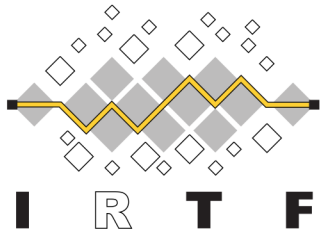
Applied Networking Research Workshop 2020



A novel hybrid distributed-routing and SDN solution for traffic engineering ANRW20

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Traffic Engineering (TE) Needs

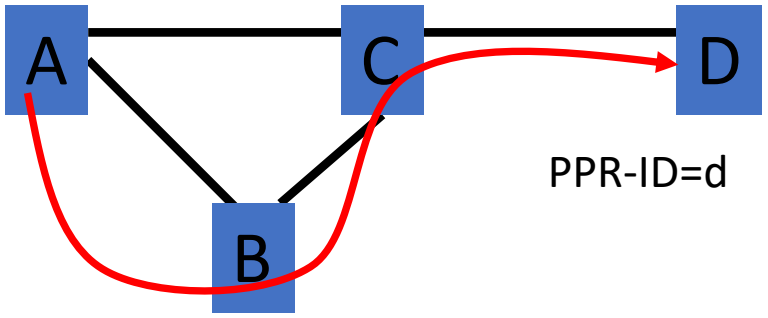
- TE requirements are becoming more demanding.
- SDN solutions work by calculating TE paths and allocating resources centrally, then communicating decisions to network nodes individually
    - + Holistic view allows for better optimization
    - - Less resilient against perturbations in network state
    - - Delayed adaptation to network changes
- Traditional routing relies on distributed algorithms
    - + Fast adaptation to perturbation in network state
    - - Considerable overhead in data synchronization
    - - Local decisions may not always be globally optimal

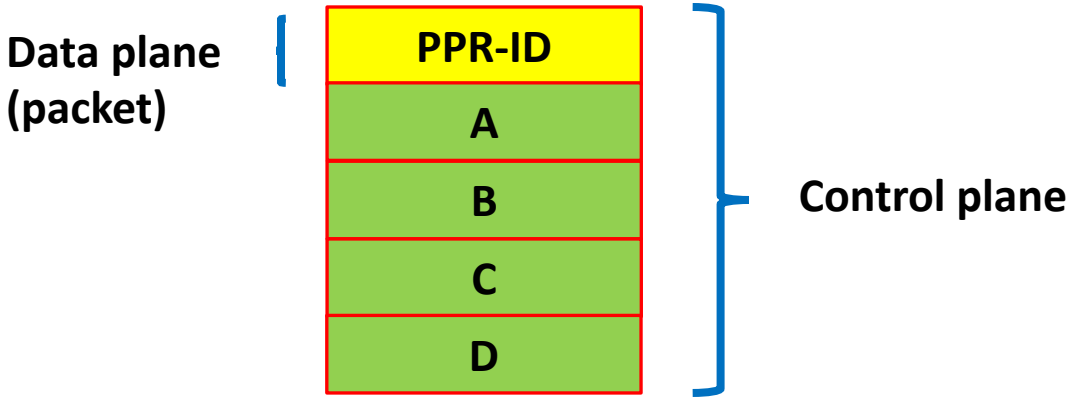
Our Proposal

- Our proposal: Hybrid solution to combine advantages of central and distributed approaches whilst avoiding the disadvantages:
  - Conceptually centralized components used to calculate TE Paths and resource allocations
  - Communicate this information in distributed manner using link-state routing protocols
  - Provide this service to multiple data planes (MPLS, MPLS-SR, IPv6, SRv6, IPv4, Ethernet)

PPR Overview

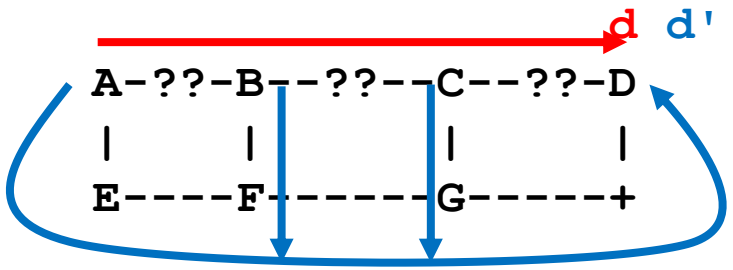
- PPR provides a method of injecting paths into link-state IGPs.
- In the data plane the packet is mapped to its intended path by the PPR-ID.
- PPR-ID is a *single* identifier in the packet.
- The format of the PPR-ID is data-plane specific (IPv6 addr, IPv4 addr, MPLS label, MAC Addr).
- PPR Interop at IETF Hackathon July 2019





See draft-chunduri-lsr-isis-preferred-path-routing for encoding deta

Traffic Engineered Repair



- Primary path is A->B->C->D and is traffic engineered
- Backup path is A->E->F->G->D and is also traffic engineered
- TE connectors provided from B and C to TE repair path.
- If A->B, or B->C or C->D fails single TE path can be used for repair

- Need TE backup paths because:
- Critical SLA traffic must use FRR with same SLA as primary: (5G uRLLC or mIOT slices)
- High b/w traffic carried on TE paths must not saturate best effort shortest-path-LFA-path/shortest-path-post-convergent-LFA-path.

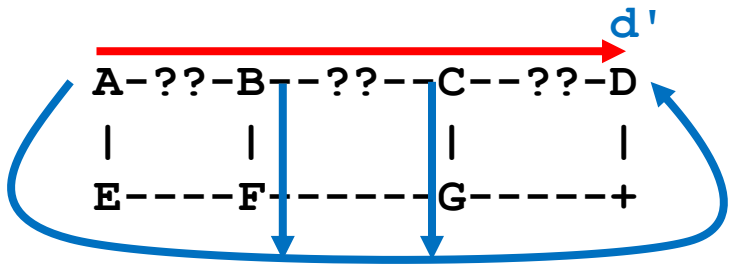
Path injected from SDN controller at any node, or for resilience at a small number of nodes.

PPR Graphs

- Described in draft-ce-lsr-ppr-graph
- TLVs describe graph as a series of lists of paths
- Any node may be a source
- A source node is annotated with the S bit
- Generally there is one destination node which has the D bit set.
- The destination has a PPR-ID associated with it.

Simple Repair Graph

- Repair is described in a single graph



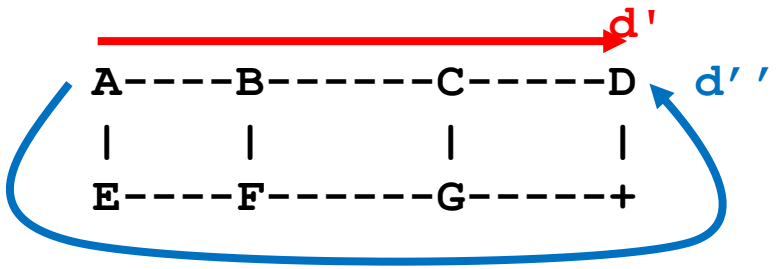
- Graph:
  - PPR-ID=d'
  - A(s)->E->F->G->D(d bit)
  - B(s)->F
  - C(s)->G

- Primary path is A->B->C->D
- Backup path is A->E->F->G->D + B->F + C->G
- If A->B, or B->C or C->D fails single PPR path can be used for repair

Centralized and Decentralized Approaches

- PPR can support both centralized and decentralized computation of the repair path.
- Any node can inject the PPR path either:
  - For itself as the PLR calculating its own repair paths
  - On behalf of an SDN controller managing the repair paths
- Multiple nodes can inject the repair for redundancy and the duplicates will be eliminated by the IGP flooding process.
- *Any* algorithm can be used to compute *any* path or graph - e.g. bespoke dis-joint path or lossless or low path.
- Such paths are independent of any other path chosen for any other purpose.

Future: Per-hop Policy/Action



- Every hop can have its own individual policy installed by the control plane for each specific PPR path e.g. :
  - Queue behavior
  - Monitoring/OAM behavior
- Path can be strategically installed by SDN controller, or tactically by edge node
- Research Question: How do we define a suitable policy expression language for PPR?
- Efficiency can be improved with Path-oriented Flooding
  - A->B->C->D to d' needs red but not blue
  - A->E->F->G->D to d'' needs blue not red
  - This needs to be done without compromising the flooding resilience that LSPs provide.
- Research Question: How do we define a resilient flooding reduction system?

Future: Resilience and Robustness

- We know how to build FRR based on PPR.
  - Research Question: Can we expand the PPR graph structures to provide TE between Detnodes nodes AND the add Packet Replication Elimination and Ordering (PREOF) functions to new data-planes such as IP?
- A system has Byzantine robustness if it can withstand active lying by its components.
  - We know how to make link-state routing Byzantine robust.
  - High value (TE) and strategic services (5G) are prime targets for attack.
  - We are proposing to use a link-state protocol to set up TE paths
  - Research Question: Can we make traffic engineered paths that are robust against Byzantine attacks (or accidents)?

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