GLID as Envelope ID

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Motivation

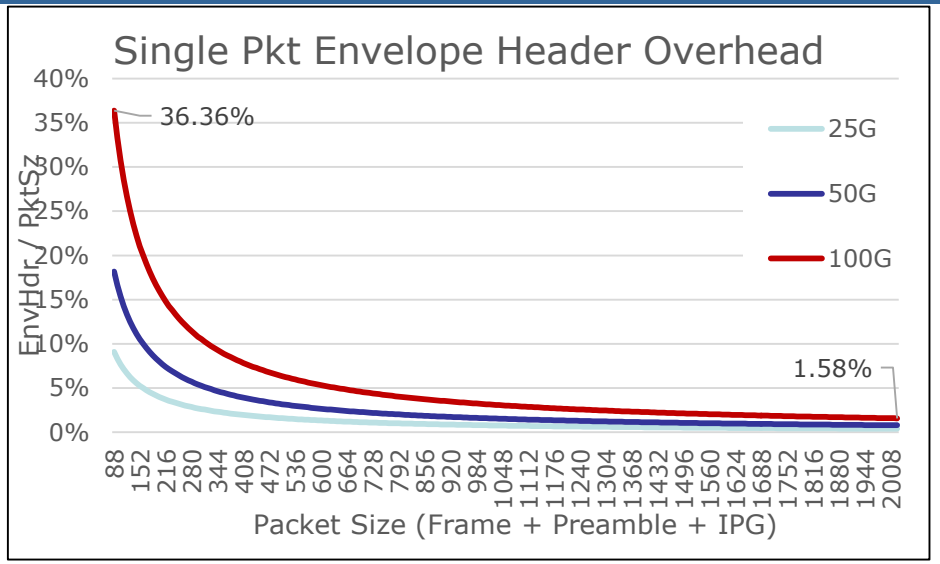
- Use the GLID as an Envelope Header and use ULID / PLID to identify the contents of the envelope
  - Gives the system more flexibility in the scheduling of data.
  - Higher efficiency due to less overhead
  - Helps limit the number of frame fragments the receiving station needs to buffer
  - Brings 100G-EPON closer to ITU PON transport model encouraging a single PON standard
  - Potentially less variable frame delay (minor)

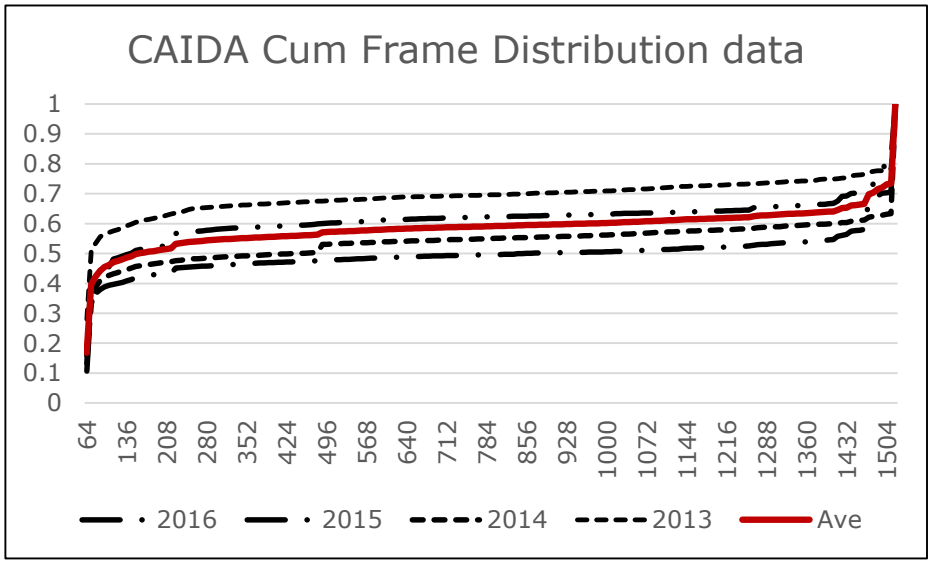
Scheduling flexibility

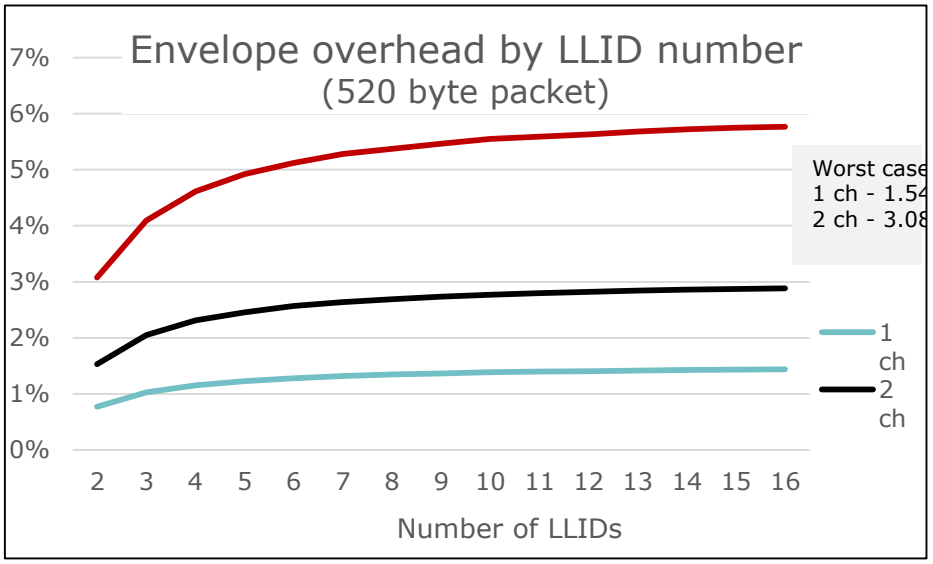
- Using GLID as the envelope ID allows the ONU to perform local scheduling of US data based on current conditions and not stale information
- Distributes the scheduling task which can bring more resources to bare on the task
- OLT can still schedule a single PLID/ULID if it is the only LLID in a group

Envelope Header overhead

- Envelope Header overhead
  - ↓ with Envelope Size
  - ↑ with number of channels
  - ↑ with the number of LLIDs
  - Varies with traffic
  - Less problematic in US (agg.)
- Overall ~4.75% (large variance)







Simulation results

Number of Ch	LLIDs	GLIDs	Sim Type	Percent Ovhd	MaxEnv (Bytes)	Notes
4	65	0	P/ULID	4.7%	3200	Scenario 1a - 4 ch, 64 ULIDs, 1 PLID; uniform ulids
		1	GLID	0.8%		
		1	GLID	0.5%	6400	Scenario 1b - same as 1 w/ large env (800 vs 400 EQ)
4	65	0	P/ULID	4.6%	3200	Scenario 2a - 4 ch, 64 ULIDs, 1 PLID;
		1	GLID	0.8%		32 subs, 4 Hi, 8 Med, 16 Typ, 4 Lo, 2 ULIDs/sub
2	65	0	P/ULID	2.3%	3200	Scenario 2b - 2 ch, 64 ULIDs, 1 PLID;
		1	GLID	0.4%		32 subs, 4 Hi, 8 Med, 16 Typ, 4 Lo, 2 ULIDs/sub
1	65	0	P/ULID	1.2%	3200	Scenario 2c - 1 ch, 64 ULIDs, 1 PLID;
		1	GLID	0.2%		32 subs, 4 Hi, 8 Med, 16 Typ, 4 Lo, 2 ULIDs/sub
4	40	0	P/ULID	2.9%	3200	Scenario 3a - 4 ch, 39 ULIDs, 1 PLID;
		3	GLID	1.9%		3 Bus, 6 SMB, 12 Res
2	40	0	P/ULID	1.8%	3200	Scenario 3b - 2 ch, 39 ULIDs, 1 PLID;
		2	GLID	0.8%		3 Bus, 6 SMB, 12 Res

Simulation

- Frame size distribution per CAIDA[2] (avg 2013-2016)
- LLID assigned per weighted avg of data capacity

1) See back-up material for details on LLID characteristics
2) Center for Applied Internet Data Analysis (CAIDA)

Fragmentation buffers

- The larger the number of LLIDs that can be fragmented the larger the fragmentation buffer problem (see kramer_3ca_1_0117)
- Using GLID as envelope ID limits the number of fragments as there are fewer envelopes and thus fewer fragments
- Helps contain chip cost

Analogous to ITU PON structure

PLID	⇔	ONU-ID
GLID	⇔	Alloc-ID
ULID	⇔	GEM-port-ID

- A more similar look & feel will encourage a single PON standard
- A single PON standard will help reduce costs on multiple levels (standardization, design & development, components, …)

Realization of GLID as EnvID

- Restrict LLID in Envelope header to be only GLID
- Allow an envelope to carry multiple PLID / ULIDs
- Utilize the same preamble replacement as is done for 10G-EPON and 1G-EPON to carry PLID/ULID
  - Envelope header describes the transport envelope
  - PLID/ULID in preamble identifies the MAC of the frame
- Some restrictions apply
  - PLID/ULID is a member of only one GLID
  - May want to consider allowing one set of GLIDs for US use and a different set for DS use (in this case a PLID/ULID would be a member of one GLID per direction)
    - Would only need 3 GLIDs in DS in a 100G-EPON mixed system;
      1 for 25G ONUs (Ch 0),
      1 for 50G ONUs (Ch0 & 1), and
      1 for 100G ONUs (4 Chs)

GLID Envelope / multiple LLIDs US

1. ONU Reports: GLID #1 = 1164

LLID A: 463 EQ — A 1000 | E 500 | G 1200 | J 1000

LLID B: 338 EQ — B 700 | D 500 | H 1500

LLID C: 363 EQ — C 1000 | F 500 | I 1400

4. Left in MAC:

LLID A: 131 EQ — G 40 | J 1000

LLID B: 187.5 EQ — H 1500

LLID C: 175 EQ — I 1400

GLID #1 = {A, B, & C}

2. OLT GATE

- DA/SA/Type/Opcode/Timestamp
- Ch = xxxx / # Gnt = 1
- Gnt Start Time
- GLID #1
- 670 EQ (5360B)
- Pad/FCS

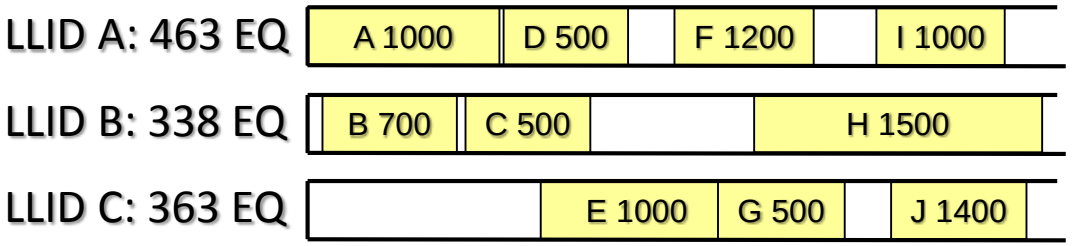
Grant

3. ONU formed this envelope

GLID, Len = 670 EQ	1	125	87.5	125	62.5	62.5	62.5	145	(EQ)
LLID A: 332 EQ		A 1000				E 500		G 1160	(Bytes)
LLID B: 150 EQ			B 700		D 500				(Bytes)
LLID C: 188 EQ				C 1000			F 504		(Bytes)

GLID Envelope / multiple LLIDs DS

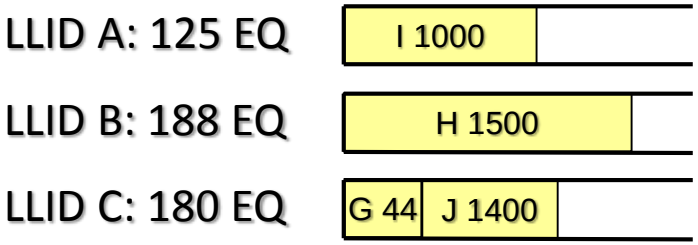
1. OLT Received:



2. OLT MPCP

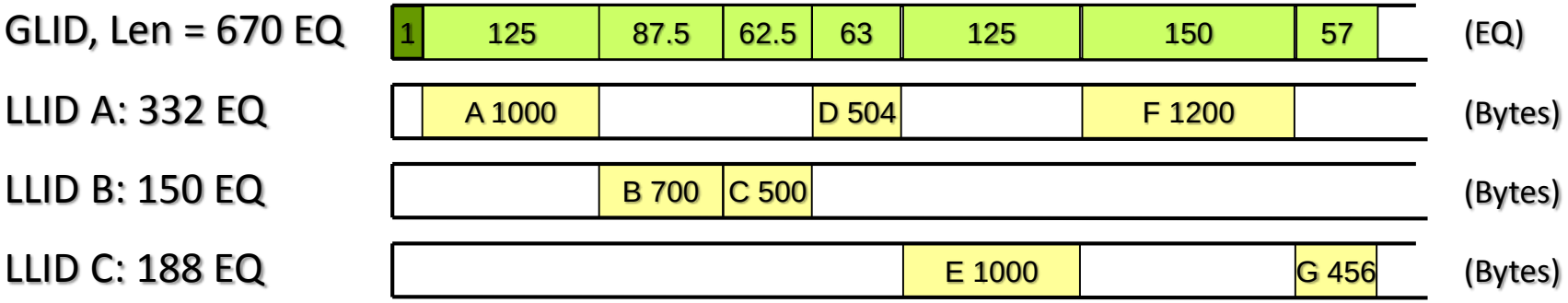
MPRS_CTRL[c][r].request()	
GLID #1 {A, B, C}	
epam = xxxxx	
env_length = 670	
LLID = A	Length = 125
LLID = B	Length = 150
LLID = A	Length = 63
LLID = C	Length = 125
LLID = A	Length = 150
LLID = C	Length = 57

4. Left in MAC:



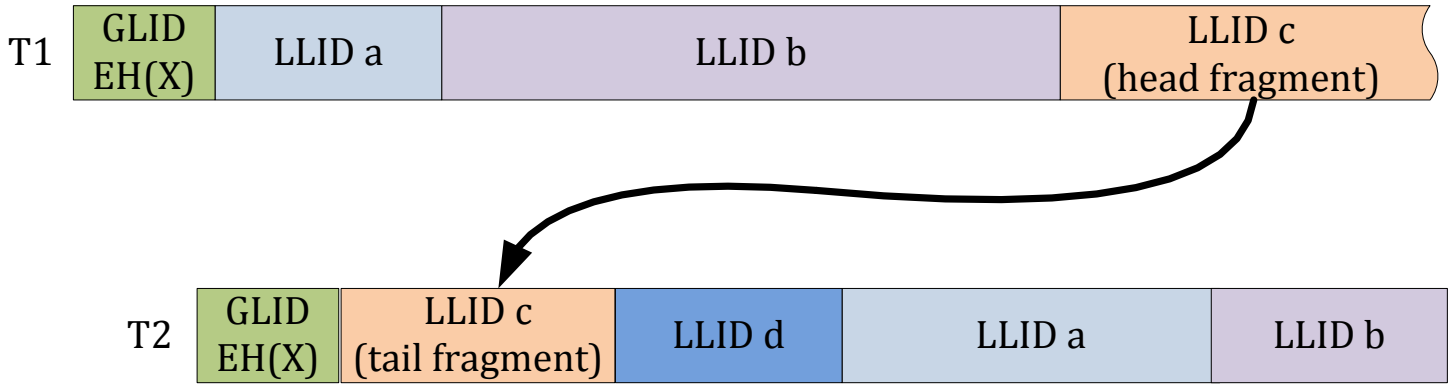
GLID #1 = {A, B, & C}

3. ONU formed this envelope



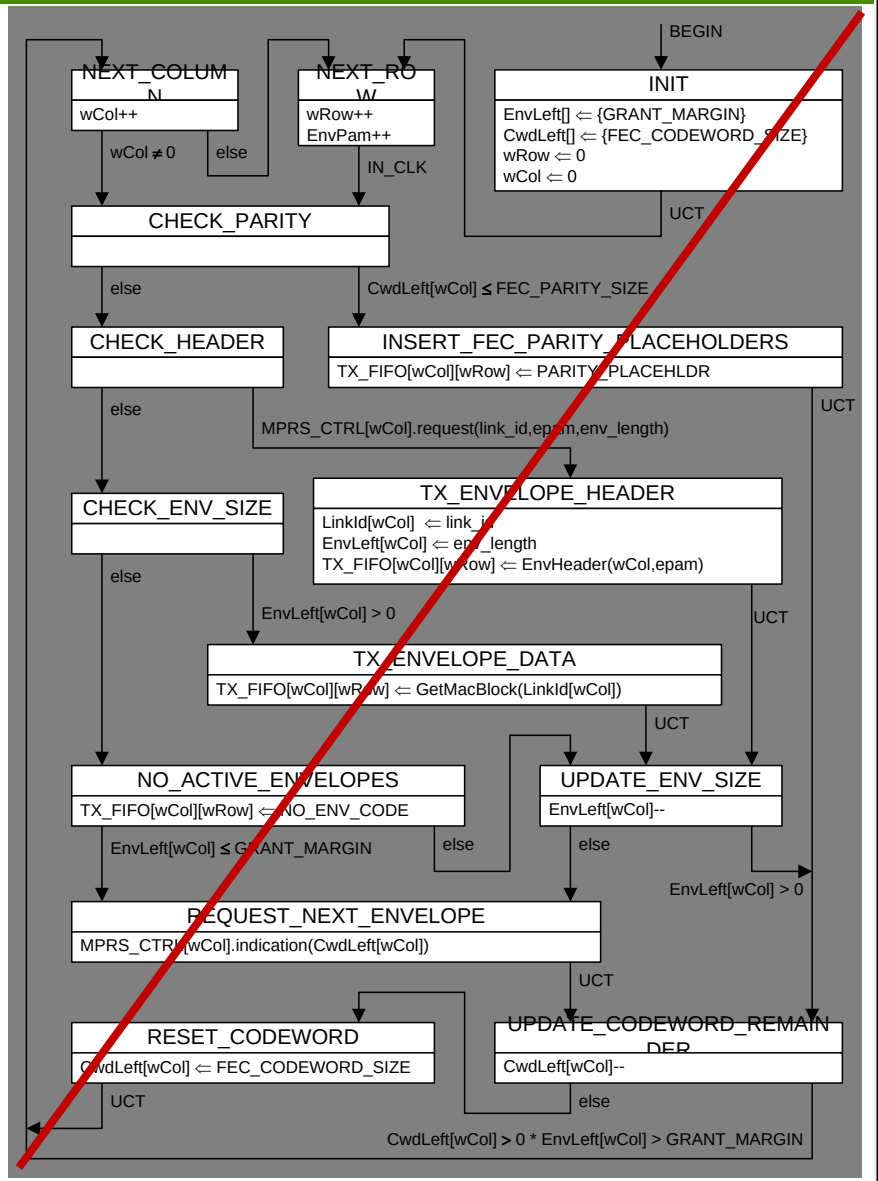
GLID Envelope Fragmentation

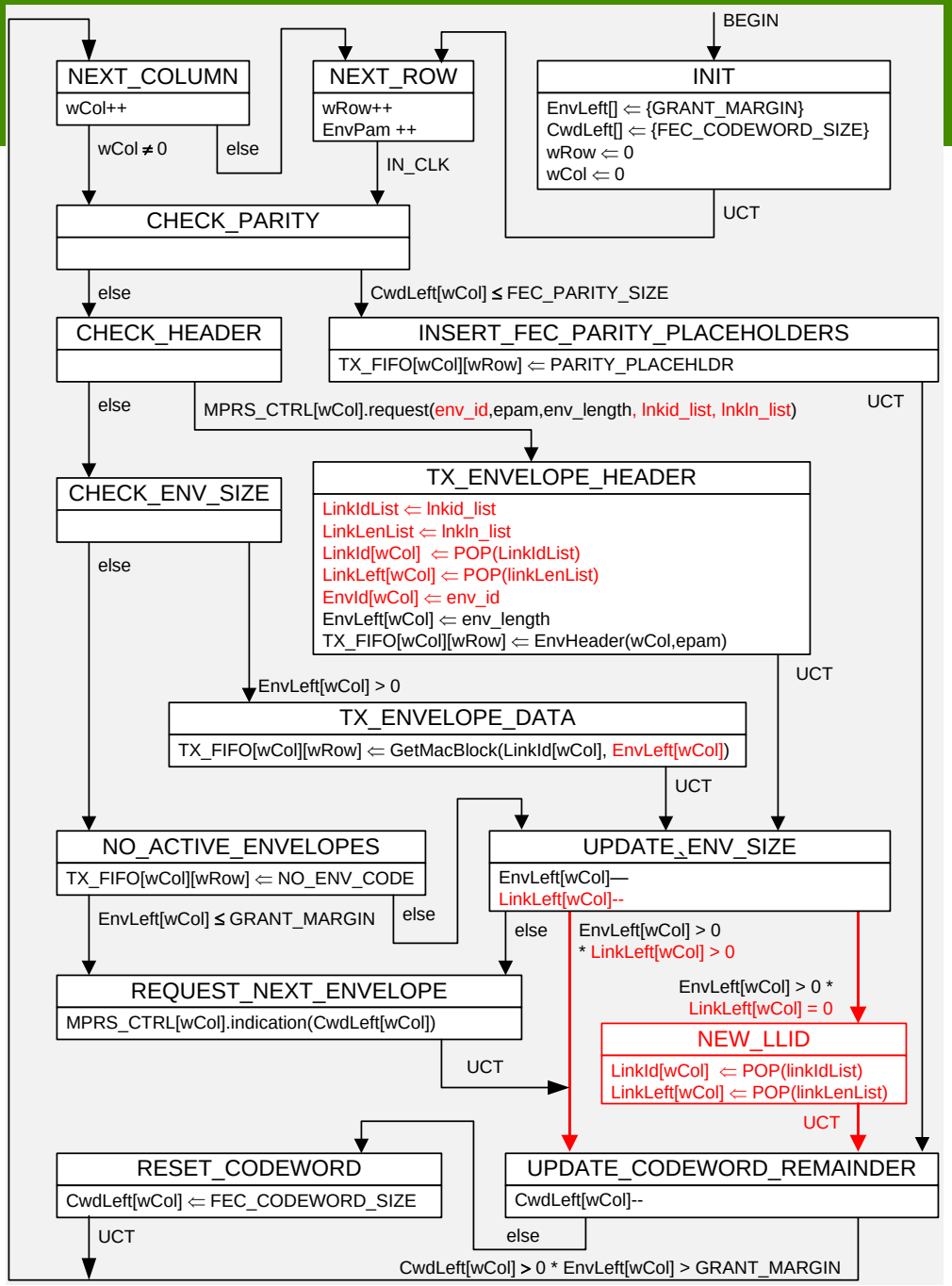
- Fragments in an Envelope
  - OLT would track fragmented LLID between envelopes
  - Next transmission from that GLID would begin with the tail fragment.
- Envelopes cannot contain embedded fragments



Detailed changes

Approved SD Changes
INPUT process

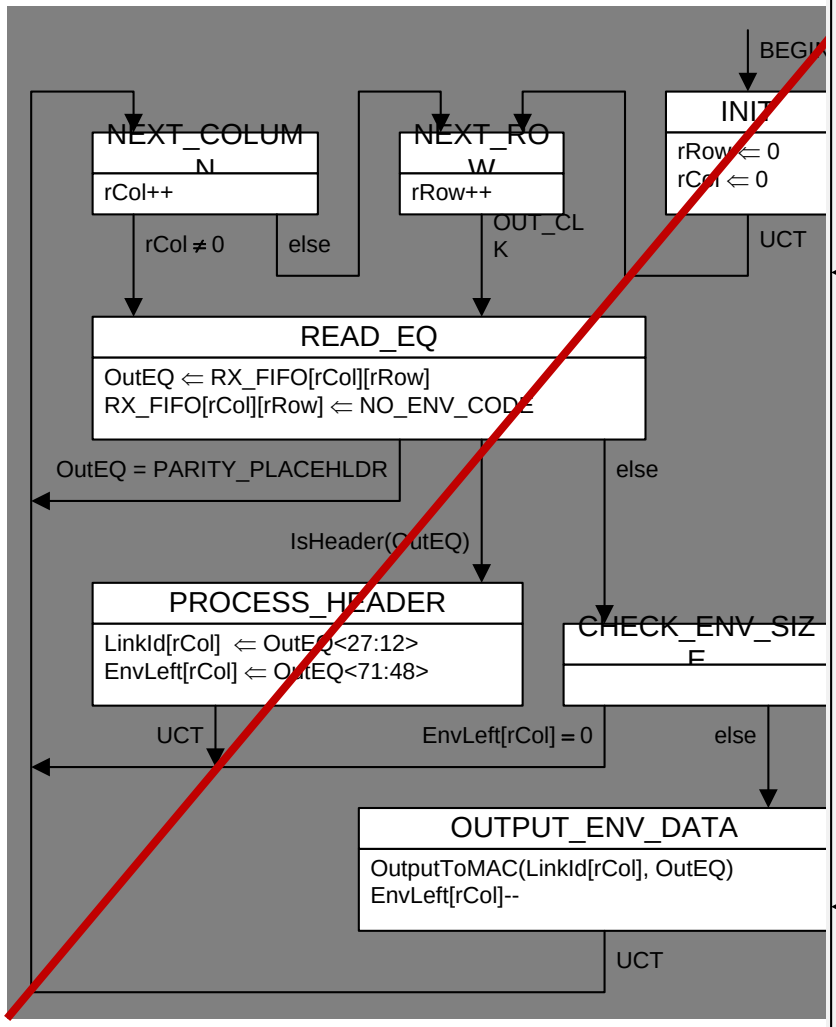




Variable / Function changes INPUT process

- Variables added
  - EnvId[col] – identifier for envelope (GLID)
  - LinkLeft[col] – length (in EQ) of PLID/ULID in an envelope
  - LinkIDList - List of PLID / ULID in the envelope
  - LinkLenList - List of lengths (in EQ) corresponding to LLIDS in linkIdList to be transmitted in the envelope. The sum of values in linkLenList are equal to env_length
- Add function
  - POP(list) – returns the next value in a list and shortens the list by removing the returned value.
- Modify function
  - GetMacBlock to not start a new frame if there is insufficient room in the envelope to transmit the entire preamble
- MPRS_CTRL.request modified
  - env_id[col] – envelope identifier value (GLID), (replaces existing link_id for an envelope)
  - lnkid_list – List of PLID / ULID in the envelope
  - lnkln_list - List of lengths (in EQ) corresponding to LLIDS in linkIdList to be transmitted in the envelope. The sum of values in linkLenList are equal to env_length.

Approved SD changes OUTPUT process



Variable / Function changes Output process

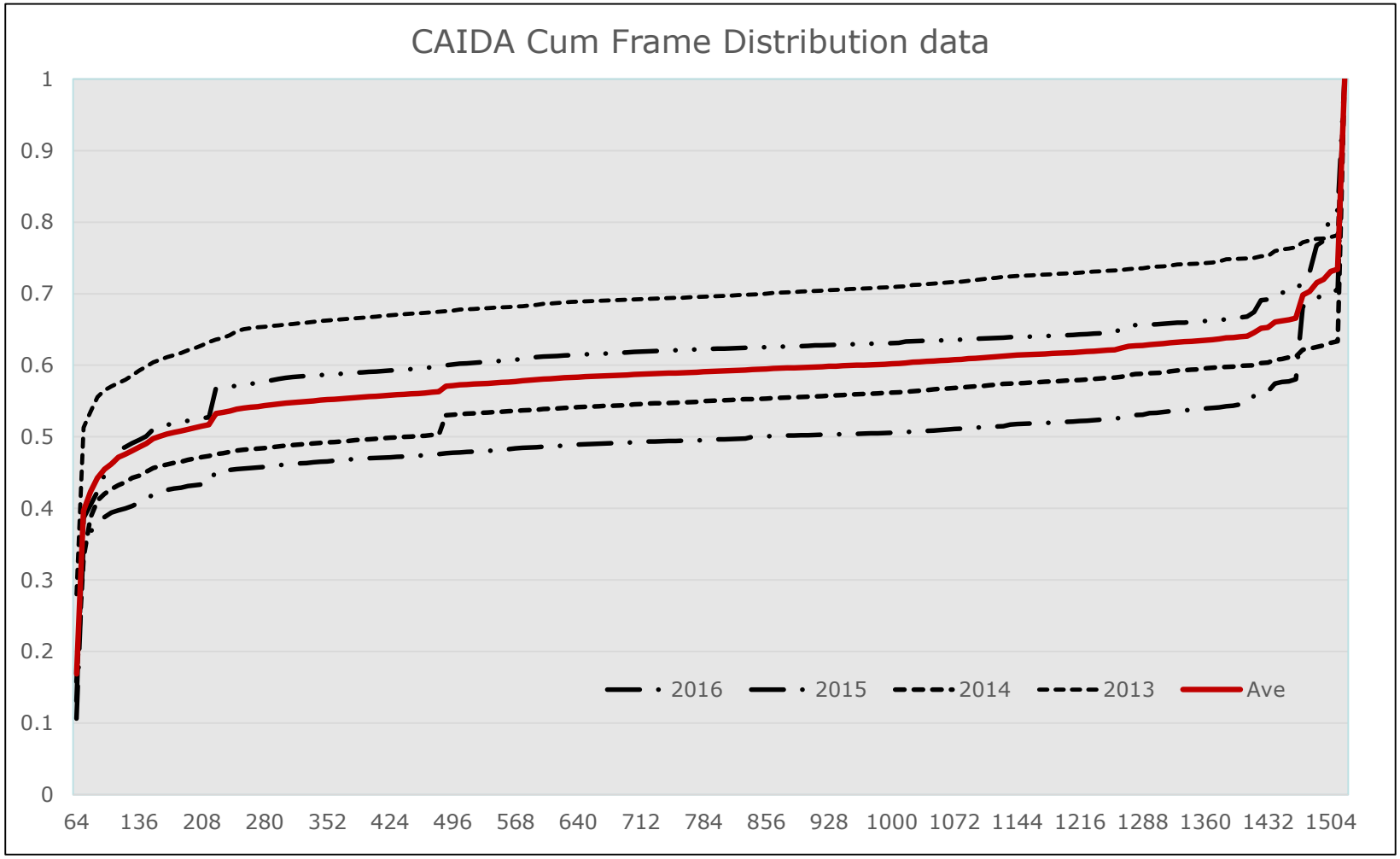
- Added Variables
  - EnvId[col] – identifier for envelope (GLID)
  - lstLnkId[EnvID[rCol]] – most recent LinkID associated with the EnvID
  - PreamF[col] – Boolean that indicates the 1st part of preamble was seen in 2nd four bytes of an EQ
- Added Functions
  - IsPreA – returns TRUE if /S/ is in the 1st half of an EQ
  - IsPreB – returns TRUE if /S/ is in the 2nd half of an EQ
- OutputToMac modified to include a four byte delay. This allows the function to determine the LLID when it sees a /S/ character even when the /S/ & LLID fields of the preamble are split over two EQs.

Conclusions

- Adopt GLID as the envelope identifier and use PLID/ULID embedded in preamble (as in 1G-EPON & 10G-EPON) to identify the specific MAC.
  - Increases system flexibility in data scheduling
    - Does not preclude granting individual ULIDs
  - Reduces envelope overhead
  - Reduces fragmentation buffer requirements (lower cost)
  - Brings 100G-EPON closer to ITU PON transport model encouraging a single PON standard

Thank You

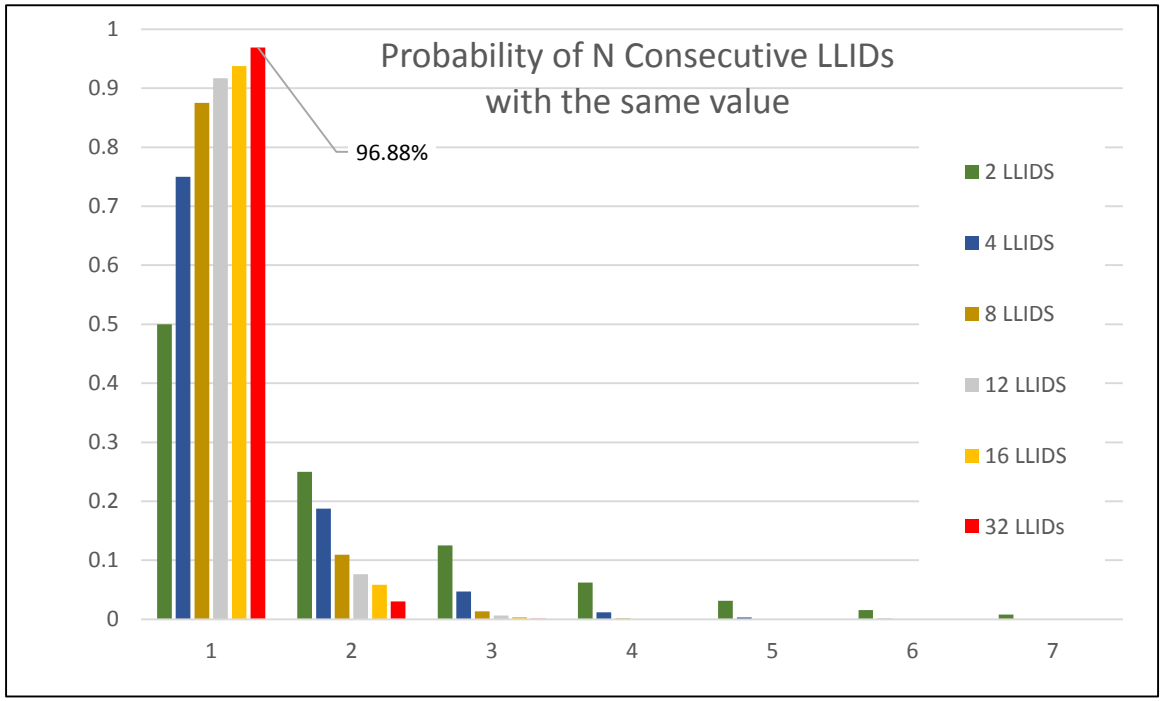
CAIDA frame distribution data



The CAIDA UCSD Statistical information for the CAIDA Anonymized Internet Traces, http://www.caida.org/data/passive/passive_trace_statistics.xml

Consecutive LLIDs

- As the number of LLIDs increases the probability of two or more consecutive frames from the same LLID decreases
  - With 32 LLIDs the probability of two or more frames from the same LLID < 4%



Scenario 1a

LLID	GLID	Data Cap (Gb/s)
1	3	1.5
2	3	1.5
3	3	1.5
4	3	1.5
5	3	1.5
6	3	1.5
7	3	1.5
8	3	1.5
9	3	1.5
10	3	1.5
11	3	1.5
12	3	1.5
13	3	1.5
14	3	1.5
15	3	1.5
16	3	1.5

LLID	GLID	Data Cap (Gb/s)
17	3	1.5
18	3	1.5
19	3	1.5
20	3	1.5
21	3	1.5
22	3	1.5
23	3	1.5
24	3	1.5
25	3	1.5
26	3	1.5
27	3	1.5
28	3	1.5
29	3	1.5
30	3	1.5
31	3	1.5
32	3	1.5

LLID	GLID	Data Cap (Gb/s)
33	3	1.5
34	3	1.5
35	3	1.5
36	3	1.5
37	3	1.5
38	3	1.5
39	3	1.5
40	3	1.5
41	3	1.5
42	3	1.5
43	3	1.5
44	3	1.5
45	3	1.5
46	3	1.5
47	3	1.5
48	3	1.5

LLID	GLID	Data Cap (Gb/s)
49	3	1.5
50	3	1.5
51	3	1.5
52	3	1.5
53	3	1.5
54	3	1.5
55	3	1.5
56	3	1.5
57	3	1.5
58	3	1.5
59	3	1.5
60	3	1.5
61	3	1.5
62	3	1.5
63	3	1.5
64	3	1.5
65	3	0.1

MaxEnv	ChCnt	LlidCnt	Assigned BW
400	4	65	96.1

Scenario 1b

LLID	GLID	Data Cap (Gb/s)
1	3	1.5
2	3	1.5
3	3	1.5
4	3	1.5
5	3	1.5
6	3	1.5
7	3	1.5
8	3	1.5
9	3	1.5
10	3	1.5
11	3	1.5
12	3	1.5
13	3	1.5
14	3	1.5
15	3	1.5
16	3	1.5

LLID	GLID	Data Cap (Gb/s)
17	3	1.5
18	3	1.5
19	3	1.5
20	3	1.5
21	3	1.5
22	3	1.5
23	3	1.5
24	3	1.5
25	3	1.5
26	3	1.5
27	3	1.5
28	3	1.5
29	3	1.5
30	3	1.5
31	3	1.5
32	3	1.5

LLID	GLID	Data Cap (Gb/s)
33	3	1.5
34	3	1.5
35	3	1.5
36	3	1.5
37	3	1.5
38	3	1.5
39	3	1.5
40	3	1.5
41	3	1.5
42	3	1.5
43	3	1.5
44	3	1.5
45	3	1.5
46	3	1.5
47	3	1.5
48	3	1.5

LLID	GLID	Data Cap (Gb/s)
49	3	1.5
50	3	1.5
51	3	1.5
52	3	1.5
53	3	1.5
54	3	1.5
55	3	1.5
56	3	1.5
57	3	1.5
58	3	1.5
59	3	1.5
60	3	1.5
61	3	1.5
62	3	1.5
63	3	1.5
64	3	1.5
65	3	0.1

MaxEnv	ChCnt	LlidCnt	Assigned BW
800	4	65	96.1

Scenario 2a

LLID	GLID	Data Cap (Gb/s)
1	3	4
2	3	4
3	3	4
4	3	4
5	3	2
6	3	2
7	3	2
8	3	2
9	3	2
10	3	2
11	3	2
12	3	2
13	3	1
14	3	1
15	3	1
16	3	1

LLID	GLID	Data Cap (Gb/s)
17	3	1
18	3	1
19	3	1
20	3	1
21	3	1
22	3	1
23	3	1
24	3	1
25	3	1
26	3	1
27	3	1
28	3	1
29	3	0.75
30	3	0.75
31	3	0.75
32	3	0.75

LLID	GLID	Data Cap (Gb/s)
33	3	1.25
34	3	1.25
35	3	1.25
36	3	1.25
37	3	0.75
38	3	0.75
39	3	0.75
40	3	0.75
41	3	0.75
42	3	0.75
43	3	0.75
44	3	0.75
45	3	0.5
46	3	0.5
47	3	0.5
48	3	0.5

LLID	GLID	Data Cap (Gb/s)
49	3	0.5
50	3	0.5
51	3	0.5
52	3	0.5
53	3	0.5
54	3	0.5
55	3	0.5
56	3	0.5
57	3	0.5
58	3	0.5
59	3	0.5
60	3	0.5
61	3	0.25
62	3	0.25
63	3	0.25
64	3	0.25
65	3	0.1

MaxEnv	ChCnt	LlidCnt	Assigned BW
400	4	65	71.1

Scenario 2b

LLID	GLID	Data Cap (Gb/s)
1	2	4
2	2	4
3	2	4
4	2	4
5	2	2
6	2	2
7	2	2
8	2	2
9	2	2
10	2	2
11	2	2
12	2	2
13	2	1
14	2	1
15	2	1
16	2	1

LLID	GLID	Data Cap (Gb/s)
17	2	1
18	2	1
19	2	1
20	2	1
21	2	1
22	2	1
23	2	1
24	2	1
25	2	1
26	2	1
27	2	1
28	2	1
29	2	0.75
30	2	0.75
31	2	0.75
32	2	0.75

LLID	GLID	Data Cap (Gb/s)
33	2	1.25
34	2	1.25
35	2	1.25
36	2	1.25
37	2	0.75
38	2	0.75
39	2	0.75
40	2	0.75
41	2	0.75
42	2	0.75
43	2	0.75
44	2	0.75
45	2	0.5
46	2	0.5
47	2	0.5
48	2	0.5

LLID	GLID	Data Cap (Gb/s)
49	2	0.5
50	2	0.5
51	2	0.5
52	2	0.5
53	2	0.5
54	2	0.5
55	2	0.5
56	2	0.5
57	2	0.5
58	2	0.5
59	2	0.5
60	2	0.5
61	2	0.25
62	2	0.25
63	2	0.25
64	2	0.25
65	2	0.1

MaxEnv	ChCnt	LlidCnt	Assigned BW
400	2	65	71.1

Scenario 2c

LLID	GLID	Data Cap (Gb/s)
1	1	4
2	1	4
3	1	4
4	1	4
5	1	2
6	1	2
7	1	2
8	1	2
9	1	2
10	1	2
11	1	2
12	1	2
13	1	1
14	1	1
15	1	1
16	1	1

LLID	GLID	Data Cap (Gb/s)
17	1	1
18	1	1
19	1	1
20	1	1
21	1	1
22	1	1
23	1	1
24	1	1
25	1	1
26	1	1
27	1	1
28	1	1
29	1	0.75
30	1	0.75
31	1	0.75
32	1	0.75

LLID	GLID	Data Cap (Gb/s)
33	1	1.25
34	1	1.25
35	1	1.25
36	1	1.25
37	1	0.75
38	1	0.75
39	1	0.75
40	1	0.75
41	1	0.75
42	1	0.75
43	1	0.75
44	1	0.75
45	1	0.5
46	1	0.5
47	1	0.5
48	1	0.5

LLID	GLID	Data Cap (Gb/s)
49	1	0.5
50	1	0.5
51	1	0.5
52	1	0.5
53	1	0.5
54	1	0.5
55	1	0.5
56	1	0.5
57	1	0.5
58	1	0.5
59	1	0.5
60	1	0.5
61	1	0.25
62	1	0.25
63	1	0.25
64	1	0.25
65	1	0.1

MaxEnv	ChCnt	LlidCnt	Assigned BW
400	1	65	71.1

Scenario 3a

LLID	GLID	Data Cap (Gb/s)
1	3	20
2	3	20
3	3	20
4	2	4
5	2	4
6	2	4
7	2	4
8	2	4
9	2	4

LLID	GLID	Data Cap (Gb/s)
22	2	0.5
23	2	0.5
24	2	0.5
25	2	0.5
26	2	0.5
27	2	0.5

LLID	GLID	Data Cap (Gb/s)
10	1	3
11	1	3
12	1	3
13	1	1.5
14	1	1.5
15	1	1.5
16	1	1.5
17	1	1.5
18	1	1.5
19	1	1
20	1	1
21	1	1

LLID	GLID	Data Cap (Gb/s)
28	1	0.25
29	1	0.25
30	1	0.25
31	1	0.25
32	1	0.25
33	1	0.25
34	1	0.25
35	1	0.25
36	1	0.25
37	1	0.25
38	1	0.25
39	1	0.25
40	1	0.1

MaxEnv	ChCnt	LlidCnt	Assigned BW
400	4	40	111.1

Scenario 3b

LLID	GLID	Data Cap (Gb/s)
1	2	10
2	2	10
3	2	10
4	2	2.25
5	2	2.25
6	2	2.25
7	2	2.25
8	2	2.25
9	2	2.25

LLID	GLID	Data Cap (Gb/s)
22	2	0.25
23	2	0.25
24	2	0.25
25	2	0.25
26	2	0.25
27	2	0.25

LLID	GLID	Data Cap (Gb/s)
10	1	2
11	1	2
12	1	2
13	1	1.25
14	1	1.25
15	1	1.25
16	1	1.25
17	1	1.25
18	1	1.25
19	1	1
20	1	1
21	1	1

LLID	GLID	Data Cap (Gb/s)
28	1	0.2
29	1	0.2
30	1	0.2
31	1	0.2
32	1	0.2
33	1	0.2
34	1	0.2
35	1	0.2
36	1	0.2
37	1	0.2
38	1	0.2
39	1	0.2
40	1	0.1

MaxEnv	ChCnt	LlidCnt	Assigned BW
400	2	40	64