Technical Engineering Center.

Timing and Synchronization:
The Journey from TDM to Next Generation Networks

Deutsche Telekom @ ITSF2008
Presentation agenda

From TDM to NGN – an overview: Synchronization is still a must

Migration challenges:

- ❶ Synchronization network migration: PRC, SSU and SEC
- ❷ Synchronization transport migration: From SDH to SyncE (... from SEC to EEC)
- ❸ Synchronization over OTN: From SDH to SyncE transparency
- ❹ Access migration: Example: Sync over xDSL

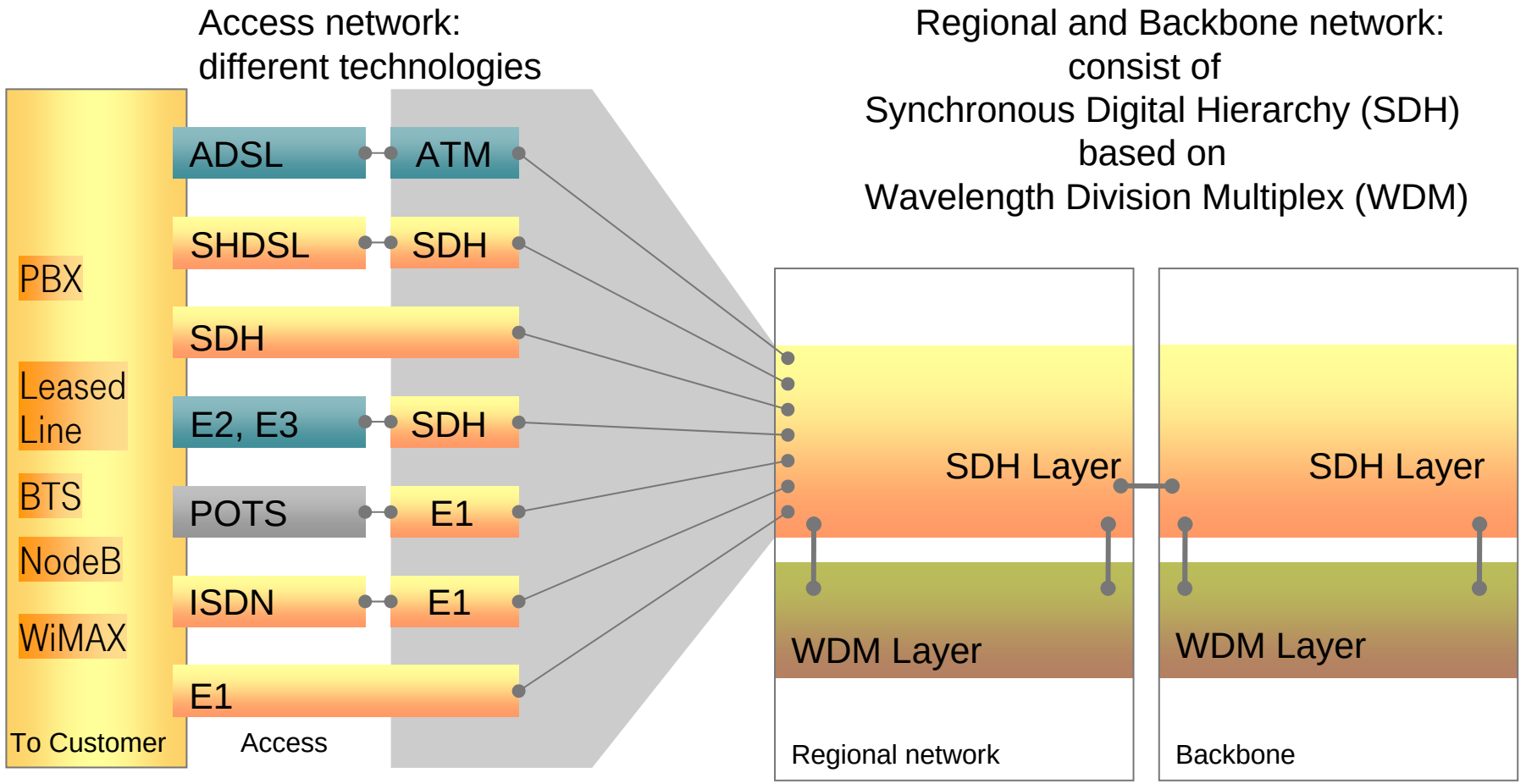
Additional issues:

- ❺ New options with Galileo
- ❻ Frequency and time synchronization belong together

Summary

From TDM to NGN – An high-level overview

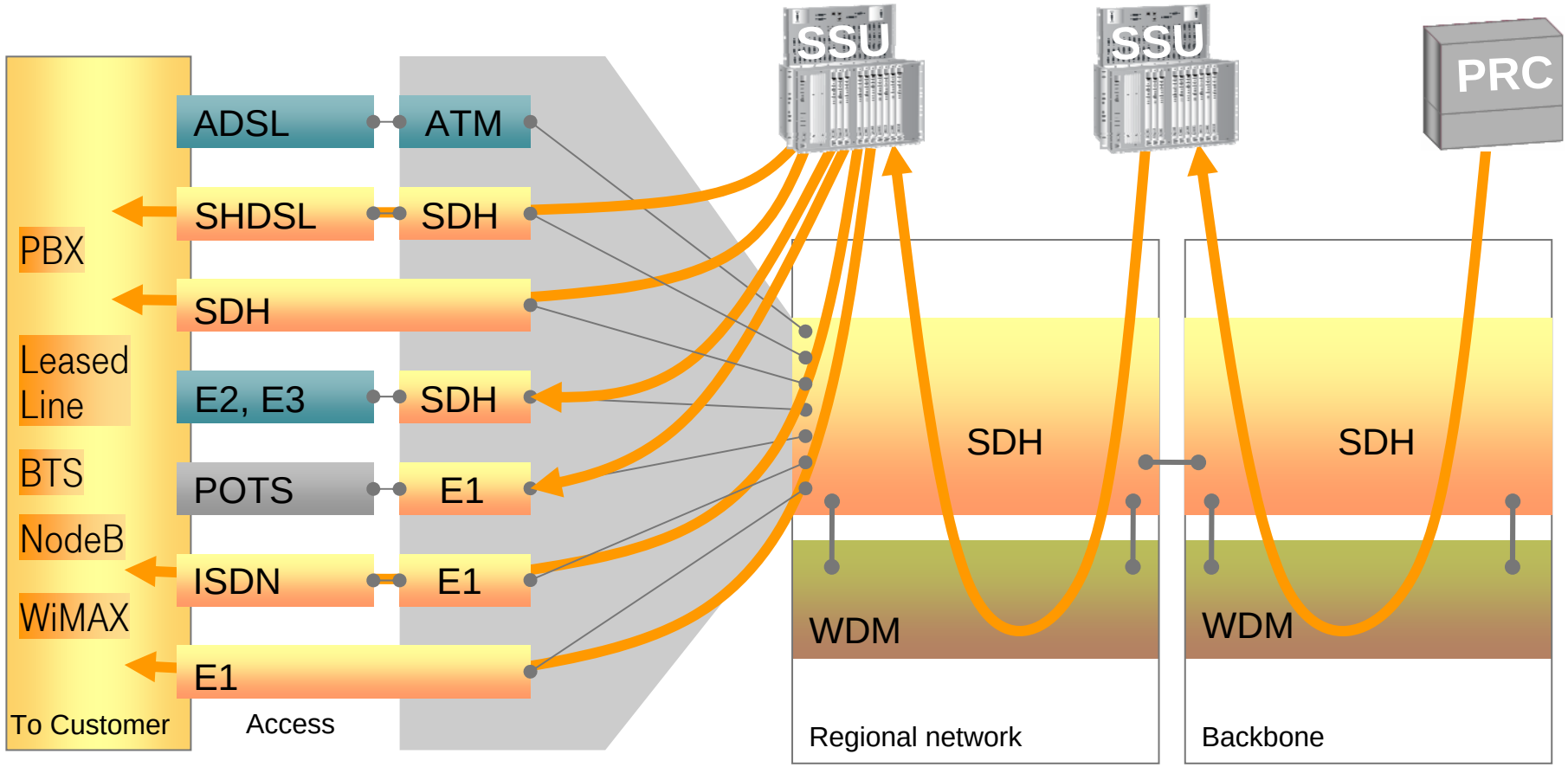
TDM



Examples, not complete

Asynchronous Synchronized Sync transparent n/a

From TDM to NGN – An high-level overview
TDM and its frequency synchronization

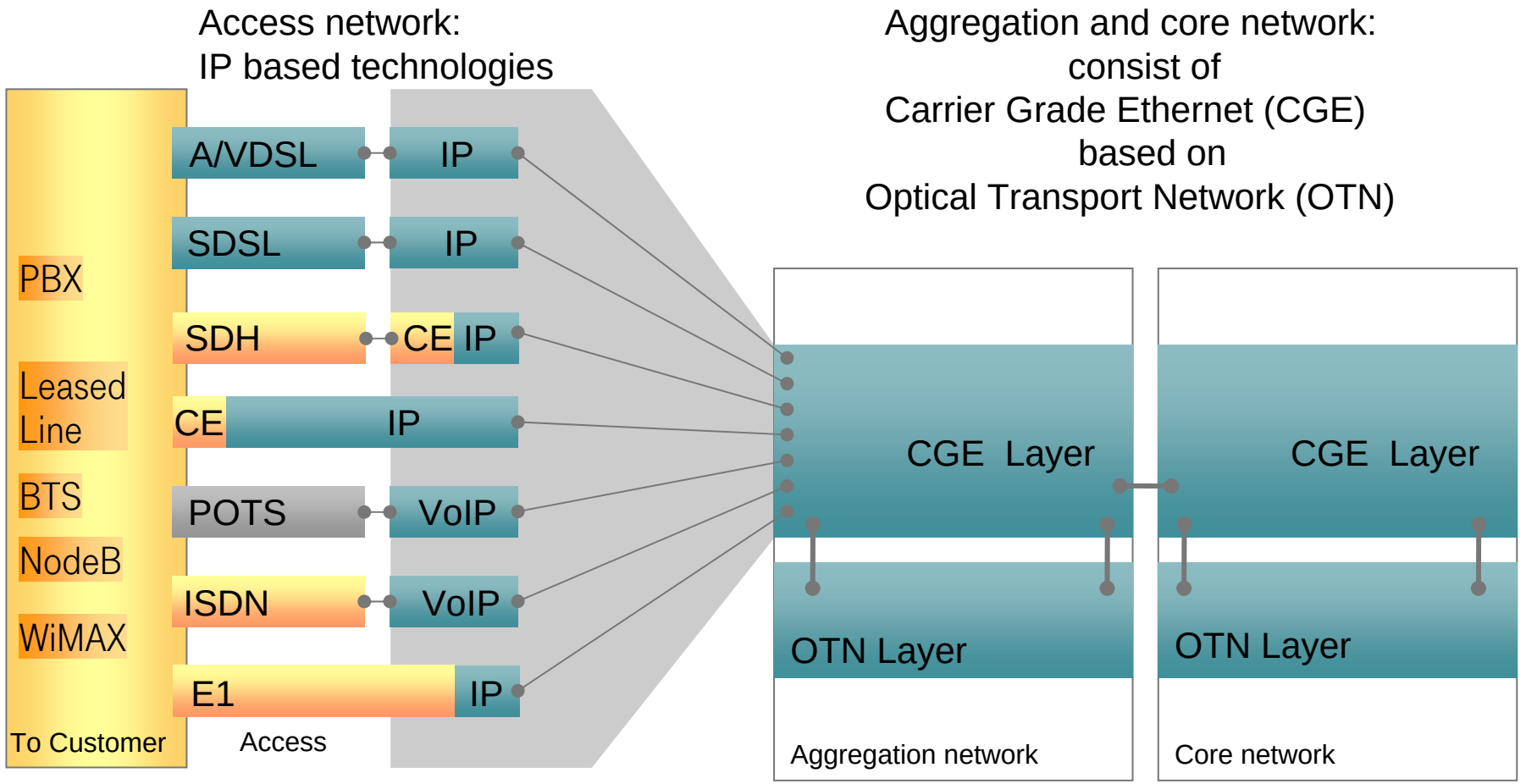


Examples, not complete

Asynchronous | Synchronized | Sync transparent | n/a

From TDM to NGN – An high-level overview

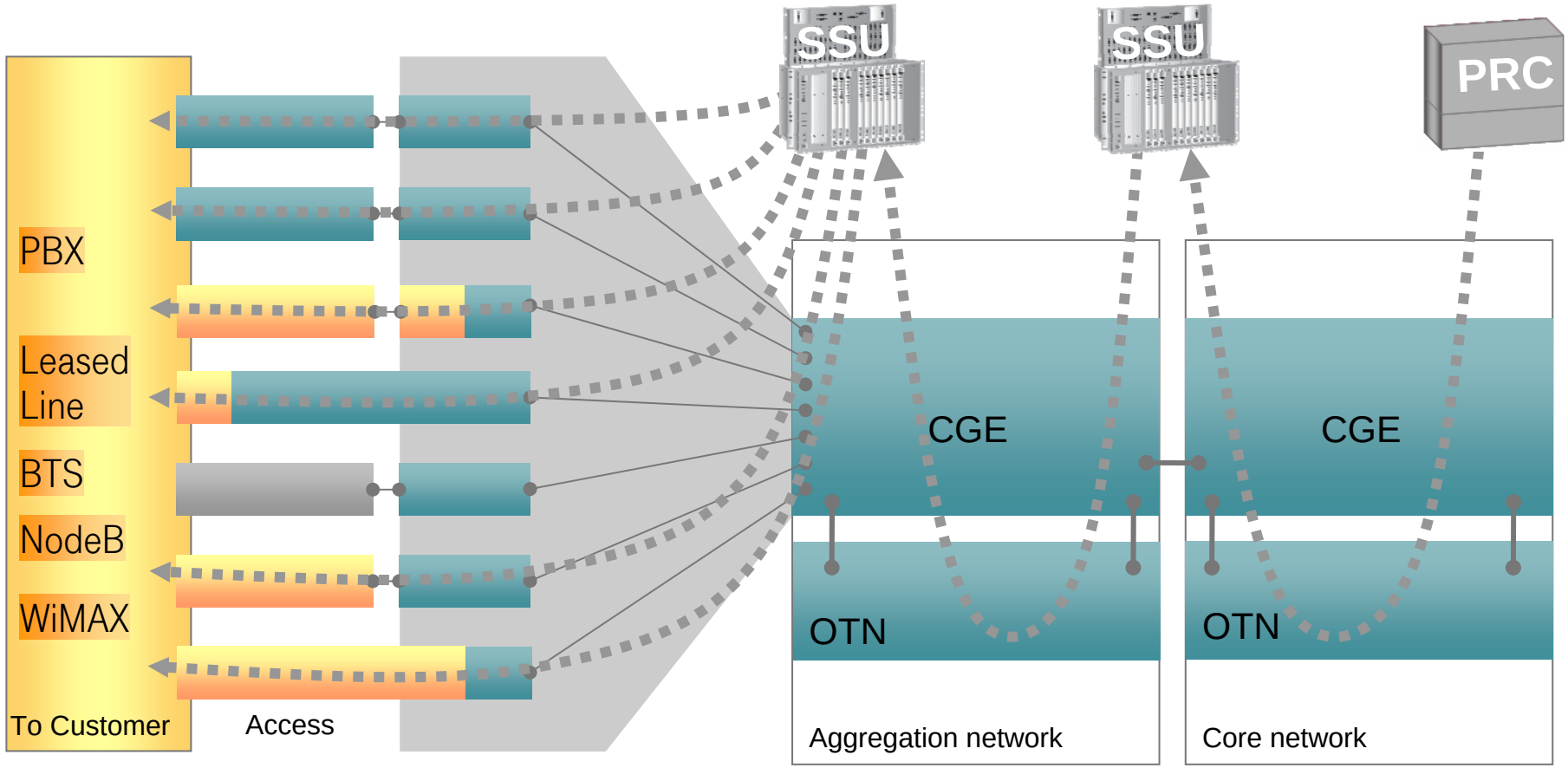
NGN



Examples, not complete

Asynchronous | Synchronized | Sync transparent | n/a

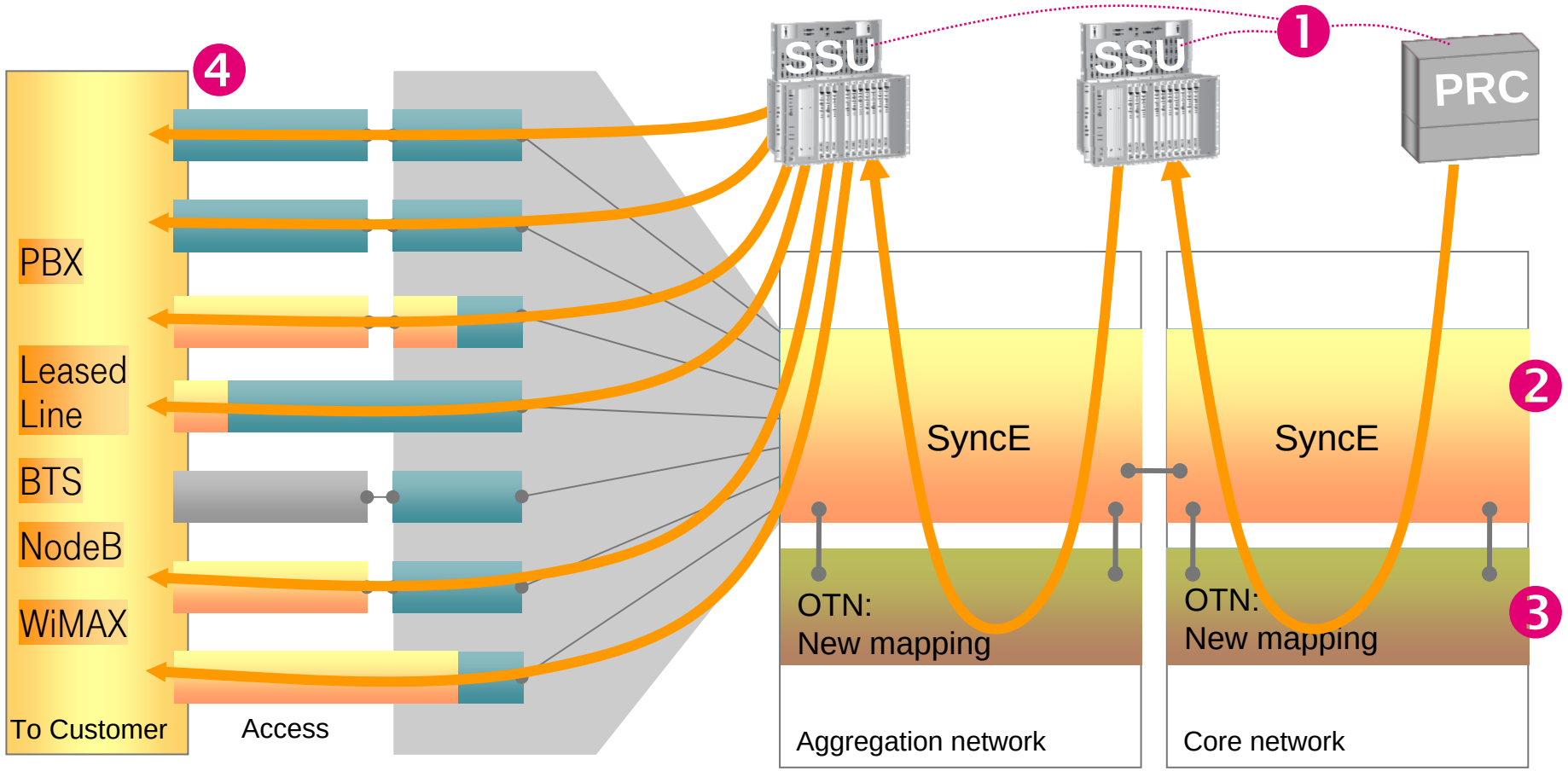
From TDM to NGN – An high-level overview
NGN and its frequency synchronization – the problem



Examples, not complete

Asynchronous Synchronized Sync transparent n/a

From TDM to NGN – An high-level overview
NGN and its frequency synchronization – the solution

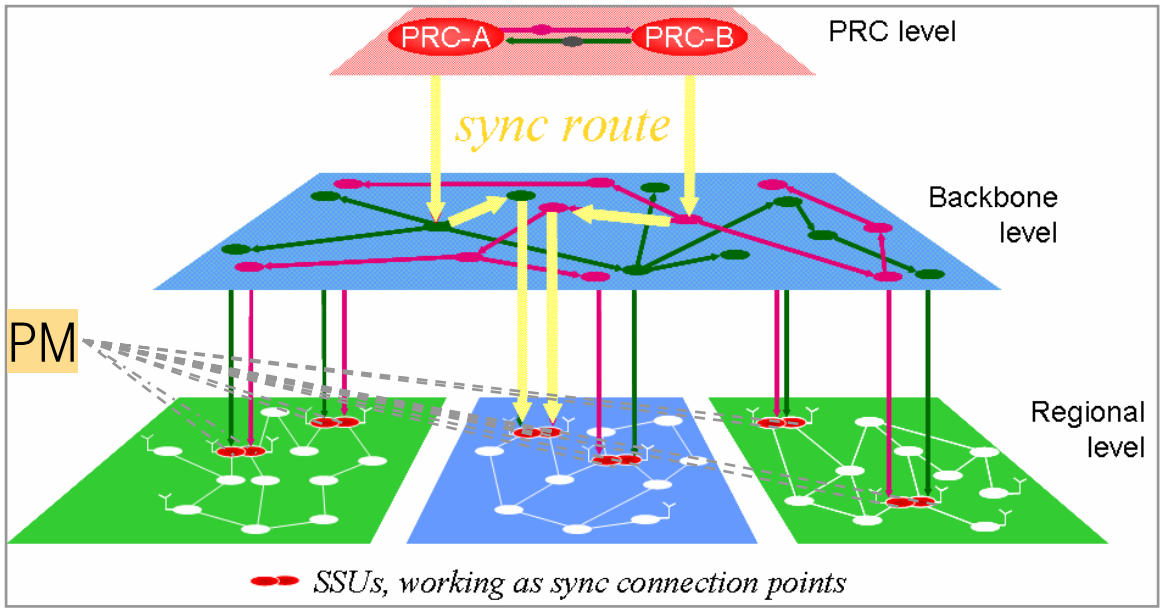


Examples, not complete

Asynchronous | Synchronized | Sync transparent | n/a

TDM to NGN migration challenges

❶ Synchronization network migration: PRC, SSU, SEC [1/2]



Elements:

PRC = Primary Reference Clock

SSU = Synchronization Supply Unit

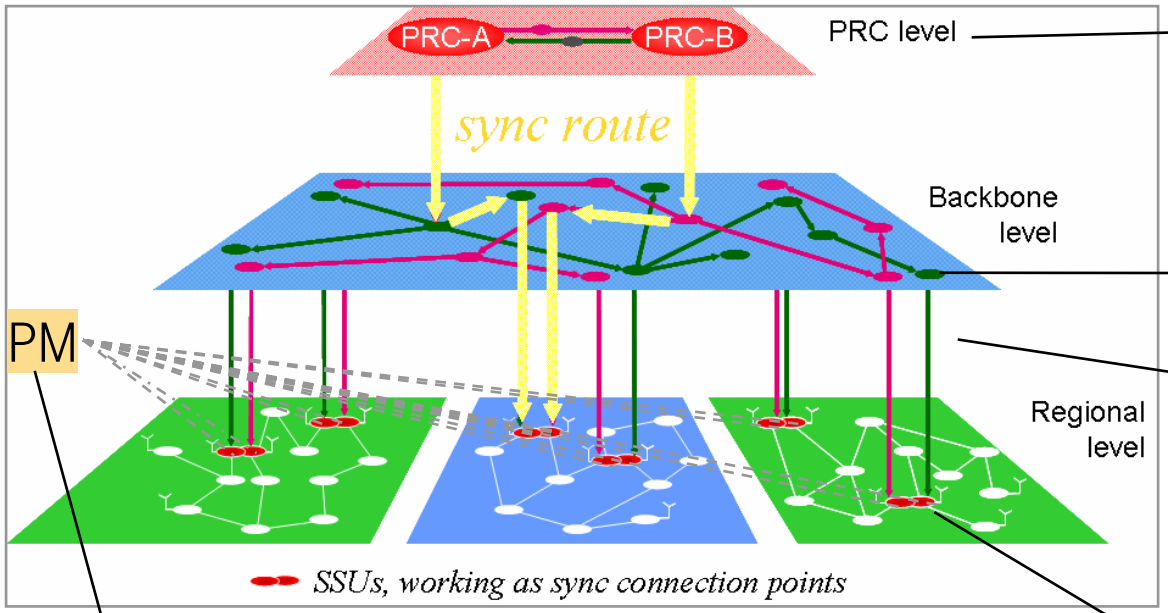
SEC = Synchronous (SDH) Equipment Clock

- Existing Synchronization Network of Deutsche Telekom
- Status: Excellent Synchronization Quality (typical MTIE much better than 1µs/day)

Details: Deutsche Telekom @ ITSF2004: 'The new Synchronization Network of T-Com'

TDM to NGN migration challenges

❶ Synchronization network migration: PRC, SSU, SEC [2/2]



PRC better than ITU-T G.811(contributing BIPM Paris for TAI/UTC) ☑

SEC acc. to G.813 ☒

❷

SDH transport network structure as basis for frequency synchronization distribution ☒

SSU better than ITU-T G.812 Type I (with Rubidium clocks) ☑

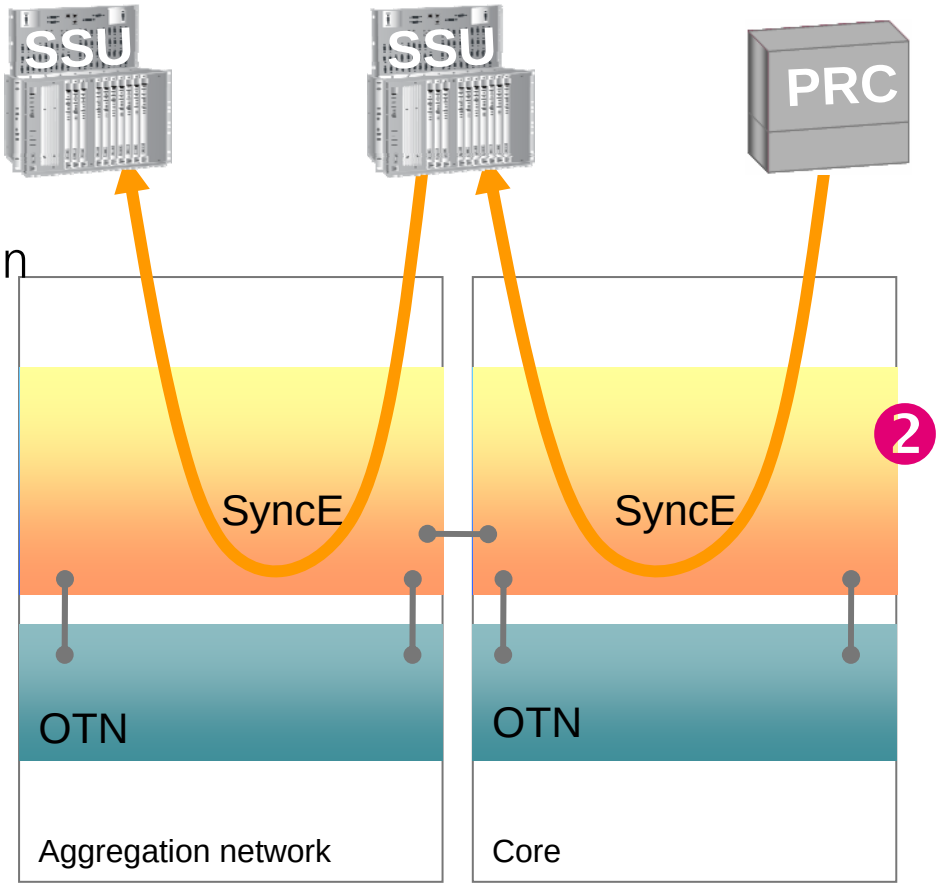
PM Performance Management System based on SSU data, developed by our own experts ☑

TDM to NGN migration challenges

❷ Synchronization transport migration: SDH to SyncE [1/2]

- Physical Layer Synchronization works well for E1 and SDH
- Ethernet Physical Layer Synchronization = SyncE follows the same principle
- SyncE
  - ..... is very stable
  - ..... is independent from any packet delay or delay variation

➥ is going to be the basic principle for Deutsche Telekom's NGN synchronization network



TDM to NGN migration challenges

❷ Synchronization transport migration: SDH to SyncE [2/2]

SyncE status

- Standardization: Specified in ITU-T G.8261, G.8262, G.8264
  Open: SyncE line jitter and wander measurements acc. to ITU-T
  - ☞ Jean-Loup Ferrant: Standards Update – ITU-T
  - ☞ Andreas Alpert: Jitter and Wander measurements in SyncE Networks
- Market situation: Chip sets available, systems offered and shown by vendors, at least on the road map

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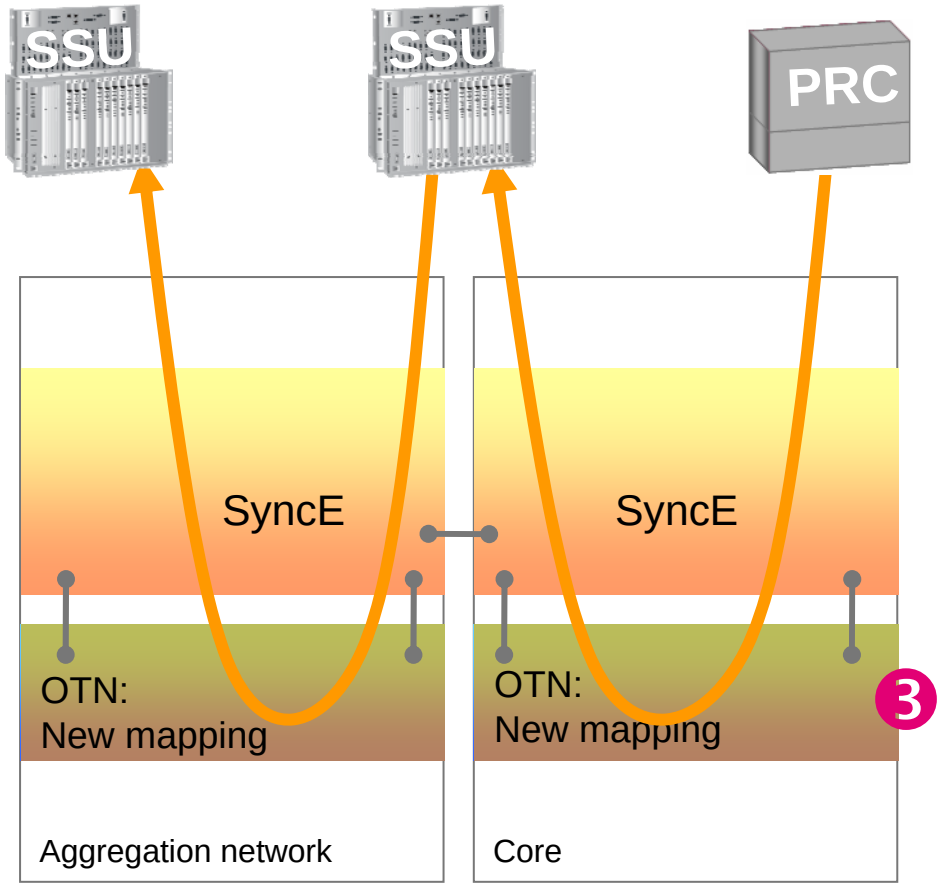
- ➥ Technical Specification: 1st step: Required for MSAN (Multi-Service Access Node) and AGS (Aggregation Switch),
  2nd step: Core Routers, SSUs, Circuit Emulation, ...
- ➥ Validation: Successfully done for first systems
- ➥ Network implementation: Planned for 2009

TDM to NGN migration challenges

❸ Optical transport migration: SyncE over OTN [1/2]

- SDH synchronization over OTN works well
- SyncE synchronization over OTN is a must
- New OTN mapping needed
- Learning from E1 over SDH:
  Mapping with higher stuffing rate needed;
  to have mapping jitter with higher frequency;
  which makes filtering easier



TDM to NGN migration challenges
❸ Optical transport migration: SyncE over OTN [2/2]

OTN status for SyncE transparency

- Standardization: Addressed in ITU-T Study Group 15, Question 11, planned for 2009
  "There is a consent in SG15Q11 to support SyncE, all new mappings aiming at minimum jitter."
- Market situation: Waiting for standards, waiting for the new mapping specification

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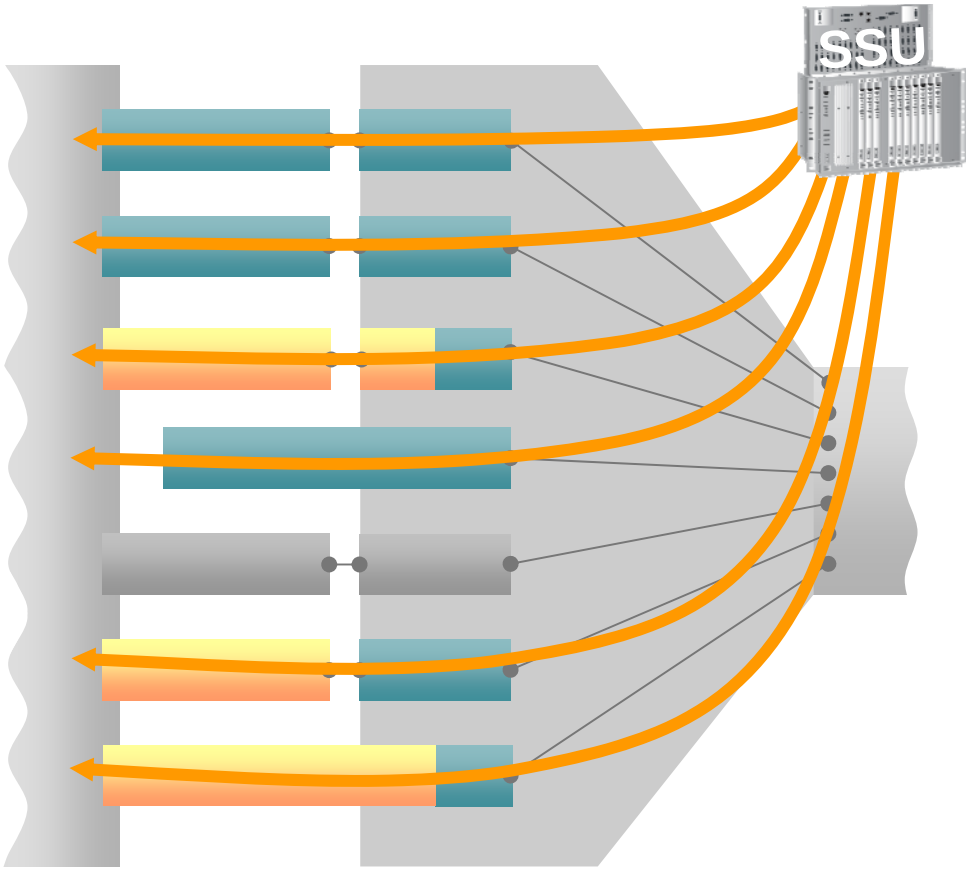
- ➥ Technical Specification: Planned
- ➥ Validation: Planned
- ➥ Network implementation: Planned

TDM to NGN migration challenges

❹ Access migration: Example Sync over xDSL [1/3]



Driver:

- Customers like mobile operators are going to migrate from E1 links to xDSL Synchronization is still needed for BTS/NodeB/ eNB
- E1 leased lines to be produced via NGN

TDM to NGN migration challenges

❹ Access migration: Example Sync over xDSL [2/3]

Options:

1. Synchronization over ADSL2 / VDSL2 using NTR (Network Timing Reference) mechanism acc. to ITU-T G.992.3 / G.993.2

   Because of cross-talk => NTR over free running ADSL/VDSL line signal is needed

   DSLAM & CPE have to support it

   Status:
   - Supported by chipsets (e. g. Infineon)
   - ↪ Required by Deutsche Telekom, offered by vendors

2. SDSL line signal to be synchronized from frequency synchronization network

   Status:
   - Available
   - ↪ Required by Deutsche Telekom, offered by vendors

3. Vendor specific solutions using packet streaming

   Status:
   - Available

TDM to NGN migration challenges

❹ Access migration: Example Sync over xDSL [3/3]

4. Software based Network Time Protocol (NTP)
   NTP packets used for frequency synchronization
   Status:
   - Available

5. Improved NTP ("Carrier Class") with Hardware time stamping
   Status:
   - Available

6. Hardware supported Precision Time Protocol (PTPv.2)
   Status:
   - PTPv.2 specified in IEEE1588,
   - Standardized application profiles have to be defined
   - First PTPv.2 solutions available, first inter-op works

   ↪ Option for eNB (LTE MBSFN)

Can be used for frequency and time or phase synchronization, Needed for LTE MBSFN (Mobile Long-Term Evolution, Multi-Media Broadcast over Single Frequency Network)

- ☞ Silvana Rodrigues: Standards Update - IEEE
- ☞ Laurent Montini: Standards Update - IETF
- ☞ Several ITSF2008 presentations dealing with PTPv.2
- ☞ Several ITSF2008 presentations dealing with LTE MBSFN synchronization

Additional issues

❺ New options with Galileo

Pro's:

- GNSS simplifies synchronization network
- Advantage of combined Galileo/GPS receivers:
  More satellites lead to better coverage
- Galileo offers guaranteed services
  (... to be paid for ...)

Con's:

- Still antenna installation costs
- Still jamming risk

27-April-2008:

The second Galileo demonstration satellite, GIOVE-B, successfully lifted off in the early morning hours of April 27 and subsequently reached its target orbit, the European Space Agency (ESA) says.

Additional issues

❺ New options with Galileo

Considerations:

1. GNSS/GPS is currently the only way to synchronize mobile technologies like TDD or future LTE MBSFN (but PTPv.2 is coming :-)
2. Option to use a non-redundant terrestrial synchronization network plus Galileo/GPS as 2nd source

➥ could be an option for Deutsche Telekom, this has not been decided yet

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❻ Frequency and time synchronization belong together

Frequency:

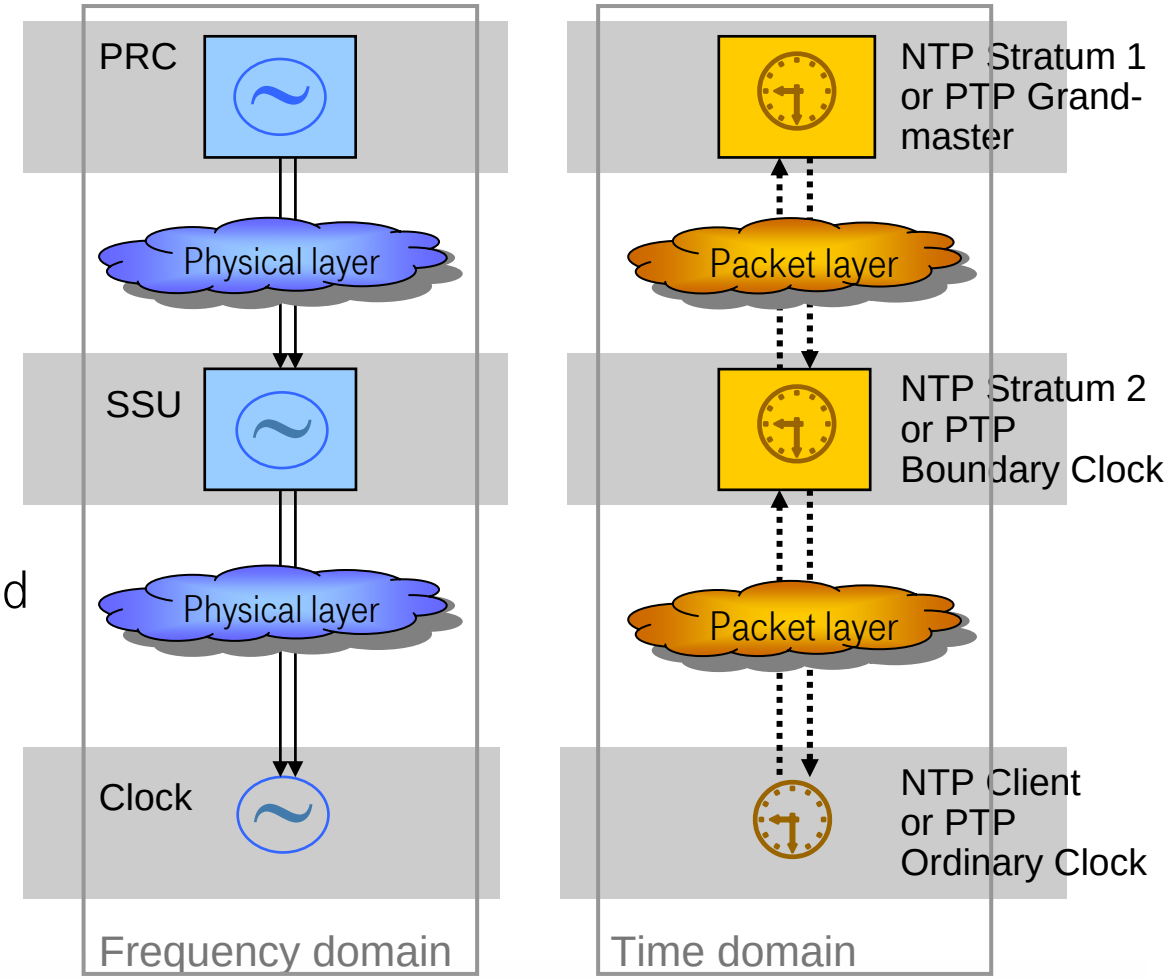
- Frequency coming from a primary cesium clock (cesium defines the second) is basis for time
- Typical output signals: 5/10 MHz and 1 pps (pulse per second)

Time:

- 1 pps signal has to be aligned with time scale TAI or UTC

At the moment:

- Frequency is supplied by a synchronization network
- Time is supplied separately by NTP or PTP



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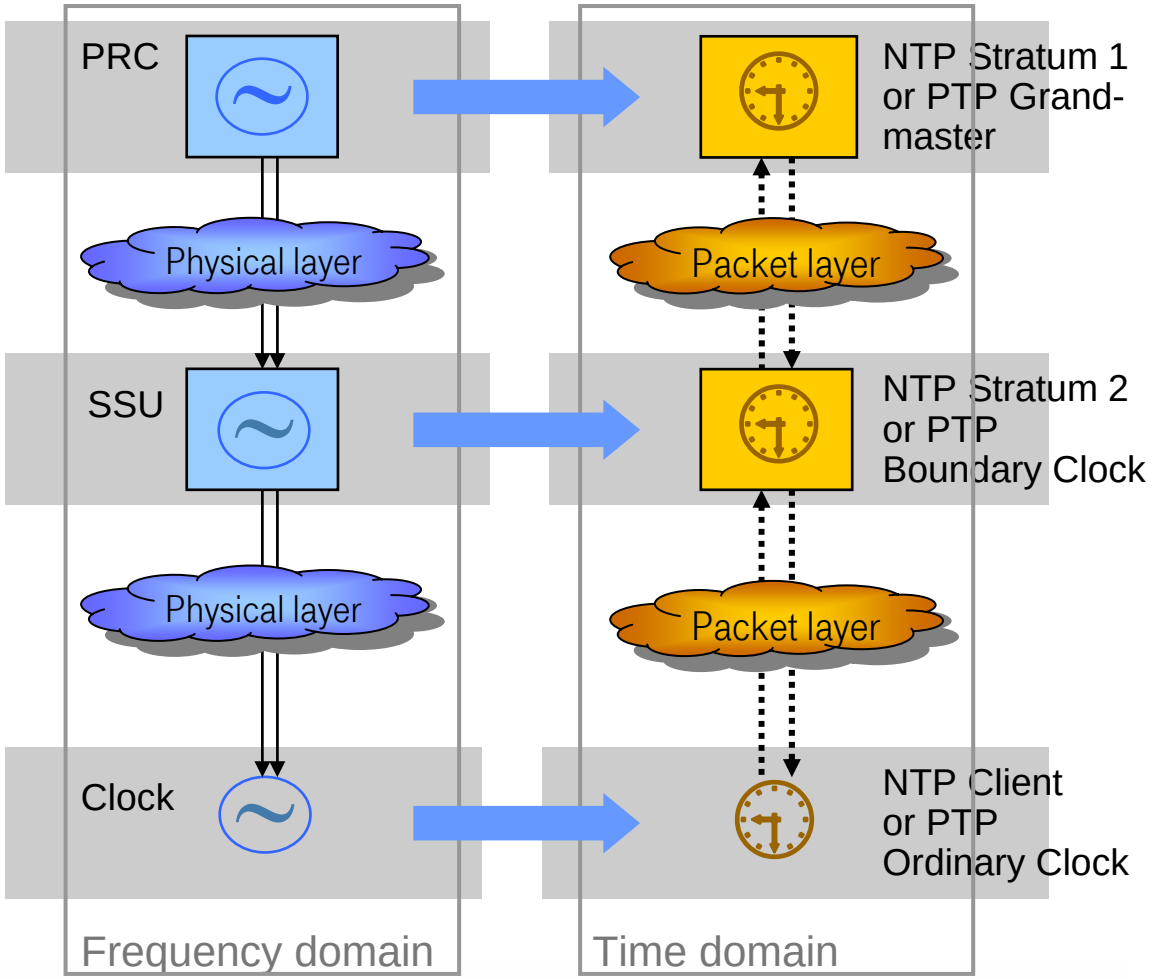
❻ Frequency and time synchronization belong together

- Time supply can profit from a high quality frequency synchronization network
- Basic frequency for time supply comes from frequency synchronization network
- Option: All clocks for time can be driven by external frequency:
  PTPv.2 Grandmaster
  PTPv.2 Boundary Clock
  PTPv.2 Ordinary Slave Clock
  any NTP Strata level clock



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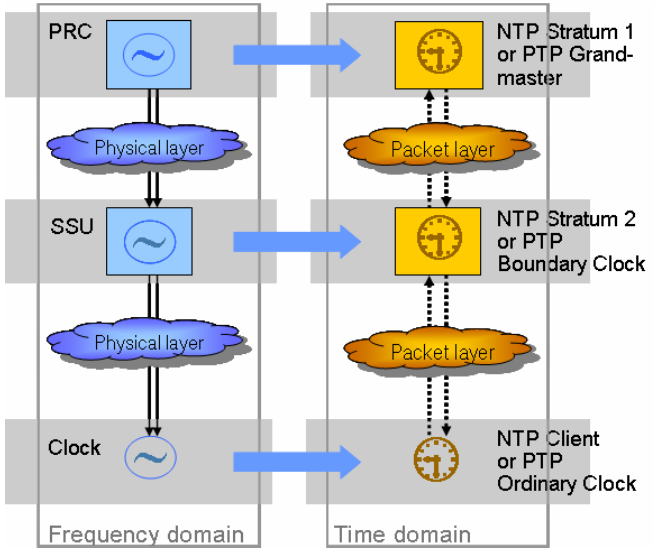
❻ Frequency and time synchronization belong together

Advantage:

- No packet traffic caused effects like delay variation for clock steering



Options:

- ➥ Better quality of time supply
- ➥ Better way to steer Boundary Clocks allows more flexibility for the PTP supply architecture
- ➥ Usage of a cheaper PTP Ordinary Clock at PTP Slave
- ➥ Less PTP packet traffic to reach the same results
- ➥ To reduce the stabilization phase (e. g. 1 min instead of 15 min)

☞ See Yakuv Stein @ ITSF2007

☞ See Deutsche Telekom Contribution @ ITU-T SG15Q13

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Summary

Timing and Synchronization: The Journey from TDM to Next Generation Networks

Deutsche Telekom way:

- Physical layer synchronization as most stable way for frequency synchronization will be used
  - SyncE as basis for synchronization network
  - SyncE for aggregation switch and multi-service access node first
- New OTN mappings for SyncE synchronization over OTN
- Access migration:
  - Different solutions acc. to different access system and different quality needs
  - E. g.: NTR (xDSL), or PTPv.2 or SyncE
- New options with Galileo to be considered
- Frequency and time synchronization growing together
  - like an Aggregation Switch PTP Boundary Clock - frequency steered by local SSU
  - or like a SSU with a Boundary Clock module inside

Thank you for your attention!

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Abbreviations

ADSL	Asymmetric Digital Subscriber Line
ATM	Asynchronous Transfer Mode
BC	Boundary Clock (PTP)
BTS	Base station (Mobile)
CGE	Carrier Grade Ethernet
CE	Circuit Emulation
CPE	Customer Premises Equipment
DSL	Digital Subscriber Line
EEC	Ethernet Equipment Clock
eNB	enhanced NodeB (for LTE)
GATE:	German Galileo Test and Development Environment
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GTFS	Workshop on Time and Frequency Services with Galileo
IP-MPLS	Internet Protocol – Multi-Protocol Label Switching
ISDN	Integrated Services Digital Network
LTE	Long Term (Mobile technology)
MBSFN	Multi-Media Broadcast over a Single Frequency Network (Mobile technology)
MTIE:	Maximum Time Interval Error
NGN	Next Generation Network
NTP	Network Time Protocol
ntpd	NTP daemon
NTR	Network Timing Reference
OTN	Optical Transport Network
PBB-TE	Provider Backbone Bridging – Traffic Engineering
PBX	Private Branch Exchange
POTS	Plain Old Telephone Service
PM	Performance Management
pps	Pulse per Second
PTF	Galileo Precise Timing Function
PTP	Precision Time Protocol
SEC	Synchronous (SDH) Equipment Clock
SDH	Synchronous Digital Hierarchy
SDSL	Symmetrical DSL
SSU	Synchronization Supply Unit
TAI	Temps Atomique International
TDD	Time Division Duplex
TDM	Time Division Multiplex
UTC	Universal Time Coordinated
VDSL	Very high data rate DSL
SyncE	Ethernet Physical Layer Synchronization acc. to ITU-T G.8261, 8262, 8264
WDM	Wavelength Division Multiplexing
WiMAX	Worldwide Interoperability for Microwave Access