• Send packets with explicit path, unicast/multicast

• Path is set of bits, one for each adjacency/interface

• Network device examines direct adjacency bits
  • P1: 7, 8, 9 (ignore all other bits)
  • Copy to each adjacency with bit set in bitstring

• Sender can set bitstring bits individually for each packet
  • No need for “flows”
**PR-EF**

(Sender inserts BIER header fields)
- Sequence number (proposed BIER-TE header extension)
- Sequence number space ID
  - Source, Selector
- Selector could be per destination (unicast), per set of receivers (multicast)
  - BIER-TE independent choice:
    - Largest number of in-flight sequence numbers
    - Undesirability of sequence number gaps

(Bitstring indicate replications for redundant copies)
- No logical different from copies made for “multicasting”.

(EF node)
- Any node – not only receiver
- EF on P1, P4 overcome for example simultaneous failure of links with 6 and 3
• Sender inserts BIER header fields
  • Sequence number (proposed BIER-TE header extension)
  • Sequence number space ID
    • Source, Selector
  • Selector could be per destination (unicast), per set of receivers (multicast)
    • BIER-TE independent choice:
      • Largest number of in-flight sequence numbers
      • Undesirability of sequence number gaps
  • Bitstring indicate replications for redundant copies
    • No logical different from copies made for “multicasting”.

• EF node
  • Any node – not only receiver
  • EF on P1, P4 overcome for example simultaneous failure of links with 6 and 3
OAM for PREF

- BIER-TE resets bitstring bits when they are used
  - “used” == Copy made across adjacency

- Receiver will see the remaining bits of bitstring from received packet

- Prior slide: If interface-3, interface-6 fail:
  - Bitstring will include bit 3 and 6 – no failure: bits 36 should be cleared

- Receiver may know sender bitstring of packets
  - E.g.: associated with sequence number space ID

- Can identify in many cases very well which path was taken
  - Distinguish copies across different path

- Can couple with statistics, OAM alerts, ...
• Ring example
  • Bits set so traffic will replicated in P1 to go clockwise until P1 and counterclockwise until P5
  • Bits likewise set so each PE1...PE5 will receive a copy

• Ingres EF will avoid dual copies P1..P2..P3 and P4..P5:
  • When clockwise packet arrives at P3, counterclockwise packet was already there. Clockwise packet dropped – before replication towards P2/P3
  • Likewise on P4 for counterclockwise packet.

• Location of overlap (P3 – P4)
  • Purely based on delay towards every node clock, counterclockwise
Bandwidth management: PCEC

- BIER/BIER-TE
  - Keep intermediate nodes ("P") free of traffic based state.
  - DetNet requirements may introduce state such as EF though
    - Not if EF is per-source (ingres PE)

- Highly desirable model ?!
  - Ingres PE shaping/marking/policing
  - Bandwidth broken /management on PCEC
  - PCEC based calculation of bitstrings, signaling back to sender PE
BIER vs. BIER-TE

- BIER bits only indicate receivers, not paths
- But can still build redundant paths
  - Dual-topology IGP or similar “disjoint path” calculations (e.g.: MRT)
  - Opinions about complexity / preferences of explicit paths (BIER-TE) vs. multitopology widely varying..

- Need to send from ingress N packets (one for each “copy”)
  - Differ in header field indicating the topology

- Duplicate elimination works unchanged
  - Does not care about “topology” field

- OAM options will not work
  - Based on received parsth bits in BIER-TE

- Solution overall should support BIER/BIER-TE
References

• RFC8279 – BIER architecture / forwarding
• RFC8296 – BIER encap MPLS/non-MPLS (no sequence number)
• draft-ietf-bier-te-arch – BIER-TE architecture / forwarding
• draft-thubert-bier-replication-elimination - PREF/OAM
• draft-huang-bier-te-encapsulation – BIER-TE encap (sequence num)
• draft-eckert-teas-bier-te-framework – BIER-TE TE framework
  • More references in this draft

• Possible place to summarize mapping of BIER-TE technologies to DetNet into framework document