Summary paper on:

GMPLS control of a multi-layer Ethernet data plane

(detailed paper in APC SPIE proceedings)

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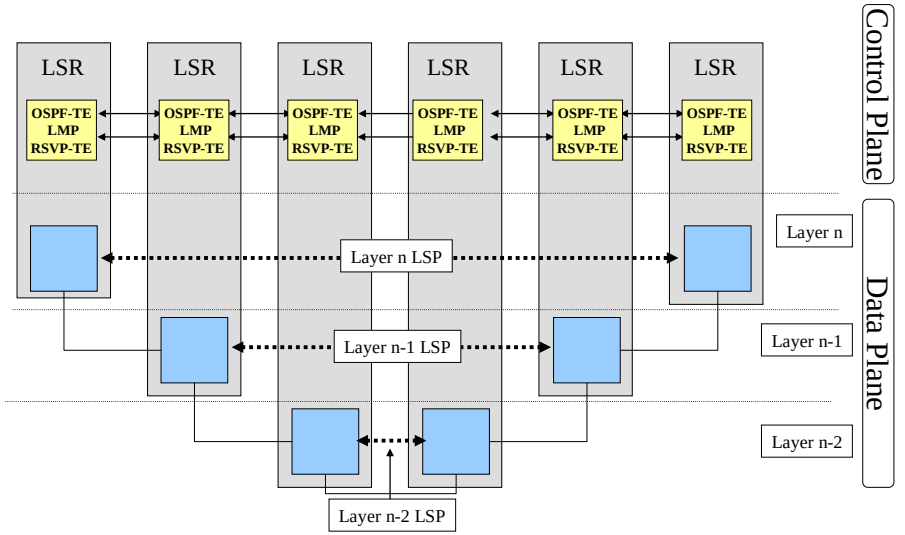
Overview & objective

- Some background
- Multi-layer Ethernet
- Some benefits
- Major protocol extensions
- Functional verification and demonstration (ECOC2010)
- Conclusions

- Objective
  - To create a control plane based multi-layer Ethernet architecture and solution, applied to an access and aggregation network scenario

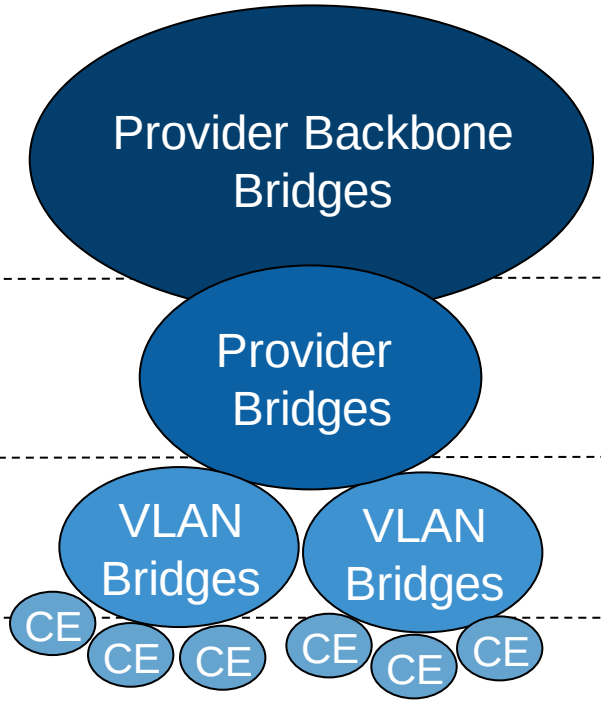
Some background
MPLS and GMPLS

- MPLS - Multi Protocol Label Switching
  - Forwards on the MPLS label – push, pop, swap
  - Mainly the “Layer 2.5” label - Eth/MPLS/IP
- GMPLS – Generalized MPLS
  - Control and data plane separation
    - Routing
    - Signalling
    - Link management
  - Generalized labels / technologies
    - MPLS label
    - Wavelengths
    - Timeslots
    - Ethernet VLAN + MACs (currently only PBB-TE support – mainly core applications)



Some background
What is multi-layer Ethernet?

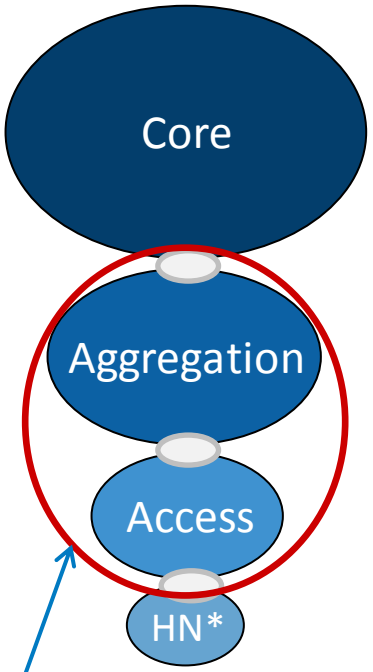
Ethernet Flavor	Coments	Ethernet Tags
802.1ah / PBB 802.1Qay / PBB-TE	Handles flat address space and inter domain address population Additional service identifier (I-SID)	+ B-DA + B-SA + [B-VLAN] + I-SID
802.1ad / PB	Adds vlan scalability	+ S VLAN
802.1Q / C-VLAN	Adds traffic separation	+ C VLAN
		DA, SA



- Commonly used in access & aggregation networks
  - 82% of all FTTH installations in Europe (ref. IDATE)
- Mainly a managed solution – centralized NMS/OSS
- Current “control plane”: spanning tree (STP) and MAC learning

GMPLS in the access & distribution
So what can a GMPLS control plane add?

- Traffic engineering e.g.:
  - path control, bandwidth reservation, prioritization...
- Link and VLAN utilization
- Adds or enhances resilience functions
- Possible CapEx and OpEx savings, e.g.:
  - Self-configuring networks – all domains
  - Simplified migration – most data plane technologies
    - "MPLS Access" and "Seamless MPLS"
  - Simple and flexible designs

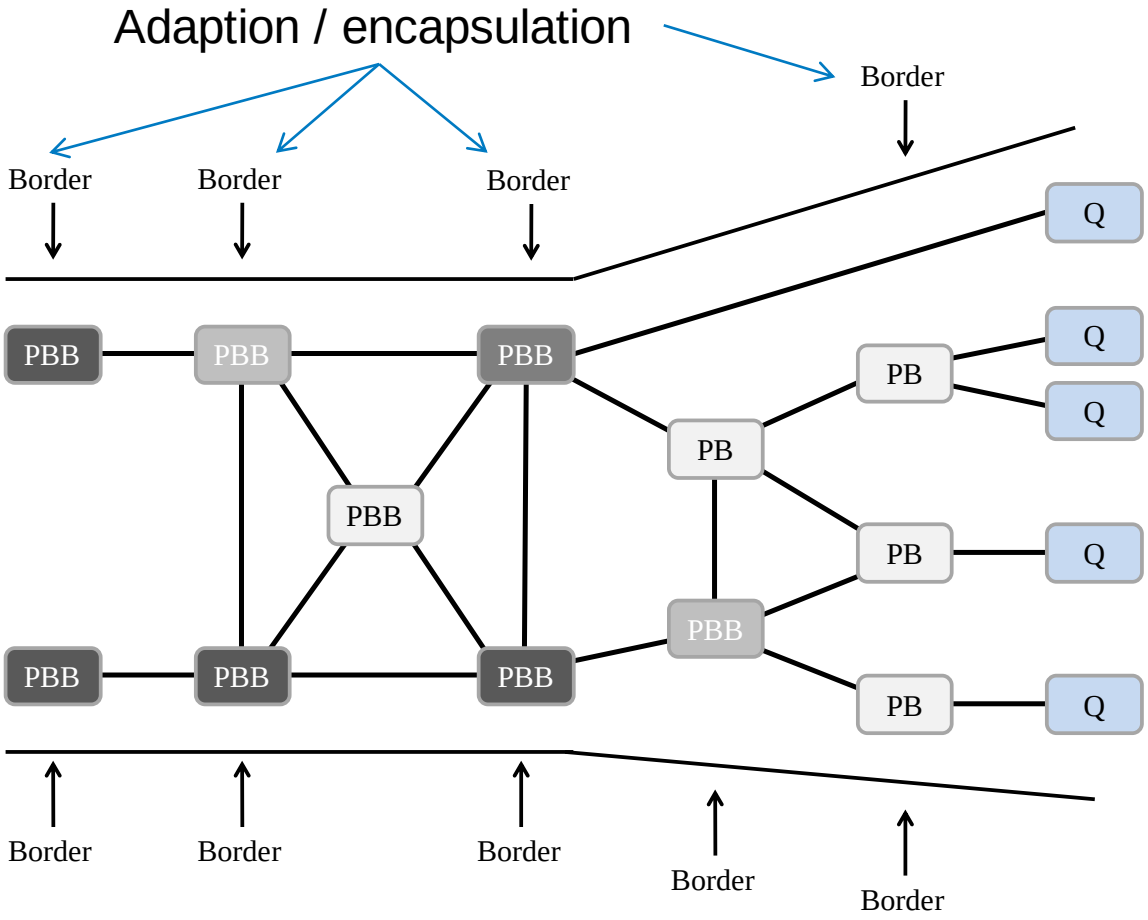


Network scope – collapsing the access and aggregation network

- Will bandwidth, energy efficiency and traffic dynamics requirements lead to the inclusion of a dynamic optical layer?

* HN – Home Network

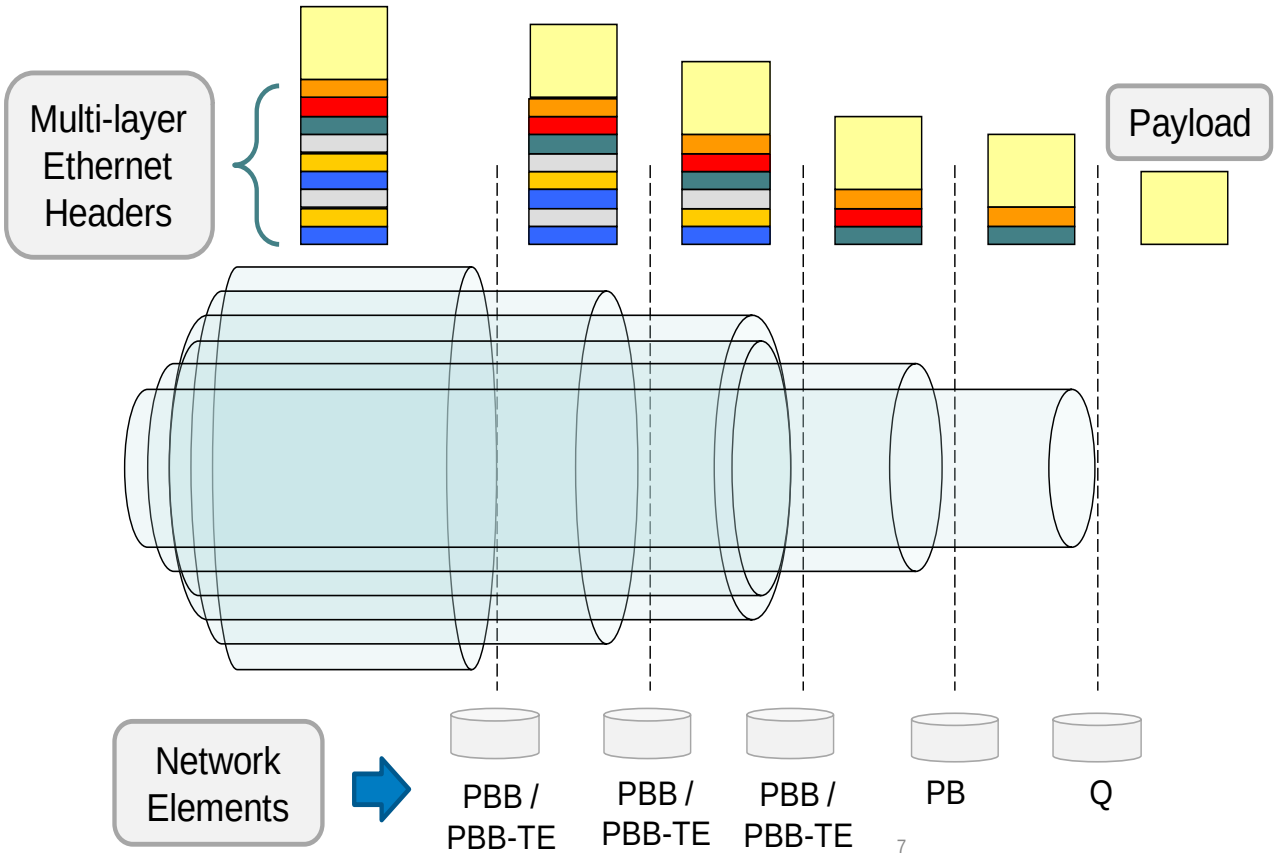
GMPLS controlled multi-layer Ethernet: Our network topology and node types



- All IEEE Ethernet 802.1Q node data plane types (Q, PB, PBB/PBB-TE)
- Ethernet type defines the layer edge
- Allows for all major resource reservation scenarios
- Data planes are implemented in Linux user-space
  - (Control plane as well)

Picture inspired by picture in IEEE 802.1Q amendment 802.1ah

GMPLS controlled multi-layer Ethernet: The end result – data plane



- Principle: Ethernet tunnels in Ethernet tunnels
- Handles multi-layer Ethernet tags:
  - C, S, I, and B tags (VIDs & I-SID)

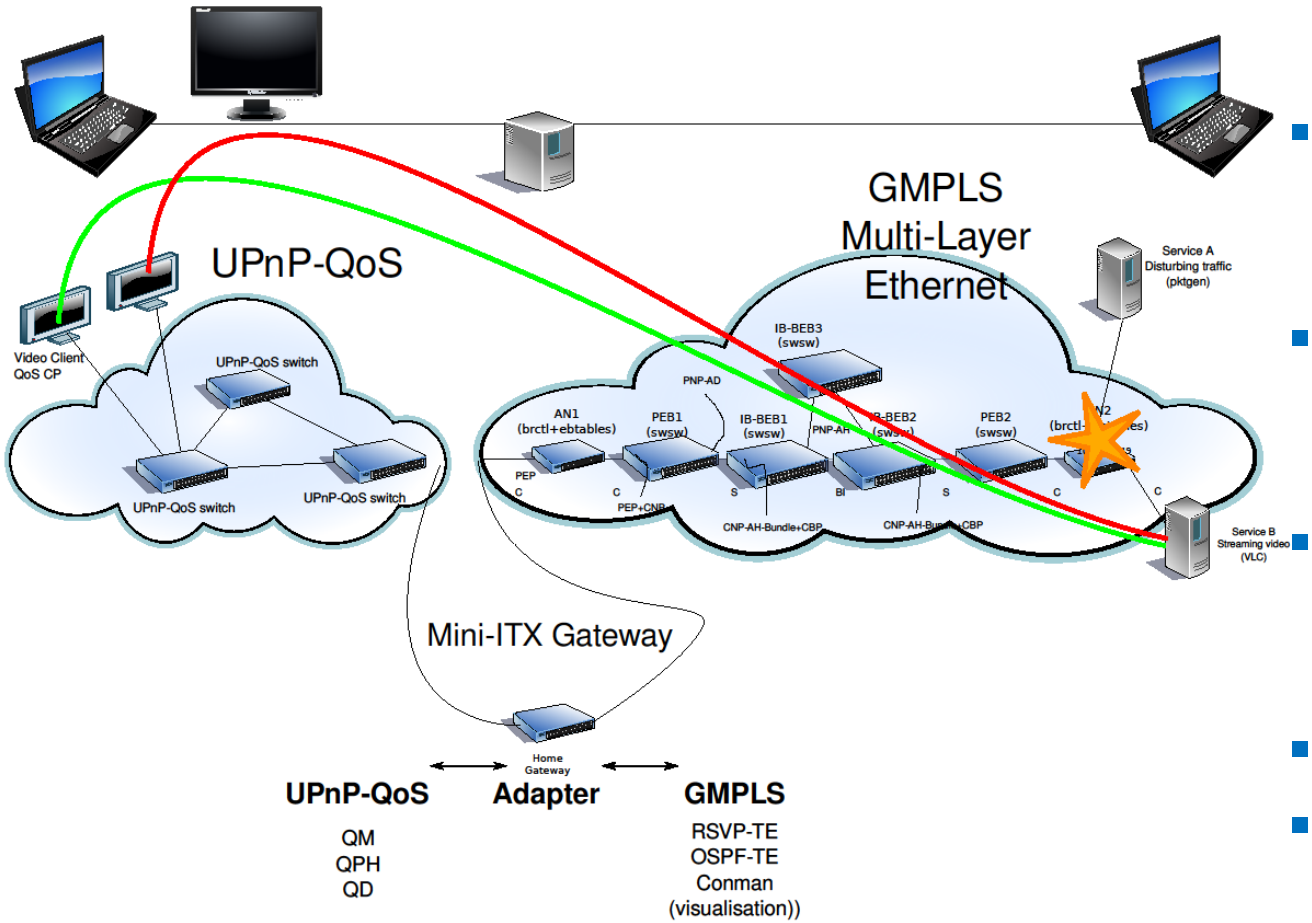
GMPLS controlled multi-layer Ethernet: Control plane components …

- Information model
  - A model that describes relevant link, port and node characteristics
- Routing
  - Disseminates information included in the information model (e.g. topology discovery), which will be used in path computation
  - Protocol: OSPF-TE
- Path computation
  - Calculates a constrained shortest path first with multi-layer Ethernet data plane verification
  - Path computation element (PCE)
  - Protocol: PCEP
- Signalling
  - Reserves multi-layer data plane resources through signalling
  - Protocol: RSVP-TE

GMPLS controlled multi-layer Ethernet: Which are the major extensions done?

- Routing extensions
  - Per port or per VID/I-SID level processing
  - Types of tags can be added by the port
  - Type of traffic it can handle (e.g. Q tagged)
- PCE and multi-layer path calculation
  - Path request / response
  - Path calculation
  - Multi-layer path validation
    - borders, correct layer, allowed node transitions etc.
- Signalling extensions
  - VLAN ID based label – signalling sessions scalability
    - MAC address learning – dynamic forwarding entries
  - VID/I-SID + MAC based label – resource allocation (LSP) scalability
    - No MAC address learning – static forwarding entries

Functional tests and verification
ECOC2010 demo



- Home, access and aggregation network
- UPnP QoS manages the home network (by IBBT)
- GMPLS in the access and aggregation network
- The adapter for inter domain interworking (together with DTU)
- QoS enabled
- PCE path requests and calculation

Conclusions

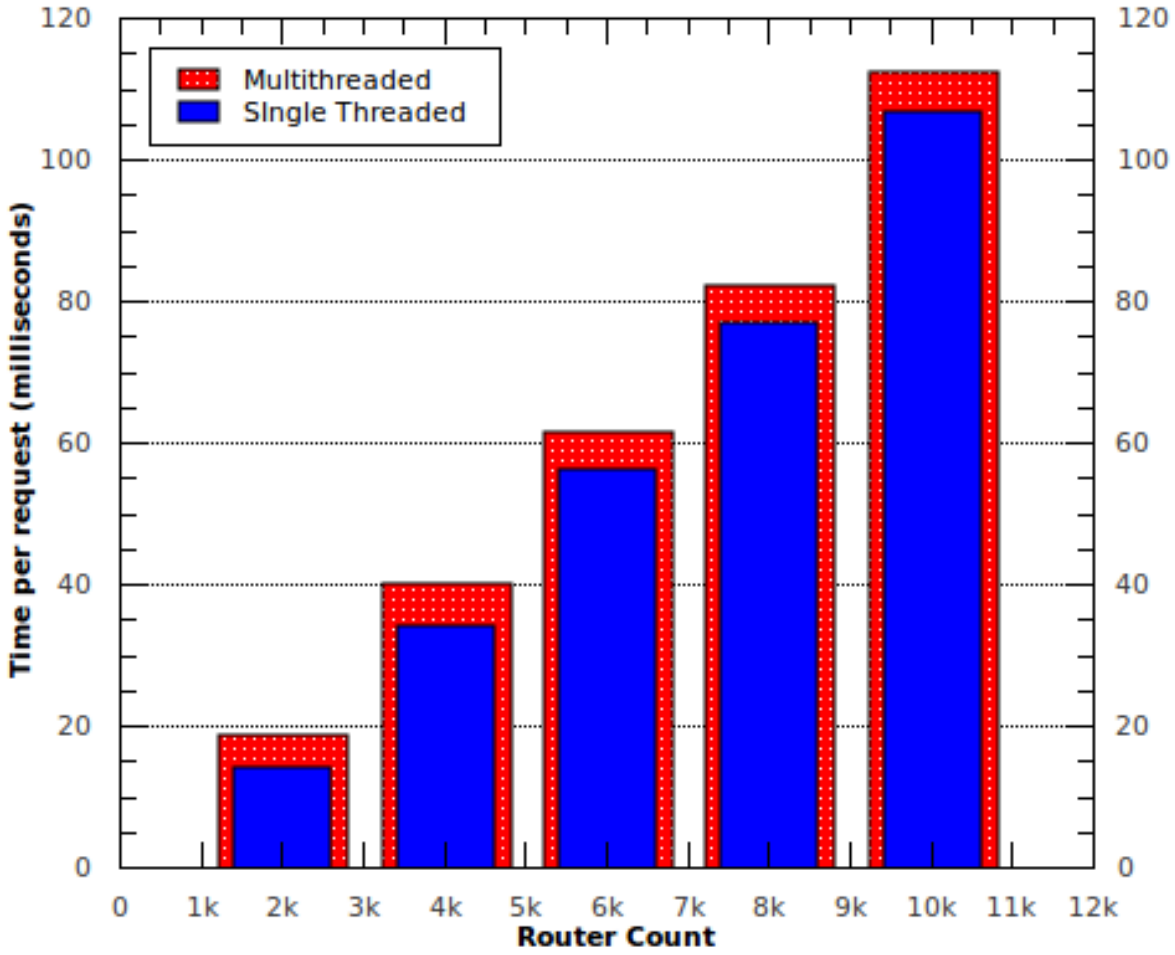
- We have created an architecture and solution for a GMPLS control plane governing a multi-layer Ethernet data plane
- We have verified and demonstrated the objective!
- It is well suited to meet future requirements on e.g.:
  - Possible locality awareness in future traffic patterns e.g. by CDNs
  - Simple and flexible designs e.g. over P2P fibre infrastructures or as a hybrid with P2P WDM PON or dynamic OTNs
  - Self-configuring network and heterogeneous data plane support
  - All topologies, Scalability, Resilience...
- Future challenges in access and aggregation networks:
  - Highly localized traffic patterns vs. energy efficiency
  - Infrastructural sharing – technology agnostic fibre infrastructures, virtualization/isolation

Questions

If this summary is not enough, a more detailed paper (15 pages) will be found in the SPIE proceedings of ACP

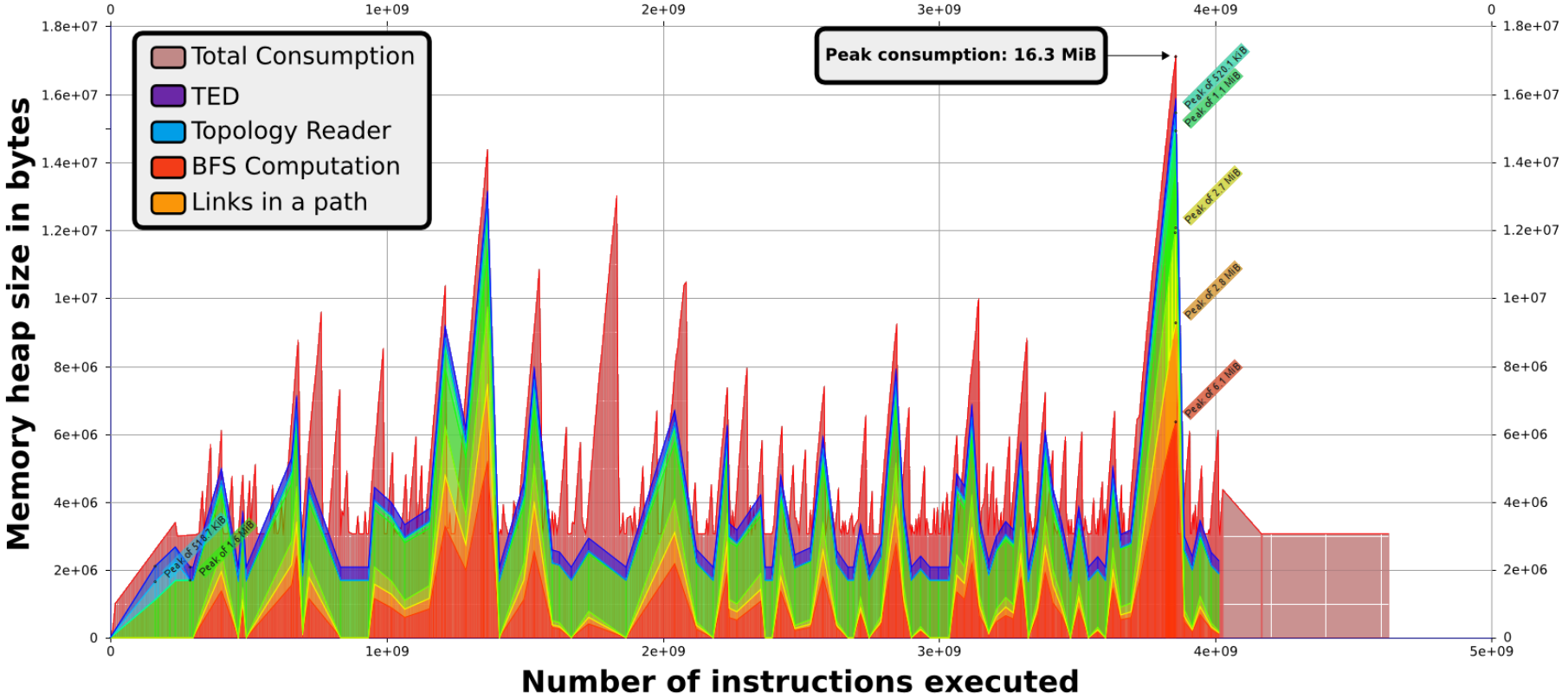
Acknowledgement to European FP 7 projects Alpha and OASE, and the DRAGON project

Performance tests and verification
PCP time performance stress test

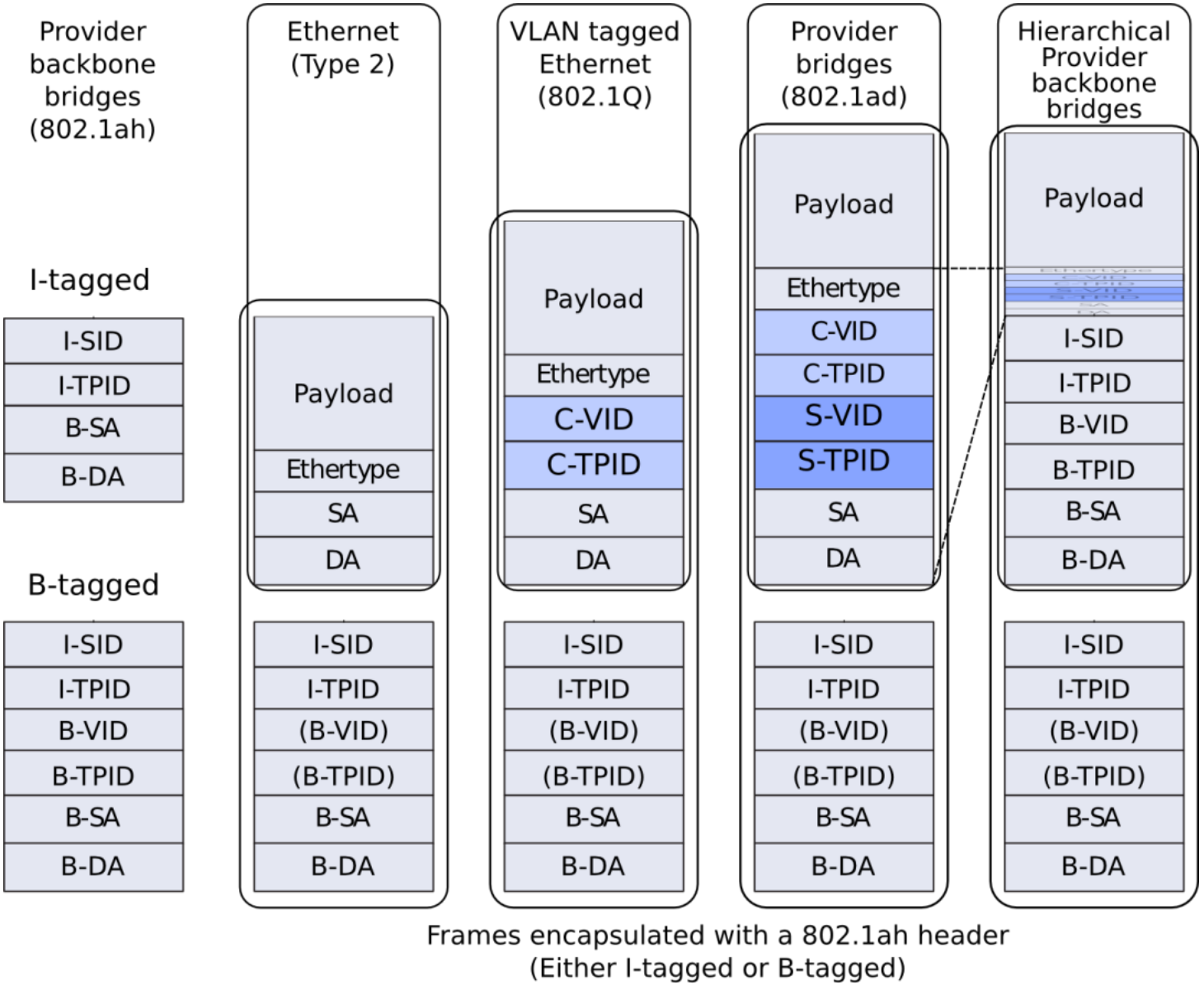


- Virtual topology with average degree of 4.7
- Linear
- Quick
- Estimated 20-30% slower with multi-layer validation

Performance tests and verification
PCE Memory performance



- Each peak = a path being calculated
- That it goes down again indicates correct memory management



Frames encapsulated with a 802.1ah header
(Either I-tagged or B-tagged)

Ethertype	Payload Identifier
SA	Source MAC Address
DA	Destination MAC Address
VID	VLAN Identifier
TPID	Tag Protocol Identifier (0x8100)
C-VID	Customer VID
C-TPID	Customer TPID (0x8100)
S-VID	Service VID
S-TPID	Service TPID (0x88a8)
I-SID	Instance Service Identifier
B-VID	Backbone VID
B-TPID	Backbone TPID (0x88a8)
B-SA	Backbone SA
B-DA	Backbone DA