CSC 525:
Computer Networks

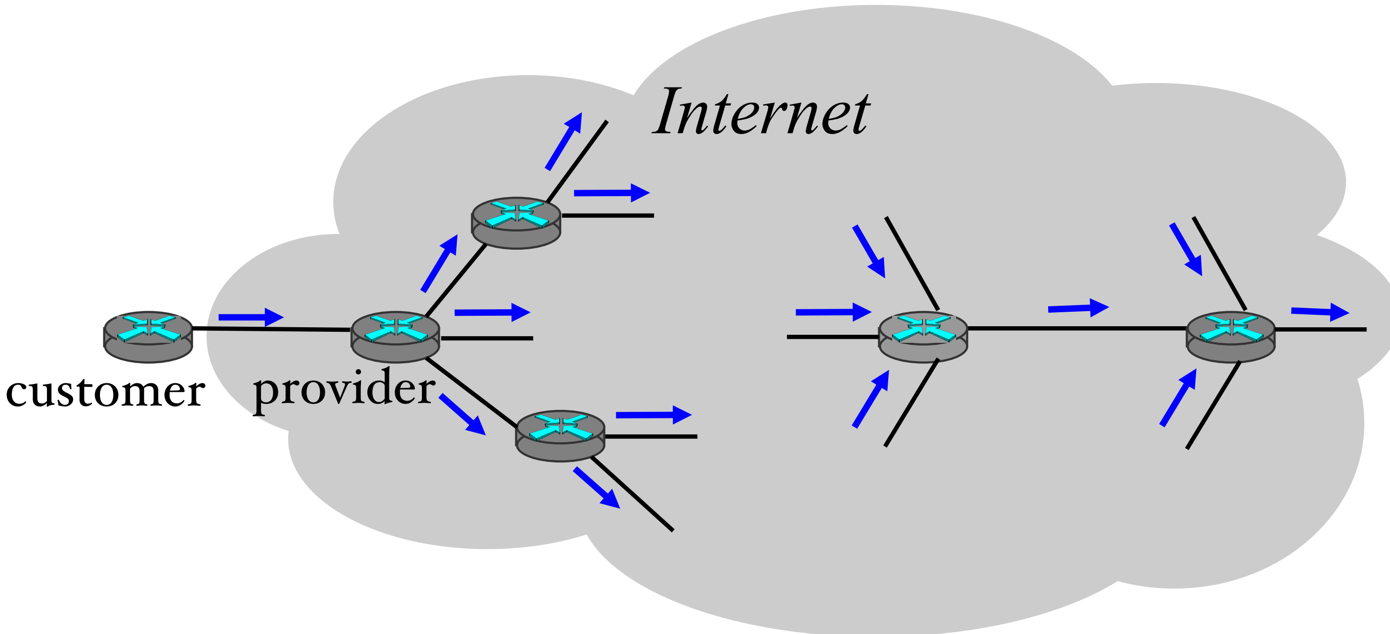
Overview

- *Route Flap Damping* is a key mechanism in BGP to maintain global routing stability.

- It's plagued by unintended interactions in the system.

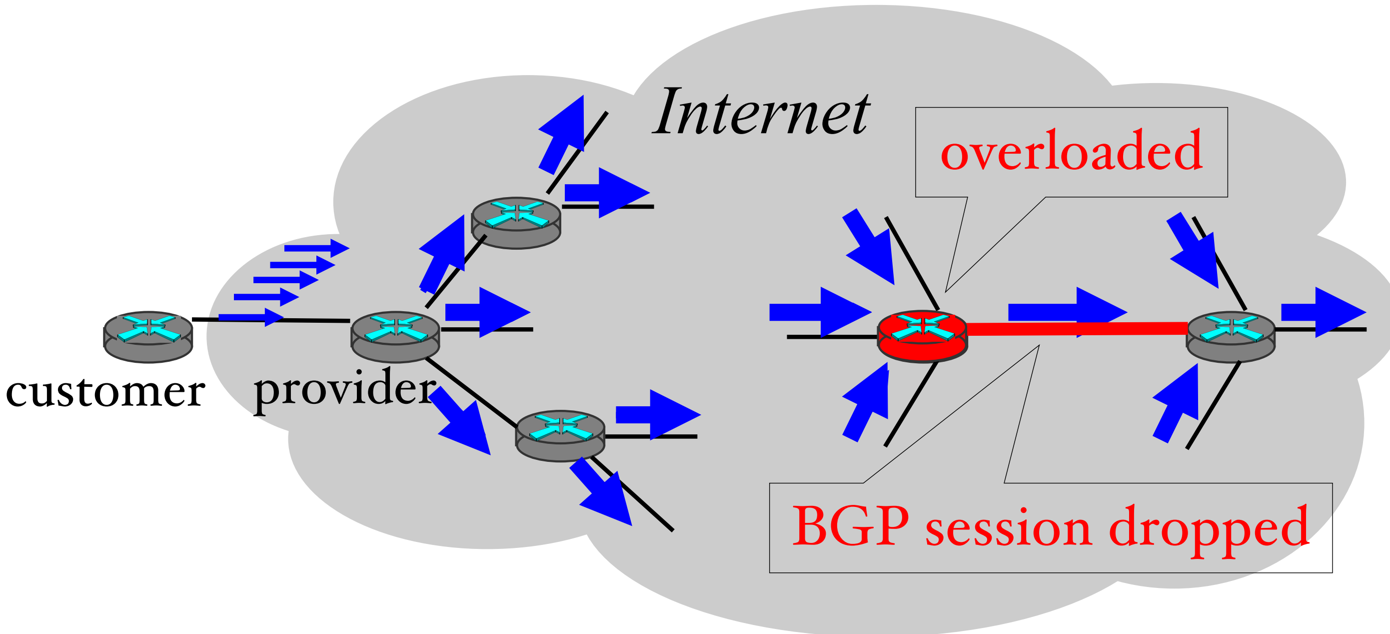
- Damping with Root Cause Notification.

Route Flapping



- Route Flap: a change of routing path
  - Caused by link up, link down etc.
  - Often triggers routing updates in the network

Route Flapping



- Extreme local instability damages global routing
  - worm attacks, flaky edge networks etc.
  - topology growth will only make it worse in the future

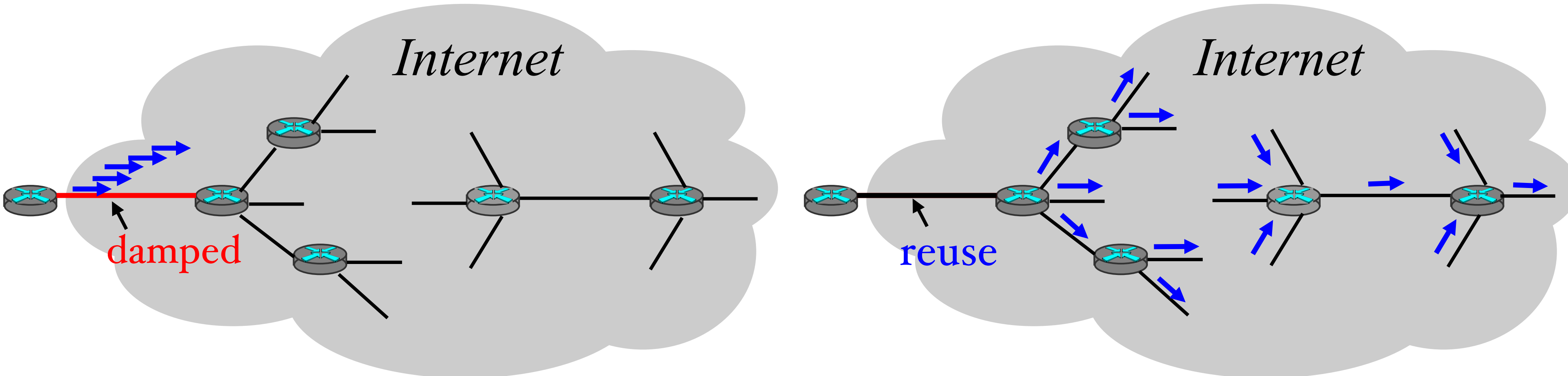
BGP’s Built-in Mechanisms

- Limit the rate of routing updates
  - Tradeoff between adaptability and stability
- MRAI
  - Fixed interval, 30 seconds between updates.
  - Suppress transient routing updates
- Route Flap Damping
  - Adaptive interval, minutes or tens of minutes
  - Suppress persistent route flapping

MRAI Timer

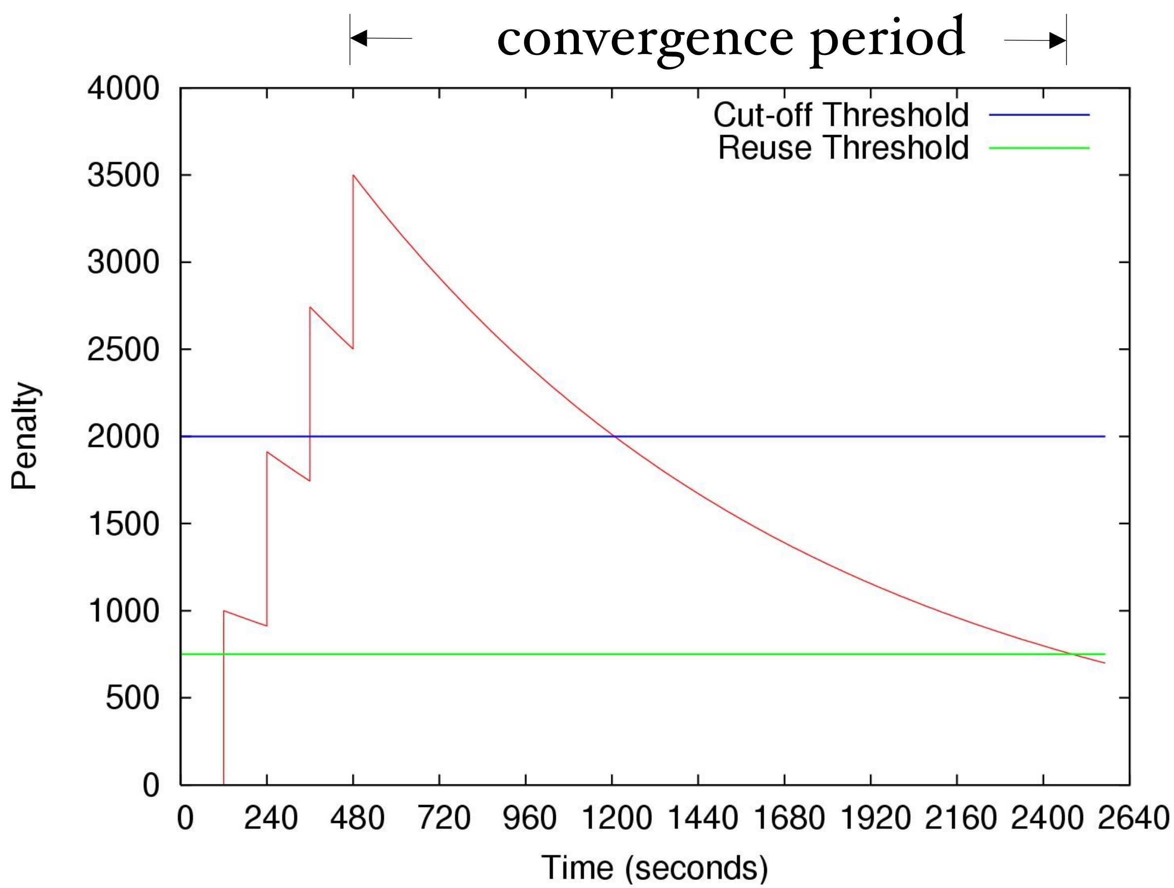
- Minimum Route Announcement Interval
  - default 30 seconds
- Space out the sending of consecutive updates
  - Not applied to the first update
  - Not applied to withdrawals
  - Per prefix (in standard) vs. per neighbor (in implementation)
- Consolidate transient updates
  - thus reduce path exploration
- Also slow down correct route information
- There's an optimal MRAI value for fast convergence
  - The value depends on the topology.

BGP Route Flap Damping



- Block (damp) frequent flaps
- Reuse after the path has stabilized
  - Only propagate the final path
- "Convergence Time": from when the flapping stops, to when the entire network learns the stable path.
  - During which the data traffic to the customer is negatively affected.
  - Not to be confused with "routing convergence."

How long to dampen a route?



- Use ***penalty*** to track route instability
  - Increase upon receiving an update
  - Otherwise decay exponentially
- Suppress the route if penalty is over the ***cutoff*** threshold
- Reuse when the penalty drops below the ***reuse*** threshold

Damping Parameters

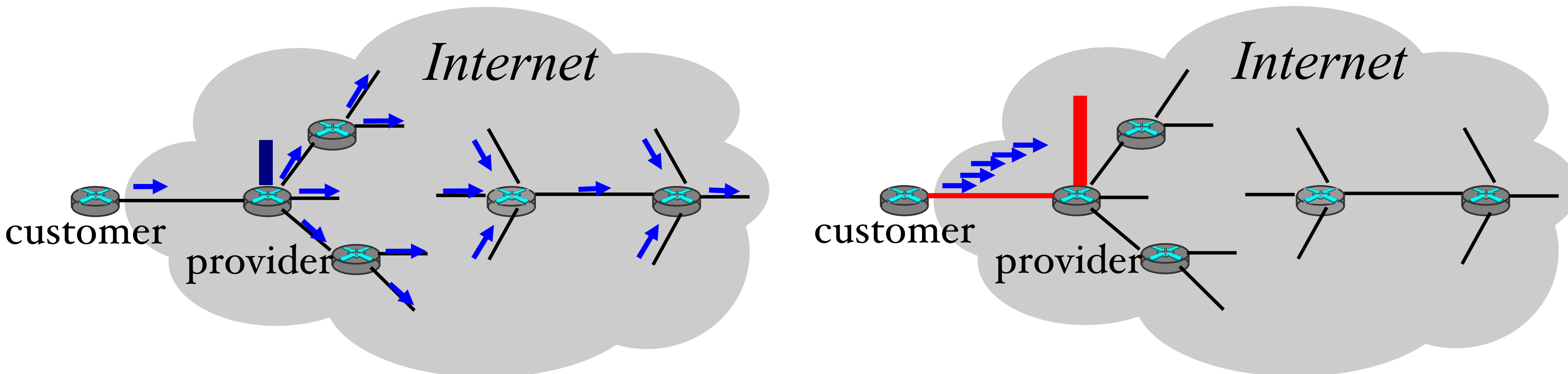
Damping Parameters	Cisco	Juniper
Withdrawal Penalty (P_W)	1000	1000
Re-announcement Penalty (P_A)	0	1000
Attributes Change Penalty	500	500
Cut-off Threshold (P_{cut})	2000	3000
Half Life (minute) (H)	15	15
Reuse Threshold (P_{reuse})	750	750
Max Hold-down Time (minute)	60	60

Decay function: $p(t) = p(t_0)\, e^{-\lambda(t-t_0)}$ $\quad H = \ln 2/\lambda$

Damping in Reality

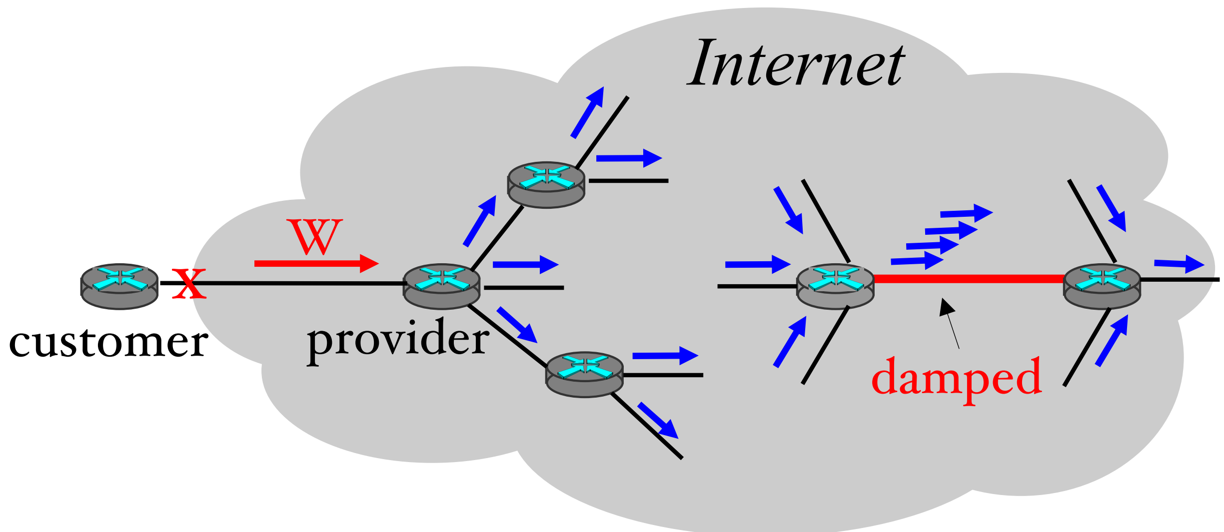
- Generally regarded as a key mechanism in maintaining global routing stability.
  - proposed by router vendors in mid 90s
  - specified in RFC 2439
  - implemented by all major vendors
- A survey shows that it's enabled by some ISPs, but not all.
- A main reason is customer's complaint of unexpected long convergence time or service disruption.

The Intended Behavior



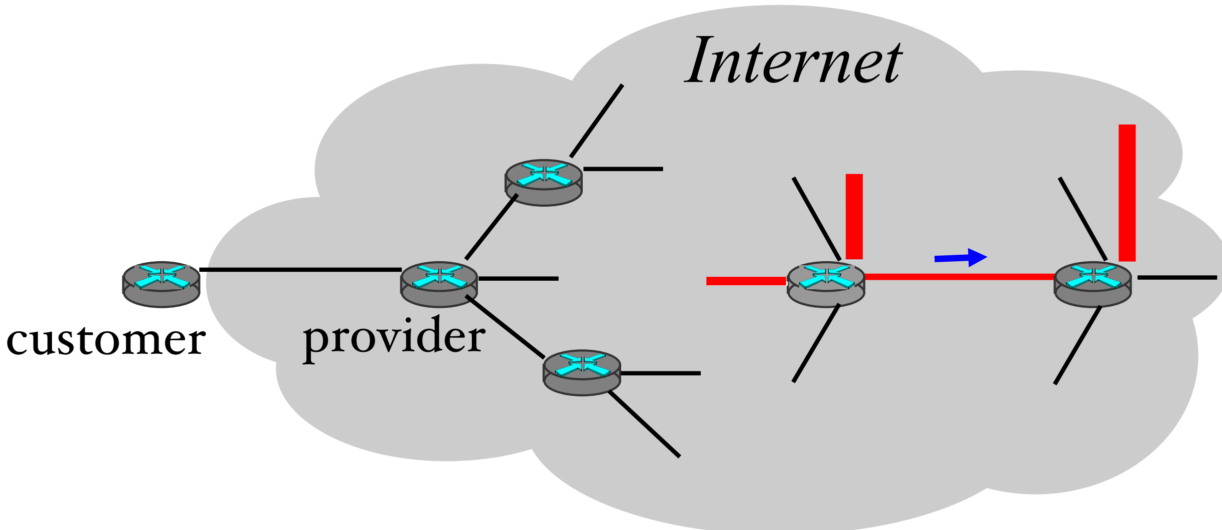
- Occasional flaps pass through without extra delay
- Persistent flaps are suppressed
  - Reduced routing updates in the network
  - Longer convergence time for customer
- The convergence time depends on the reuse timer at the provider router.

Path Exploration ➔False Damping



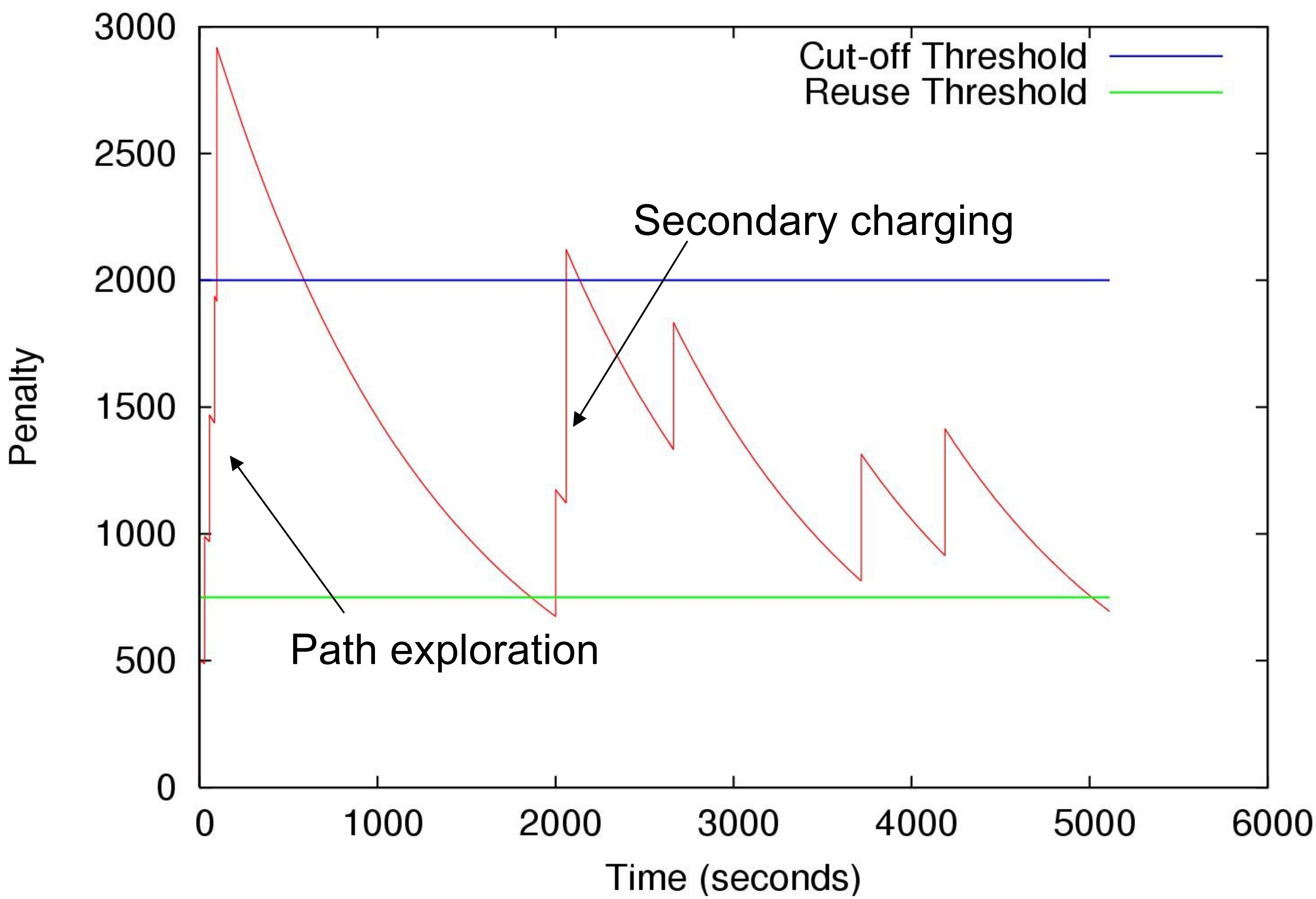
- A single flap may trigger false damping somewhere *in the network*
  - BGP explores alternate paths during routing convergence.
  - Withdrawals cause more path exploration than announcements

Secondary Charging



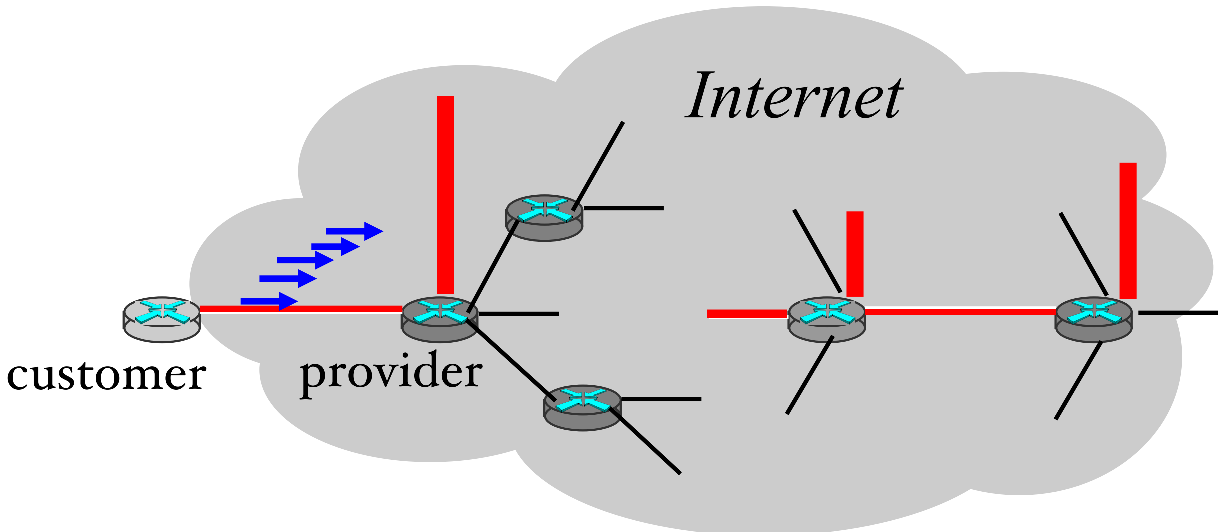
- Different routers may have different reuse timers.
- Updates after reuse can re-charge penalty value at other routers and delay their route reuse.

Example



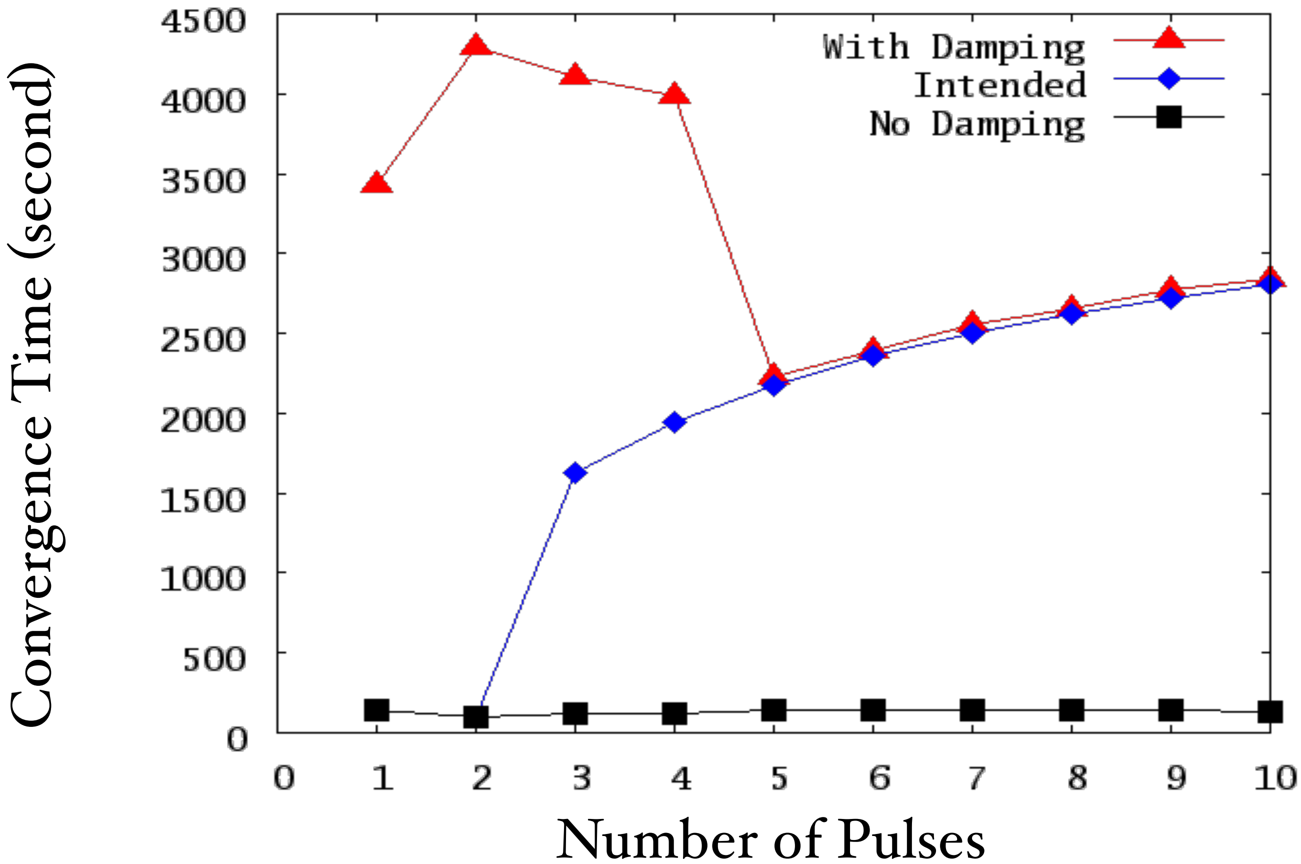
3000
2500
2000
1500
1000
500
0
0
1000
2000
3000
4000
5000
6000
Penalty
Time (seconds)
Cut-off Threshold
Reuse Threshold
Secondary charging
Path exploration

Muffling Effect



- Under persistent flaps, the provider router will have the highest penalty value.
  - When it reuses the route, the penalty values at other routers will be low, thus no secondary charging.
- Convergence time thus is determined by when the provider router reuses its route, i.e., the intended behavior.

Simulation Result



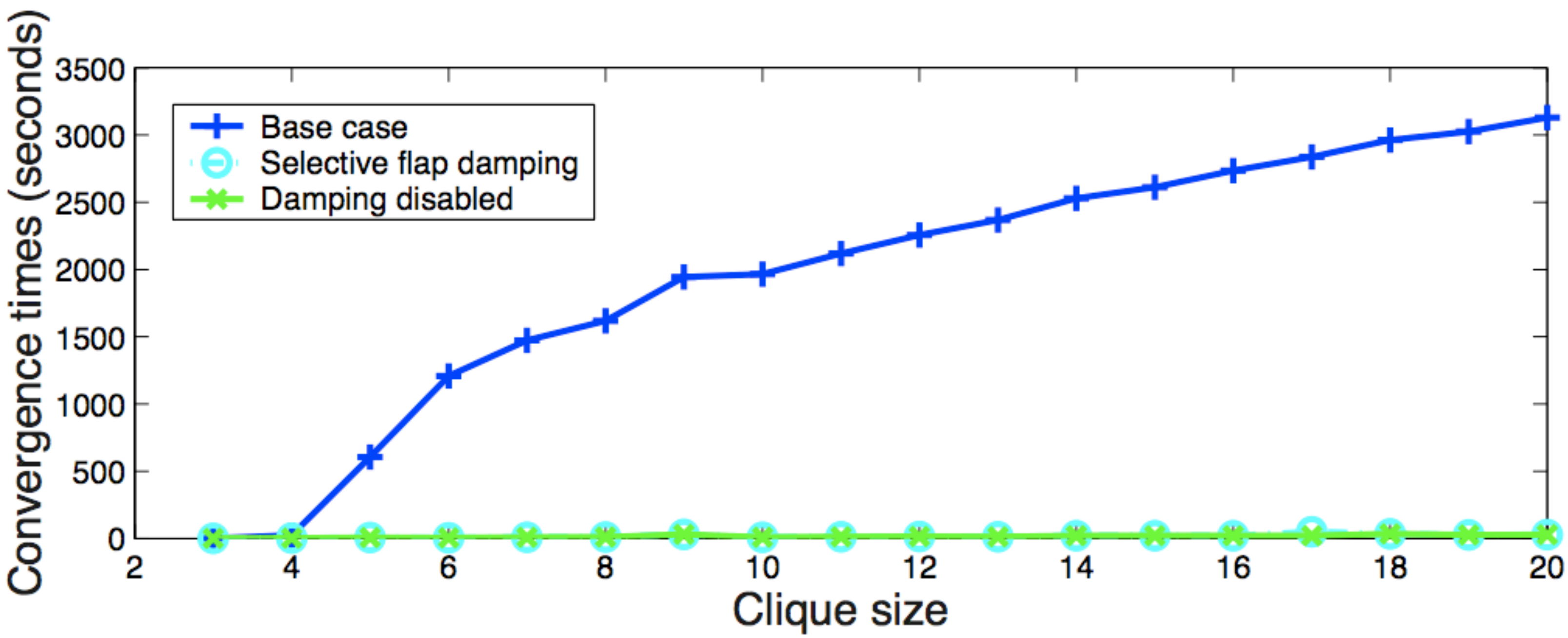
1 pulse = 1 link down and 1 link up

Solution

- Selective Route Flap Damping
- Robust Damping

Selective RFD

- Each router appends its local preference to its BGP updates
- Decreasing trend of route preference is the sign of path exploration
  - Don't increment damping penalty upon path exploration.



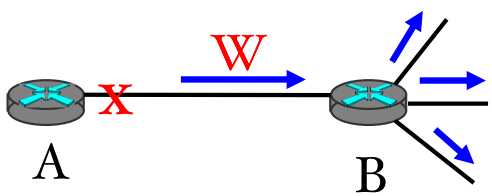
Robust Damping

- Damping penalty should increase only after a real ***flap***, not every ***update***.
  - Path exploration, secondary charging and potentially other interactions cause multiple updates per flap (or per routing event).
  - E.g., inconsistent damping parameters at different routers can cause secondary charging.

- Solution: Explicit root cause notification

Root Cause Notification (RCN)

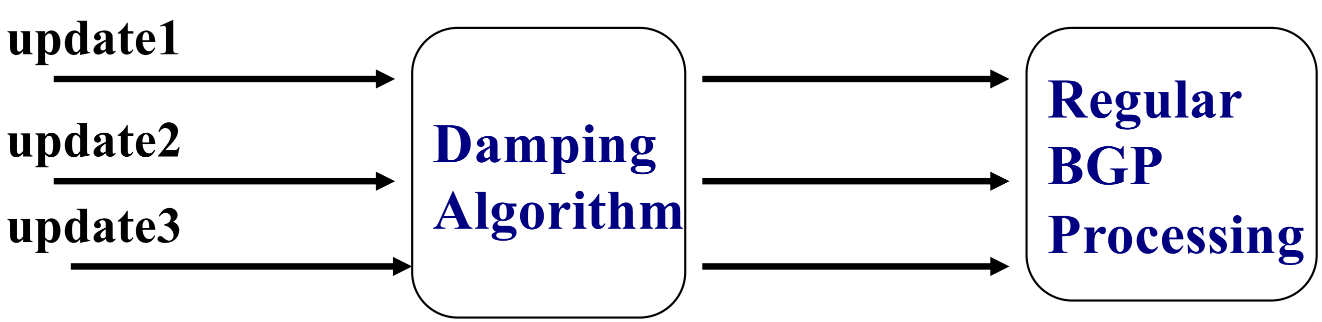
- Root cause is the original event that triggers an update.
  - rcn = {location, status, sequence number}
- Attach rcn to every update
  - updates triggered by the same event carry the same rcn.
- Can be used for many purposes
  - Speed up routing convergence
  - Help diagnosis
  - Fix damping



rcn = {location = A-B, status = down, seq = 1}

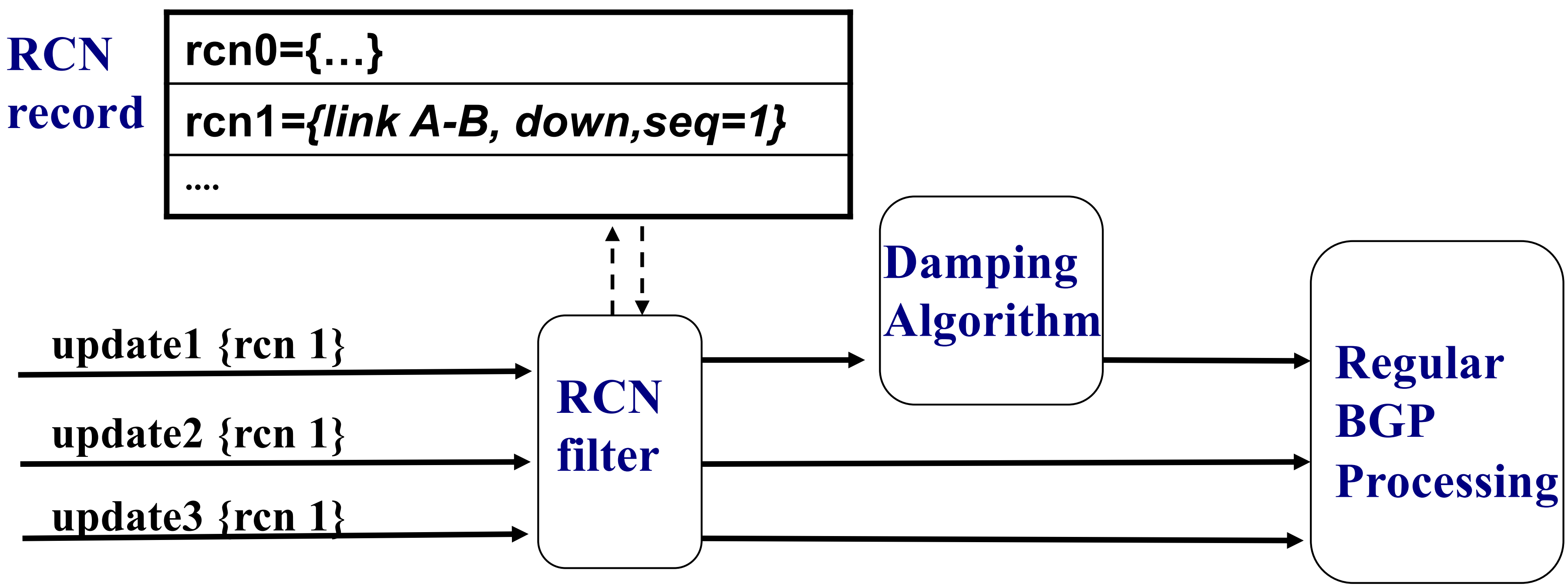
Original Damping

- Every update is passed to the damping module and causes penalty increase.

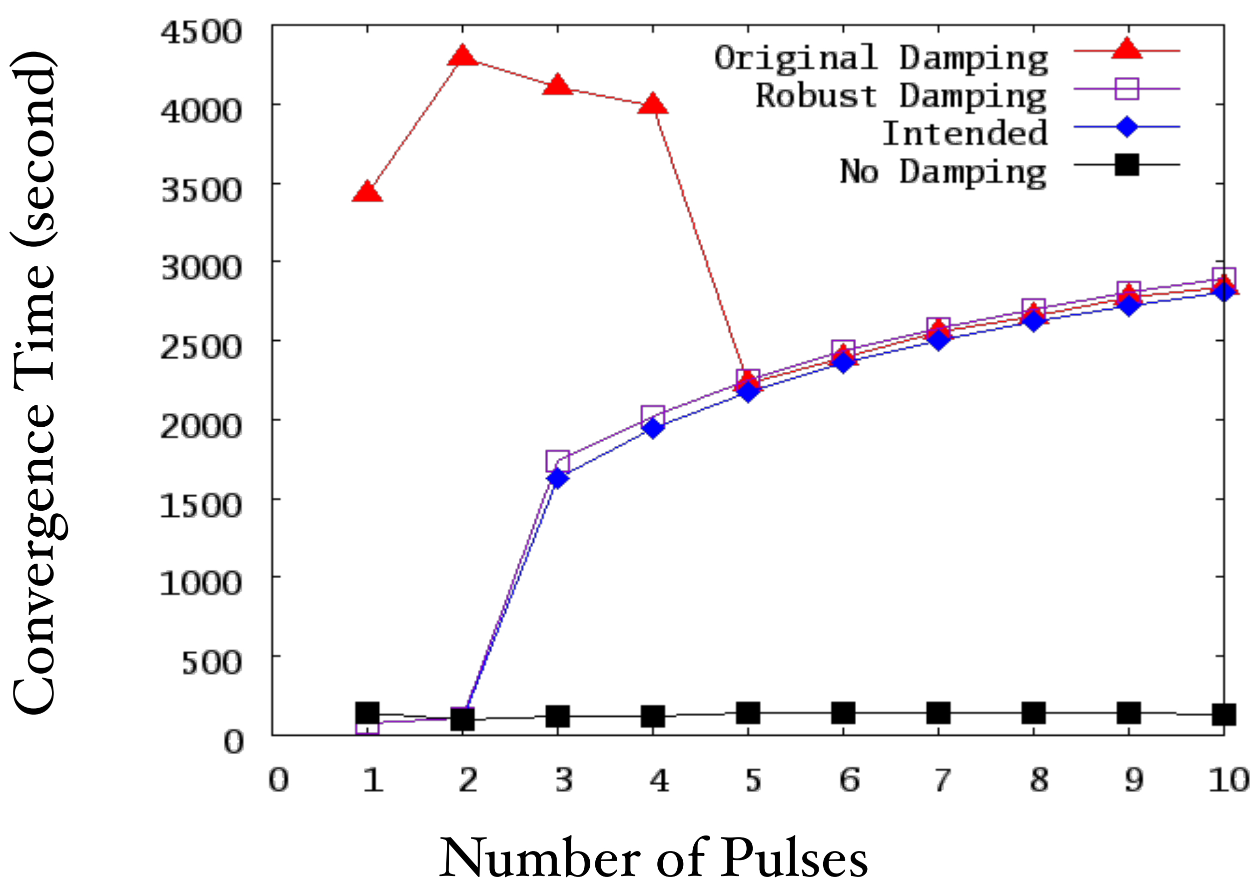


Robust Damping

- Only updates with new root causes are passed to damping module, so that each flap is penalized only once.



Simulation Result



1 pulse = 1 link down and 1 link up

Summary

- The damping mechanism
  - How it works, and why
- Understand the behavior in a large scale distributed system
  - With a few flaps, secondary charging and path exploration exacerbates convergence time.
  - With persistent flapping, muffling effect makes convergence time match intended behavior.
- Damping with RCN
  - What is RCN
  - How it helps remove unintended interactions in damping