DetNet
Basic concept and Services

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Topics

- DetNet
  - Essentials
  - Forwarding characteristics
  - Building blocks / Functions
  - Protocol stack (sub-layers)
  - Components / Nodes
  - Service types
  - Some scenarios / Examples
- Summary

Overview
DetNet essentials

- DetNet
  - operates at the IP/MPLS layer
  - is for networks that are under a single administrative control or within a closed group of administrative control.
  - is NOT for large groups of domains such as the Internet.

- DetNet service provides a capability for the delivery of data flows with
  - (1) extremely low packet loss rates and/or
  - (2) bounded end-to-end delivery latency

Note1: These characteristics are accomplished by dedicating network resources such as link bandwidth and buffer space to DetNet flows and/or classes of DetNet flows, and by protecting packets (e.g., by replicating them along multiple paths.

Note2: Unused reserved resources are available to non-DetNet flows as long as all guarantees are fulfilled.

Forwarding characteristics
Latency, Loss and In-order-delivery

Forwarding parameters from source to destination:

— Minimum and maximum end-to-end latency;
timely delivery, and bounded jitter (packet delay variation) derived from these constraints

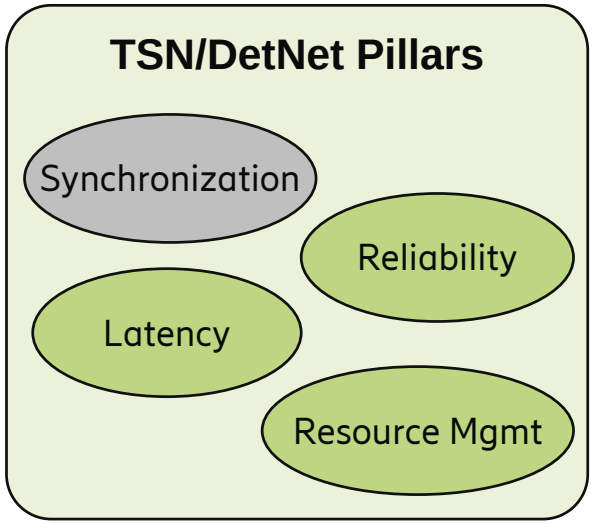
— Packet loss ratio

— Upper bound on out-of-order packet delivery;
some DetNet applications are unable to tolerate any out-of-order delivery

Note: It is a distinction of DetNet that it is concerned solely with worst-case values for the end-to-end latency, jitter, and misordering. Average, mean, or typical values are of little interest, because they do not affect the ability of a real-time system to perform its tasks.

In general, a trivial priority-based queuing scheme will give better average latency to a data flow than DetNet; however, it may not be a suitable option for DetNet because of its worst-case latency.

DetNet building blocks
Combinations depends on flow requirements



- Congestion protection
  - allocating resources along the path of a DetNet flow, e.g., buffer space or link bandwidth
  - addresses two of the DetNet QoS requirements: latency and packet loss.
- Service protection
  - addresses random media errors and equipment failures
  - e.g., packet replication and elimination (against failures), packet encoding (against media errors), re-ordering (ensure in-order delivery)
- Explicit routes
  - addresses impact of the convergence of routing or bridging protocols (i.e., temporary interruptions)

Note: congestion protection provided via congestion detection and notification is explicitly excluded from consideration in DetNet.

Note2: synchronization out-of-scope in DetNet discussions. It is expected to be provided by appropriate solutions.

DetNet mechanisms I.
Ensure required forwarding characteristics

- Congestion protection
  - Eliminate congestion loss
    (properly designed queuing, no packets are dropped due to a lack of buffer storage)
  - Jitter reduction
    (to enable the convergence of sensitive non-IP networks onto a common network infrastructure)

- Explicit routes
  - A.k.a. nailed down paths
    (dynamic control protocols + a network topology event impacts packet delivery)

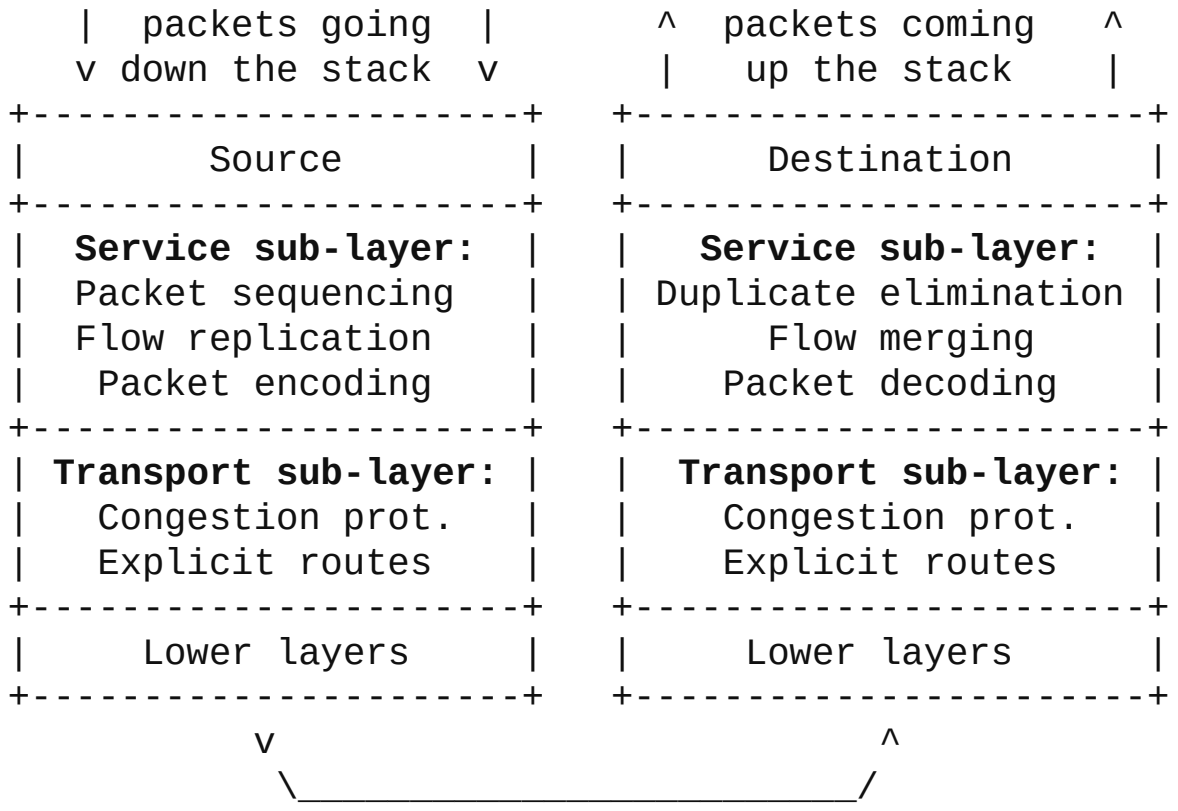
DetNet mechanisms II.
Ensure required forwarding characteristics

- Service protection
  - PREOF functions
    - PRF: packet replication function
      sends copies of the same packets with sequencing information over multiple paths
    - PEF: packet elimination function
      discards duplicates based on sequencing information and history of received packets
    - POF: packet ordering function
      out-of-order impact the amount of buffering at the destination to properly process received data
  - Packet encoding
    encoding the information into multiple transmission units; using multiple paths; combining units

Note: Packet replication and elimination does not react to and correct failures; it is entirely passive.

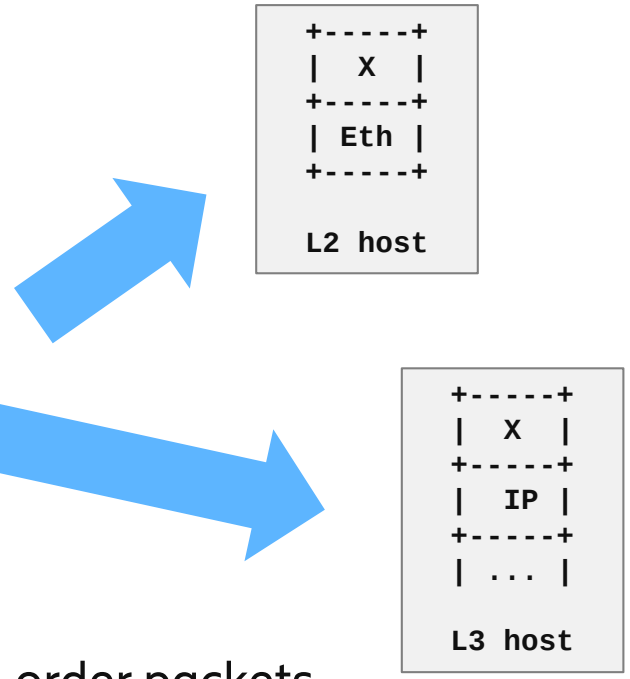
DetNet protocol stack
Service and Transport sub-layers

- DetNet functionality is implemented in two adjacent sub-layers in the protocol stack:
  - DetNet service sub-layer:
    provides DetNet service (e.g., service protection), to higher layers in the protocol stack and applications
  - DetNet transport sub-layer:
    supports DetNet service in the underlying network (e.g., by providing explicit routes and congestion protection) to DetNet flows



Flow specific information
Encapsulation …

- It is application specific
  - how data is encapsulated
  - what information encoded in header fields
- Application data flow types
  - Layer-2: encapsulated in Ethernet (e.g., a TSN Stream)
  - Layer-3: encapsulated in IP

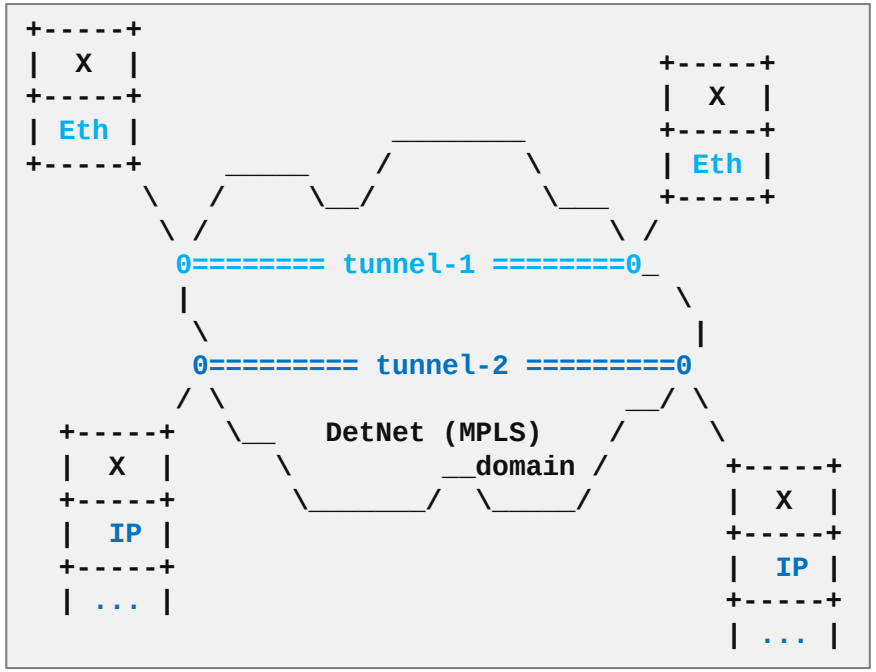


- DetNet related mechanisms require two attributes
  - Flow-ID: to identify the flow the packet belongs to
  - Sequence number: to recognize duplicate packets and re-order packets

- DetNet specific encapsulation formats coming soon …

DetNet service types
"Forwarding paradigm: Bridging vs. Routing"

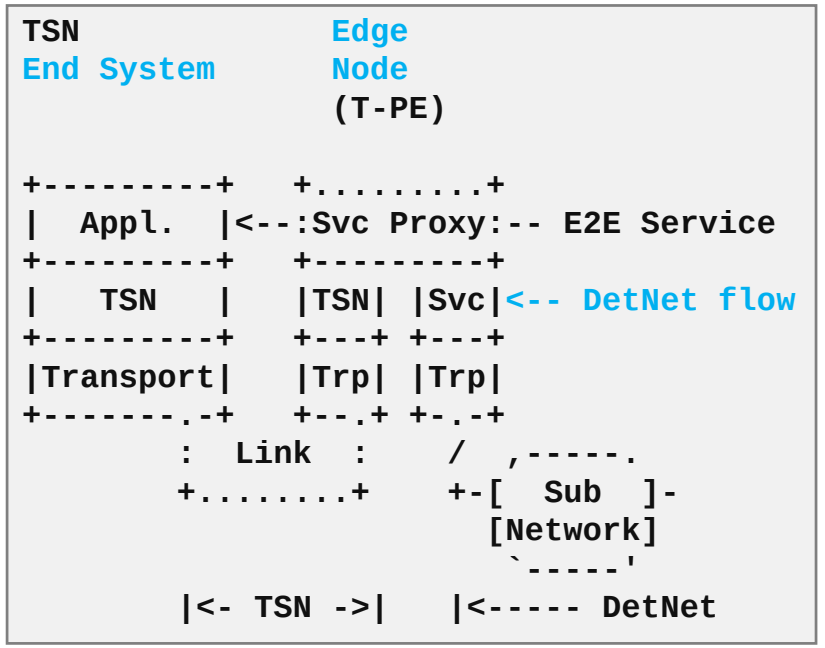
- DetNet Layer-2 service
  - End-systems share broadcast domain
  - Forwarding over the DetNet domain is based on L2 (MAC) addresses (i.e. dst-MAC), or on received interface [RFC3985]
  - L2 headers MUST either be kept, or provision must be made for their reconstruction at egress from the DetNet domain

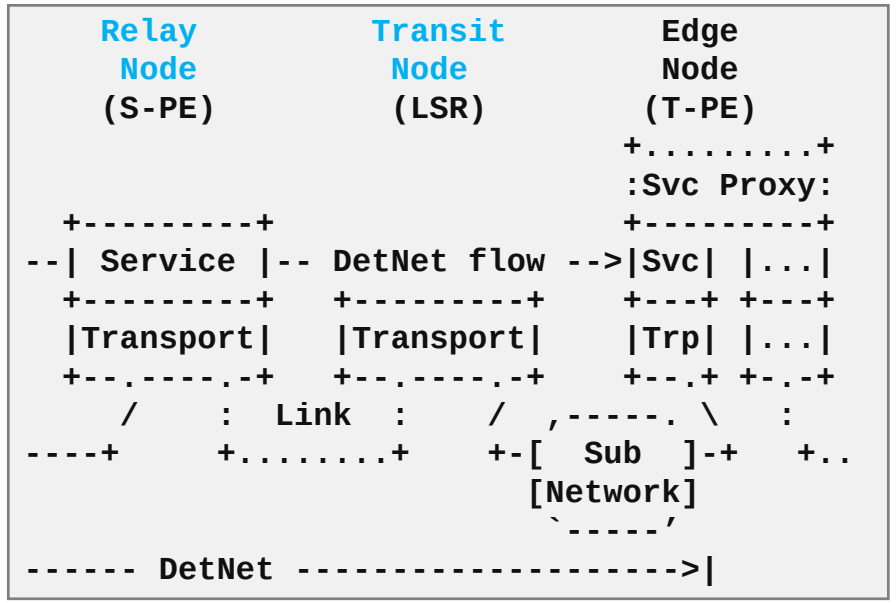


- DetNet Routing service
  - End-systems in different broadcast domains
  - IP headers are modified per standard router behavior, e.g., TTL handling

DetNet components
End-systems and DetNet nodes

- "Deterministic Network" is composed of
  - DetNet (enabled) end systems:
    - A.k.a. "host" (IETF), and an "end station" (IEEE 802). Sources or destinations of DetNet flows.
  - DetNet relay nodes
    - includes a DetNet service sub-layer function and DetNet transport sub-layer functions as well.
  - DetNet edge nodes:
    - a DetNet relay node that acts as a source and/or destination at the DetNet service sub-layer. (It is analogous to a Label Edge Router (LER) or a Provider Edge (PE) router.)
  - DetNet transit nodes
    - operates at the DetNet transport sub-layer, provides congestion protection over those paths. (An MPLS LSR is an example of a DetNet transit node.)

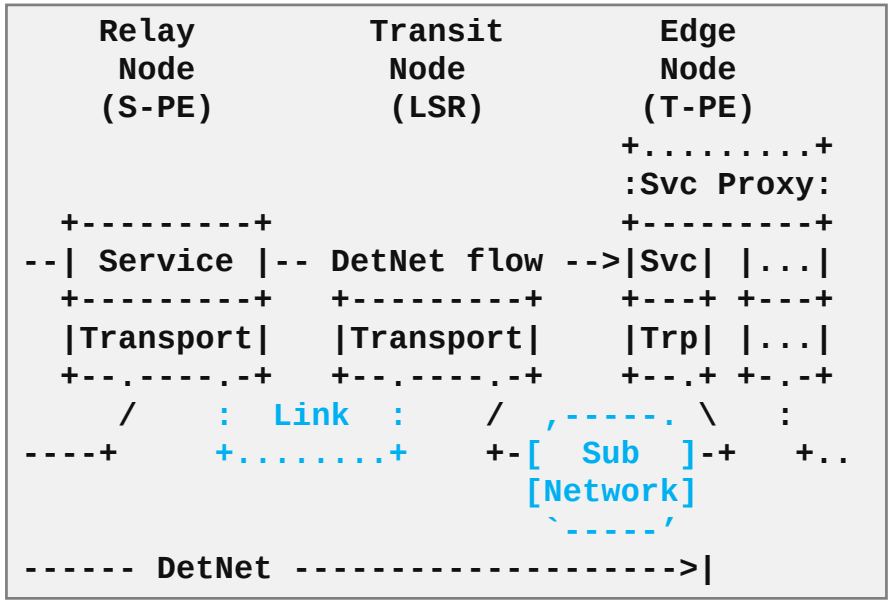




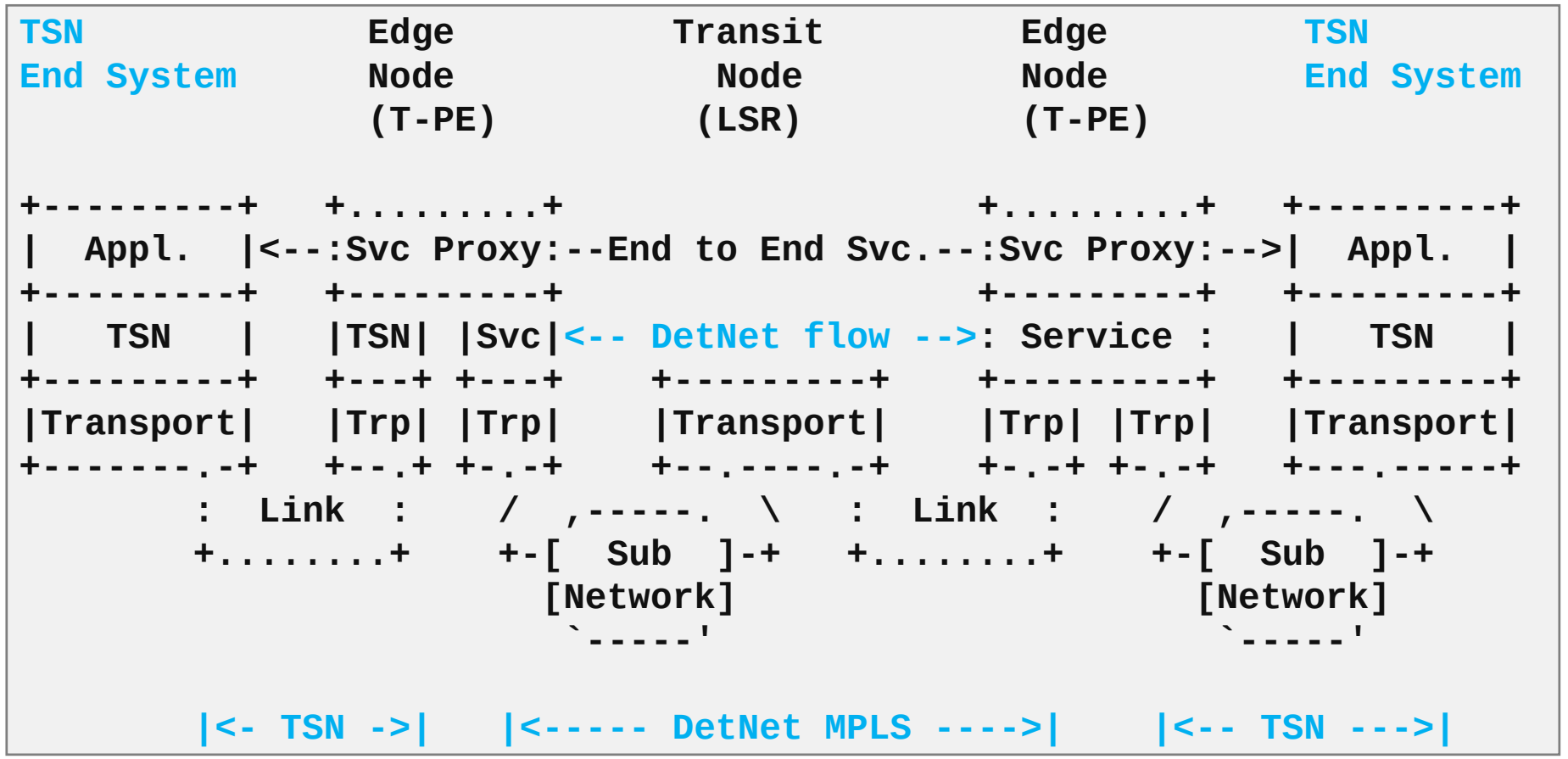
DetNet components (cont.)
Links and sub-networks

- All DetNet nodes are connected to sub-networks
  - point-to-point link is also a simple sub-network
  - sub-networks provide DetNet compatible service for support of DetNet traffic
  - examples: MPLS TE, IEEE 802.1 TSN.

- Multi-layer DetNet systems may also be possible, where one DetNet appears as a sub-network, and provides service to a higher layer DetNet system

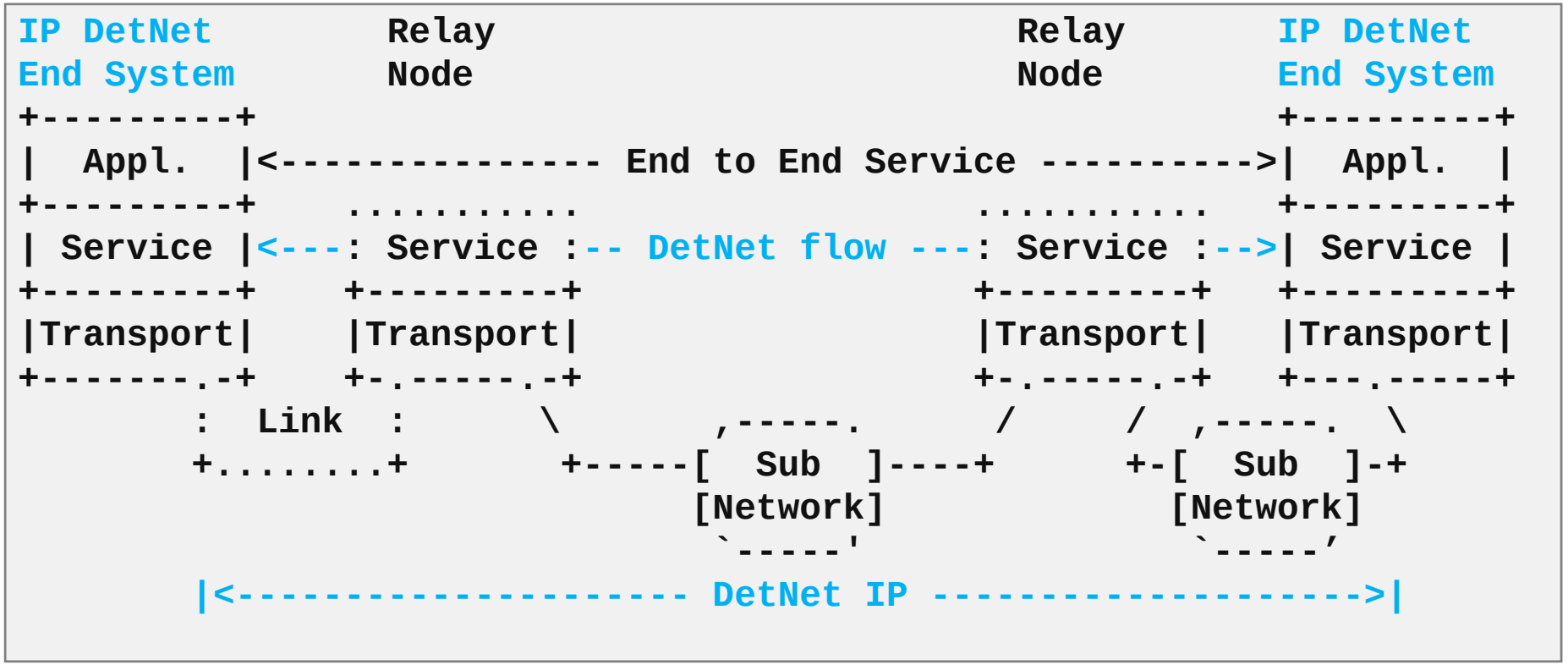


Service scenarios example I.
DetNet Layer-2 service: TSN over DetNet (MPLS)



Service scenarios example II.

DetNet Layer-3 service: DetNet (DN) Enabled IP Network



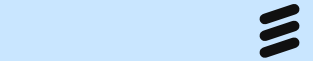
Summary
DetNet in a nutshell

Deterministic Networking

— provides guaranteed delivery with bounded low latency, low delay variation, and extremely low loss
— extreme values (µsec, lossless, …) often appear, but the main target is guaranteed upper bound

Techniques/functions used include:

— Reserving data plane resources
for DetNet flows in some or all of the intermediate nodes along the path of the flow
— Providing explicit routes
for DetNet flows that do not immediately change with the network topology
— Distributing data from DetNet flow packets
over time and/or space to ensure delivery of each packet's data in spite of the loss of a path



Questions …