ARIA Networks

Intelligence for Next Generation Networks

Management, Planning, and Provisioning of Point-to-Multipoint Transport Connections

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Agenda

- Point-to-Multipoint Services and Application Requirements
- Evolution of Point-to-Multipoint Based Technologies
- Point-to-Multipoint Transport & Service Concepts
- Signaling and Routing Solutions for MPLS-TE and GMPLS
- Point-to-Multipoint Path Computation for Traffic Engineering
  - Point-to-multipoint routing requirements
  - Point-to-multipoint path computation requirements
  - Existing path computation technologies
  - Holistic Path Computation
- In Summary

P2MP Services

- Multicast user traffic
  - IP Multicast and now mLDP
  - Multicast VPNs
  - Content distribution including video services
- Replication at the point of attachment to the core network
  - A possible solution
  - Puts stress on the PE
  - Makes poor use of the core network resources
- Hence require replication within the network
- Two options
  - Build a distribution tree from point-to-point connections with well-known replication servers
  - Use point-to-multipoint transport connections (GMPLS LSPs)

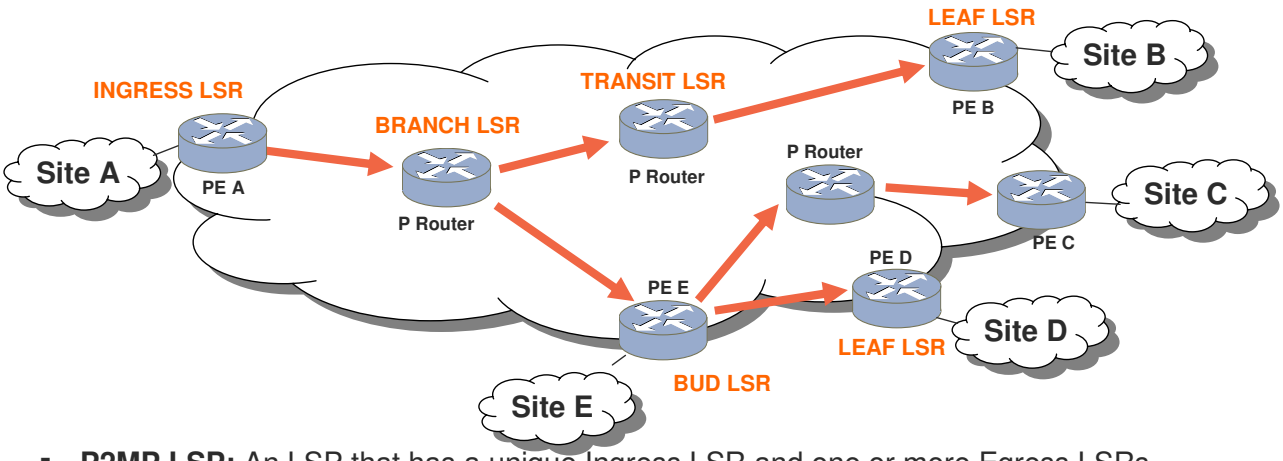
P2MP Application Requirements

- Requirements for quality video services
  - High bandwidth
  - Fast service start-up (rapid graft and prune for channel switching)
  - Minimise network transmission cost
    - Minimise the aggregate cost of the tree
  - Minimise data delivery delay, hop count, or path length
    - Minimise per branch attributes
- Other requirements for resilience
- P2MP MPLS-TE is already being deployed
- How do we build and plan the transport networks for these services and applications?

Evolution of P2MP Technologies

- P2MP transport connections require data replication at branches
- Many transport technologies are already capable of replication
  - Packet (MPLS)
  - Ethernet
  - TDM
  - Lambda
- Optical technologies achieve replication
  - Through OEO devices and optical splitters
  - Function is similar to that used for APS or “drop-and-continue”
- Replication branching may be limited in all technologies
  - Round-robin packet or frame replication
  - Limited OEO branching capabilities
  - Signal loss through optical splitters

Transport & Service Concepts

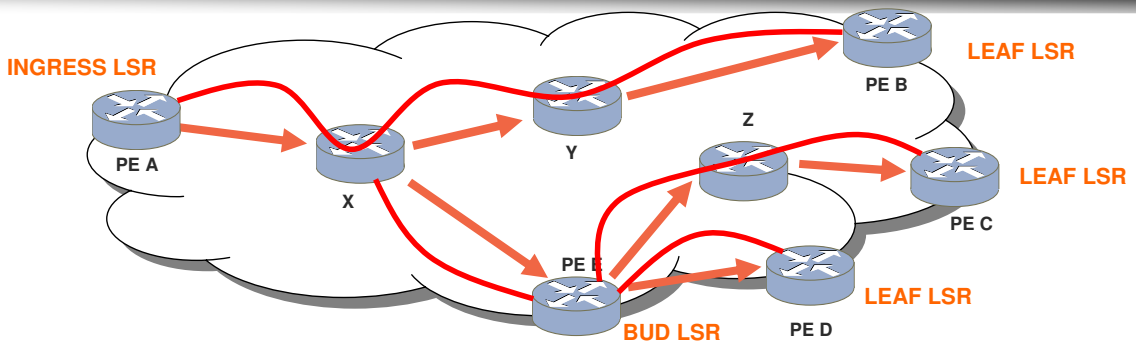


- **P2MP LSP:** An LSP that has a unique Ingress LSR and one or more Egress LSRs.
- **Branch LSR:** An LSR of a P2MP LSP that has more than one downstream LSR.
- **Leaf LSR:** Egress LSR of a P2MP LSP.
- **Transit LSR:** An LSR of a P2MP LSP that has an upstream and downstream neighbour.
- **Bud LSR:** An LSR of a P2MP LSP that is an egress (leaf), but also has one or more directly connected downstream LSRs.

P2MP Signaling Solutions

- draft-ietf-mpls-rsvp-te-p2mp-06.txt
  - “Extensions to RSVP-TE for Point-to-Multipoint TE LSPs”
  - Equally applicable to MPLS-TE and GMPLS
  - Practical solution for all transport technologies (MPLS-TE, T-MPLS, Ethernet, TDM, Lambda, Fibre)
- Simple additions to Path and Resv message
  - Session object identifies the whole P2MP tunnel (all leaf nodes)
  - New object for individual leaf identifiers (destinations)
  - Explicit routes (and recorded routes) represented as successive branch-to-leaf paths
  - Can signal a tree using one or more Path messages

P2MP Explicit Route Example



- Tree can be represented as a set of root-to-leaf paths
  - {A, X, Y, B}, {A, X, E, Z, C}, {A, X, E, D}, {A, X, E}
- Explicit Path is encoded as a sequence of branch-to-leaf sub-paths
  - {A, X, Y, B}, {X, E}, {E, Z, C}, {E, D}
- Saves duplicate encoding in Path messages
- RROs can be encoded the same way

P2MP Routing Requirements

- P2MP Traffic Engineering operates on the existing TED
  - Massive simplification when upgrading a network to support P2MP
- Optional ability to advertise the P2MP capability of a node
  - Only necessary where there are mixed capabilities in a network
  - Achieved through the new TE Node Capabilities TLV (OSPF and IS-IS)
    - draft-ietf-ccamp-te-node-cap-05.txt
  - Three capabilities can be advertised
    - Ability of the LSR to act as a branch node on a P2MP LSP
    - Ability of the LSR to act as a bud LSR on a P2MP LSP
    - Ability of the LSR to supports P2MP RSVP-TE signaling

P2MP Path Computation Requirements

- Support of complex services
  - High levels of QoS demand multiple constraints
    - Minimal cost, minimal delay, high bandwidth, etc.
    - Computing a minimum-cost tree (Steiner tree) is NP-hard
    - Constraints may conflict with each other
  - May multiple 'parallel' connections to support one service
  - Resource (i.e. lambda) continuity issues
- Path diversity or congruence
  - End-to-end protection with link, node, or SRLG diversity
  - Mesh (m:n) service protection
  - Congruent paths for fate-sharing (e.g. virtual concatenation)
- Global concurrent network optimisation
  - Compute multiple trees and consider moving existing trees to accommodate new trees.
  - Consider multiple complex constraints, including lower (optical) constraints.

Existing Path Computation Technologies

- Existing techniques do not to meet the needs of increasing service complexity
  - Lack of sophisticated path computation technologies
  - QoS based P2MP services are required
- Single-service computations
  - CSPF is functional for shortest-path-to-destination trees
    - Works for multiple constraints, but does not optimise network usage (it is not Steiner)
    - Conventionally used to satisfy real-time requirements
  - Modified CSPF can compute multiple paths
    - Good for solving k-disjoint paths, but hard to apply to P2MP
- Linear programming can optimise a whole network
  - Can take long periods to develop a solution
  - Not flexible to changing demands, new topologies, new constraints, new service types
- But can it do it fast enough?
  - More constraints mean slower computation times
  - More paths mean more complex computation
  - Large networks are phenomenally complicated and LSPs may have 100s of leaves

Holistic Path Computation

- Solving the whole network is hard
  - Balancing conflicting constraints for different services
  - Considering all services at once to avoid trap conditions
  - Computing huge networks with thousands of services
  - Handling P2MP LSPs with 100s of destinations
- Holistic path computation solves the entire network in one pass
  - Necessary for full optimisation
  - Needs to be adaptive to changes in topology and services
  - Must be flexible to mixes of service types and contested bandwidth
- Possible to consider lower or higher layer network constraints
  - SRLGs
  - Optical and link-level protection
  - Service policies
  - Additional bandwidth requests

Can it be achieved in real time?

Solutions

- Complex and holistic path computations
  - CPU-intensive
  - “Impossible” in real time
  - Intractable using traditional mechanisms
- Requires a new approach
- Heuristic processes assess the network and derive an optimal solution
  - Non-deterministic nature is “scary” !
  - May produce a different, but correct solution each time
  - Highly flexible to a variety of topologies
  - Can handle any number of constraints and service types
    - P2MP and P2P services at the same time
    - Protection services
    - etc.
  - Full network optimisation

In Summary

- P2MP transport connections are required
  - To deliver customer services
  - To make optimal use of the network
- P2MP transport technologies are ready for deployment
  - Data plane technologies can support P2MP
  - Control plane extensions are ready and proven
- Linear programming does not extend well to P2MP traffic engineering
- Highly sophisticated planning and modelling tools are required
  - Complex services including P2MP
  - Network failure analysis
  - Capacity planning
  - Concurrent network reoptimisation
- Holistic traffic engineering can achieve significant improvements in network optimization and the delivery of P2MP services.