

# BIER-TE TEAS framework

## IETF101

draft-eckert-teas-bier-te-framework-00

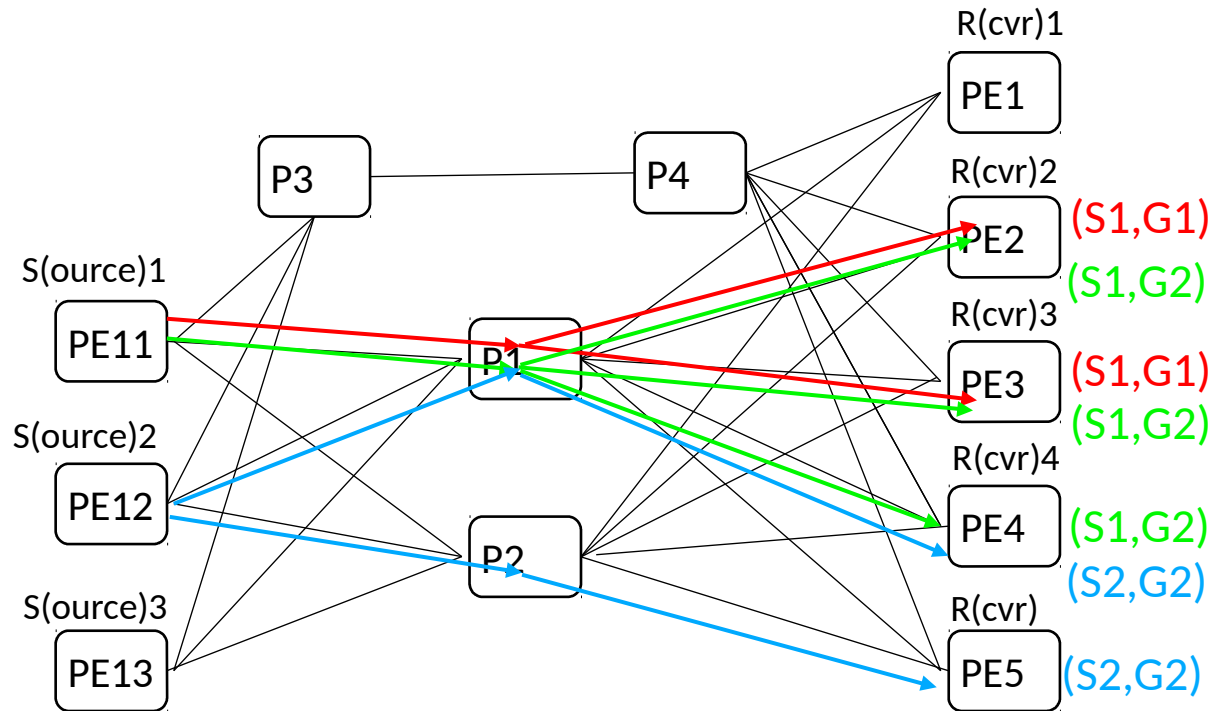
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# Background

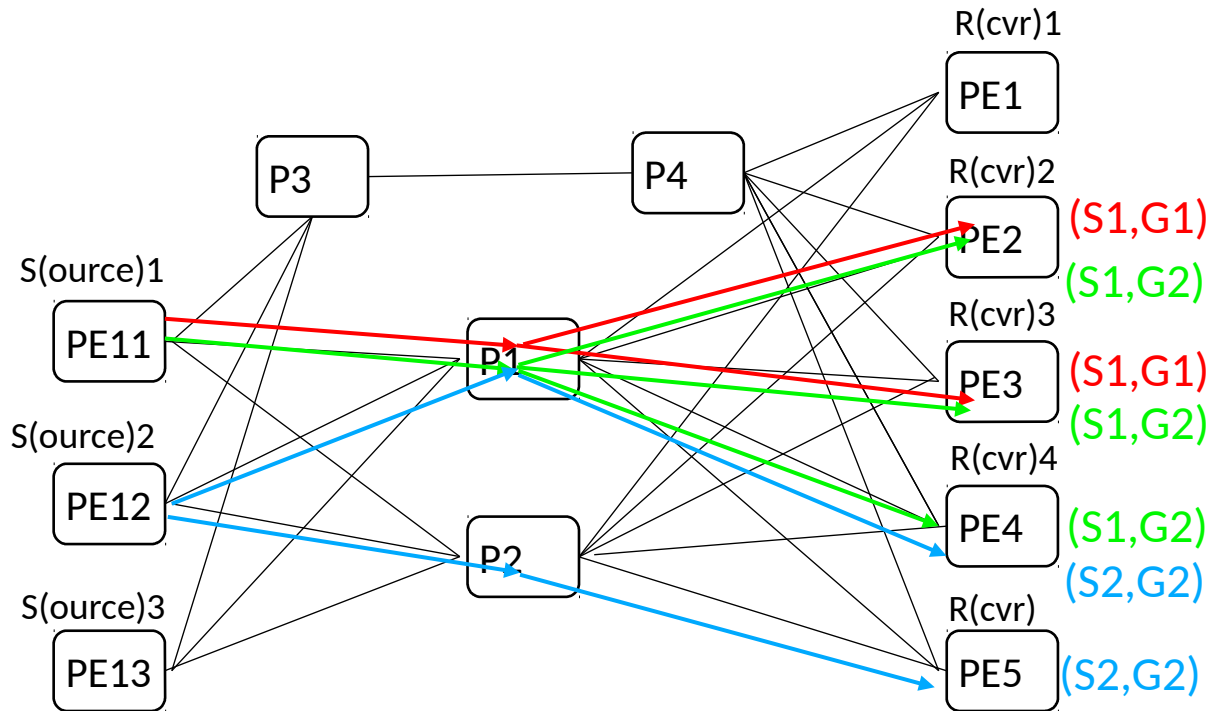
# Multicast, BIER, BIER-TE

*Slides with text only for reference after IETF101 presentation:*

# Traditional IP multicast problems

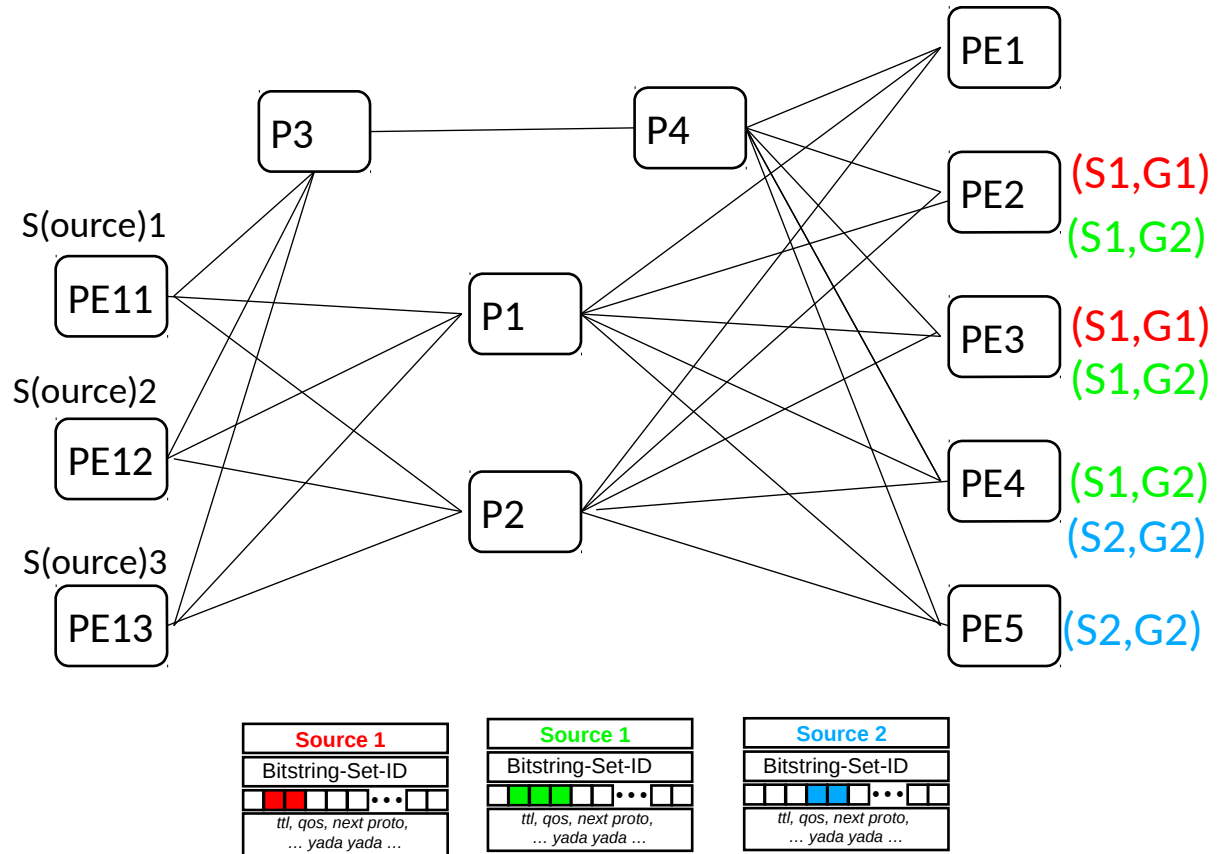


# Traditional IP multicast problems

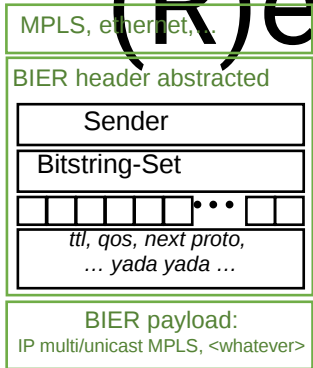


- Tree state on P nodes
  - (S,G) – per source S, per receiver group G
  - 3 sender, 5 receiver: up to  $2^3 * 2^5$  trees
  - Real networks (src,group large) -> impossible
  - Aggregation == wasted traffic
  - Forwarding, control plane state, signaling
  - Performance operations problem long before 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)

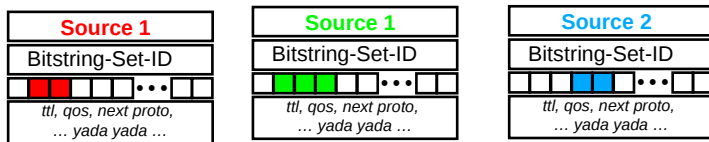
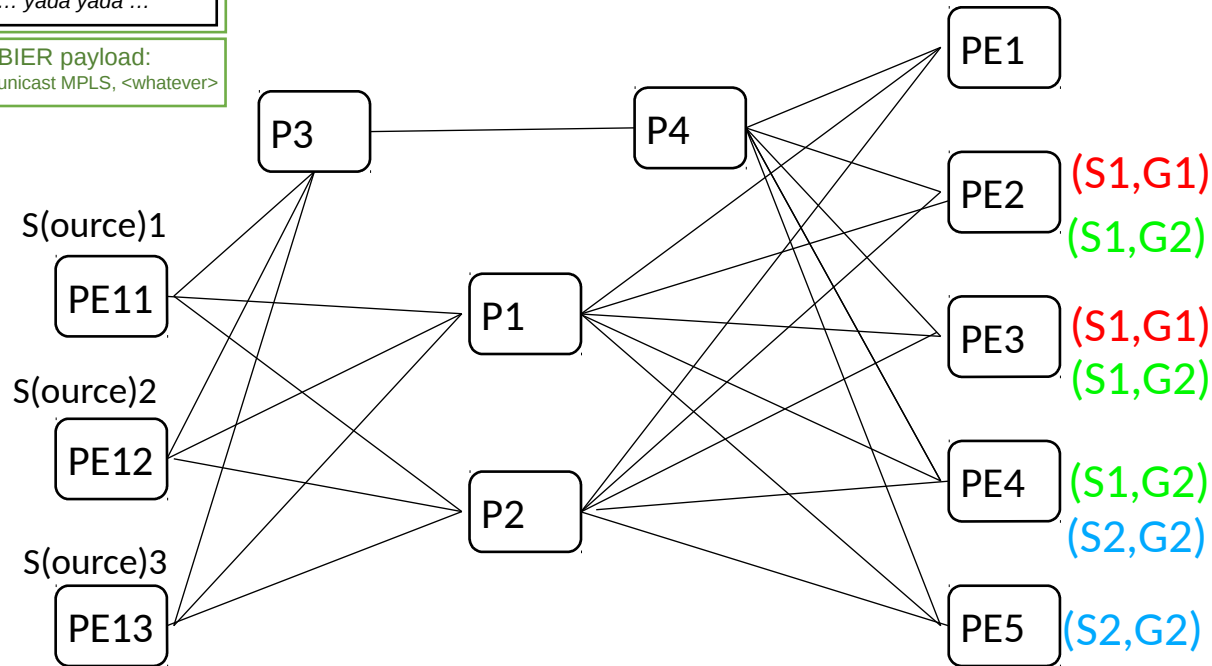
# BIER – (B)IT (I)ndexed (E)xplicit (R)eplication



# BIER – (B)IT (I)ndexed (E)xplicit (R)eplication

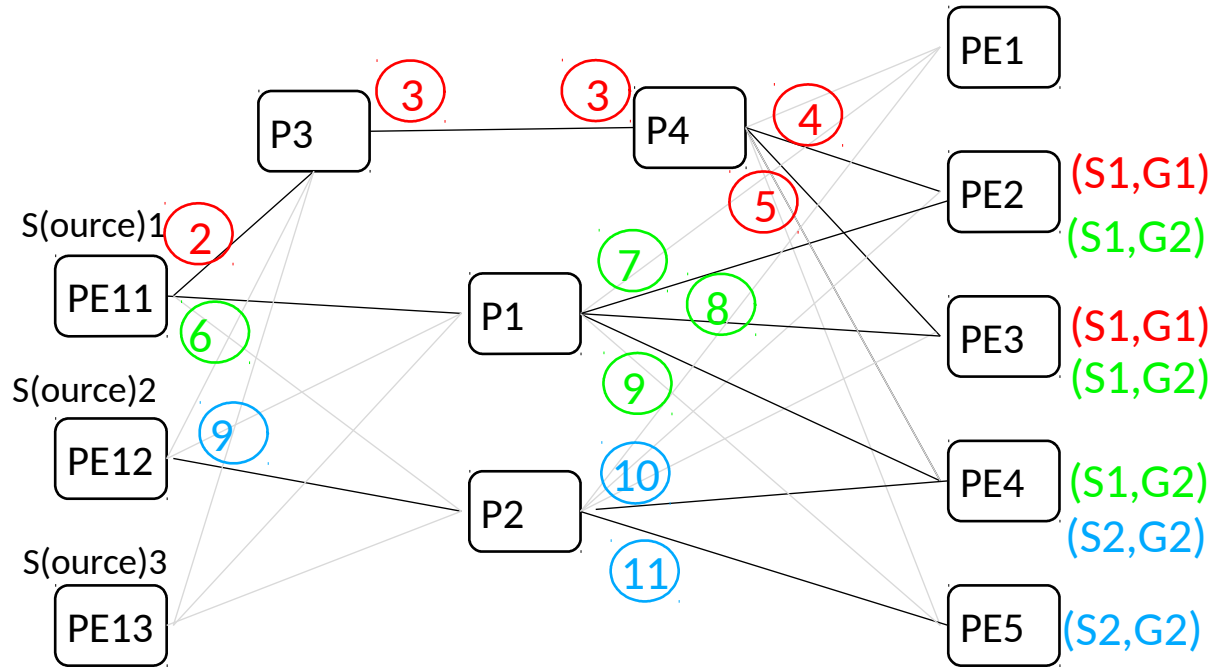


Actual name: BFIR-id  
Actual name: BIFT-id  
The BitString



- **STATELESS:** No tree state on P nodes
  - No tree signaling/control either !
- BIER ‘for SR dummies experts’
  - ‘BIER packet header indicates a SET OF egress-PE node-SIDs’
- Up to 256 egress 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)



Unused links/adjacencies greyed out for clarity

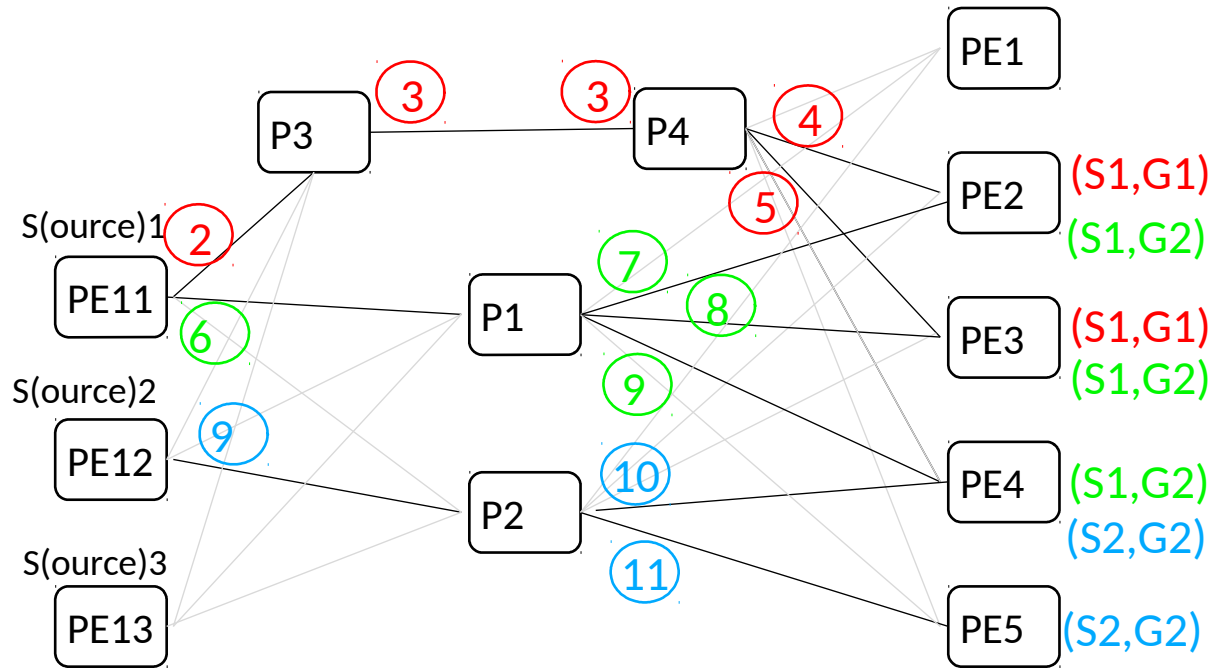
Bitstrings:

(S1,G1) = 2 3 4 5

(S1,G2) = 6 7 8 9

(S2,G2) = 9 10 11

# BIER-TE – BIER with traffic engineering (1)



Unused links/adjacencies greyed out for clarity

Bitstrings:

(S1,G1) = 2 3 4 5

(S1,G2) = 6 7 8 9

(S2,G2) = 9 10 11

- BIER BitString indicate BFER-id
  - Aka: Receiver PE (or wherever BIER domain ends)
- BIER-TE BitStrings indicate transit adjacencies
  - Most simple: every interface in topology is a bit
- 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
- Optimizations to reduce “bit-waste”
  - Bit semantics:
  - P2p link bit (e.g.: bit 3 on both adjacencies of interface)
  - Lan, stub, flood, punt, ... bits
- Any traffic engineering
  - NO STATE – Engineer path (graph!) of every packet individually through bitstring fom sender (BFIR) in BIER(-TE) header.
- Bit waste... ?
  - BIER: 1 packet ~ 256 receivers
  - BIER-TE 1 packet ~ 100 receivers ?
    - See further slides



# 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
  - $\text{PathSet-}i(\text{bfir-}j) = ( \text{bfer-}k \mid \{ \text{bitstring-}i\text{-}j\text{-}k \} )$
- Configure traffic classes to use a BIER-TE Pathset:
  - E.g.: BFIR-10: VPN-foobar traffic should use Pathset-7(10)
- BIER:  $\text{BitString}(\text{set of BFER-}k) = \text{OR}(\text{BFER-}k\text{-id bits})$
- BIER-TE:  $\text{BitString}(\text{set of BFER-}k) = \text{OR}(\text{bitstring-}i\text{-}j\text{-}k)$
- 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)*

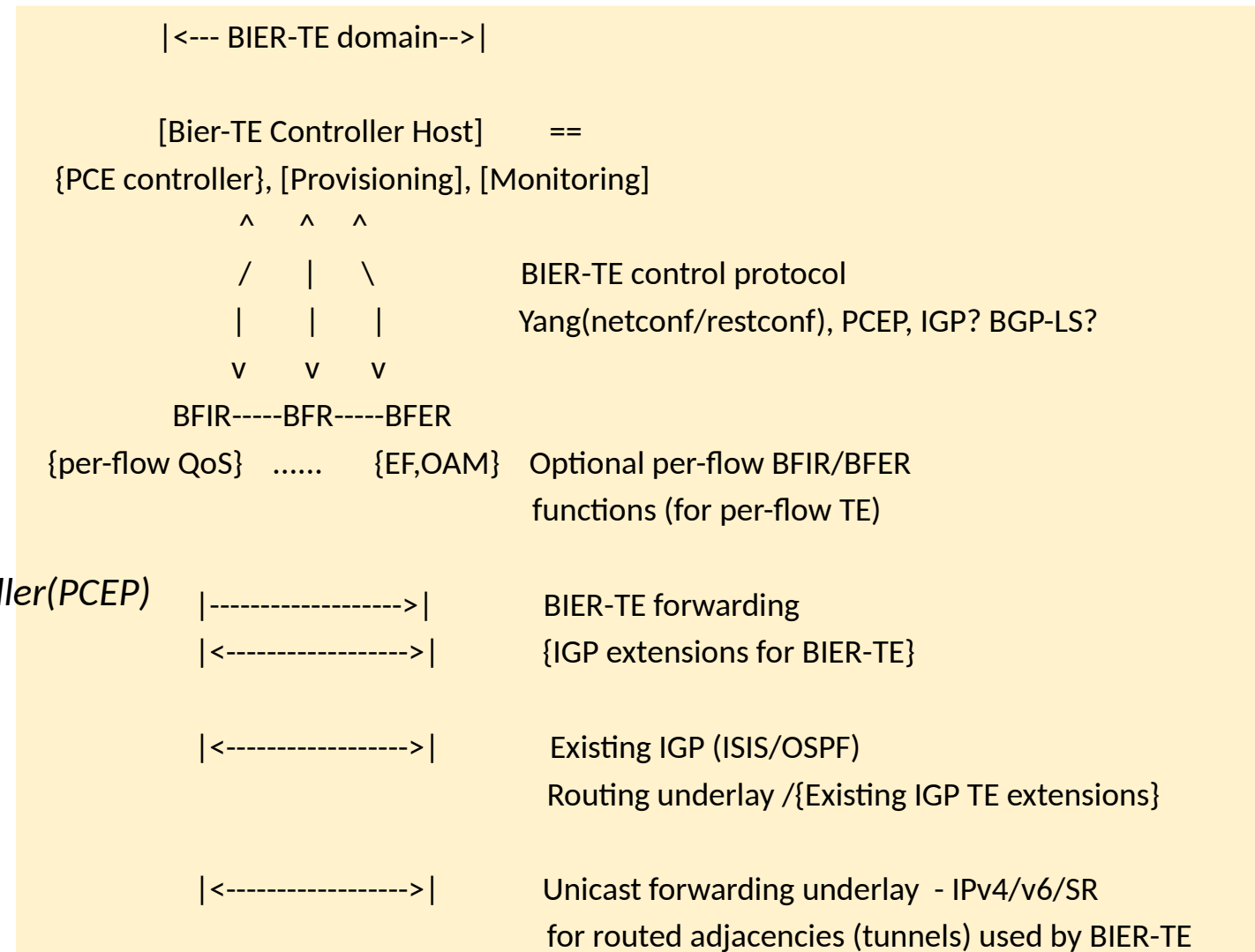
## PREF, flow QoS (optional, e.g: DetNet)

BFIR

*Insert PREF sequence number, flow-id*

BFER (receiver)

*Elimination function, OAM /  
 Sequence number, flow-id*



# BIER-TE data model (topology)

# BIER - Expressing Topology

## • BIER Topology

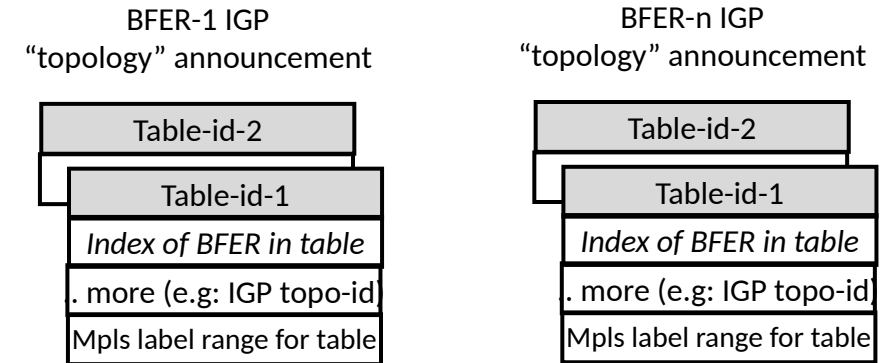
- Flooded information by BFR about themselves
- BFER include their BFR-ID
- MPLS: All BFR include label ranges (similar to SR)  
Each table identified by a label from the range.

## • 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



*Flooded 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

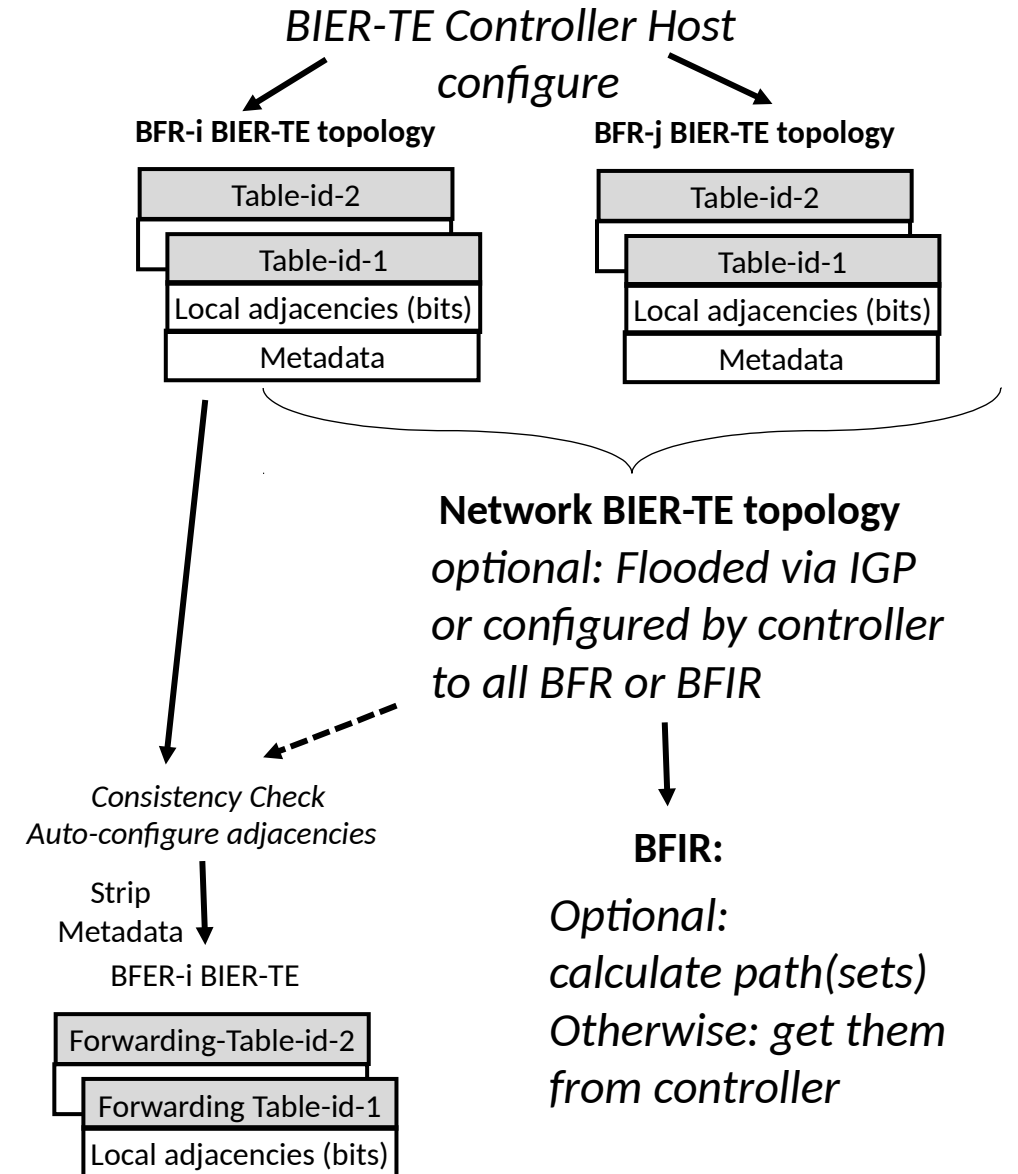
Forwarding Table-id-2		
Forwarding Table-id-1		
BitIndex	F-Bitmask	Next-hop
1	0111	R1
...		
256	11000	R5

# 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
- 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
- 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
- No equivalent of BIER Routing Table
  - But table of path(sets)/bitstrings required on BFIR



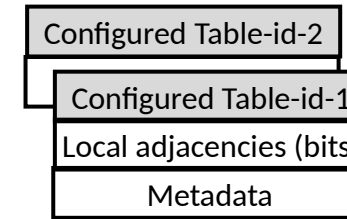


# BIER-TE Topology: configured / operational

BIER-TE Controller Host configures

- 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 remove 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) ?!

Configured BFR-i BIER-TE topology



All BFR-i +

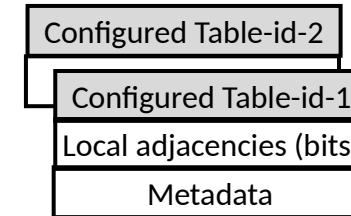
Configured Network BIER-TE topology

Consistency Check  
Auto-configure adjacencies

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

Operational Network BIER-TE topology

Operational BFR-i BIER-TE topology



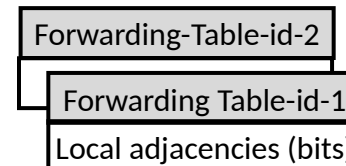
All BFR-i +

BFIR:

Optional:  
calculate path(sets)

Otherwise: get them  
from controller

Strip ↓ Metadata  
BFR-i BIER-TE





# 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", (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)

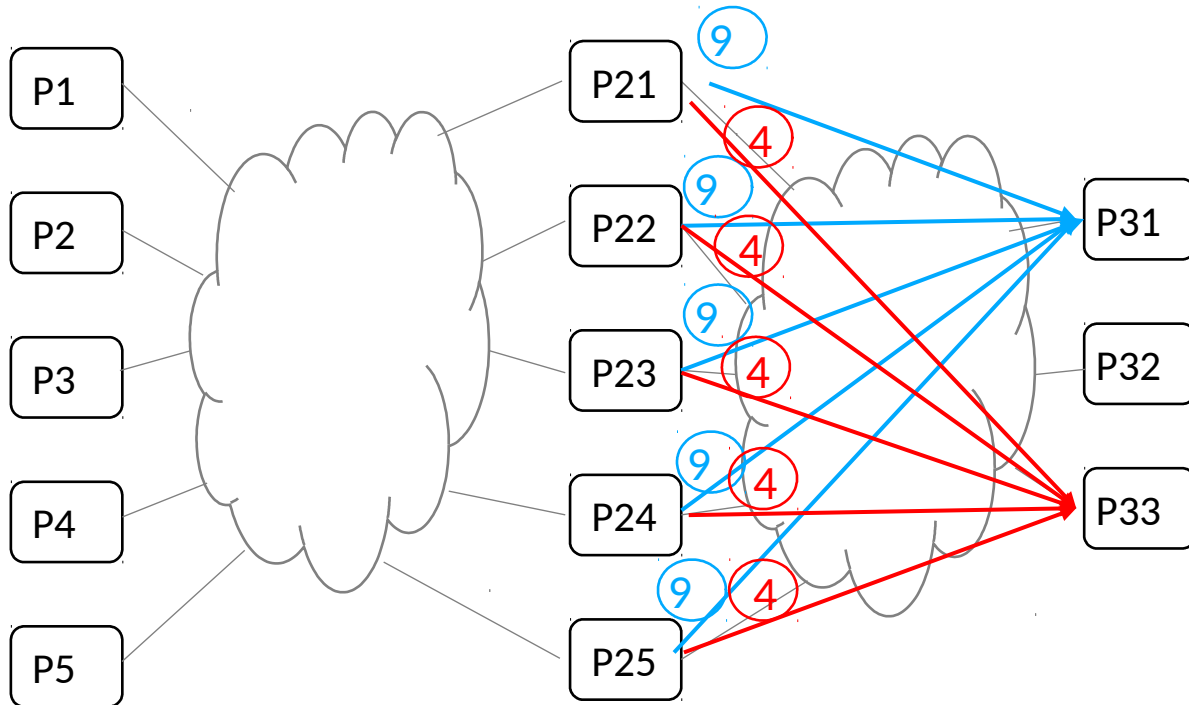
**BitIndex:** 1...BSL

**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)



Ingres-group:  
midpoint2

- 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,...