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

IETF 112 / INTAREA

draft-eckert-bier-cgm2-rbs-00

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Based on design/work from
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Why INTAREA

- *Why not ? (is IntArea only for Unicast ? ;-)*

- To inform INTAREA of a great example, how further work on more intelligent (variable length) addressing helps to solve currently worked on routing problems better!

  - Some call (“locator type”) addresses forwarding instructions (i like that too)
  - IMHO whatever we call them, it is still routing

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 tateless 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.

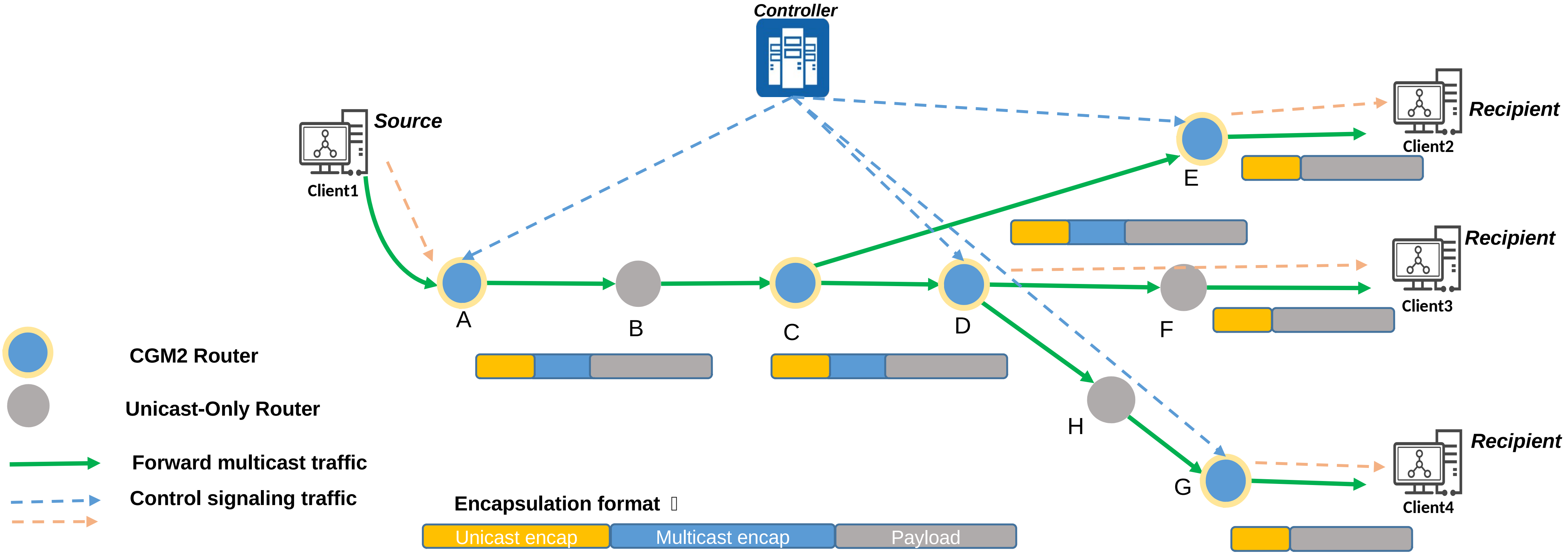
Fix the bitstring addressing issue

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

- End-to-end integration with controller plane

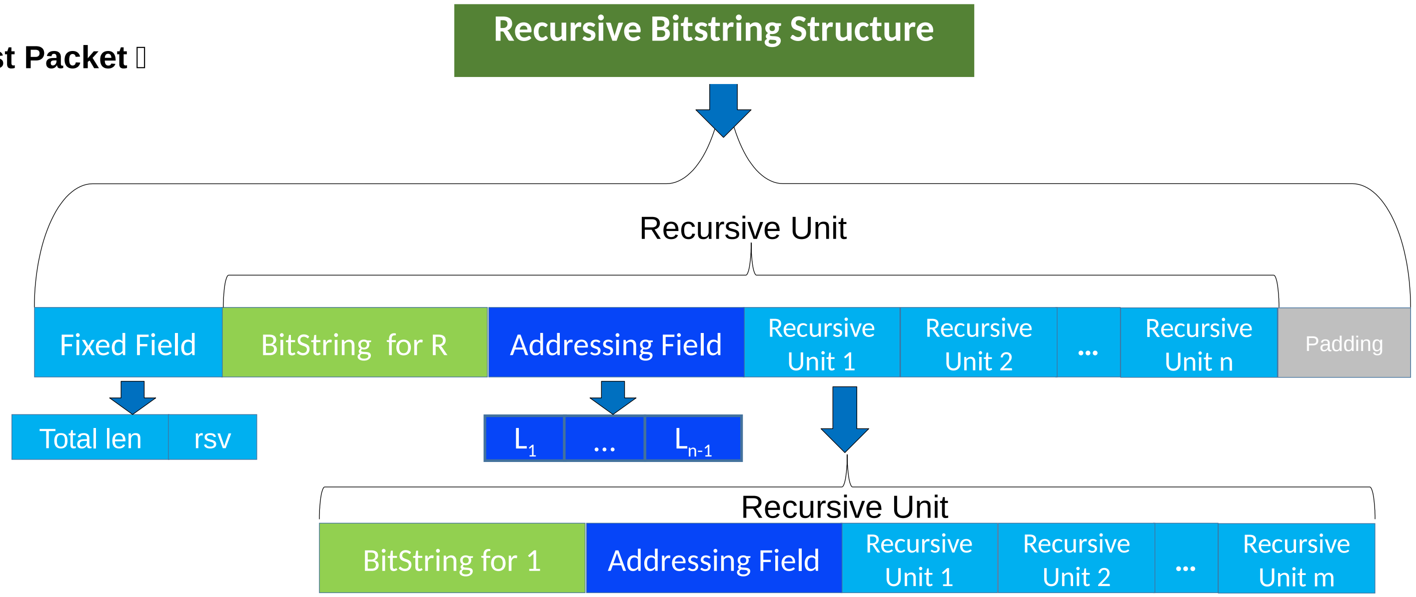
Complete TE services via controller plane and forwarding plane

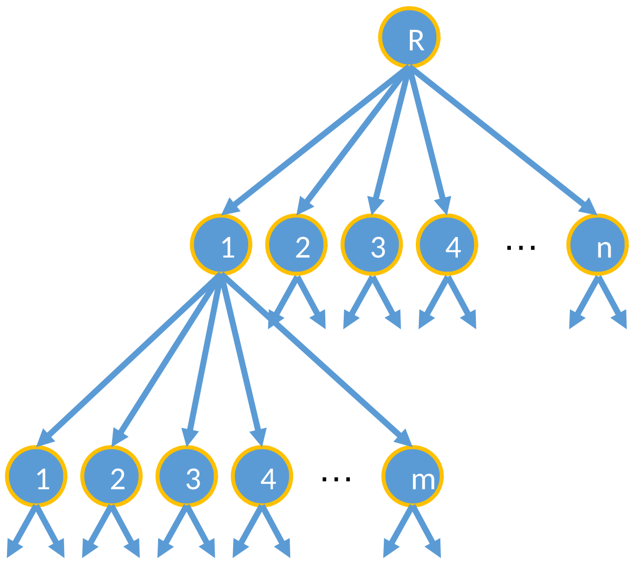
- Deterministic Latency, Path Selection (Steiner, diverse, …)



Recursive Bitstring Structure (RBS)

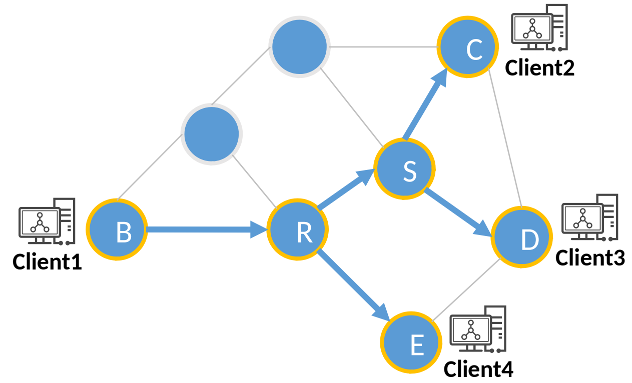
Multicast Packet：





- **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:



Bitmap(B): 0 1

Index	Next hop
0	client1
1	R

Forwarding table(B)

Bitmap(R): 0 1 1

Index	Next hop
0	B
1	S
2	E

Forwarding table(R)

Bitmap(S): 0 1 1

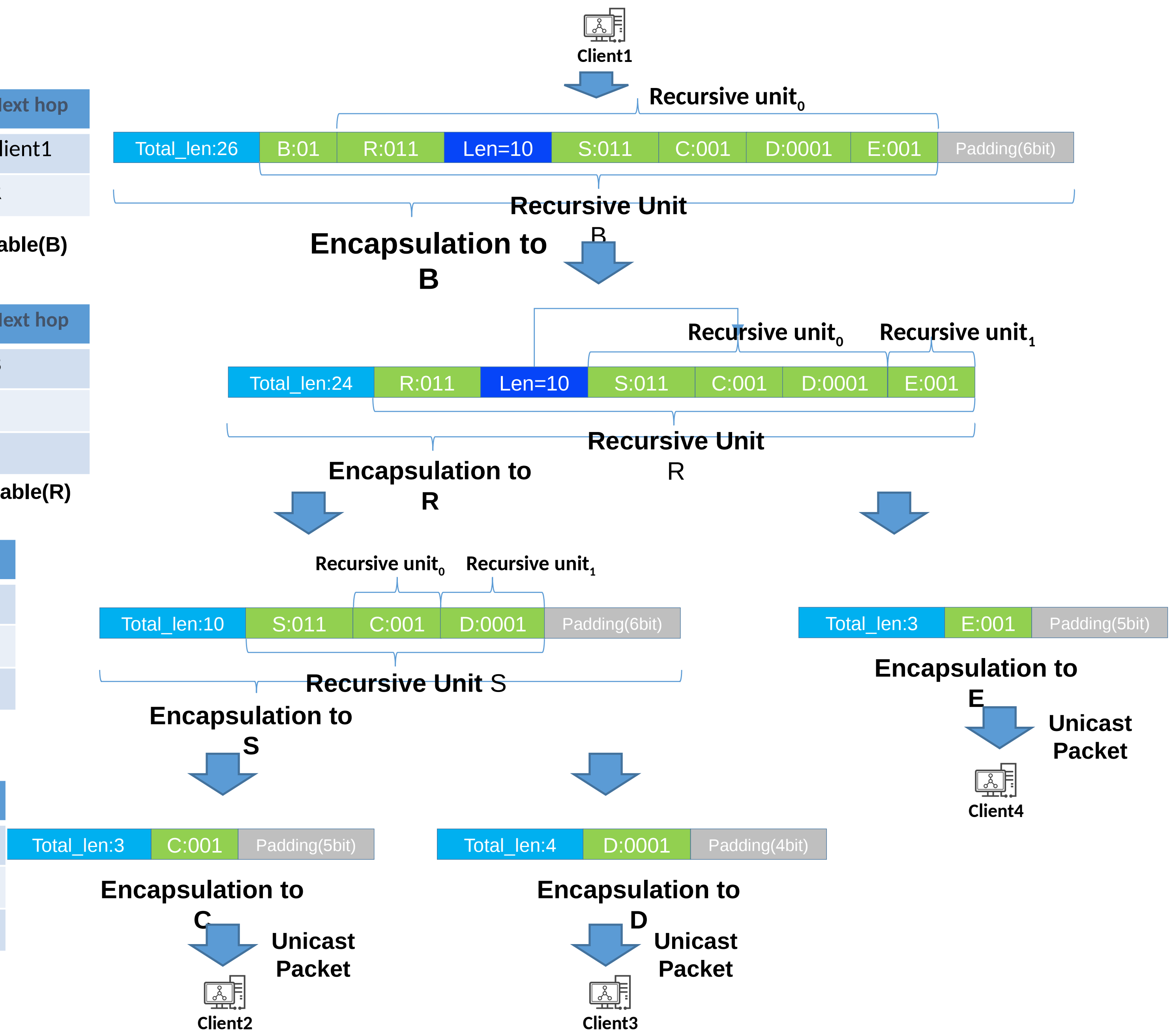
Index	Next hop
0	R
1	C
2	D

Forwarding table(S)

Bitmap(C): 0 0 1

Index	Next hop
0	S
1	D
2	client2

Forwarding table(C)



- **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.)

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