# ITU-T Architecture standards and impacts to network operations

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# ITU-T Sync architecture and impacts to network operation

- Presentation intent:
  - Overview of ITU-T Sync/Packet network architecture work
    - Describe progress on G.pacmod (G.8264) since ITSF 2006
    - Review ITU-T "architecture" concepts and their impacts
  - Provide some initial thoughts on the impact of this work on network operation
    - Hopes to answer the question: "Why all these strange blocks?"
    - Provides some guidance on moving from TDM based sync to packet based sync
  - Identify what is needed to go forward

# ITU-T Sync architecture and impacts to network operation

- Introduction
- **ITU-T synchronization work**
- G.805 functional modeling
- Packet network functional modeling
- Synchronization aspects of packet networks
- Potential operational impacts
- Summary and future work

# ITU-T synchronization architecture

- Q13/15 work on synchronization aspects of packet networks began in April 2003
  - First work Recommendation on synchronization aspects of Ethernet networks, now G.8261 (February 2005)
  - Subsequent work started on
    - G.8262 (G.paclock) : Clocks for Ethernet networks (first version: completed June 2007)
    - G.8264 (G.pacmod): Architectural models
    - Updates to G.8261
  - Three recommendations form the basis for work in ITU-T

# Progress made since ITSF 2006

- ITSF 2006 presentation covered initial work on packet network architecture relative to synchronization
  - “work in progress” started February 2006
- Since then, considerable work:
  - March 2007 (San Jose)
  - June 2007 (Geneva)
  - September 2007 (Ottawa)
- Progress on G.pacmod (G.8264)
  - Refined scope of initial document
  - Defined potential content based on expected maturity level of concepts
  - Target date for ***first version***: February 2008

# G.8264 (G.pacmod)

## Scope:

This Recommendation outlines the requirements on Ethernet Transport networks with respect to Time and Timing and details the required architecture in formal modelling language. A number of methods may be used to transport Time and Timing which maybe physical layer based or protocol layer based. The method used will be dependent on the actual architecture and what may be supported.

Timing flows are used to describe where and how time and timing will flow through the architecture. Such flows describe what is functionally allowed as an acceptable timing source. Such a source may only be available for use within the equipment or maybe available outside as a client service.

# G.8264 Detail

- Current draft contains information related to packet network synchronization:
  - Packet network architectures
  - Timing flows (including functional blocks)
  - Next Generation timing architectures
  - Time of Day distribution
  - Ethernet SSM
  - Synchronization management.
- First version is expected to be finished February 2008.
  - Alignment with G.8261, G.8261
  - Future versions to include additional material based on technical maturity.

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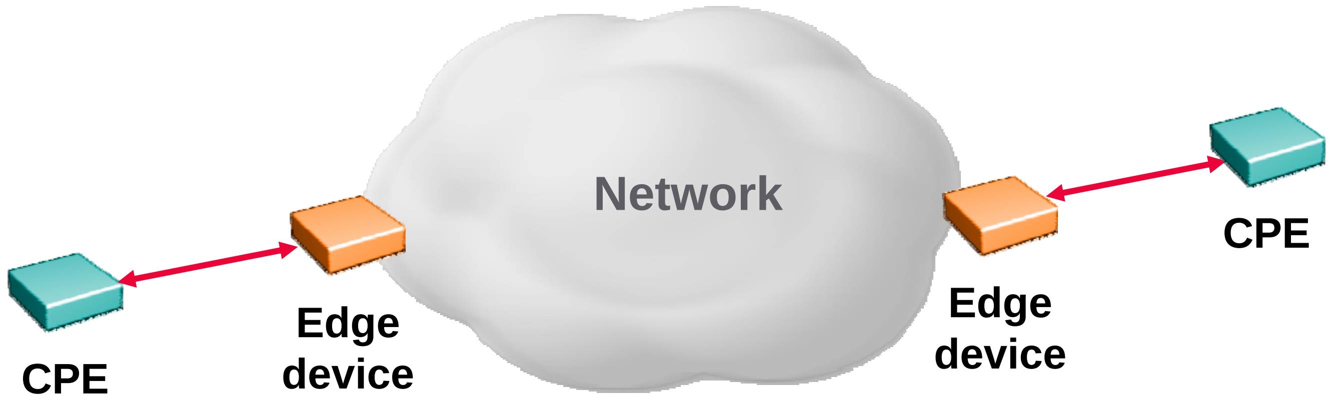
# Architectural modeling

- Concept of functional modeling introduced in ITSF 2006
- Is this a model?




- No: Does not provide enough detail
  - Network operator needs added detail to manage network
  - Equipment vendor needs more details on the “nuts and bolts”.

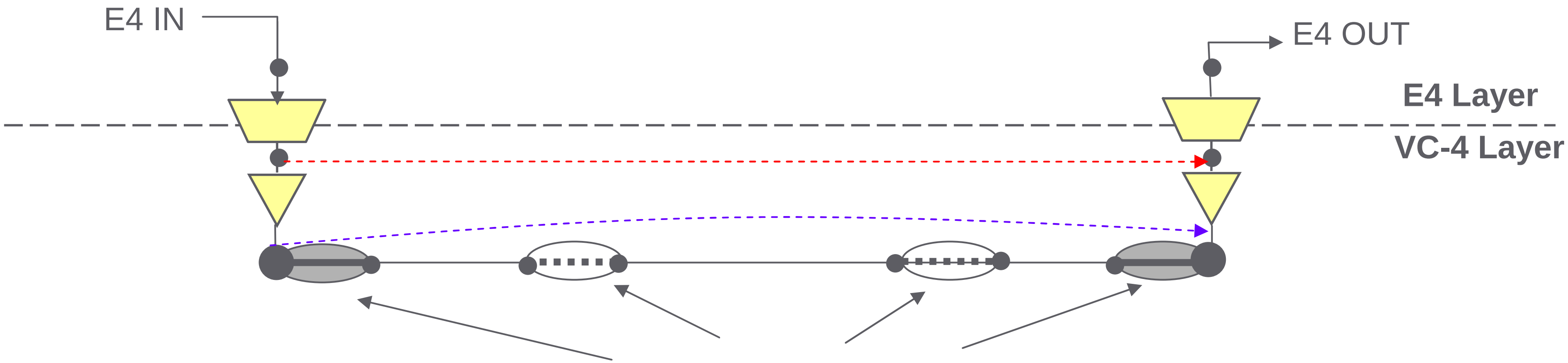
# Solution: ITU-T modeling language based on G.805

- ITU-T G.805 provides the modeling language to describe transport networks
  - Describes functional blocks that form a transport network.
  - Defines “architecture”
- Defines transport “layers”
  - Networks are managed on a per-layer basis
  - Interactions between the layers follow client/server relationships
  - OAM is defined on a per-layer basis
- G.805 features
  - Well defined function interactions
  - Fully recursive: define as few or as many layers as necessary
  - Technology independent methodology
  - Does not restrict implementation

# G.805 Modeling Concepts (cont'd)

- Commonly seen components in models:
  - Trails: support the end-to-end transfer of information
  - Adaptation, trail termination and connection functions
- Value**:**
  - Function interactions fully understood from the network level
  - Allows complete specification of equipment
  - The network is fully manageable
- Related ITU-T Recommendations:
  - Extensions for packet mechanisms (introduces flows)
  - Technology specific descriptions of architectures
  - Synchronization

# G.805 Layer Networks

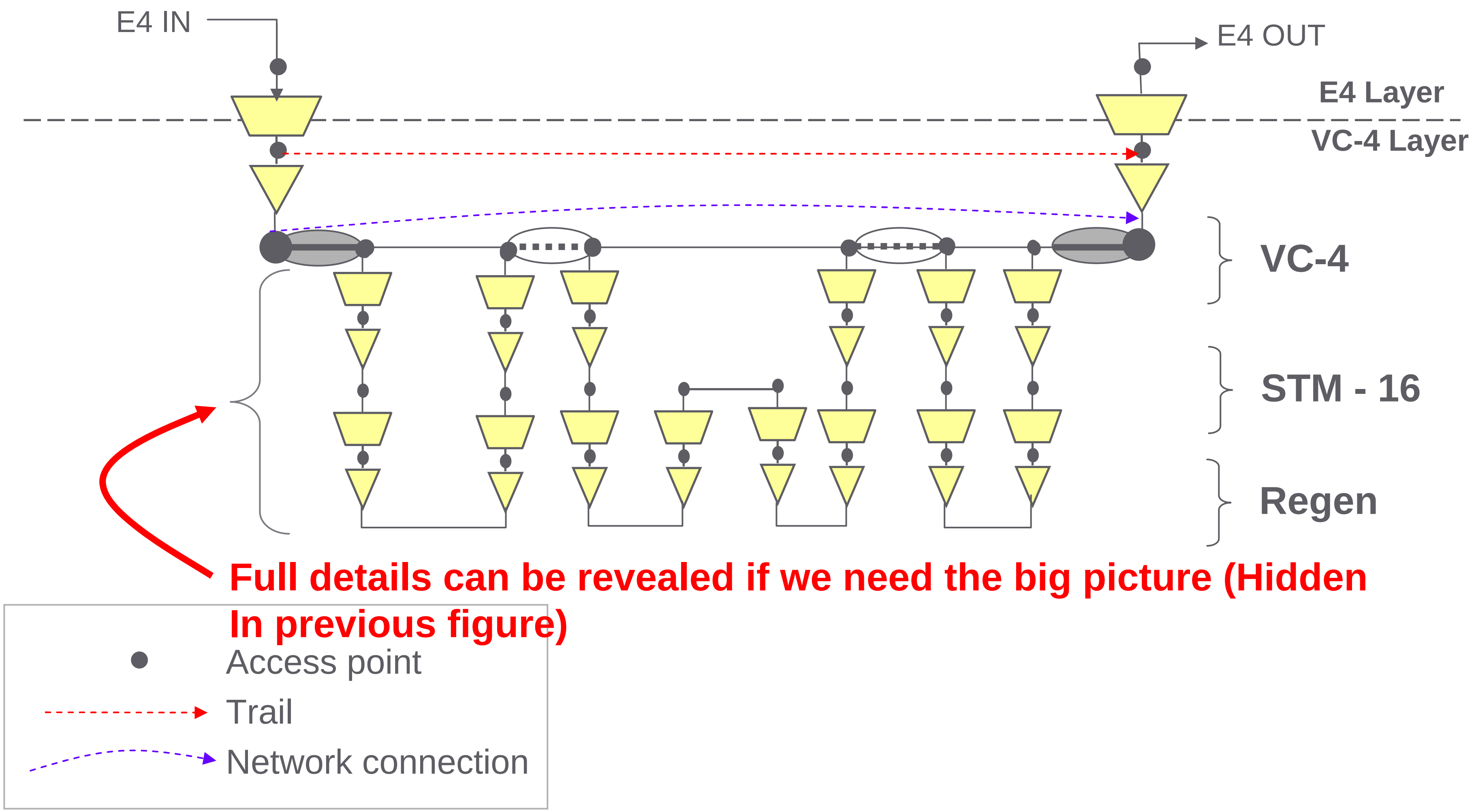



•'subnetwork connections' signifying traversal across a switching matrix

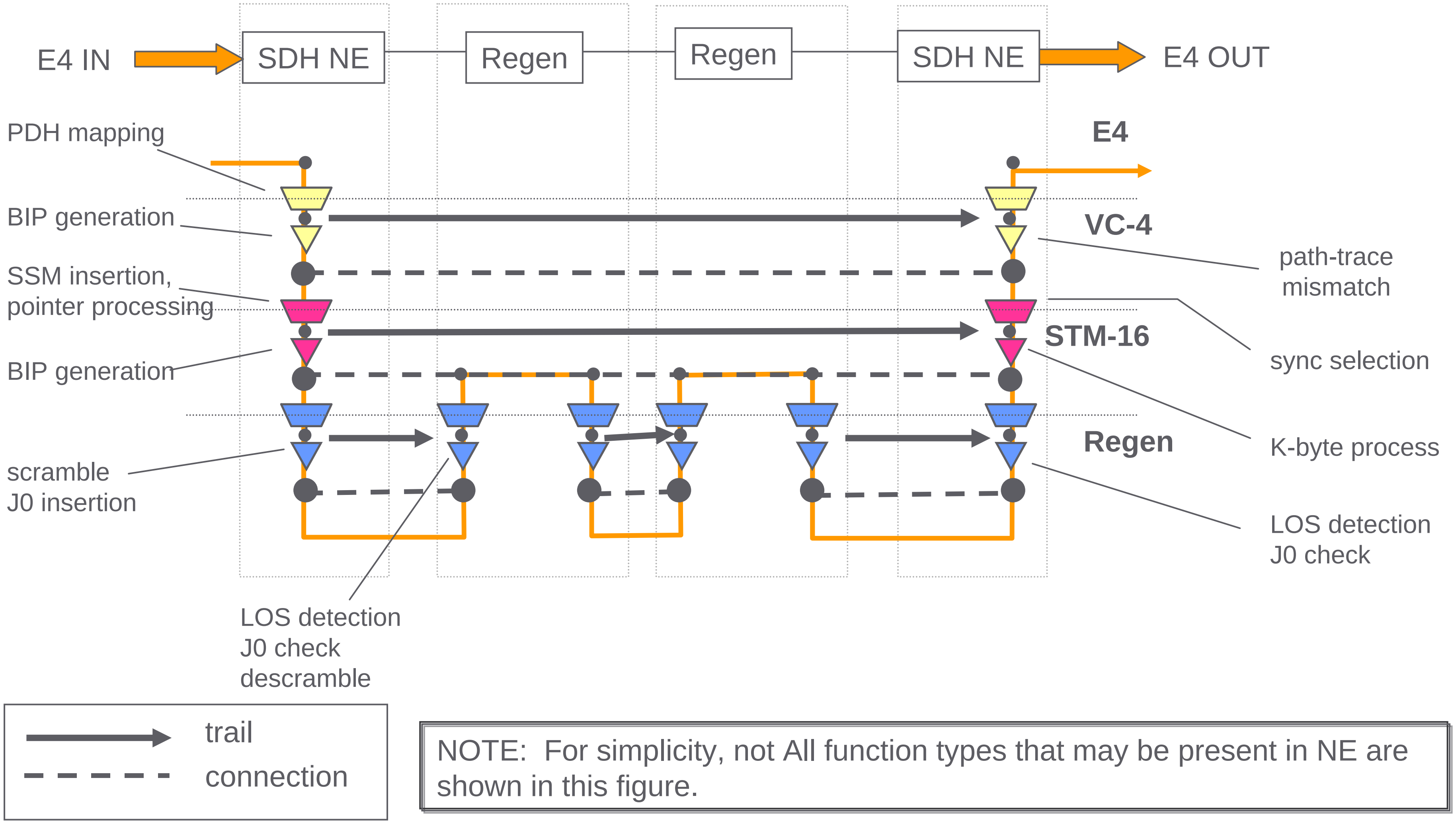
***•model allows us to hide lower layers so we can focus on how we manage a specific layer network***

Access point
Trail
Network connection

# G.805 Layer Networks



# Example: SDH Overhead Detail Revealed




NOTE: For simplicity, not All function types that may be present in NE are shown in this figure.

# Application of modeling to Packet networks

- Describes the Ethernet model
- ITU Ethernet model provides starting point to look at the synchronization aspects of packet network.
- ITU-T developed G.8010 to describe Ethernet networks in terms of G.805 like functional models
  - Allows greater understanding of the distribution of network functions and how these are managed.

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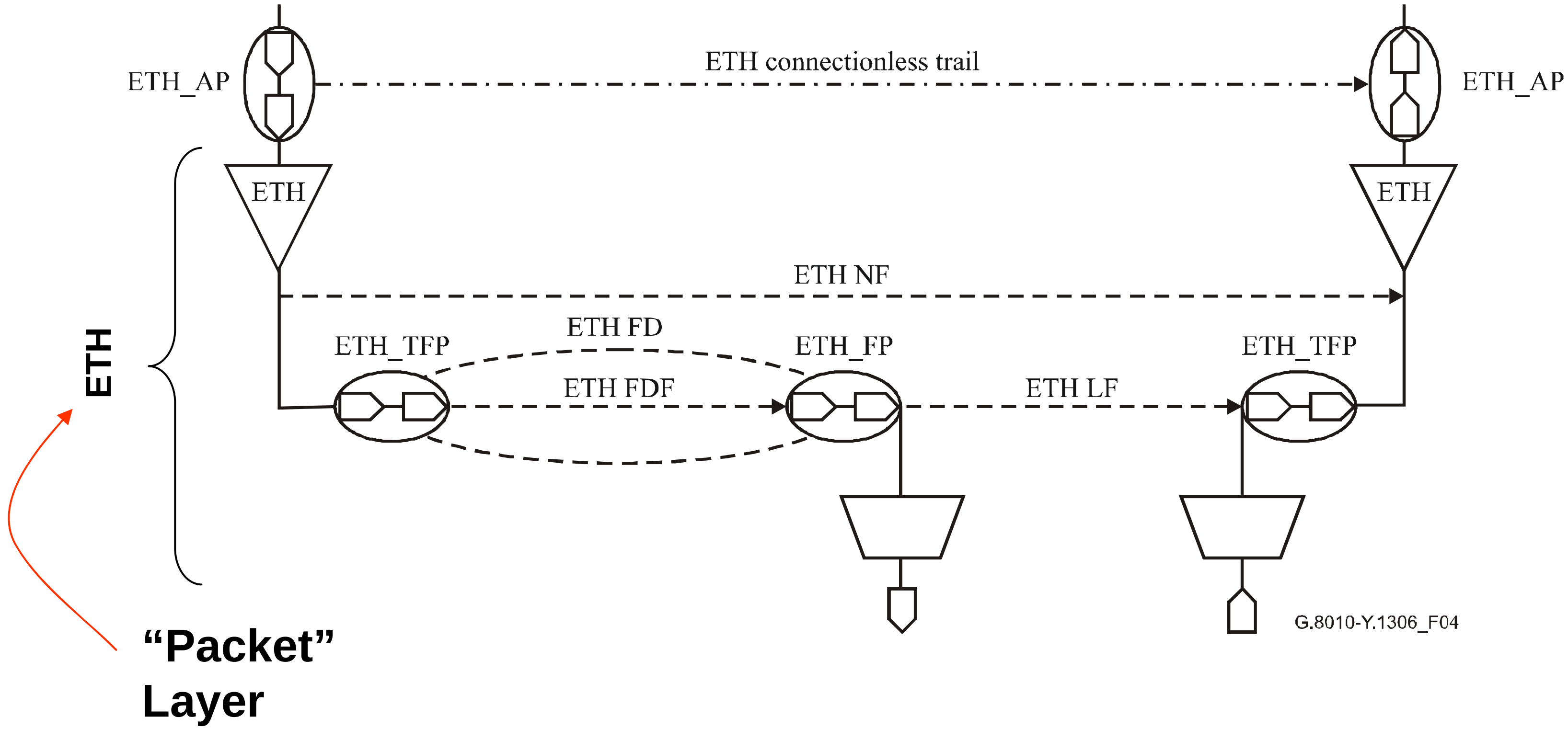
# Synchronizing packet networks: the ITU-T Ethernet Model (G.8010)

- The ITU-T Ethernet network model (G.8010) describes Ethernet as two layers: ETH and ETY (Packet, physical)



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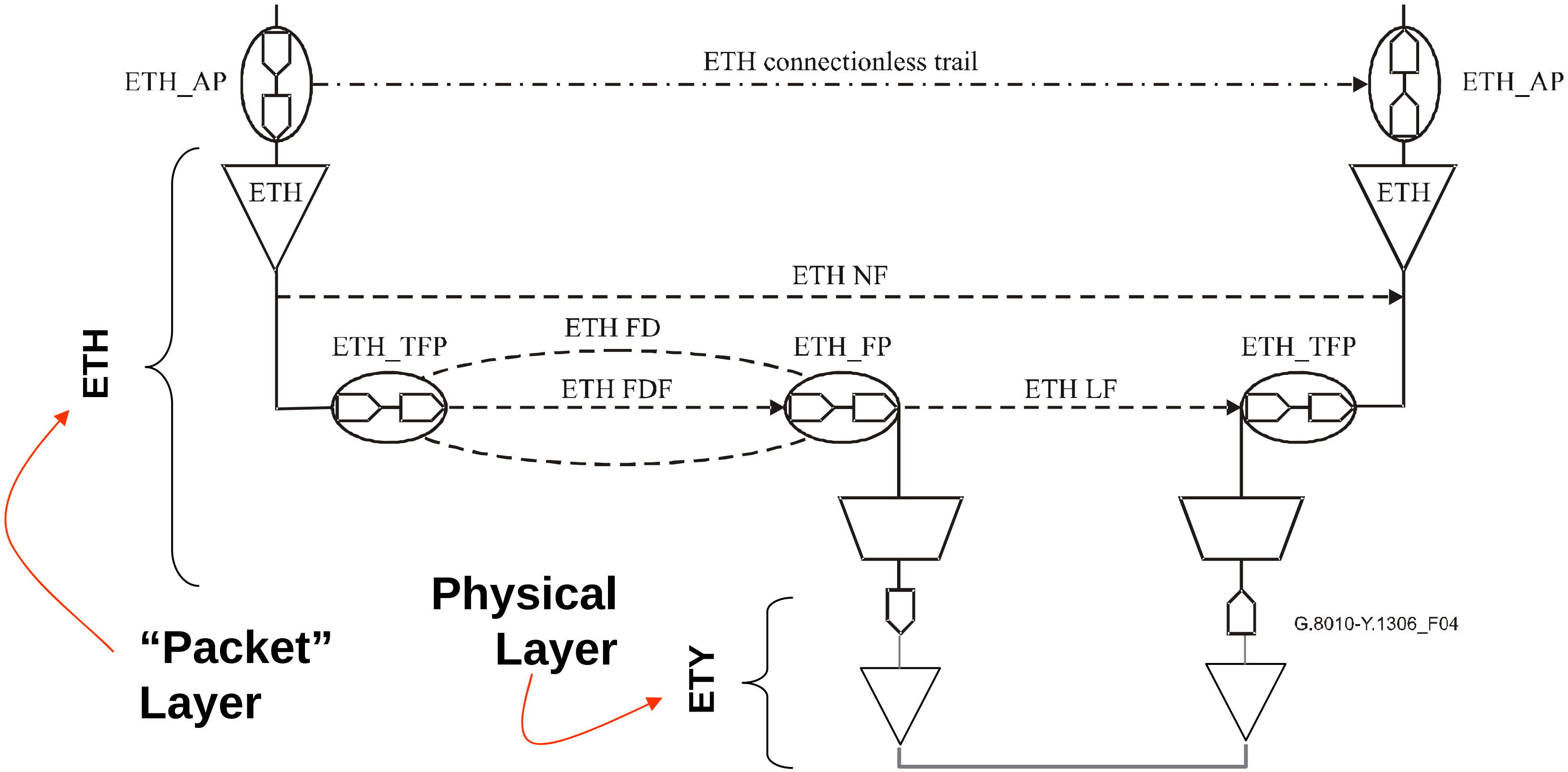
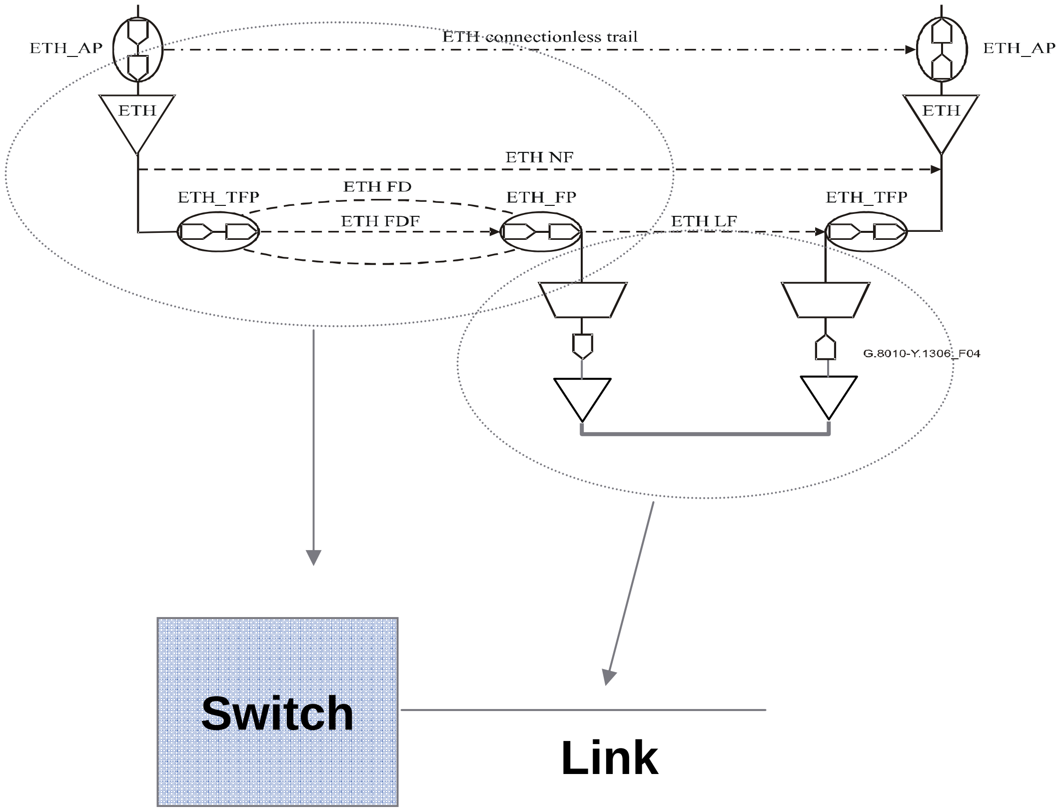
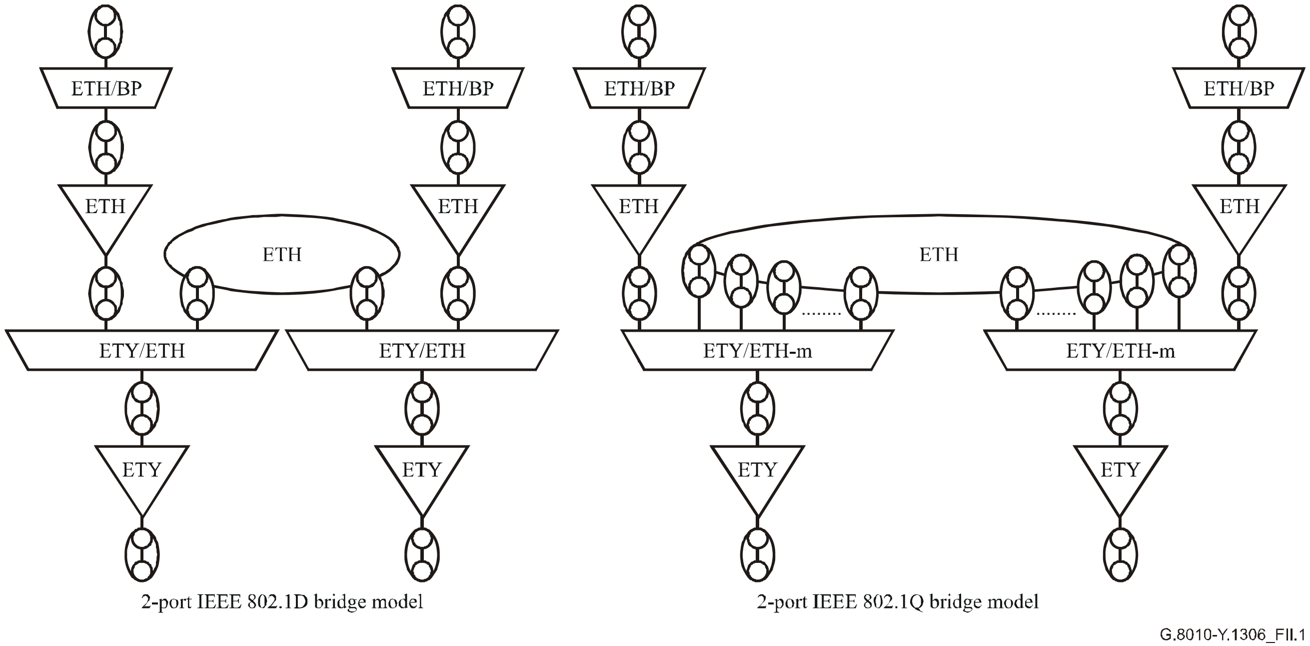


# What the functional model represents



# Additional model examples

## G.8010/Y.1306 model of 2-port bridge



# The functional blocks contain details needed to implement functions

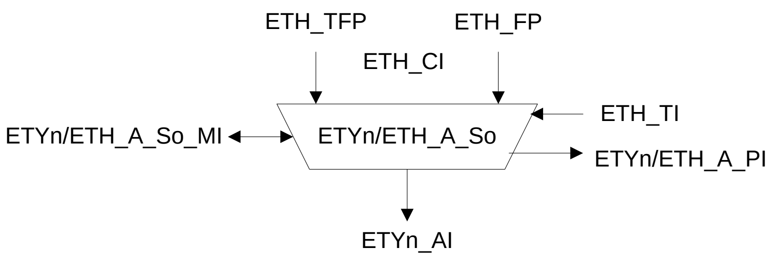



**Figure 10-6/G.8021/Y.1341 – ETYn/ETH_A_So symbol**

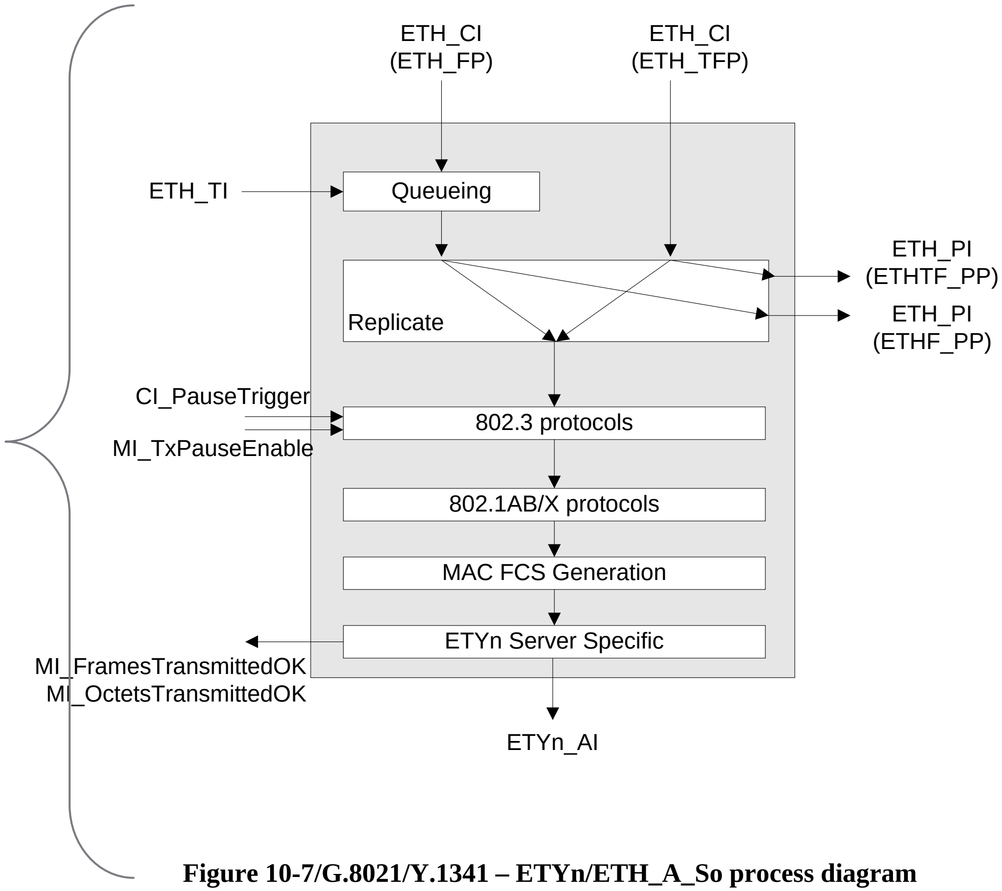



**Figure 10-7/G.8021/Y.1341 – ETYn/ETH_A_So process diagram**

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# Synchronization issues in Packet networks

- Packet technology key to next generation networks
  - Some services will still require synchronization support (e.g.CES, RAN).
- Specific synchronization areas currently under study in standards:
  - Current sync distribution
  - Synchronous Ethernet
  - IEEE1588 timing distribution
  - Circuit emulation (CES)
  - Time of day distribution/Phase distribution
- Open questions:
  - How do synchronization aspects inter-relate?
  - What functionality is needed to implement synchronization functions:
    - at the network level?
    - at the equipment level?
  - What are the timing distribution requirements:
    - at the network level?
    - at the equipment level?
  - How do we manage it all?
- Starting point: look at the network architecture (model) first.

# Example: Packet support of PDH services

- IWF is defined to carry PDH over packet networks
- Key questions:
  - What timing support do we need?
  - Where do we get it?

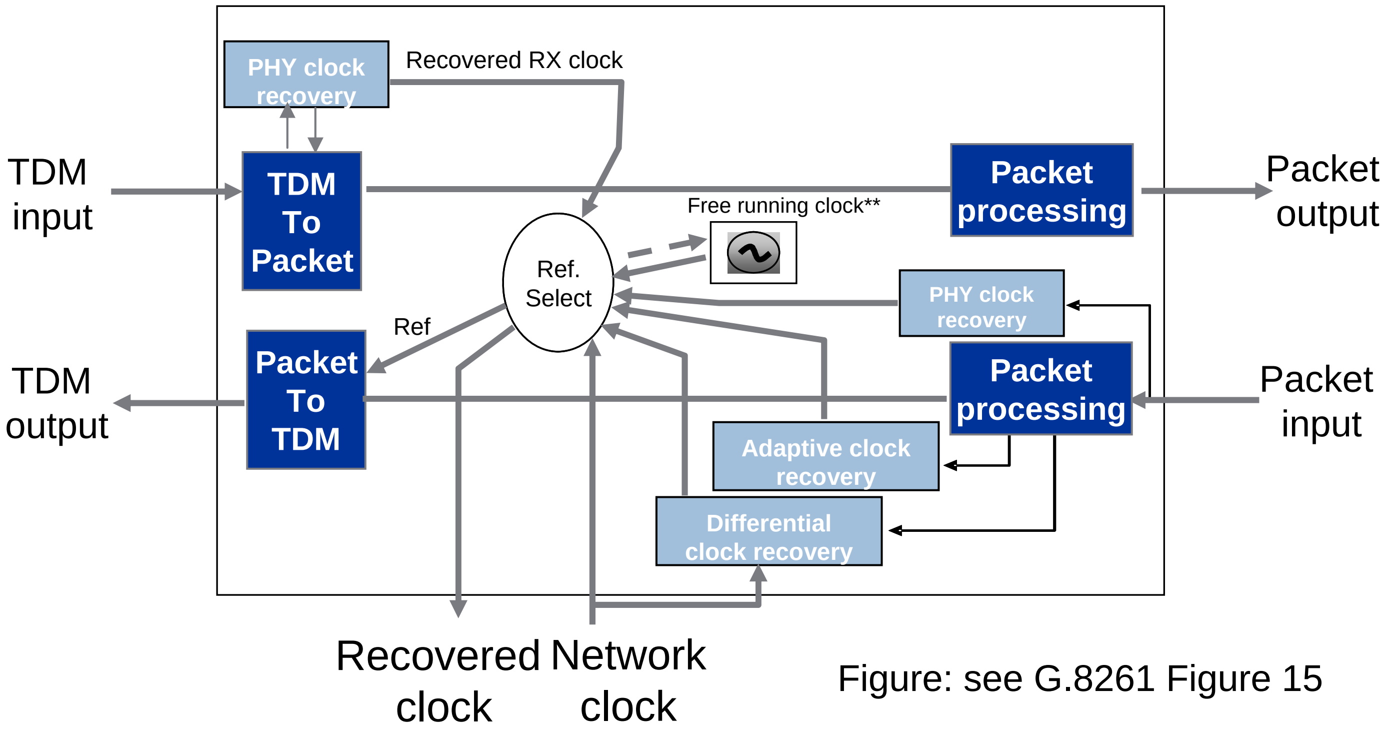
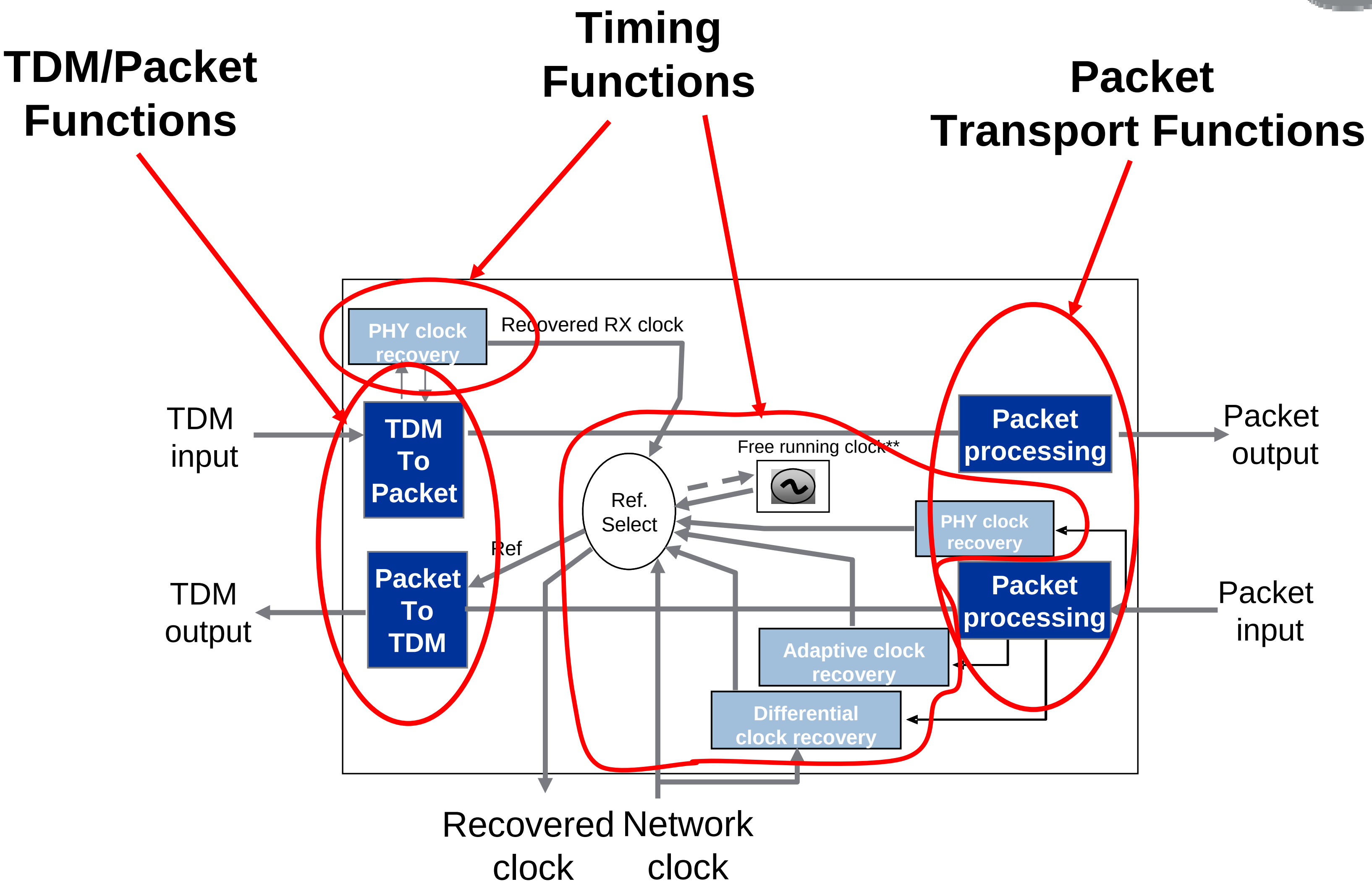
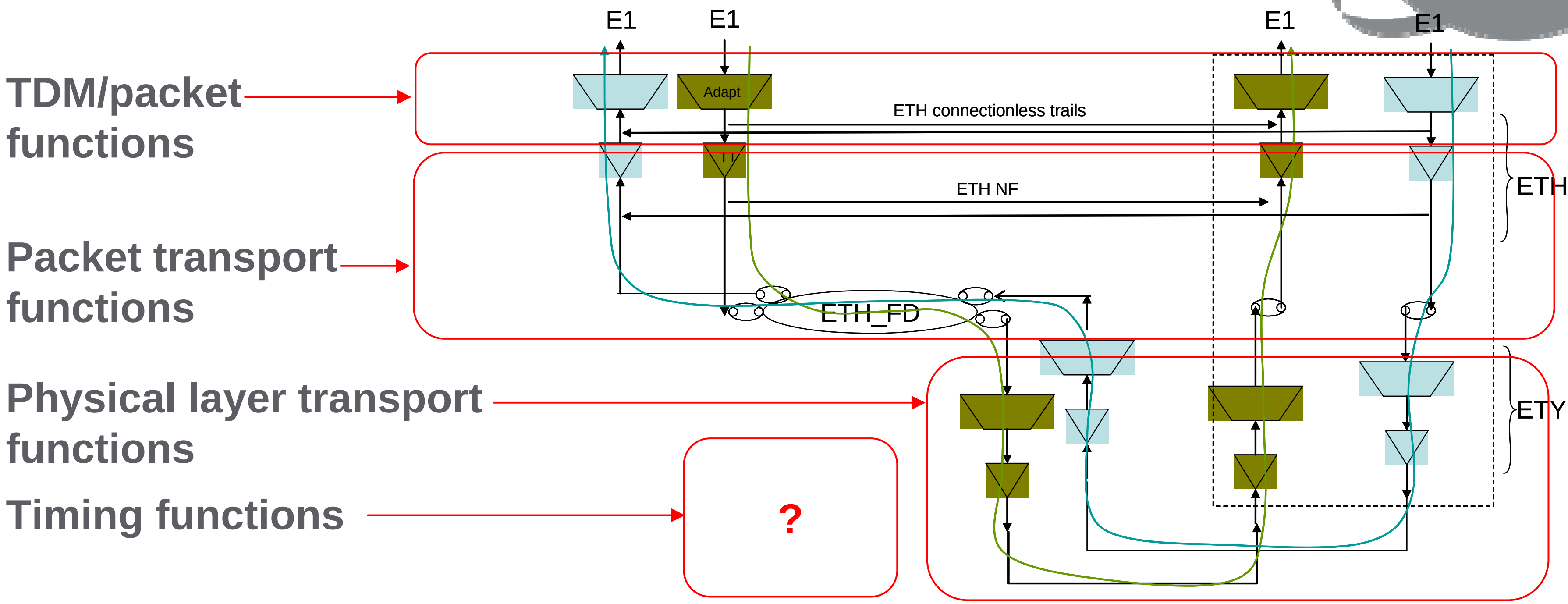



Figure: see G.8261 Figure 15

# Identifying IWF Functionality



# Mapping The CES IWF to Ethernet




- Mapping IWF functions to architecture shows function interactions
- Some functions are now seen to be distributed across a network
- Architecture may require additional functions to support timing

# Recall how we need to time the IWF?

- Timing reference is needed at each IWF (Differential timing case)

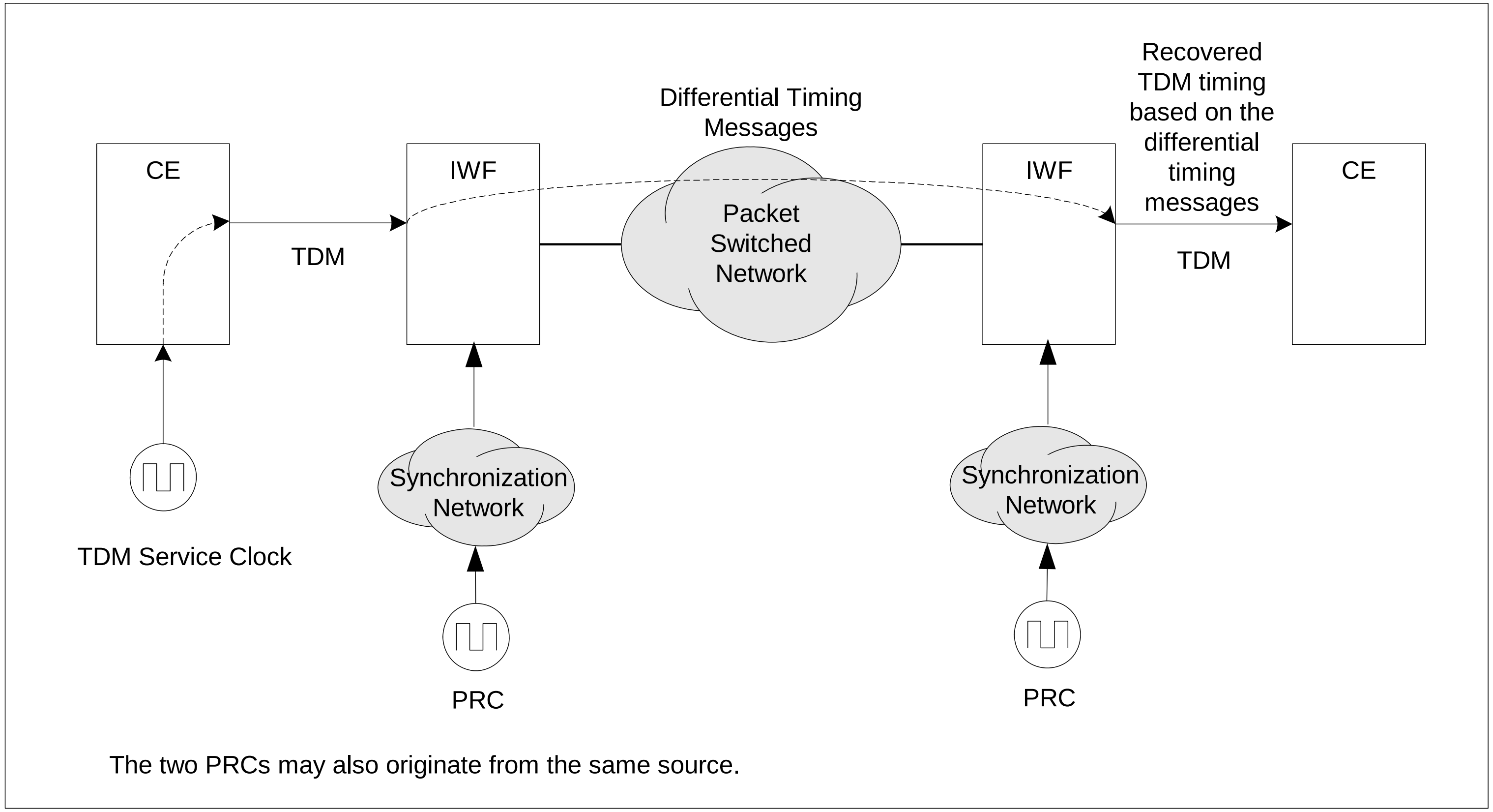
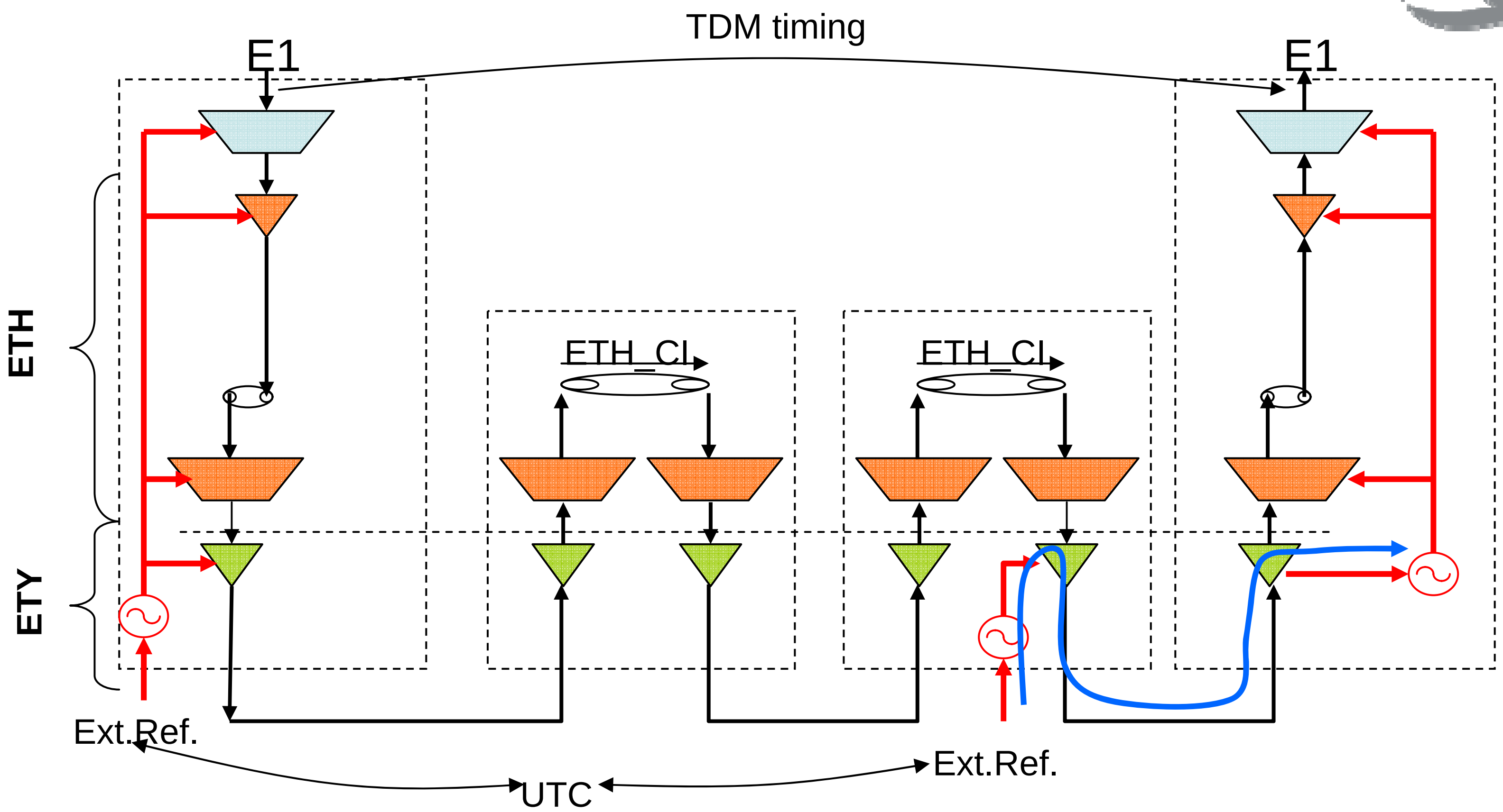


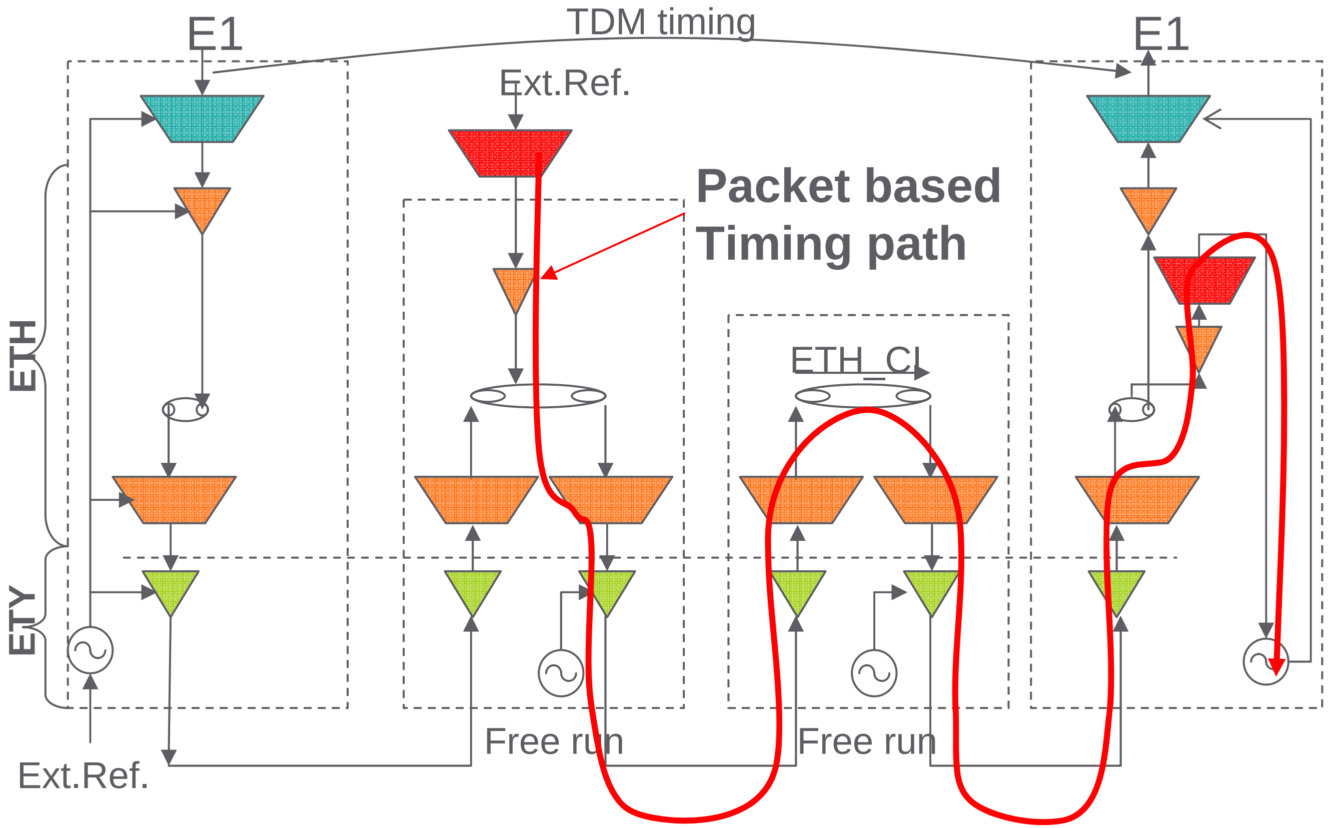

Figure 7/G.8261 – Example of Timing Recovery operation based on Differential Methods

# Adding Timing Functions




- We can now see where we need to provide timing to the functional blocks to fully support a specific service or network architecture.

# Alternative Approaches to Timing Distribution in Packet Networks




- Functional modeling allows us to look at alternatives.
- Above figure shows a situation where a timing reference is passed via packet means (e.g. IEEE1588 or similar)

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# Operational aspects:

- Network architecture defines the functional blocks that are needed to implement and manage a set of timing functions necessary for sync transport.
- Main areas:
  - Sync Ethernet
  - Ethernet SSM
  - CES
  - Packet timing mechanisms
  - Time-of-day distribution

# Operational aspects: Sync Ethernet

- Sync Ethernet is a simple concept:
  - Time the Phy layer with an SDH type clock.
  - Not new, first 10G WAN PHY (circa 2001) were actually network timed.
  - Ethernet links are timed with clocks that have the same behaviour as SEC clocks.
- Operationally:
  - Sync network engineering: No impact to current sync engineering: SyncE looks like an SDH MS section.
  - Hybrid networks (SDH and Packet) will co-exist allowing graceful migration of sync network

# Operational aspects: Ethernet SSM

- Ethernet may be free-running with +- 100ppm clocks
  - Ethernet with EEC clocks: timing links can be engineered as SDH timing links. One-for-one replacement
  - SSM must be deployed in order to make use of Sync Ethernet.
- Ethernet and SDH mechanisms differ
  - SDH: Dedicated overhead
  - Ethernet: uses a new 802 “slow” protocol
  - Although different mechanisms, both apply to the same type of layer. SSM for Ethernet would look and feel like SSM for SDH
- Operational impacts:
  - SSM is mandatory. Some provisioning will be required (minimal).

# Operational aspects: CES

- CES offers a means of carrying existing E1 private line services over a packet transport infrastructure
- Architecturally, network model looks like PDH mapping onto SDH.
- Mechanisms are vastly different:
  - Adaptive, differential, time-stamp based
- Operational impacts:
  - Mechanisms have not been standardized, interoperability between different vendor solutions requires confirmation
  - Packet based impairments (PDV, packet loss) present different challenges compared to SDH.
  - Traffic engineering may be required to guarantee SLAs

# Operational aspects: packet based timing mechanisms

- Frequency transfer with packets rather than Layer 1
  - Examples: NTP, IEEE 1588
- Potentially very appealing as a mechanism to provide timing to multiple locations from a single “server”
  - Provision multiple timing paths
  - Adds time/frequency
- Operational impacts:
  - Sync engineering currently based on traffic path or L1 (SDH)
  - Packet based timing adds a third path that needs to be engineered.
  - May require traffic engineering changes
  - What about and SSM? Hardware assisted time stamping?
  - Further work clearly needed

# Operational aspects: Time-of-day distribution

- Current sync network distributes frequency
  - Time-of-day is currently supported as an overlay network (e.g. NTP servers) or via satellite (GPS)
  - Components include time-servers (e.g NTP) over transport paths.
  - Can time-of-day distribution be integrated with frequency?
    - If so, what level of accuracy is required?
    - How do we accommodate failure (Time holdover?)
    - What about phase?
  - Operational impact:
    - Likely good potential for equipment savings (SSU/Time server)
    - Need to augment existing frequency based systems with time
    - Further work clearly needed.

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# Summary

- Functional modeling utilizes formalized techniques to allow provides the details necessary to understand the distribution of functions throughout a network.
  - Function interactions fully understood from the network level
  - Allows complete specification of equipment
  - The network is fully manageable
- New synchronization functionality can be described at the network level.
  - New functional blocks can be specified.
  - Layered network approach allows separation of concerns
  - Will allow impacts on operations to be clearly identified
- Good progress is being made in standards. But work not complete yet.

# Summary (2)

- Work also underway to cover:
  - Time of day, phase
    - Requirements
    - Distribution methods
    - Time services
  - Packet based methods
    - NTP? IEEE 1588?
    - How do these fit within the network?
  - Additional details also needed for equipment and architecture Recommendations outside of Q13/15
    - G.8010, Ethernet Architecture
    - G.800, unified model
    - G.8021, Ethernet equipment

# Finally: Sync work in other standards bodies

- Synchronization related work is ongoing in other standards bodies. Some examples:
  - IEEE
    - 802.3 Ethernet
    - AVB (Audio Video Bridging)
    - IEEE 1588 (PTP)
  - MEF
    - Wireless backhaul project
    - Circuit Emulation services (CES)
  - IETF
    - Tictoc (expected to start in December 07)
    - NTP
- ITU Intent is not to duplicate work, but to understand how things fit together to support services carried over the packet based infrastructure

# ITU-T References

- General architecture/models
  - G.805: Generic functional architecture of transport networks
  - G.809: Functional architecture of connectionless layer networks
- Technology specific descriptions of architectures,
  - G.803: Architecture of transport networks based on the synchronous digital hierarchy (SDH)
  - I.326: Functional architecture of transport networks based on ATM
  - G.872: Architecture of optical transport networks
  - G.8010: Architecture of Ethernet layer networks
  - G.8110: MPLS layer network architecture
- Synchronization:
  - G.781: Synchronization layer functions
  - G.8261: Timing and Synchronization aspects in Packet Networks

Documents are available at http://www.itu.int/rec/T-REC/e

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