Consensus Routing : The Internet as a Distributed Sytem

Presented By

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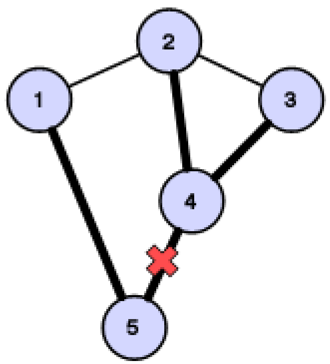
Overview

- Introduction
- Consistency Issues
- Consensus Routing Overview
- Stable Mode
- Transient Mode
- Evaluation

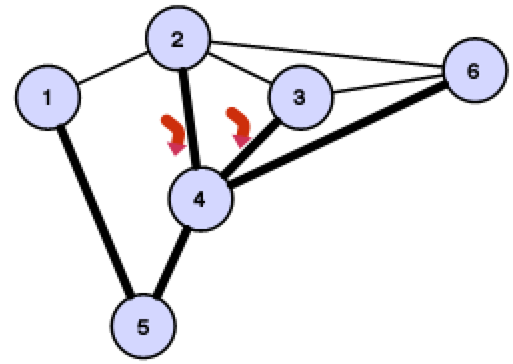
Introduction

- Traditional Routing Protocols(BGP, OSPF, RIP)
  - Responsiveness (liveliness) over consistency(safety)
- Lack of consistency is at the root of bigger problems in Internet.
- BGP updates cause 30% packet loss and 90% of this loss is due to transient loops.
- Goal is to design a simple, practical routing protocol that allows general routing policies and achieves high availability.

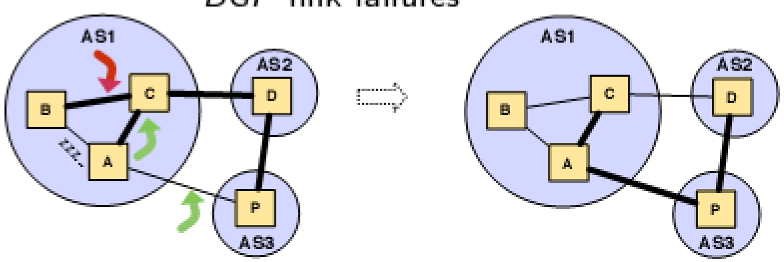
Consistency Issues



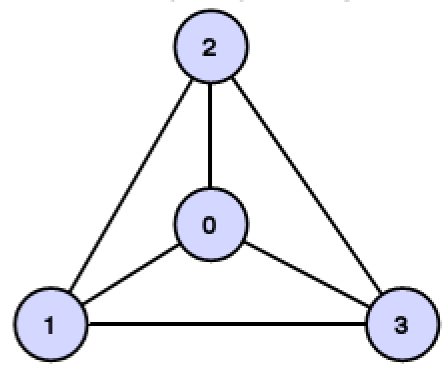
BGP link failures



BGP policy change



iBGP link recovery



BGP policy cycles

Consensus Routing

- Safety : A router forwards a packet strictly along the path adopted by the upstream routers unless if the adopted route encounters a failed link or router.
- Liveliness : The network reacts quickly to failures or policy changes and ensures high end to end availability.
- Key idea is to cleanly separate safety and liveliness concerns.
- Consistency is achieved using a distributed coordination algorithm among the routers.
- Packets are forwarded using two modes 1) Stable mode that only uses consistent routes and 2) Transient mode that heuristically forwards packets when a stable route is not available

Stable Mode

- Update Log (Step-1)

Router State

Routing Information Base (RIB)

History

Stable Forwarding Table (SFT)

Triggers: (*AS number, trigger number*), when to generate a new trigger

- Link or next-hop router failed
- Local policy change
- A route from neighbor replaced current route.

PROCESS_UPDATE(B, r, t):

1. Add the update's trigger t to the local set of incomplete triggers I_A.
2. Process the update as in BGP. Let *old* and *new* be the best route to the prefix before and after the update. We define *next_hop* for a route to be the first AS in the route.
3. Add the *received update* (t, r) to the head of the *History* list. Consider the following cases:
   (a) *old.next_hop* is not B, and *new.next_hop* is not B: do nothing since the best route has not changed.
   (b) *old.next_hop* is not B, and *new.next_hop* is B: propagate *new* to neighbors with trigger t', where t' is a newly generated trigger. Add the *selected update* (t', new) to the start of *History*.
   (c) *old.next_hop* is B: propagate *new* to neighbors with unchanged trigger t. Add the *selected update* (t, new) to the start of *History*.
4. Remove t from I_A.

- Distributed Snapshot (step-2)

An update can be incomplete at an AS when the snapshot is taken because 1) the update is in I_A 2) AS is waiting for MRAI timer to propagate the update 3) the update is in transit from neighboring AS.

SNAPSHOT:

1. Save the sequence of triggers in *History* as $\overline{H}_A$.
2. Start logging any triggers received on channels other than the one on which the marker was received.
3. Initialize the set of incomplete triggers $\overline{I}_A$ to ϵ. Add the set of triggers in I_A to $\overline{I}_A$; these triggers correspond to the updates currently being processed.
4. Scan the outgoing queues for updates waiting on MRAI timers to expire, and add their triggers to $\overline{I}_A$.
5. Send a marker to all neighbors.
6. Stop logging triggers on a channel upon receiving a marker on that channel.
7. Once the marker has been received on all channels, add logged triggers to $\overline{I}_A$. These correspond to updates in transit during the snapshot.

- Frontier Computation (Step-3)
- Aggregation : Sending $\bar{H}_A$ *and* $\bar{I}_A$ to all consolidators .
- Consolidators – Tier-1 ASes
- Consensus : All consolidators reach consensus on Set of ASes S and set of incomplete updates I.

COMPUTE_INCOMPLETE($S, \overline{I}_A[\,], \overline{H}_A[\,]$):

1. Initialize $I = \bigcup_{A \in S} \overline{I}_A$.
2. Do until I reaches a fixed point:
   (a) For each $t \in I$, for each A do:
      i. if t occurs in $\overline{H}_A$, add the first occurrence of t and all subsequent triggers in $\overline{H}_A$ to I.

- Flood : The consolidators flood the set of incomplete triggers I and membership set S to all ASes.

- Building Forward Table (Step-4)

BUILD_SFT(I, S):

1. Copy the current SFT to be its previous SFT.
2. For each destination prefix p:
   (a) Find the latest *selected update* $u = (t, r)$ in p's *History* such that t is complete, i.e., neither t nor any preceding trigger is in I.
   (b) Adopt r as the route to p in the new SFT.
   (c) Drop all records before u from p's *History*.

- View Change

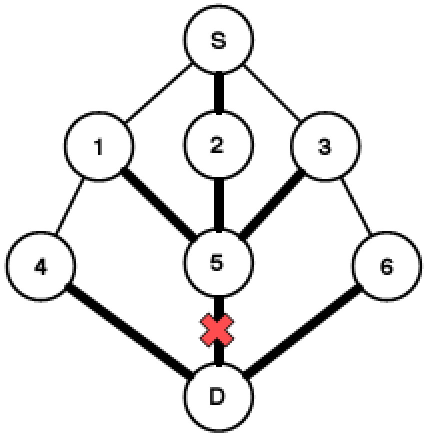
Maintains K^{th} and $(K+1)^{th}$ SFT in epoch K+1.

- Multiple Routers in an AS
  - One or more routers act as local consolidators.

- Protocol Robustness
  - AS fails to send its snapshot in time : It will not be used for forwarding traffic in the next epoch.
  - Consolidator fails : Distributed Consensus algorithm ensures consistent view.
  - Recovery : Recovered AS will exchange paths with neighbors, compute SFT and participate at the end of the epoch.

Transient Mode

- Packet forwarding mode when stable route is not available at a router.
  - Routing Deflections
  - Detour Routing
  - Backup routes



- Implementation issues?

Evaluation

- Routing protocols effectiveness is studied in three cases :

  1) Link failures

  2) Traffic engineering accomplished by announcing and withdrawing sub-prefixes.

  3) Traffic engineering accomplished by AS path prepending.

- Consensus routing added about 8% in update processing overhead and about 11% additional lines of code to the BGP implementation.

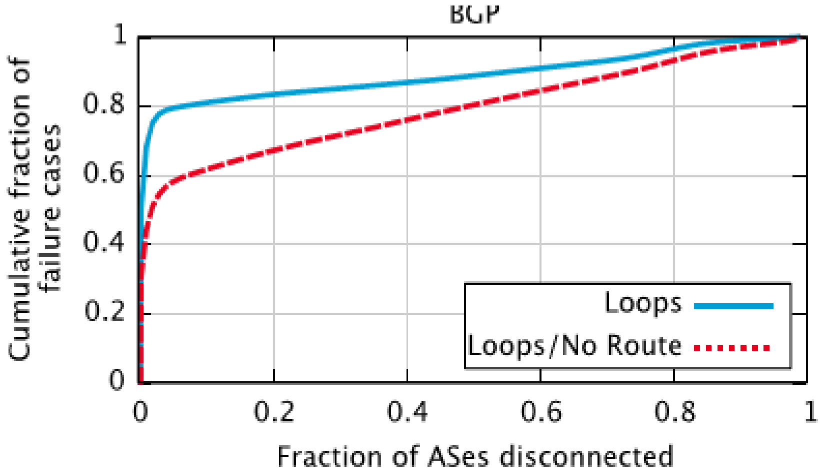


Figure 6: Loops and disconnectivity in BGP following a failure.

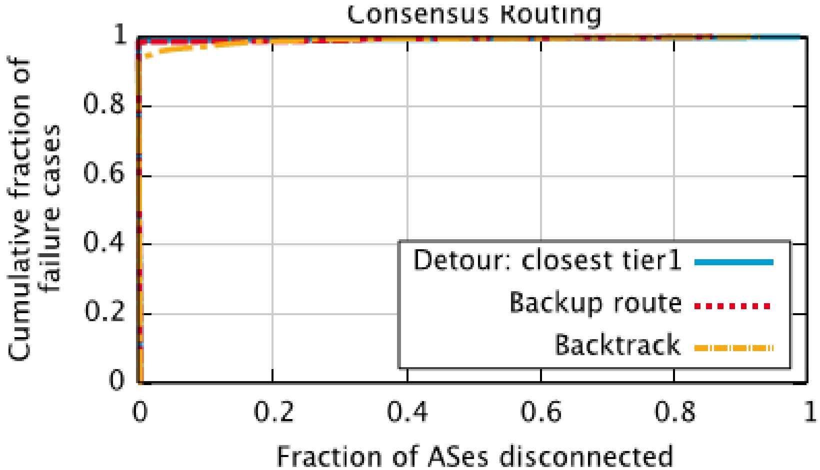


Figure 7: Disconnectivity in consensus routing following a failure.

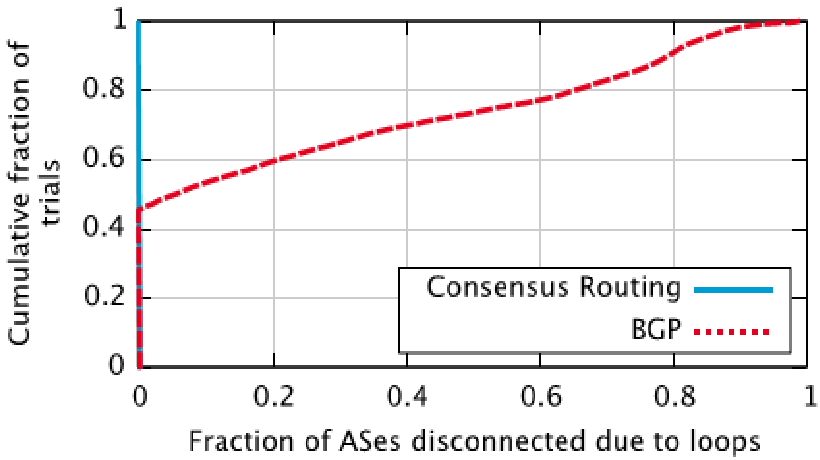


Figure 8: Traffic engineered subprefixes causes loops in BGP.

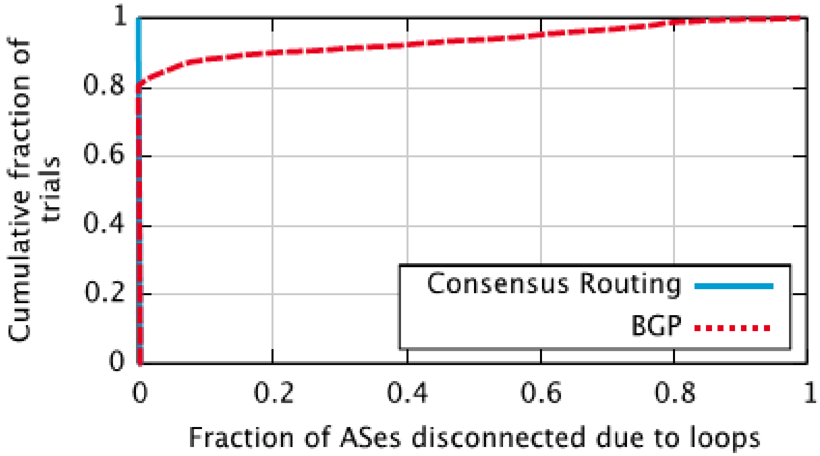


Figure 9: Path prepending causes intra-domain loops in BGP, leading to disconnectivity.

Overhead of Consensus routing

- Volume of Control Traffic

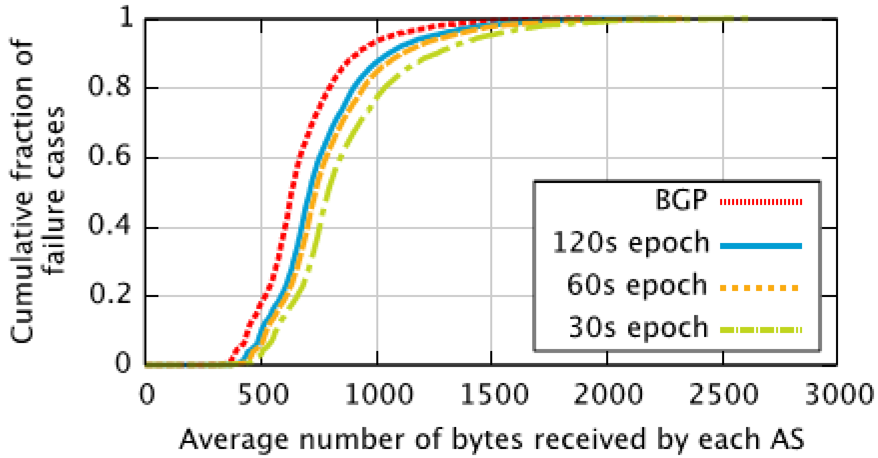


Figure 10: Control traffic required by consensus routing.

- Cost of Consensus

Number of nodes	Time when first node learns value	Time when last node learns value
9	434 ms	490 ms
18	485 ms	1355 ms
27	590 ms	1723 ms

- Path Dilation

Response Time

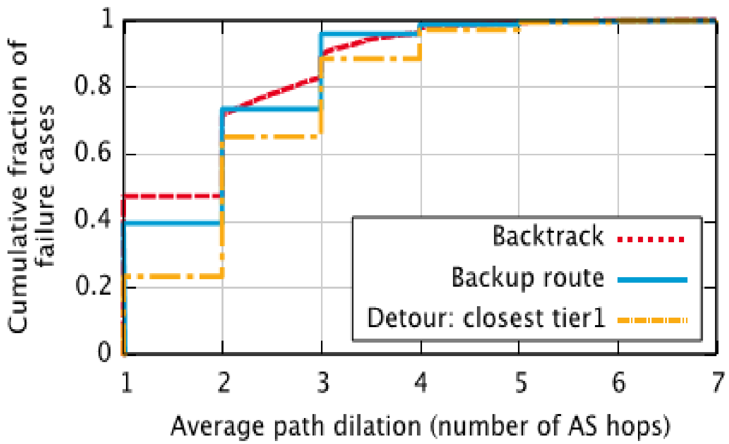


Figure 11: Path dilation incurred by interdomain transient mode options.

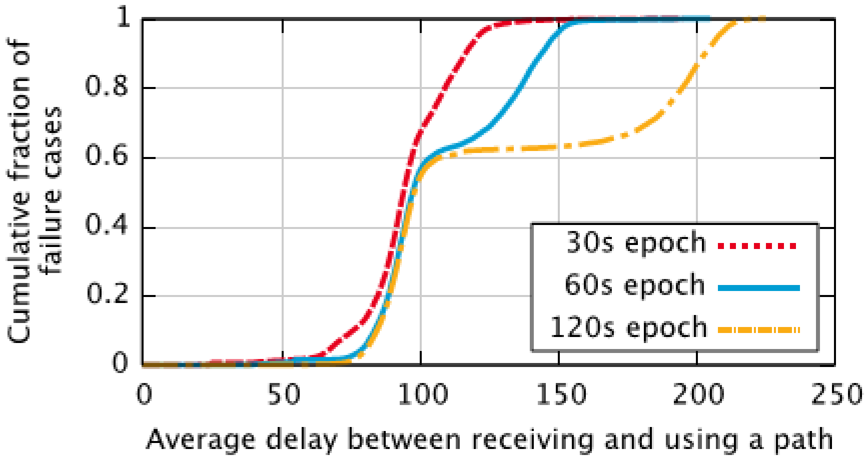


Figure 12: Delay incurred by consensus routing between receiving and using a path.

Discussion

- Scalability of this approach?
- Handling Malicious AS to achieve consensus?
- Highly dynamic network topology – where links change rapidly between time of SFT and time of snapshot?

Thank you

Questions and Suggestions