Carrier Grade Minimalist Multicast (CGM2) using Bit Index Explicit Replication (BIER) with Recursive BitString Structure (RBS) Addresses

IETF 112 / BIER

draft-eckert-bier-cgm2-rbs-00

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Based on design/work from
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What is wrong with BIER-TE ?

BIER-TE is the best multicast forwarding solution for its target constraints:

- BIER per flow/tree stateless forwarding with added stateless traffic steering…
- When we can only reuse the pre-existing BIER-TE ”flat-bitstring”
- and only no…minimal changes to BIER forwarding algorithm.

But this comes at undesirable limitations / complexities:

N-bit bitstring can address only fixed set of N-M BFER (e.g.: N=256)

- Because every bit of address is statically assigned to an adjacency (e.g.; BFER)
- M is number of bits needed to ’steer’ packets (BFR). Also fixed, potentially sub-part of topo.
- Same static mapping issues exist in BIER, but less severe

Result (as seen from BIER-TE draft):

- Design complexities minimizing required M bits (LAN, hub&spoke, p2p, overlay topologies, …). Controller and network operator.
- Larger number of copies with different bitstrings to reach arbitrary subset of BFER in large network
- OPS and CONTROLLER COMPLEXITY, less TRAFFIC EFFICIENCY for FORWARDING PLANE SIMPLICITY.

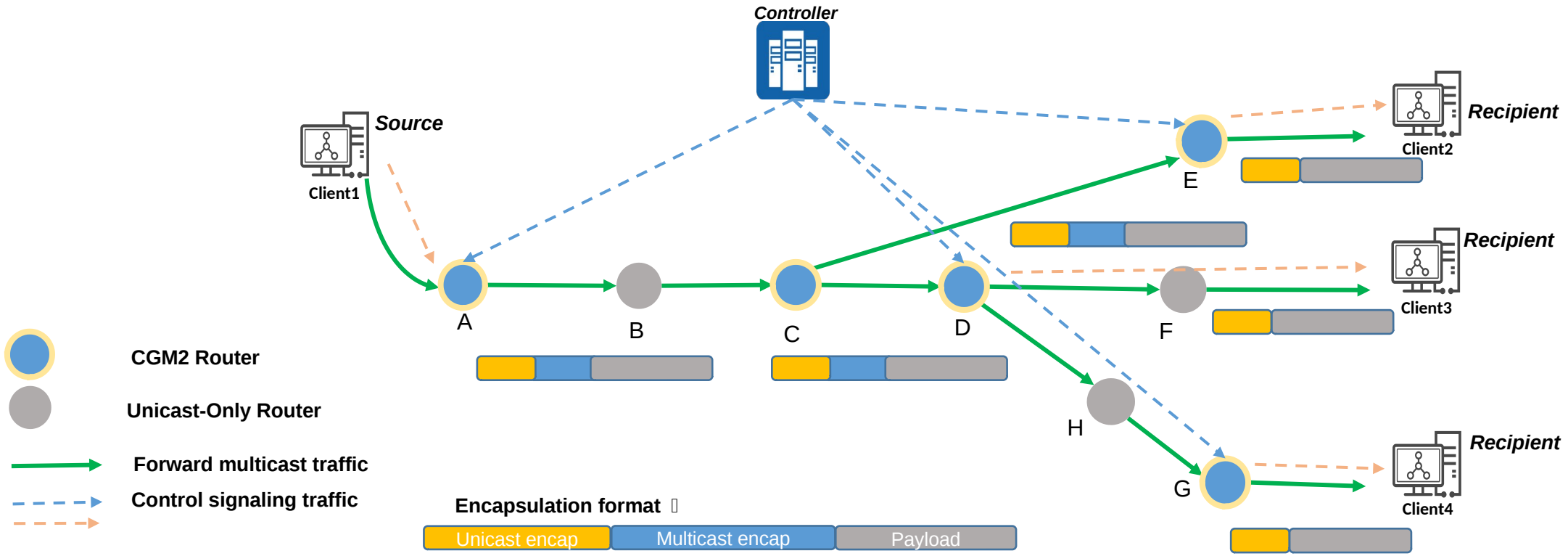
Fix the bitstring addressing issue

Eliminate duplication: IP multicast on top of bitstring forwarding (“overlay”)

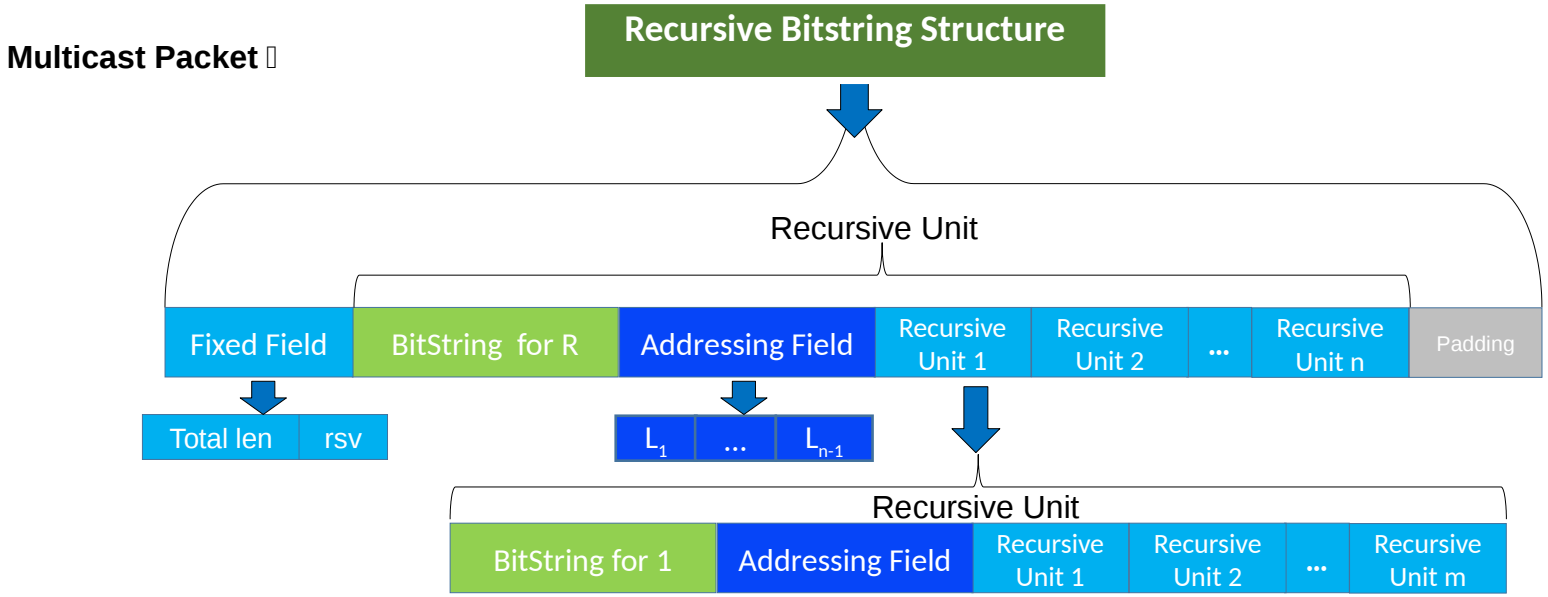
- End-to-end integration with controller plane

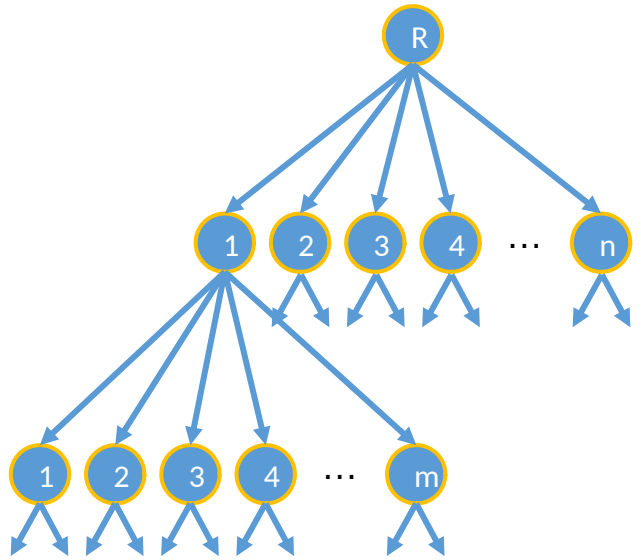
Complete TE services via controller plane and forwarding plane

- Deterministic Latency, Path Selection (Steiner, diverse, …)



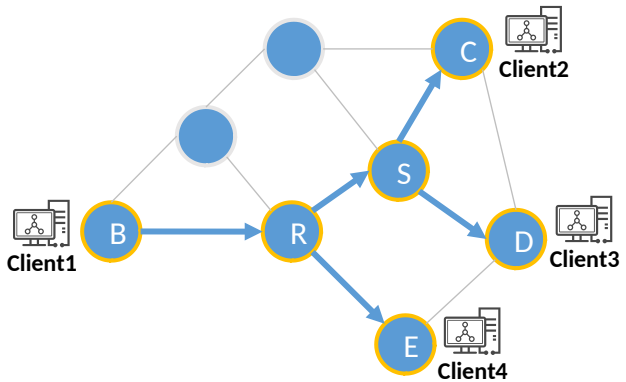
Recursive Bitstring Structure (RBS)



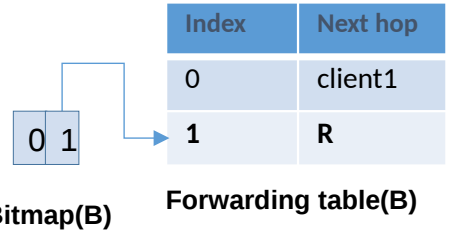


- **Fixed Field**
  - ✓ Total len indicate the total length of the Recursive Unit, Filed length can be set flexibly to 8/16/32, with bit/byte/word. Padding is not included.
  - ✓ Rsv: Reserved Fields
- **Recursive Unit**
  - ✓ **Bitstring** instructs a node to locally duplicate packets and forwarding – like a BIER-TE bitstring (but without complex options)
  - ✓ **Addressing Field** length of 'child' recursive units .
  - ✓ **Recursive Unit** has the same structures as the unit it sits in.
- **Padding** (Optional) Used for alignment to byte (or larger).

Example:

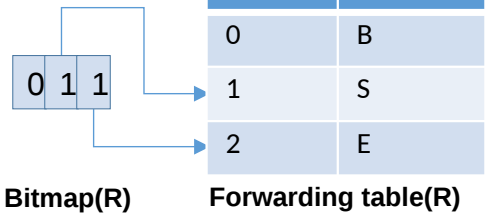


- **Multicast route identifier**
  - ✓ Define the local bitmap
  - ✓ Each bit corresponds to a multicast object, which denote the direct delivery destination of multicast packet.
- **Forwarding table**
  - ✓ Each table entry corresponds to a bit in the bitmap.
  - ✓ Instruct the forwarding method to the corresponding multicast object (outgoing interface, next hop address, etc.)



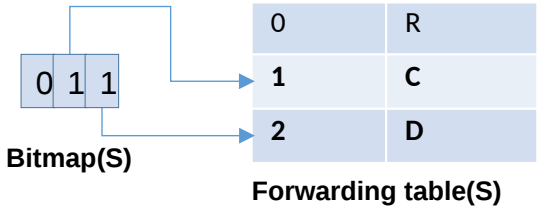
Index	Next hop
0	client1
1	R

Forwarding table(B)



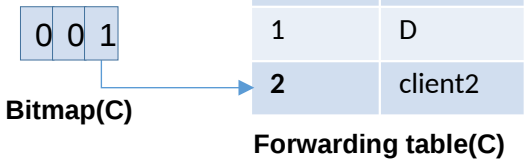
Index	Next hop
0	B
1	S
2	E

Forwarding table(R)



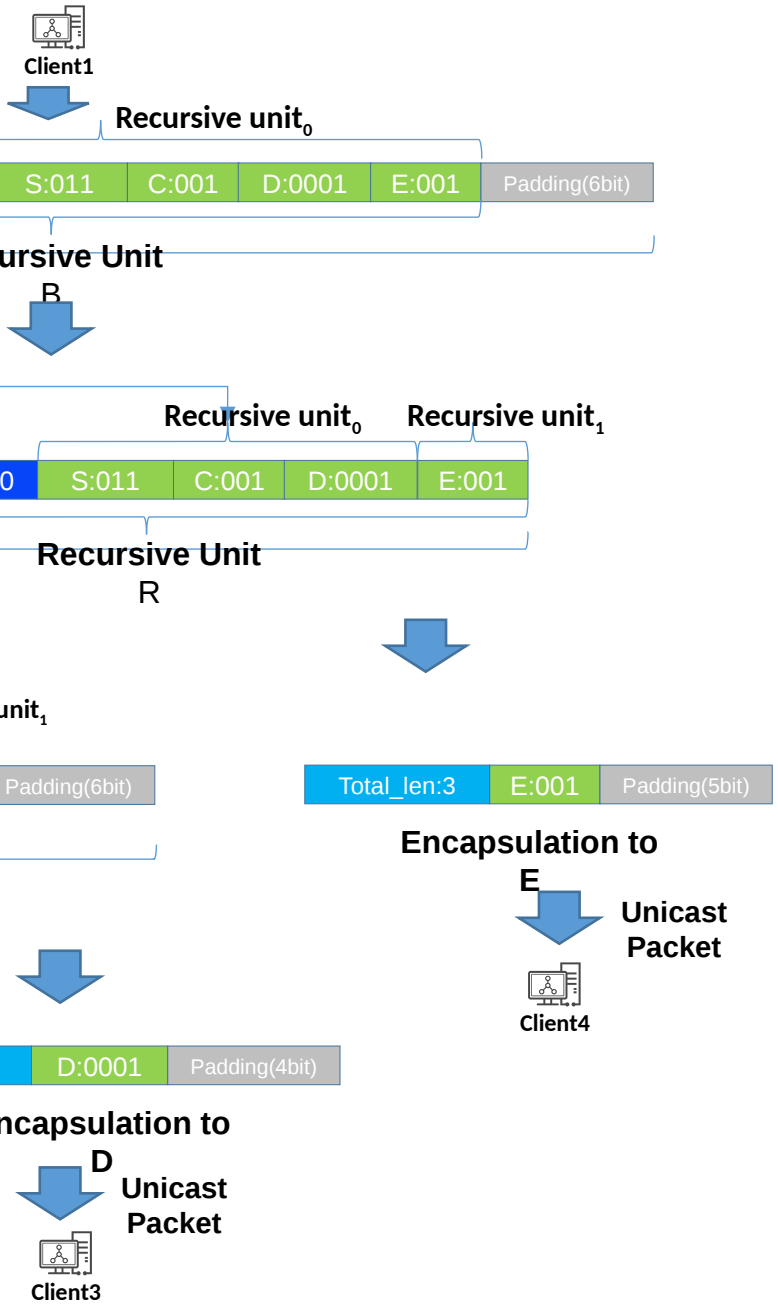
Index	Next hop
0	R
1	C
2	D

Forwarding table(S)



Index	Next hop
0	S
1	D
2	client2

Forwarding table(C)



The bug in this example is left as an exercise to the reader

Simplifications / Performance Enhancements

Naturally no need for loop prevention measures (as in BIER/BIER-TE) (no clear bits)

No need to split up topology into different SI and/or multiple SD bitstrings

No (or much smaller) need to create optimized bit semantics.

- Just use all adjacencies of topology and/or shortest tunnel adjacencies over unicast-routers.

Especially for ‘sparse’ (small number of BFER) distributions

- Can encode any subset and steering in single RBS address == single packet packet
- If majority of packet have sparse receiver sets. Duplicate packet reduction maximized.

When total number of BFR too large for desired max RBS address structure (eg: > 512 bit ?)

- Controller can arbitrary duplicate/split distribution tree to create multiple packets for ‘sub-trees’.

Forwarding Pseudocode

```
void ForwardRBSPacket (Packet)

RBS = GetPacketMulticastAddr(Packet);
Total_len = RBS;
Rsv = Total_len + length(Total_Len);
BitStringA = Rsv + length(Rsv);
AddressingField =  BitStringA + BIFT.entries;

// [1] calculate number of recursive bits set in BitString
CopyBitString(*BitStringA, *RecursiveBits, BIFT.entries);
And(*RecursiveBits,*BIFTRecursiveBits, BIFT.entries);
N = CountBits(*RecursiveBits, BIFT.entries);


// Start of first RecursiveUnit in RBS address
// After AddressingField array with 8-bit length fields
RecursiveUnit = AddressingField + (N - 1) * 8;


RemainLength = *Total_len - length(Rsv) - BIFT.entries;

Index = GetFirstBitPosition(*BitStringA);
```

```
while (Index) {
  PacketCopy = Copy(Packet);

  if (BIFT.BP[Index].recursive) {
    if(N == 1) {
      RecursiveUnitLength = RemainLength;
    } else {
      RecursiveUnitLength = *AddressingField;
      N--;
      AddressingField += 8;
      RemainLength -= RecursiveUnitLength;
      RemainLength -= 8; // 8 bit of AddressingField
    }
    RewriteRBS(PacketCopy, RecursiveUnit,
                           RecursiveUnitLength);
    SendTo(PacketCopy, BIFT.BP[Index].adjacency)

    RecursiveUnit += RecursiveUnitLength;
  } else {
    DisposeRBSheader(PacketCopy);
    SendTo(PacketCopy, BIFT.BP[Index].adjacency);
  }
  Index = GetNextBitPosition(*BitStringA, Index);
}
```

Other thoughts

- Natural variable length address (structure)
  > Compared to naturally fixed-size in BIER/BIER-TE

- Forwarding plane complexity
  > Basic Bitstring replication the same as BIER-TE (only simple subset of adjacencies required)
  > Main added work:
    - For each R)eplicating adjacency:
      locate offset/length of Recursive Unit for adjacency, rewrite RBS to that Recursive Unit

- TBD: stochastical analysis/comparison of efficiency (#copies), compared to BIER/BIER-TE
  > Wide comparison space…

- Packet encoding
  > Not purpose of this draft
  > Could just use RFC8296 and be considered ‘yet another BIFT mode’ (BIER, BIER-TE, BIER-RBS)
  > Or any other encap if more desirable / applicable

THE END