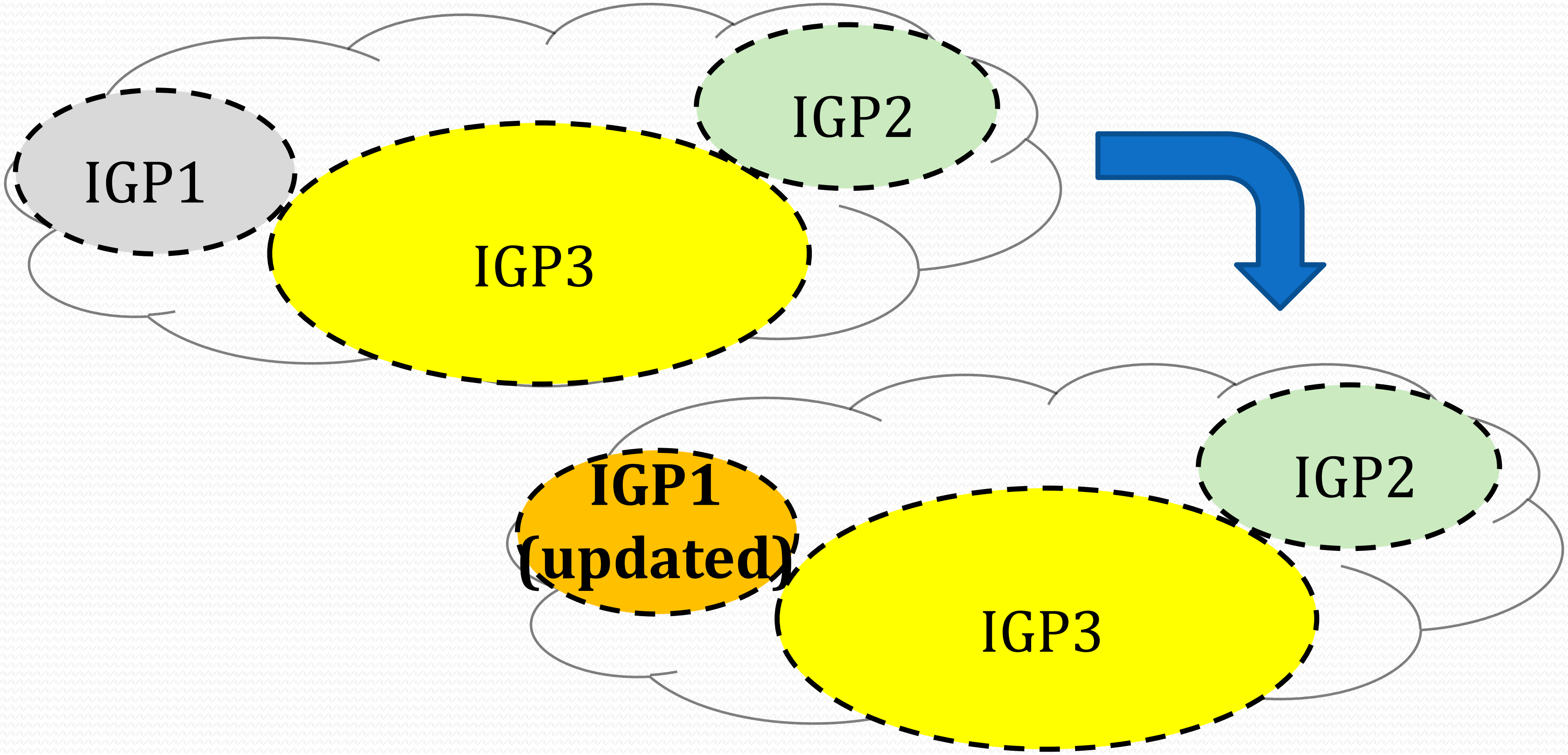
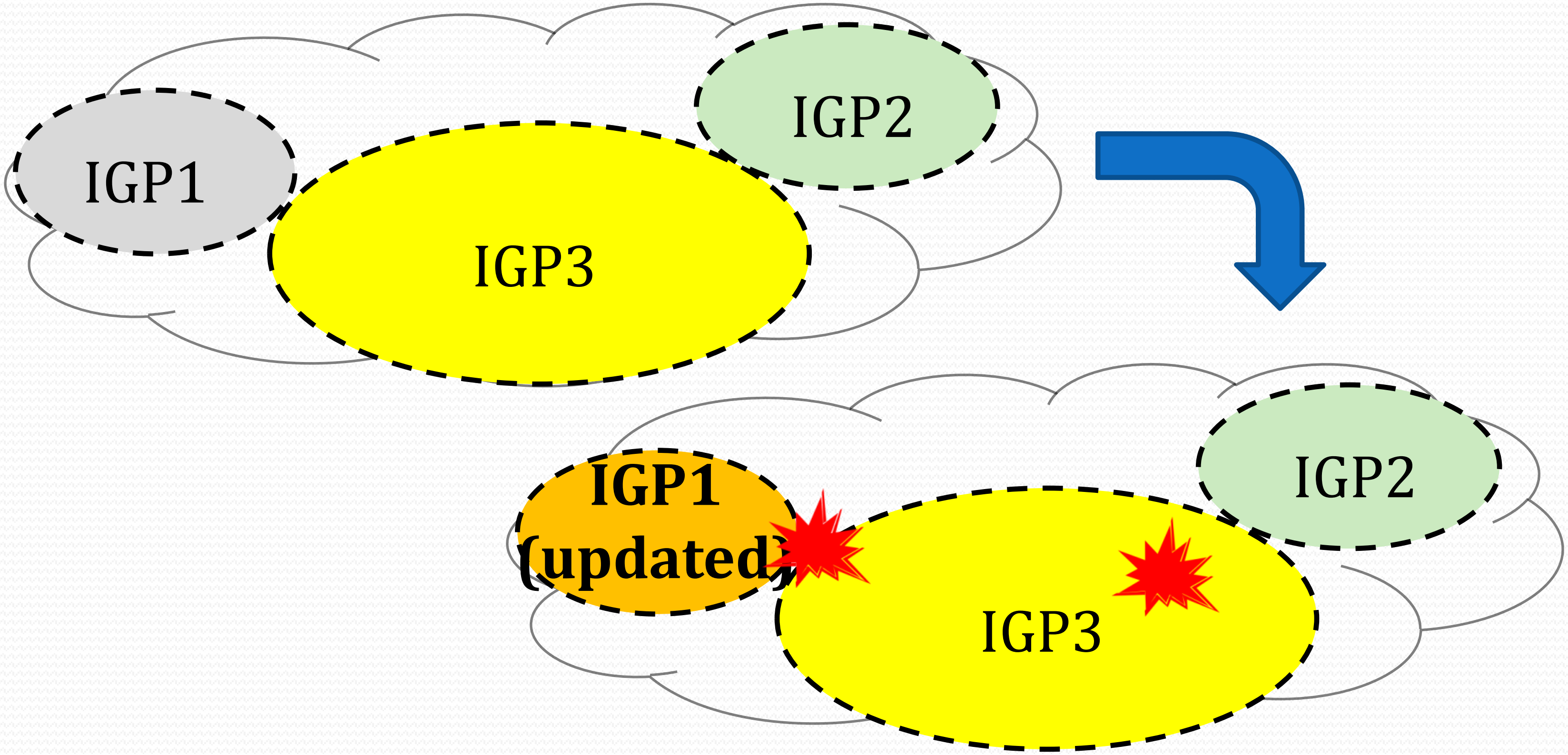
Single-RD reconfigurations



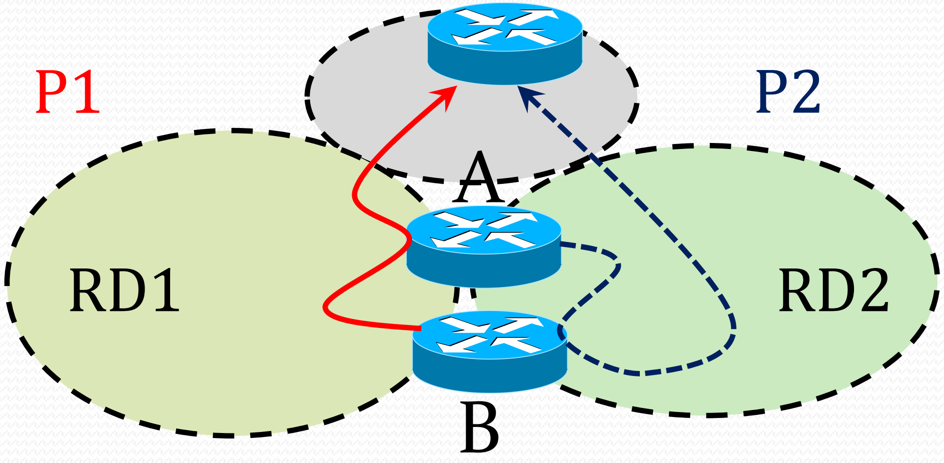
Existing techniques may not work



We now refer to SITN

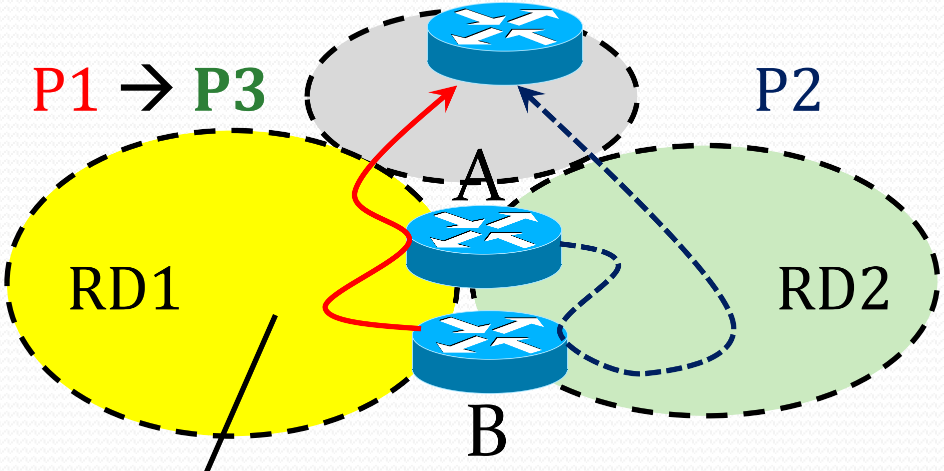
- introduce the final configuration
  - de-preferred
- swaps preference between initial and final configuration
  - on a per-router order
  - in a carefully-computed order

SITN disruption example



- AD(P1) < AD(P2) for both A and B

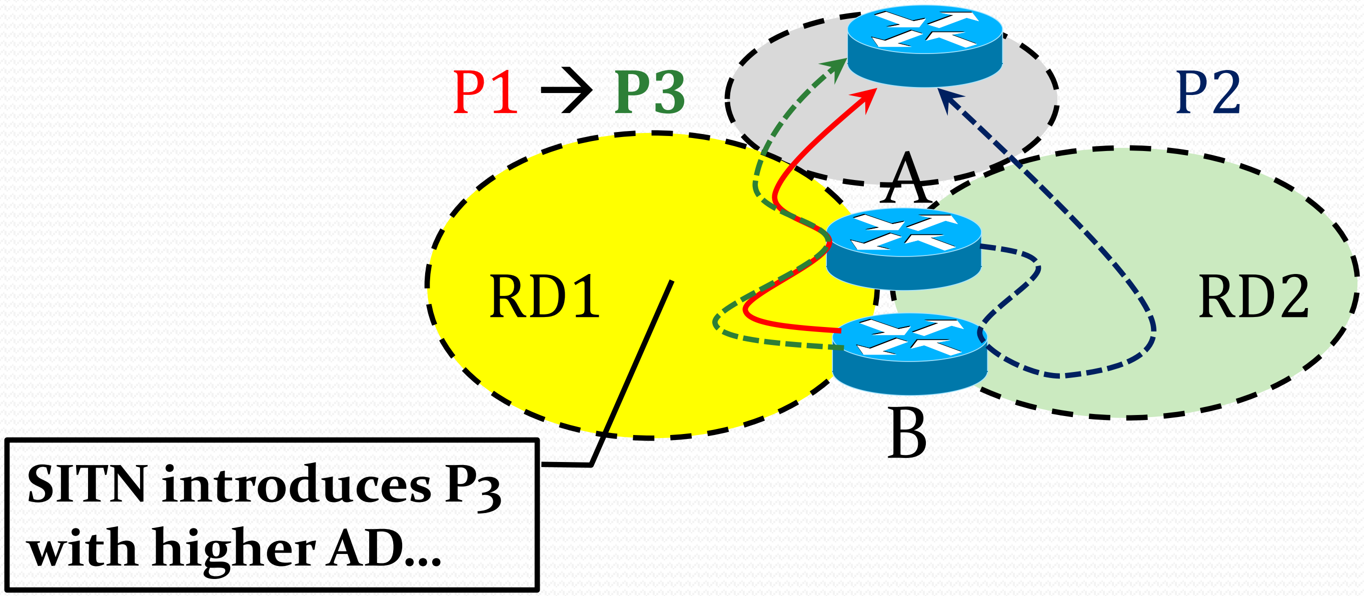
SITN disruption example



to be reconfigured

- AD(P1) < AD(P2) for both A and B

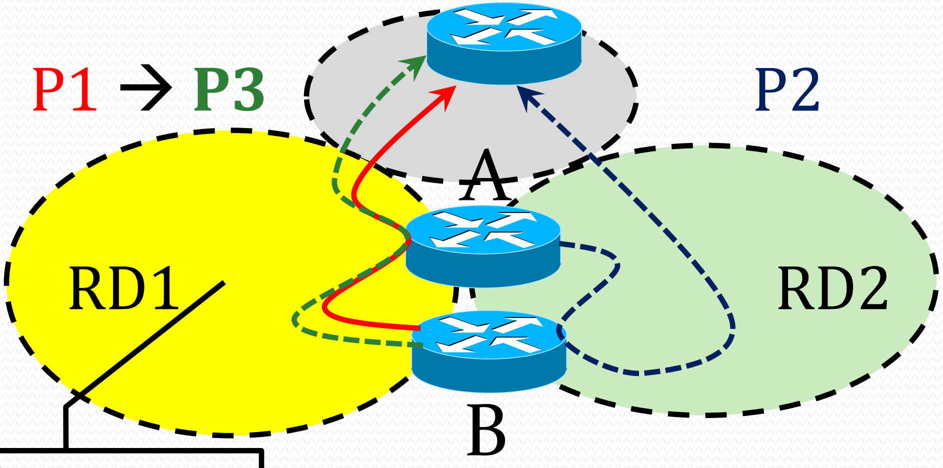
SITN disruption example



SITN introduces P3 with higher AD…

- AD(P1) < AD(P2) < AD(P3) for both A and B

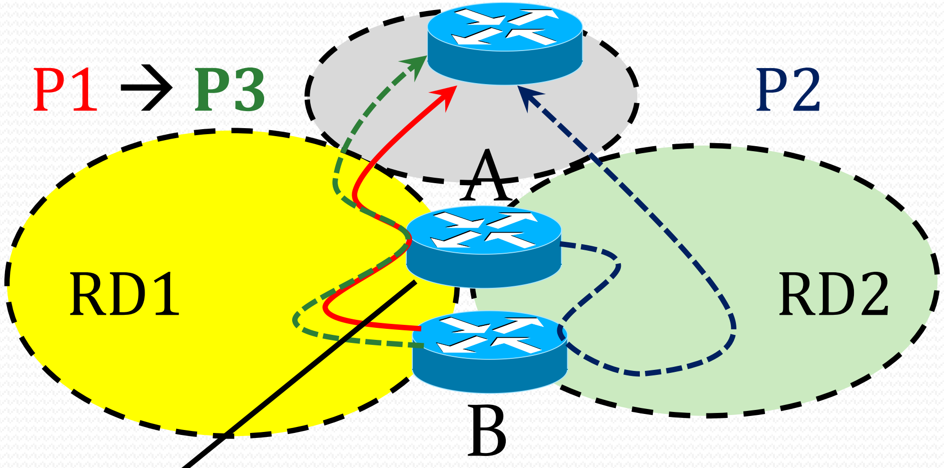
SITN disruption example



… and swaps preferences on routers in a given order

- AD(P1) < AD(P2) < AD(P3) for both A and B

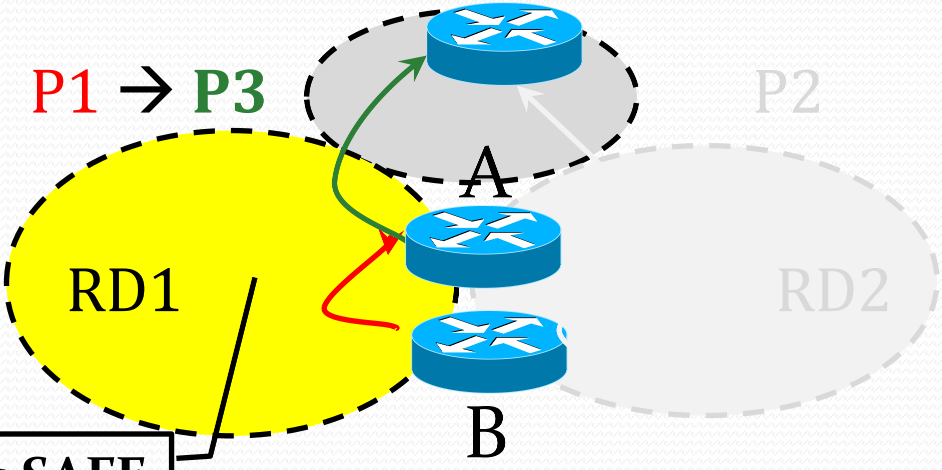
SITN disruption example



e.g., starting from A

- AD(P2) < AD(P3) < AD(P1) for A
- AD(P1) < AD(P2) < AD(P3) for B

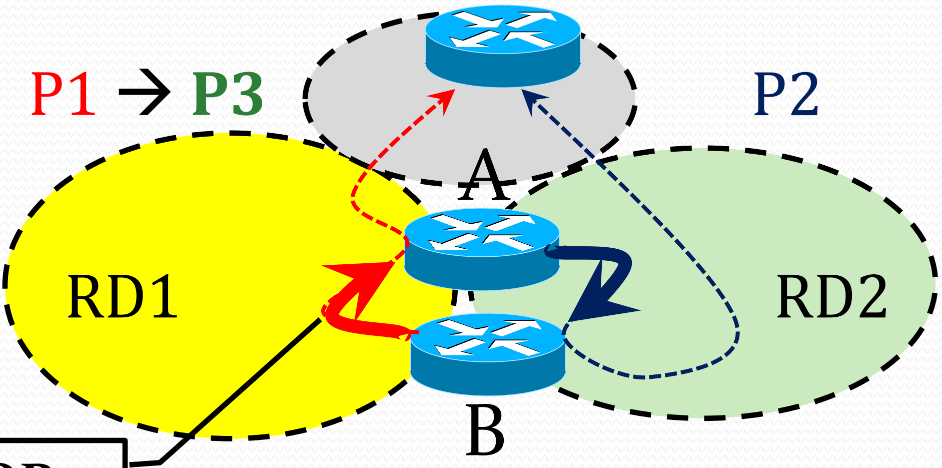
SITN disruption example



starting from A is SAFE in a single-RD network

- AD(P2) < AD(P3) < AD(P1) for A
- AD(P1) < AD(P2) < AD(P3) for B

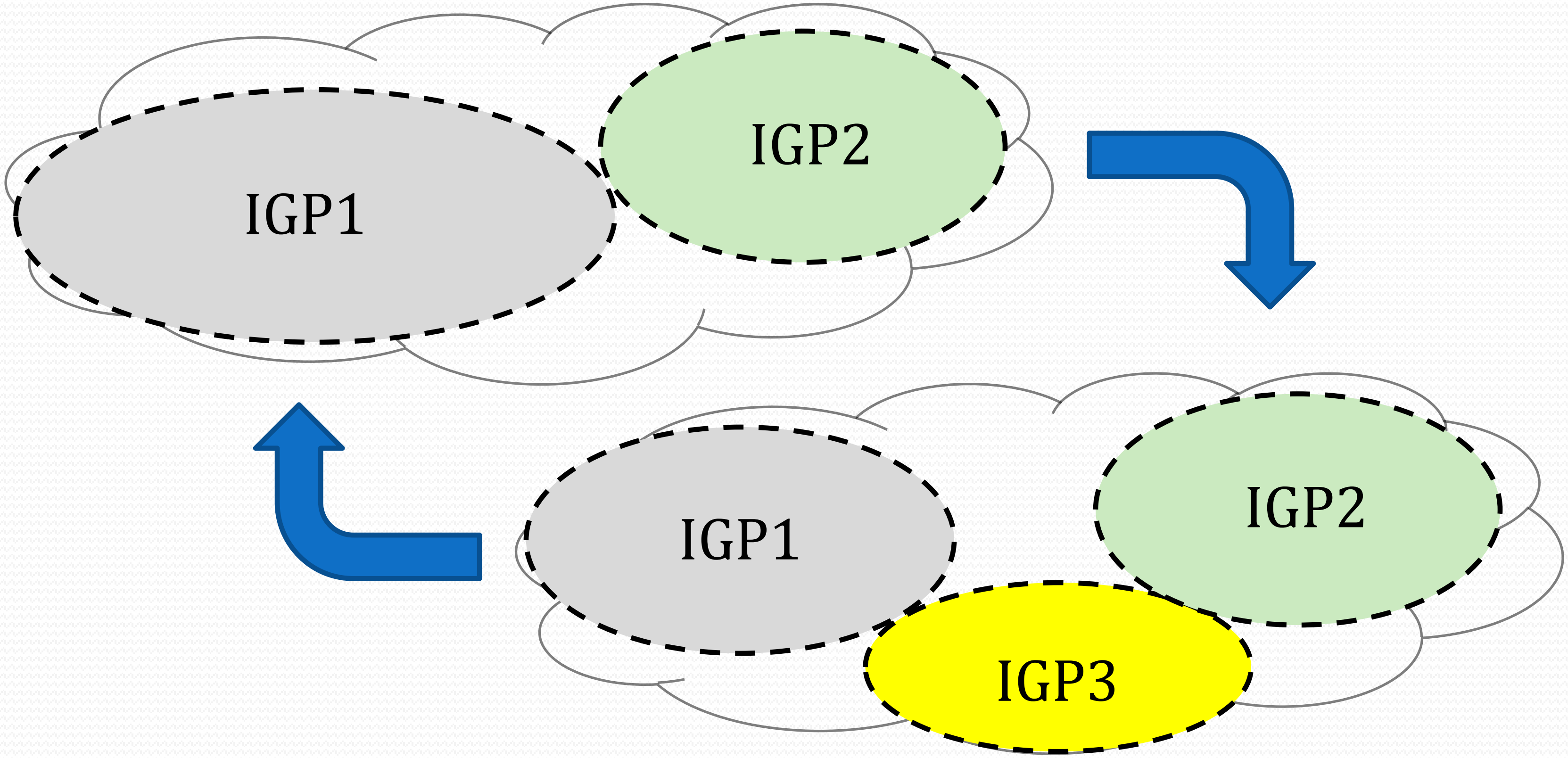
SITN disruption example



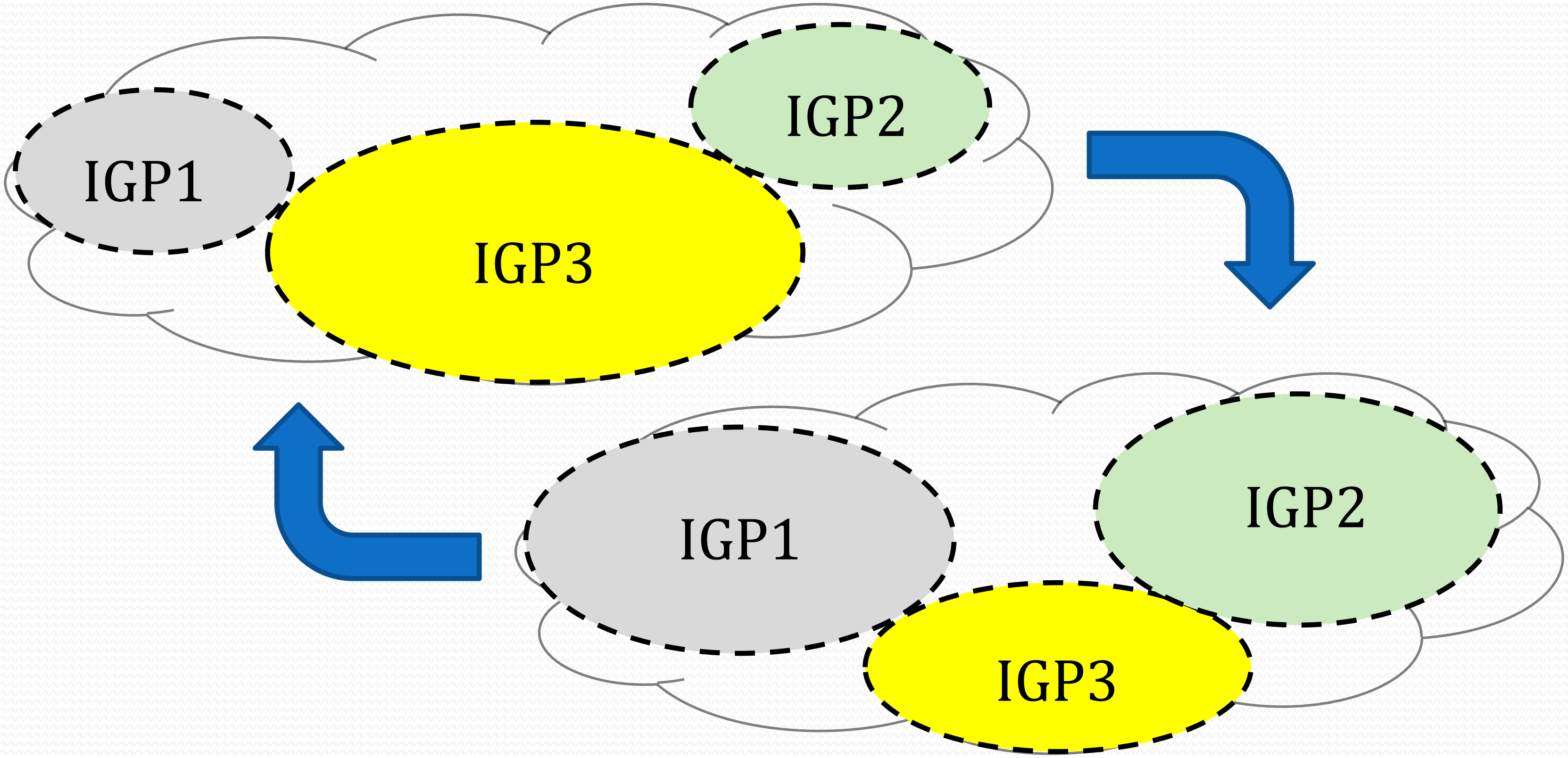
but causes a LOOP in the presence of P2

- AD(P2) < AD(P3) < AD(P1) for A
- AD(P1) < AD(P2) < AD(P3) for B

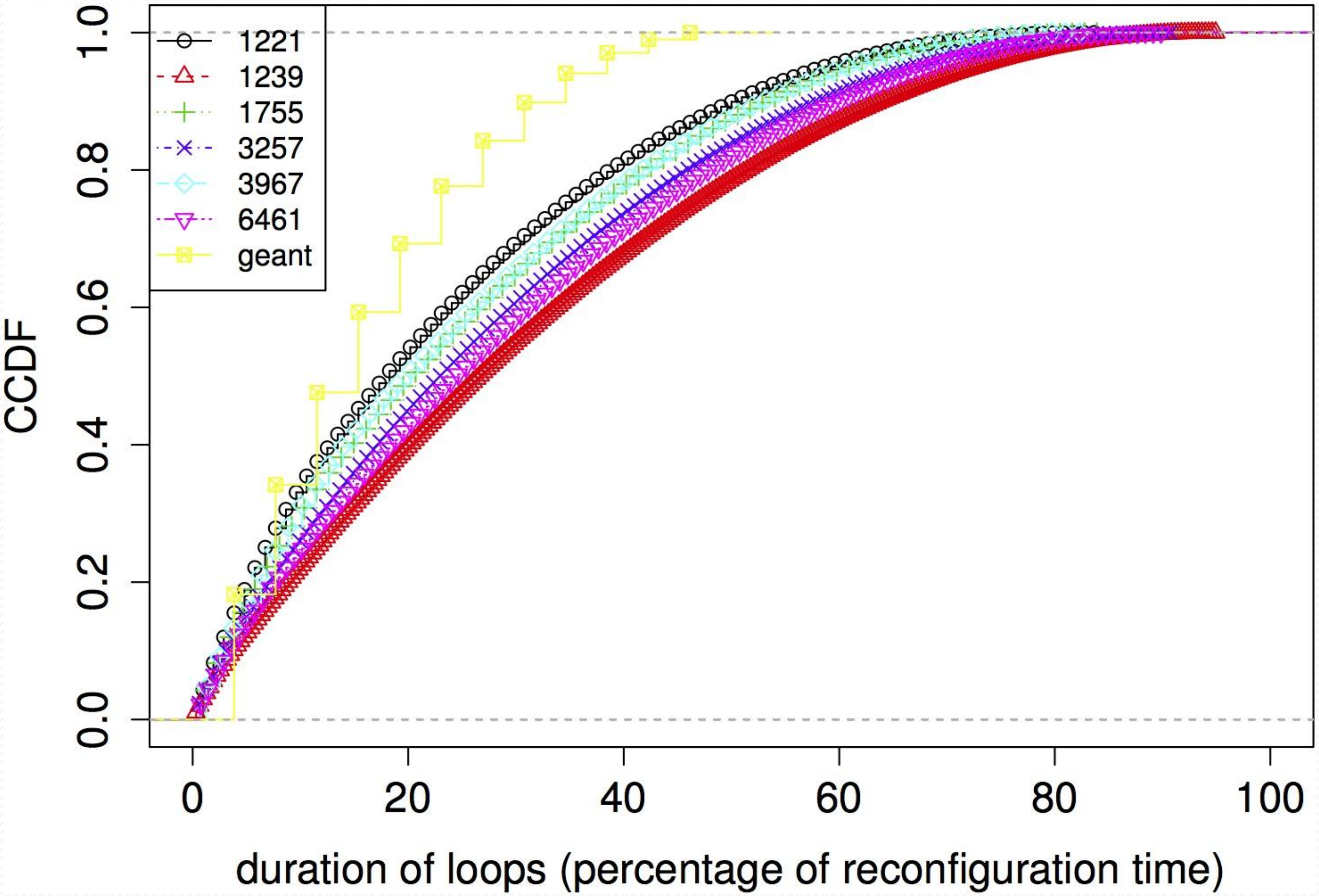
Multi-RD reconfigurations



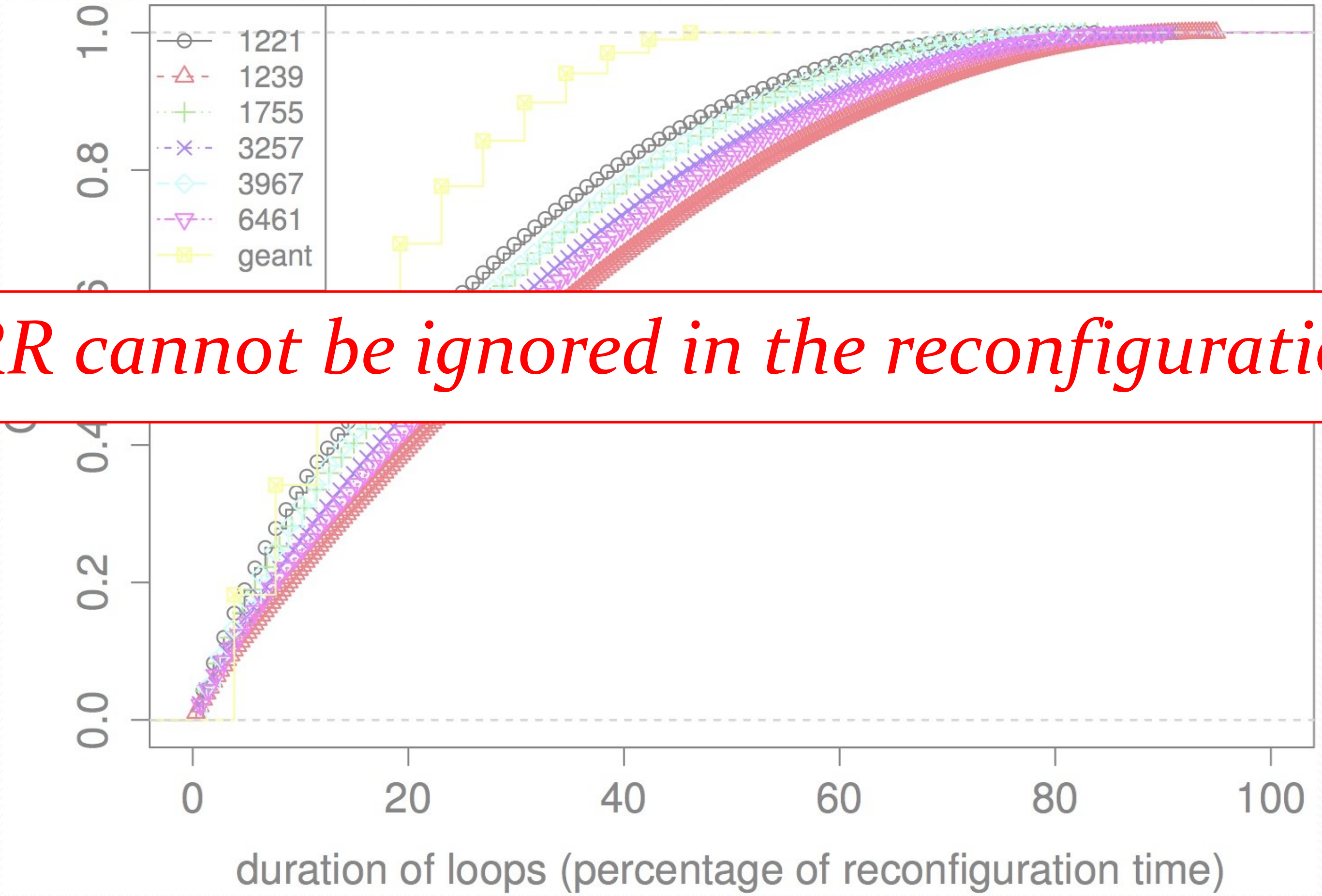
Multi-RD reconfigurations



Long-lasting loops can occur



Long-lasting loops can occur



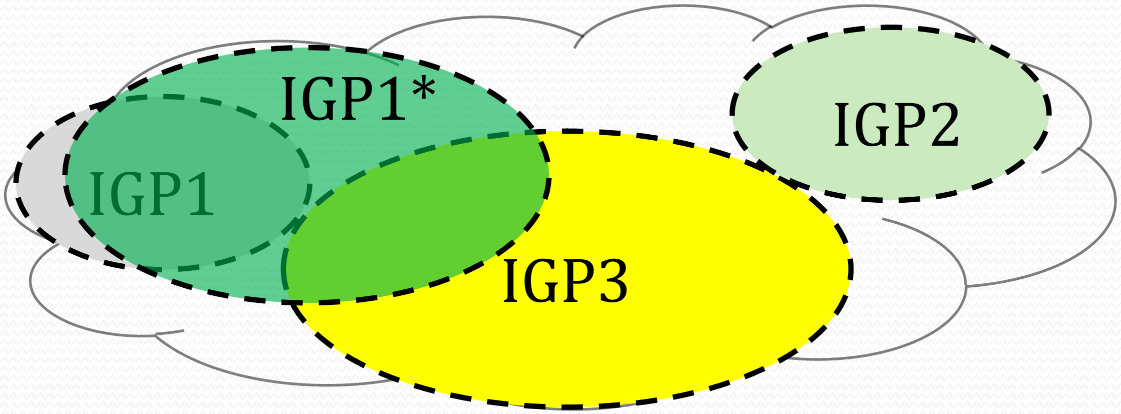
RR cannot be ignored in the reconfiguration!

Known techniques hard to extend

- Additional router-level operations
  - activating/de-activating RR
- Available routes change during the reconfiguration
  - route selection influences RR, and vice versa
  - new routes can be announced
  - existing routes can be withdrawn
- Previous RR theory does not apply
  - assumes one routing instance per RD

Previous RR theory does not apply

- Multiple instances per RD
  - in single/multi-RD reconfigs
- Nested RDs
  - in multi-RD reconfigs



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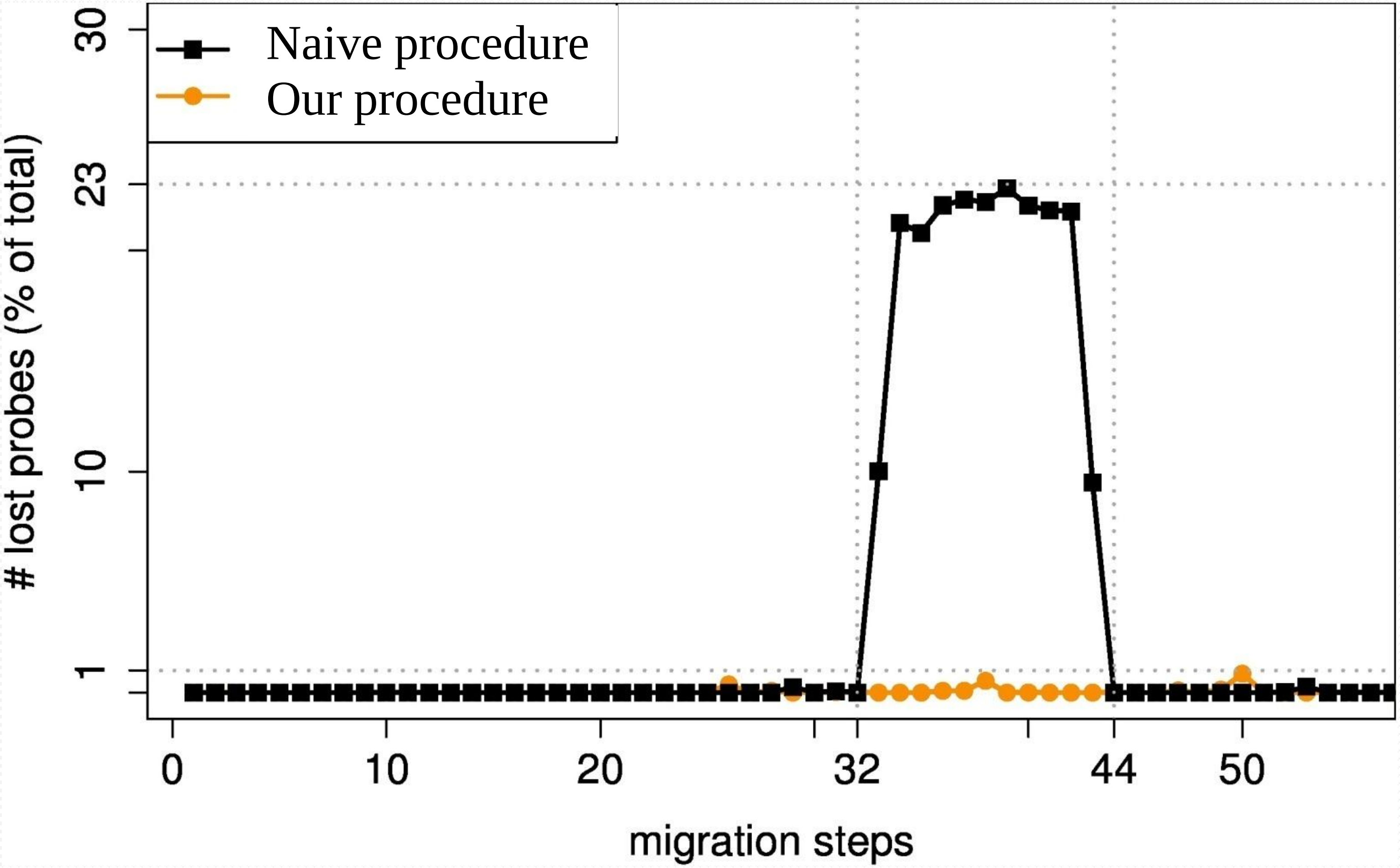
Safe single-RD reconfigurations

- Looser RR correctness conditions for disjoint RDs
  - each RD is assigned a unique AD interval
  - absence of loops internal to any RD
- Safe procedures
  - extending previous techniques
  - always applicable via AD interval pre-adjustment

Safe multi-RD reconfigurations

- New RR correctness conditions for nested RDs
  - all routers prefer the innermost RD
  - each shortest paths within any RD crosses at most one RR router
- Safe procedures
  - extending the SITN approach
  - supporting RD splitting/merging/reshaping

Live safe RD split (on virtual Geant)



Conclusions

- Study of practical reconfigurations
  - in enterprise networks with multiple RDs
  - overcoming limitations of prior work
- Extended RR theory
  - looser sufficient conditions for RR correctness
  - for both disjoint and nested RDs
- Safe reconfiguration procedures
  - based on our theory extension
  - validated via prototype implementation

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Thanks for attention!
Questions??