BIER-TE TEAS framework

IETF101

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Background
Multicast, BIER, BIER-TE

Slides with text only for reference after IETF101 presentation:
Traditional IP multicast problems
Traditional IP multicast problems

- Tree state on P nodes
  \((S,G)\) – per source \(S\), per receiver group \(G\)
  3 sender, 5 receiver: up to \(2^3 \times 2^5\) trees

Real networks (src,group large) -> impossible

Aggregation == wasted traffic

Forwarding, control plane state, signaling
Performance operations problem long before limits

- PIM, mLDP
  - No non-shortest path tree support native (use MT-IGP)
  - No cost reduced tree (eg: \((S2,G2)\) – better both via P2)
  - “randomized” ECMP control
  - mLDP somewhat better than PIM (later design)

- RSVP-TE P2MP
  - Most expensive state (control, signaling)
  - But allows to path engineer trees arbitrarily
  - No support for \((*,G)\) trees (as in PIM, mLDP)
BIER – (B)IT (I)ndexed (E)xplicit (R)eplication
• **STATELESS**: No tree state on P nodes
  - No tree signaling/control either!
• BIER ‘for SR dummies experts’
  - ‘BIER packet header indicates a SET OF egres-PE node-SIDs’
• Up to 256 egres PE, each one encoded as 1 bit in 256 bit “bitstring” in the bier packet header
• BIER-IGP extensions:
  - SPF routes for these SIDs bits
• PE/P node forwards/replicates BIER packet:
  - One copy sent to each interface that is (according to IGP) leading to one or more bits set in packets BitString.
  - (also reset on each copy bits not reachable according to SPF route via that interface)
• Many sets of 256 possible BitStrings:
  - Bit set identifier in BIER header (BIFT-id)
  - Source needs to send one packet for each set of up to 256 receivers
• Nice ECMP and MT-IGP support, but
  - **But no generic path engineering**
BIER-TE – BIER with traffic engineering (1)

Bitstrings:
(S1,G1) = 2 3 4 5
(S1,G2) = 6 7 8 9
(S2,G2) = 9 10 11

Unused links/adjacencies greyed out for clarity
BIER-TE – BIER with traffic engineering

1. BIER BitString indicate BFER-id
   - Aka: Receiver PE (or wherever BIER domain ends)

2. BIER-TE BitStrings indicate transit adjacencies
   - Most simple: every interface in topology is a bit

3. Forwarding rule: every node (BFR = P/PE):
   - Replicate based on only on direct adjacency bits
   - Resets bit when using its adjacency
   - Eg: P1 - looks only at bits 7, 8, 9 in example & resets them

4. Optimizations to reduce “bit-waste”
   - Bit semantics:
     - P2p link bit (e.g.: bit 3 on both adjacencies of interface)
     - Lan, stub, flood, punt, ... bits

5. Any traffic engineering
   - NO STATE – Engineer path (graph!) of every packet individually through bitstring fom sender (BFIR) in BIER(-TE) header.

6. Bit waste... ?
   - BIER: 1 packet ~ 256 receivers
   - BIER-TE 1 packet ~ 100 receivers?
     - See further slides

Bitstrings:
- (S1,G1) = 2 3 4 5
- (S1,G2) = 6 7 8 9
- (S2,G2) = 9 10 11
BIER-TE – BIER with traffic engineering (2)

• Routed adjacencies (save the bits):
  • Tunnel adjacency (GRE/MPLS/SR label stack/...) to desired next-hop
  • Replication may only be required on limited number of nodes in (larger) topologies
  • Tunnel through non BIER-TE capable nodes

• DetNet (or similar)
  • PREF – Packet Replication and Elimination Function (DetNet)
    • Transmit packets twice with flow-ID and sequence number – across disjoint paths
    • Remove duplicate copies via sequence number “deduplication” on destination

• BIER-TE header proposed to include sequence number (and ‘existing’ flow-id)

• BIER-TE can be interesting not only for multicast but also unicast
  • Replication e.g.: only/primarily for PREF. not for ‘multicasting’

• PREF suggested to be part of the BIER-TE TEAS framework
  • Can maybe also be defined to be independent of BIER-TE
  • But some BIER-TE specific OAM aspects.
Pathsets: Determine BIER-TE Bitstrings

- Pathset: result of (controller/BFIR) calculations of paths
  - PathSet-i(bfir-j) = ( bfer-k | {bitstring-i-j-k} )

- Configure traffic classes to use a BIER-TE Pathset:
  - E.g.: BFIR-10: VPN-foobar traffic should use Pathset-7(10)

- BIER: BitString(set of BFER-k) = OR (BFER-k-id bits)
- BIER-TE: BitString(set of BFER-k) = OR (bitstring-i-j-k)

- Bitstring-i-j-k can be redundant (e.g.: for PREF)

- More complex with minimum cost ("steiner") trees
  - Adding/removing destination requires recalculation
  - Still much faster/easier than recalculation plus re-signaling (RSVP-TE/P2MP)
BIER-TE TEAS framework
(proposed / incomplete)
BIER-TE signaling architecture (proposed)

Configuration

“BIER-TE topology”
- When BIER-TE service added/changed
- When network topology changes

Traffic: Bitstrings/PathSets
- Precalculate on controller/PCEP
- Send to BFIR (and BFER for PREF/OAM)
- Allow BFIR to calculate itself
- Allow BFIR to dynamically request from Controller (PCEP)

PREF, flow QoS (optional, e.g: DetNet)
- BFIR
  - Insert PREF sequence number, flow-id
- BFER (receiver)
  - Elimination function, OAM /
  - Sequence number, flow-id

--- BIER-TE domain--- |
|--- BIER-TE Controller Host ---|
|[Bier-TE Controller Host] == |
|{PCE controller}, {Provisioning}, {Monitoring} |
| ^ ^ ^ |
| / | \ |
| | | |
| v v v |
|BFIR-----BFR-----BFER|
|{per-flow QoS} ...... {EF,OAM}|
|Optional per-flow BFIR/BER functions (for per-flow TE)|

|-------------->| BIER-TE forwarding
|<--------------| {IGP extensions for BIER-TE}
|<--------------| Existing IGP (ISIS/OSPF)
Routing underlay / [Existing IGP TE extensions]
|<--------------| Unicast forwarding underlay - IPv4/v6/SR
for routed adjacencies (tunnels) used by BIER-TE
BIER-TE data model (topology)
BIER - Expressing Topology

• BIER Topology
  • Flooded information by BFR about themselves
  • BFER include their BFR-ID
  • MPLS: All BFR include label ranges (similar to SR)  
    Each table identified by a label from the range.

• BIER Routing Table
  • Constructed from received IGP announcements
  • List of bit (indices) for BFER
  • Next-hop – from path calculation
  • BFER IP identifier (“BFR-Prefix”)
    • Just tying BFER bitindex (BFER-id) to IP routing
      Not needed by BIER forwarding

• BIER Forwarding Table
  • BitIndex and Next-hop copied from BIER Routing Table
  • F-Bitmask: mask of all bits to the same neighbor
    • Used during forwarding when creating copy to neighbor
      reset all other bits for copy to this neighbor

Flooding Table-1
  Table-id-2
  Index of BFER in table
  more (e.g: IGP topo-id)
  Mpls label range for table

Flooding Table-2
  Table-id-2
  Index of BFER in table
  more (e.g: IGP topo-id)
  Mpls label range for table

Flooding via IGP
  Path selection – e.g.: SPF
  for each received topology Announcement

Routing Table-id-2
  Routing Table-id-1
  BitIndex | BFER IP identifier | Next-hop
  1       | ...             | R1
  256     | ...             | R5

Forwarding Table-id-2
  Forwarding Table-id-1
  BitIndex | F-Bitmask | Next-hop
  1       | 0111      | R1
  256     | 11000     | R5
BIER-TE - Expressing Topology (proposal)

1. BIER-TE BFR-i Topology
   - Local adjacencies (bits used by BFR), metadata
   - Configured by controller to each BFR-i

2. BIER-TE BFR-i Forwarding Table
   - Almost the same as BIER-TE BFR-i Topology without metadata
   - Plus auto configured bits/adjacencies
   - Minus inconsistent/inoperable bits

3. BIER-TE Network Topology
   - Set of all BIER-TE BFR-i Topologies
   - Needed on other BFR only for consistency check or adjacency auto-configuration
   - Needed on other BFIR for local path calculation

4. No equivalent of BIER Routing Table
   - But table of path(sets)/bitstrings required on BFIR
BIER-TE Topology: configured / operational

- **Distinguish “configured” and “operational”**
  - Path calculation (controller, BFIR) depends on actual operational BIER-TE network topology
    - Because configured topology does not include auto-configured bits/adjacencies. But does include adjacencies that may not be operational.
  - Inconsistency discovery / auto-configuration depends on configured consistency
    - Because operational topology will not show inconsistency when remode node already disabled bits due to inconsistency discovered.

- **BIER-TE Forwarding table same as configured topology table**
  - Except no need for metadata in forwarding table
  - Operational topology table stands in for forwarding table externally
  - No need to export forwarding table (device internal) ?!

**Operational BFR-i BIER-TE topology**

- Configured BFR-i BIER-TE topology
  - All BFR-i

**Network BIER-TE topology**

- Configured
- Operational

**Disability non-working adjacencies (e.g.: down neighbors)**

**BFIR:**

- Optional: calculate path(sets)
- Otherwise: get them from controller
BIER-TE Topology: Adjacency types

local_decap:
  VRF / context: (TBD)

forward_connected: (send to interface)
  dest: link (ifIndex)
  [, addr (nexthop)]
  DNR: boolean (Do Not Reset)

forward_routed:
  destination: ... (router-id, SID
  TBD: path/encap info (e.g: SR SID stack)

ECMP:
  list of 2 or more adjacencies, forward_connect and/or forward_routed
BIER-TE Topology

BFR: <bfr> (eg: BFR-prefix of BFR)

Instance: "configured", "operational", "learned-configured", "learned-operational" (of this BFR itself)

"learned-configured", "learned-operational" (from another BFR)

BIFT-ID: <SD subdomain,BSL bitstring length,SI Set Identifier>

BIFT-Name: string (optional)

BFR-id: 16 bit (BIER-TE ID of the <bfr> in this BIFT or undefined if not BFER)

Ingres-groups: (list of) string (1..16 bytes) (group that <bfr> is a member of)

EF: <TBD> (optional, parameters for EF Function on this BIFT)

OAM: <TBD> (optional, parameter for OAM Function on this BIFT)

Bits: #BSL (List of bits – BitStringLength, e.g.: 265)

BitIndex: 1...BSL

BitType(/Tag): "unassigned", "down", (no adjacencies – maybe compress data struct)

"unique", "p2p", "lan", "leaf", "node", "flood", "group"

(Names: (list of 0 or more) string (1..16 bytes) (for BitTypes that require it)

List of 0 or more adjacencies:

as on previous slide (most bits have 1 adjacency, but could be list)
BIER-TE – (partial) auto configuration (proposal)

- Avoid configuring bits 4, 9 each on P21,...P25
- Configure P21,...P25:
  - member of ingres-group: midpoint2
- Configure for P31
  - bit 9 type “group”, name “midpoint2”
- Configure for P33
  - bit 4 type “group”, name “midpoint2”
- “configured” instance of topology shows above config
  - Not operational – no adjacencies for bits 4, 9!
- “operations” instance of topology shows
  - P21,...P25:
    - Bit 4 type “p2p_unidirectional”, routed_adjacency to P33
    - Bit 9 type “p2p_unidirectional”, routed_adjacency to P31
BIER-TE path selection
TBD: Path selection

• First model to define?
• Yang model for PathSet
  • Configuration/Provisioning from controller/operator
  • Map to traffic classes

• Request/Reply model via PCEC?

• Hopefully guidance from TEAS
  • Would like reuse of existing solutions, adopt to BIER-TE
BIER-TE bandwidth management
TBD: Bandwidth/QoS management

• Bandwidth allocation / bandwidth aware path selection

  • Local decision on controller
    -> Requires dynamic request of Bitstrings/Pathsets by BFIR from controller
    -> Preferred initial option

  • Local decision on BFIR
    -> Not currently considered, but possible:
    -> Keep midpoint BFR free of traffic related state (BIER principle)
      -> RSVP-TE/IGP bandwidth extensions inappropriate
    -> BFIR could signal path resources it has allocated to other BFIR
      -> Signaling could use BIER/BIER-TE – only BFIR need to be receivers
Next steps ?!

• Discuss / determine order of next steps
  • Yang/PCEP configuration model first ?

• Improve framework according to TEAS guidance

• Finalize topology model
  • Discuss in LSR acceptable topology information

• PREF, OAM,...