

# 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:

- ① Synchronization network migration: PRC, SSU and SEC
- ② Synchronization transport migration: From SDH to SyncE (... from SEC to EEC)
- ③ Synchronization over OTN: From SDH to SyncE transparency
- ④ Access migration: Example: Sync over xDSL

Additional issues:

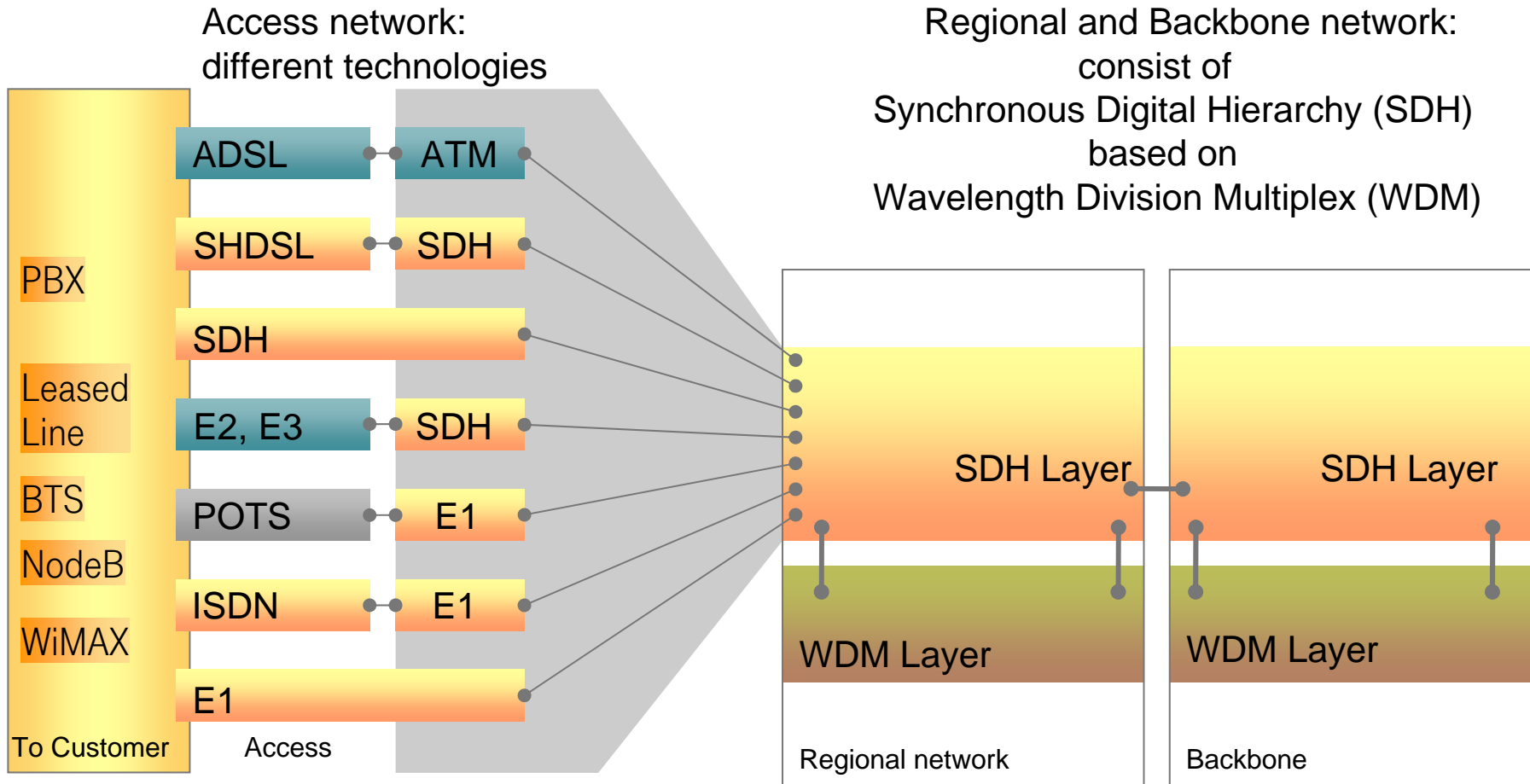
- ⑤ New options with Galileo
- ⑥ Frequency and time synchronization belong together

Summary



# From TDM to NGN – An high-level overview

## TDM



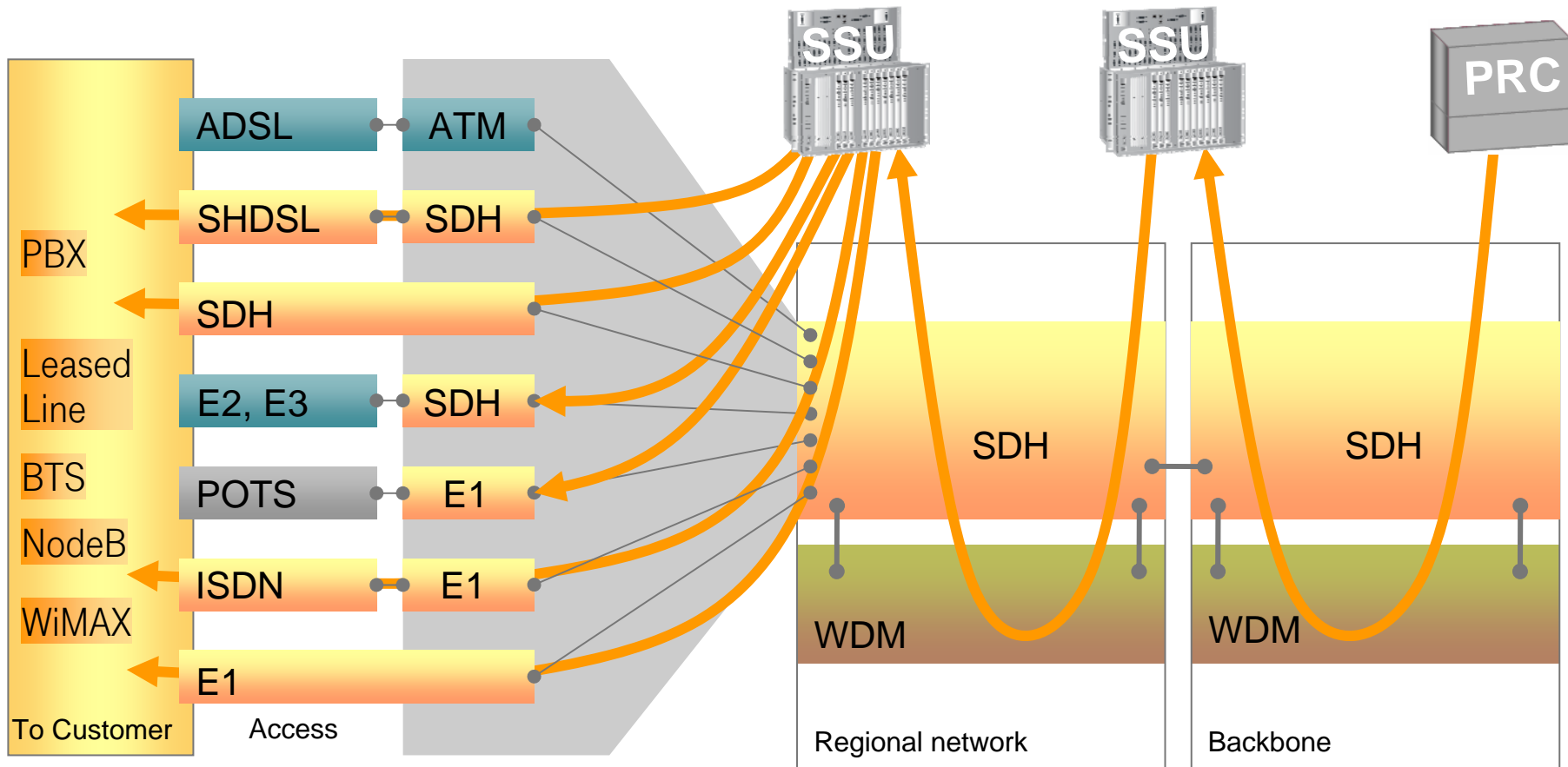
*Examples, not complete*



Asynchronous    
  Synchronized    
  Sync transparent    
  n/a

# From TDM to NGN – An high-level overview

## TDM and its frequency synchronization



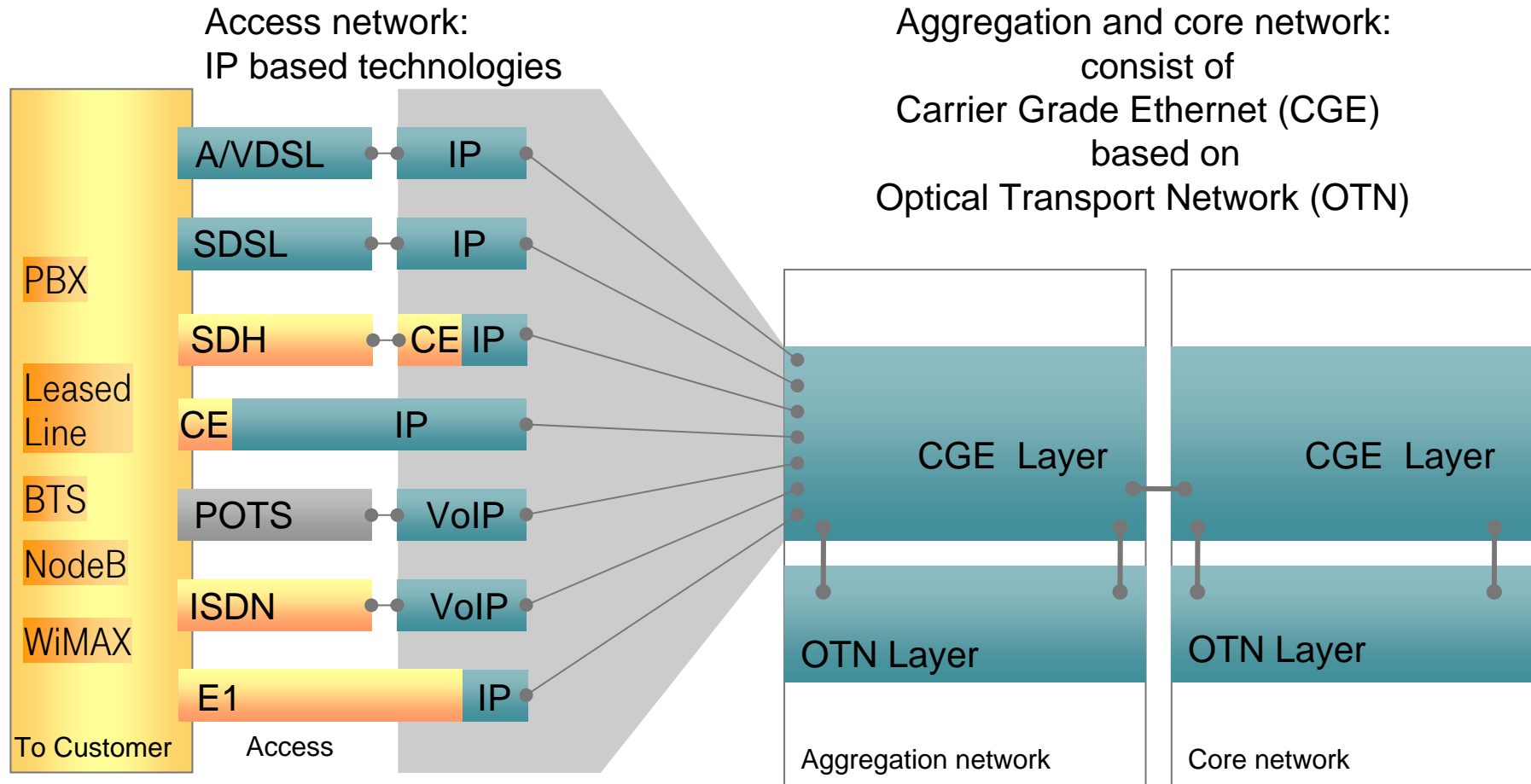
*Examples, not complete*



Asynchronous
  Synchronized
  Sync transparent
  n/a

# From TDM to NGN – An high-level overview

## NGN

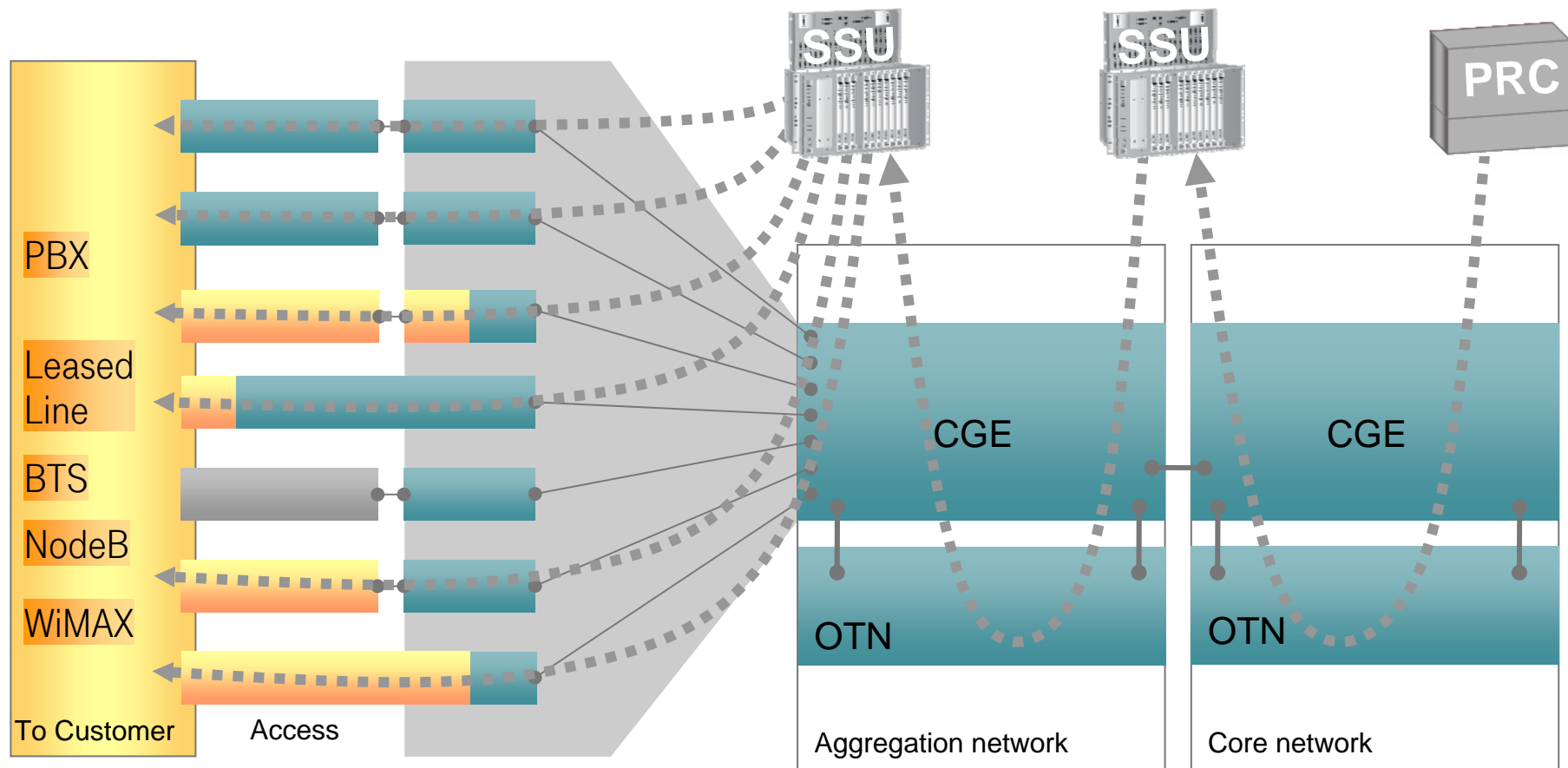


*Examples, not complete*



# From TDM to NGN – An high-level overview

## NGN and its frequency synchronization – the problem



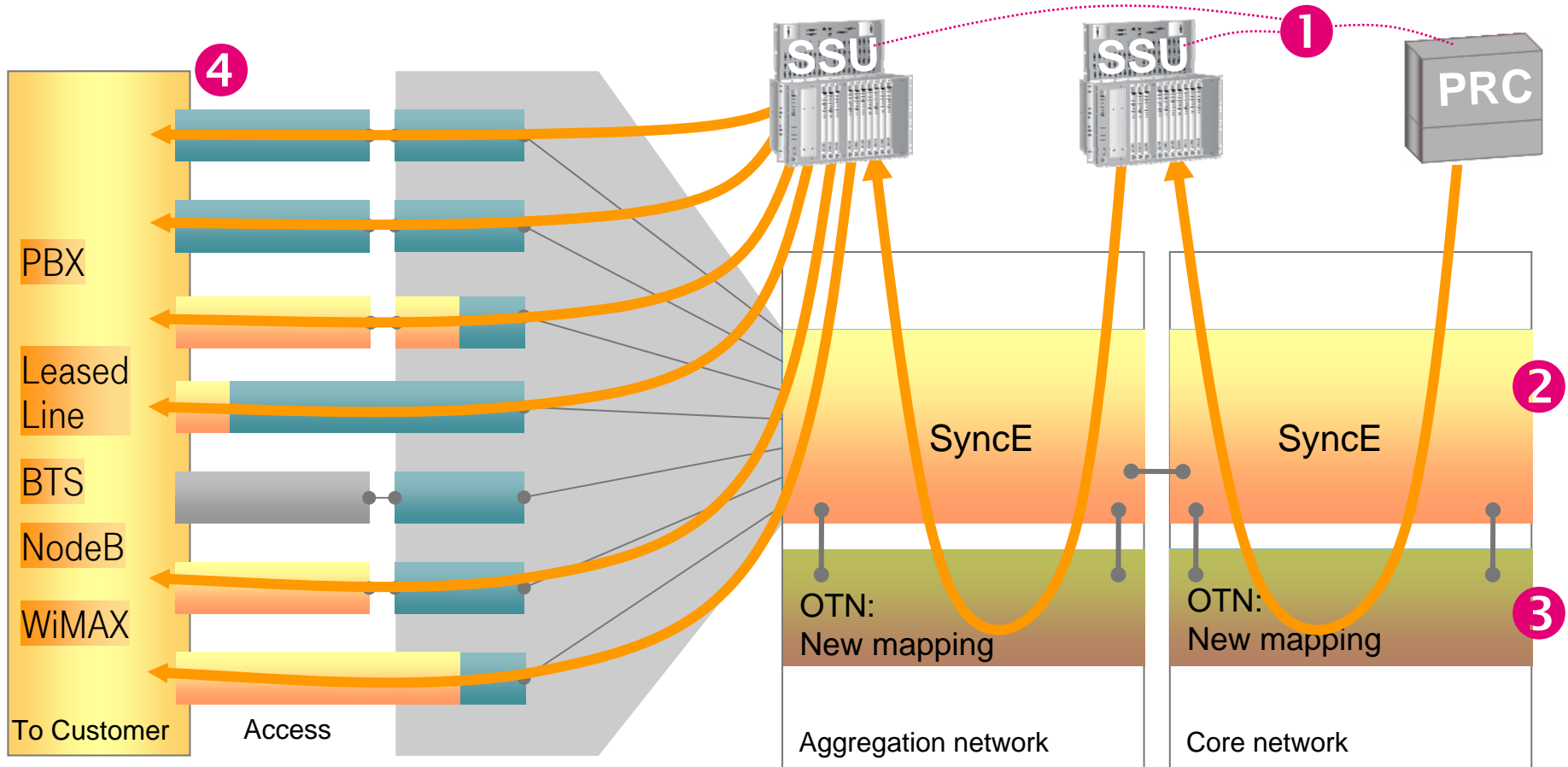
*Examples, not complete*



Asynchronous
  Synchronized
  Sync transparent
  n/a

# From TDM to NGN – An high-level overview

## NGN and its frequency synchronization – the solution



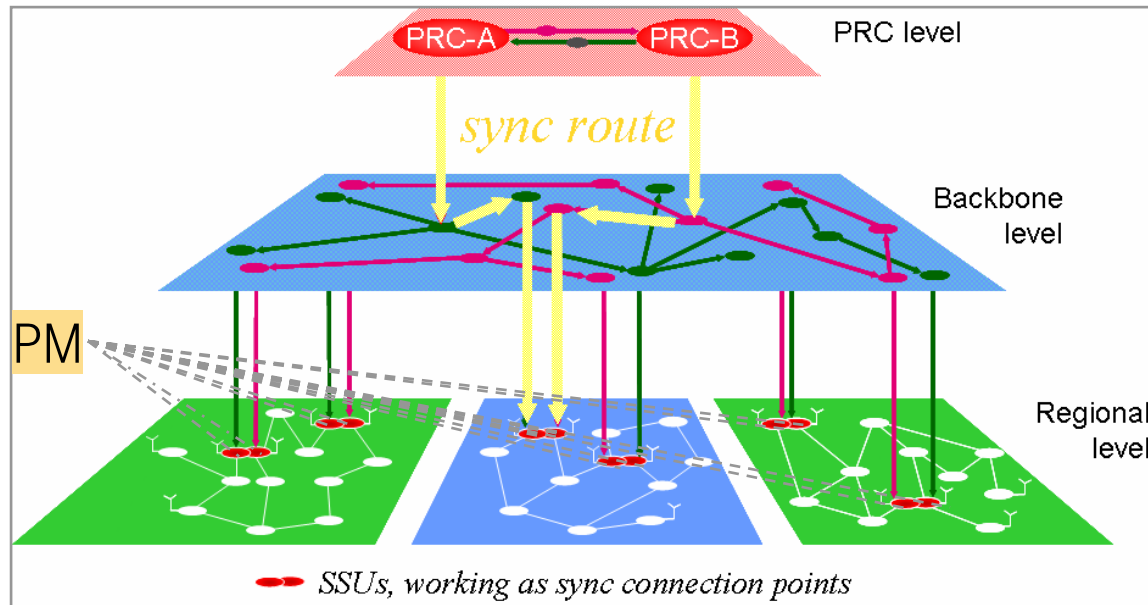
*Examples, not complete*



Asynchronous   Synchronized   Sync transparent   n/a

# TDM to NGN migration challenges

## 1 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  $1 \mu\text{s}/\text{day}$ )

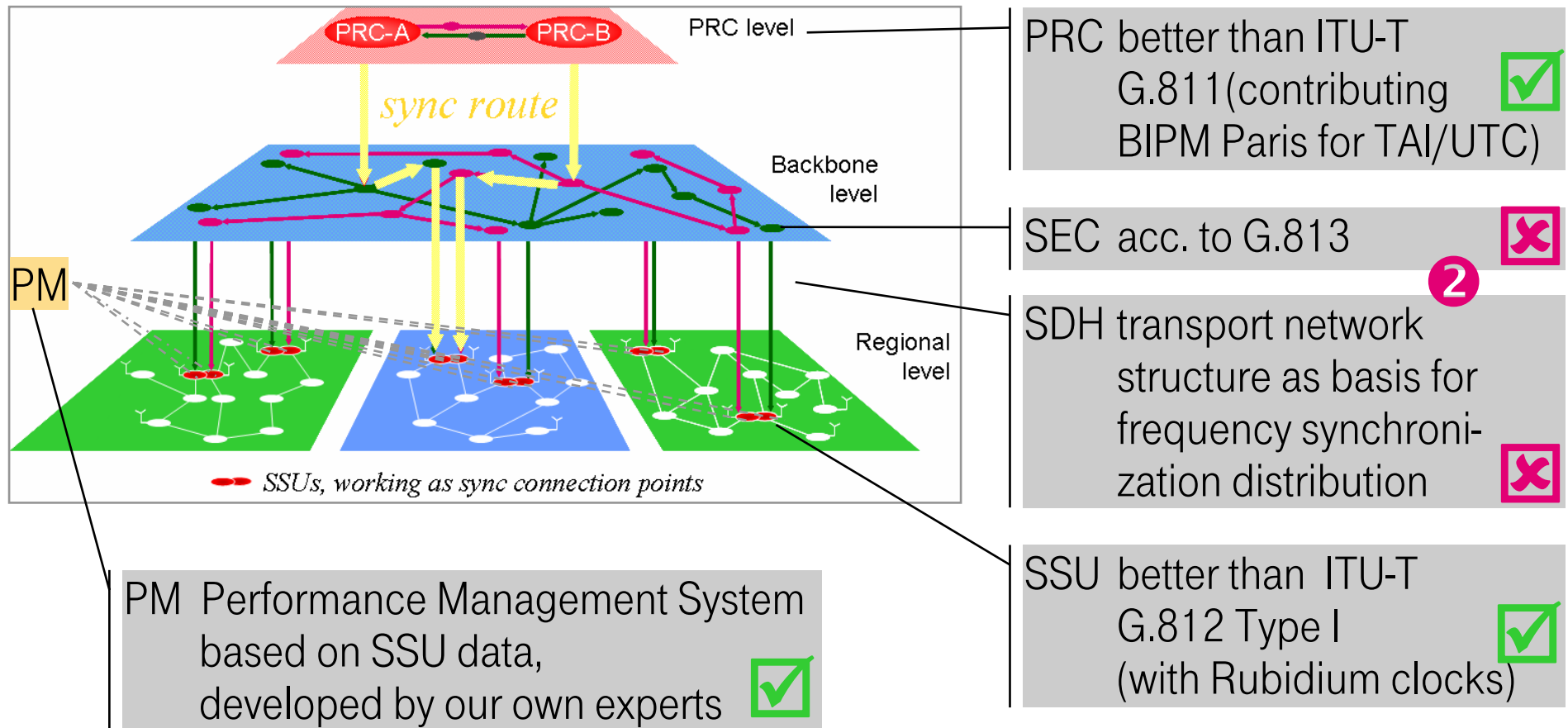
Details: Deutsche Telekom @ ITSF2004: 'The new Synchronization Network of T-Com'





# TDM to NGN migration challenges

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



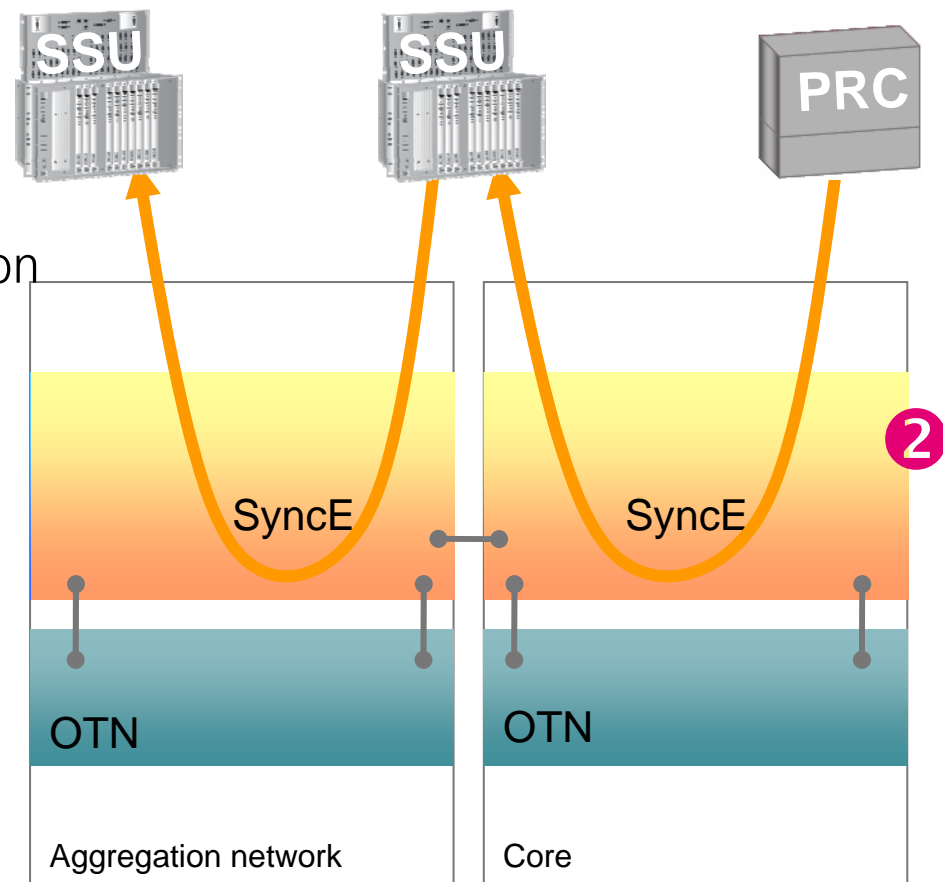
# TDM to NGN migration challenges

## ② 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

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



# TDM to NGN migration challenges

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

### SyncE status

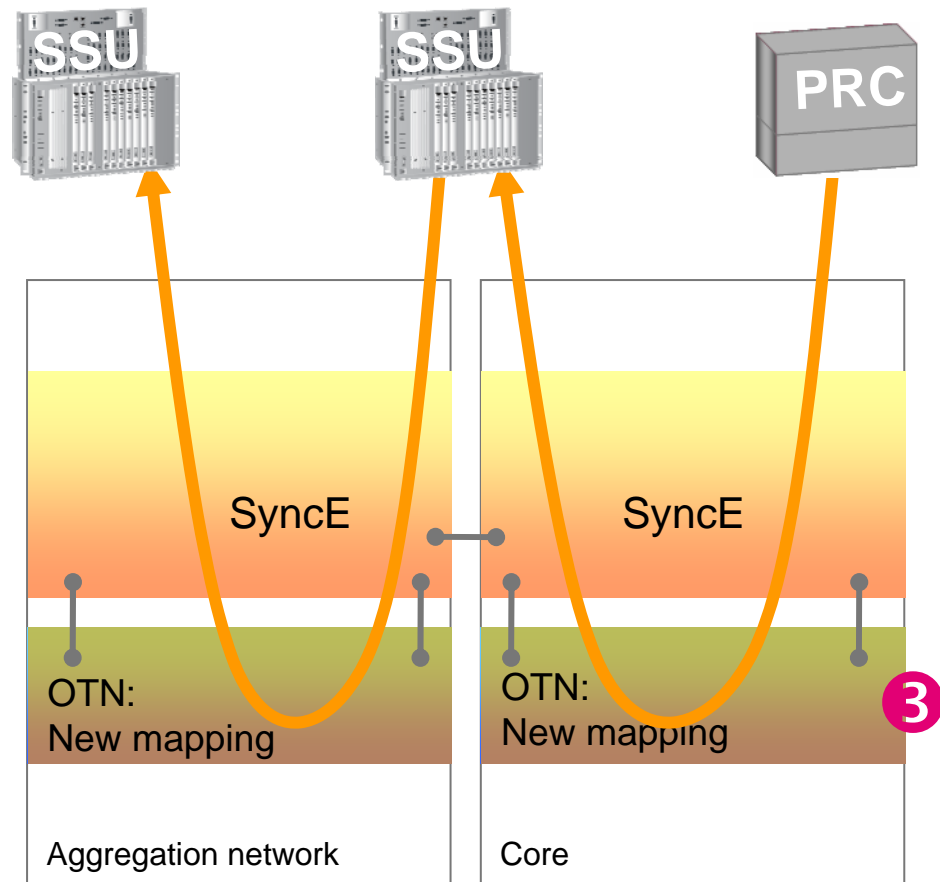
- Standardization: Specified in ITU-T G.8261, G.8262, G.8264  
Open: SyncE line jitter and wander measurements  
acc. to ITU-T
    - ☞ Jean-Loup Ferrant: Standards Update – ITU-T
    - ☞ Andreas Alpert: Jitter and Wander measurements in SyncE Networks
  - Market situation: Chip sets available, systems offered and shown by vendors, at least on the road map
- 
- ↪ Technical Specification: 1<sup>st</sup> step: Required for MSAN (Multi-Service Access Node) and AGS (Aggregation Switch),  
2<sup>nd</sup> step: Core Routers, SSUs, Circuit Emulation, ...
  - ↪ Validation: Successfully done for first systems
  - ↪ Network implementation: Planned for 2009



# TDM to NGN migration challenges

## 3 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

## ③ Optical transport migration: SyncE over OTN [2/2]

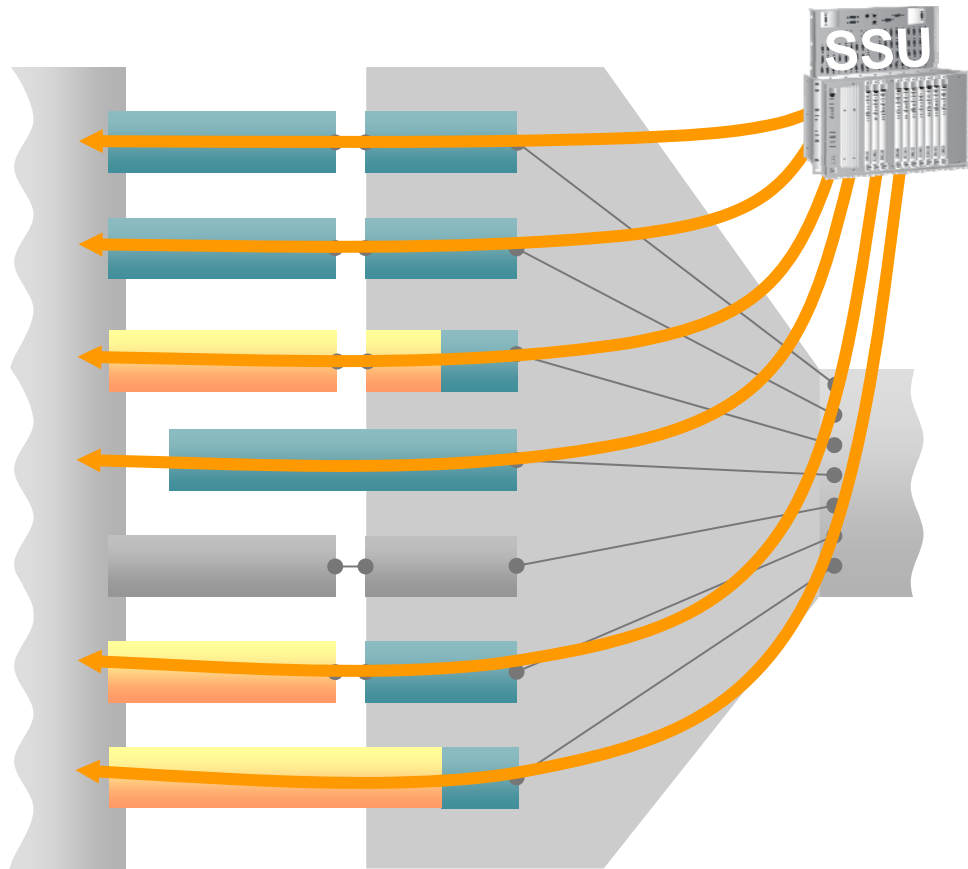
### OTN status for SyncE transparency

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



# TDM to NGN migration challenges

## ④ 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

## ④ 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

## ④ 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

### 5 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

### 5 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 2<sup>nd</sup> source
- 
- ↪ could be an option for Deutsche Telekom, this has not been decided yet



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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.



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## ⑥ Frequency and time synchronization belong together

Frequency:

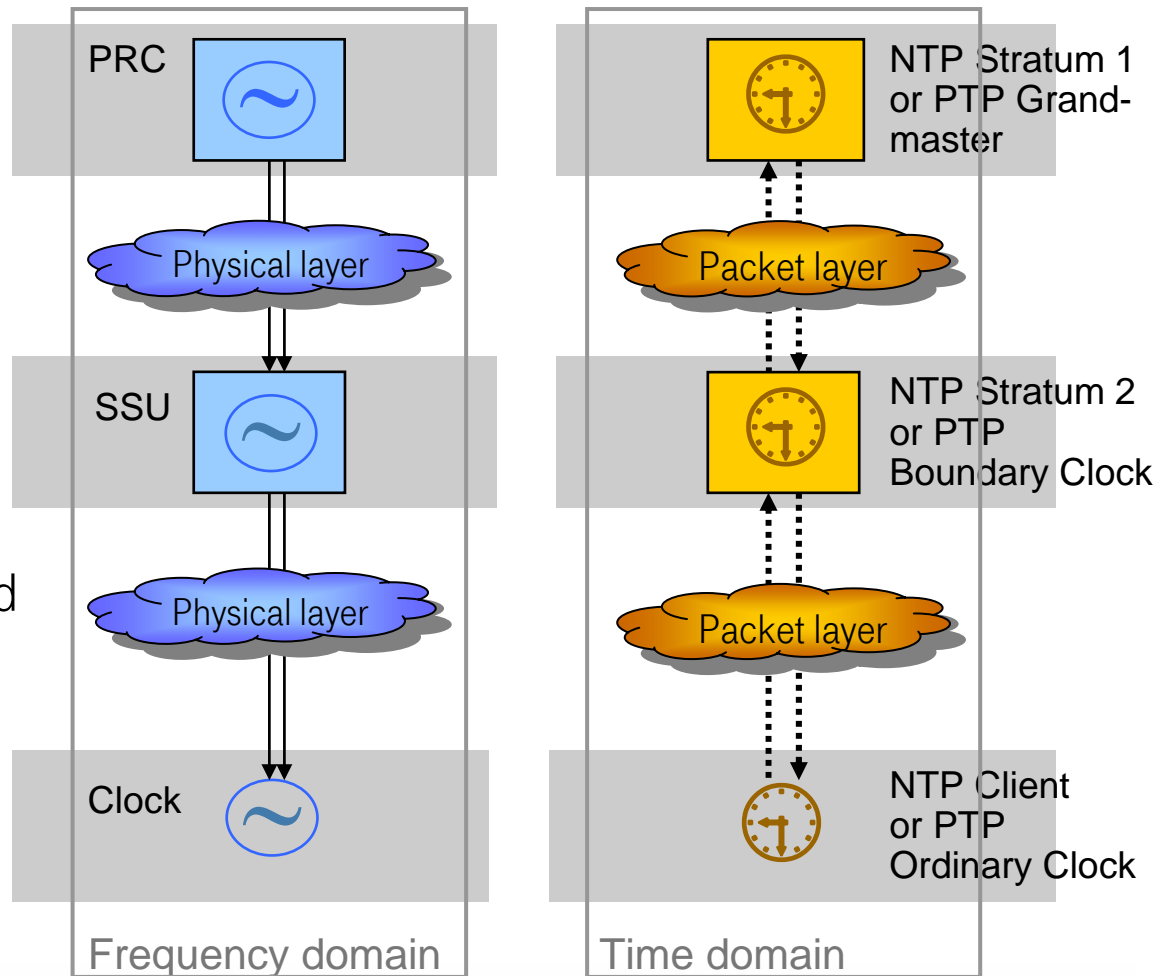
- Frequency coming from a primary cesium clock (cesium defines the second) is basis for time
- Typical output signals: 5/10 MHz and 1 pps (pulse per second)

Time:

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

At the moment:

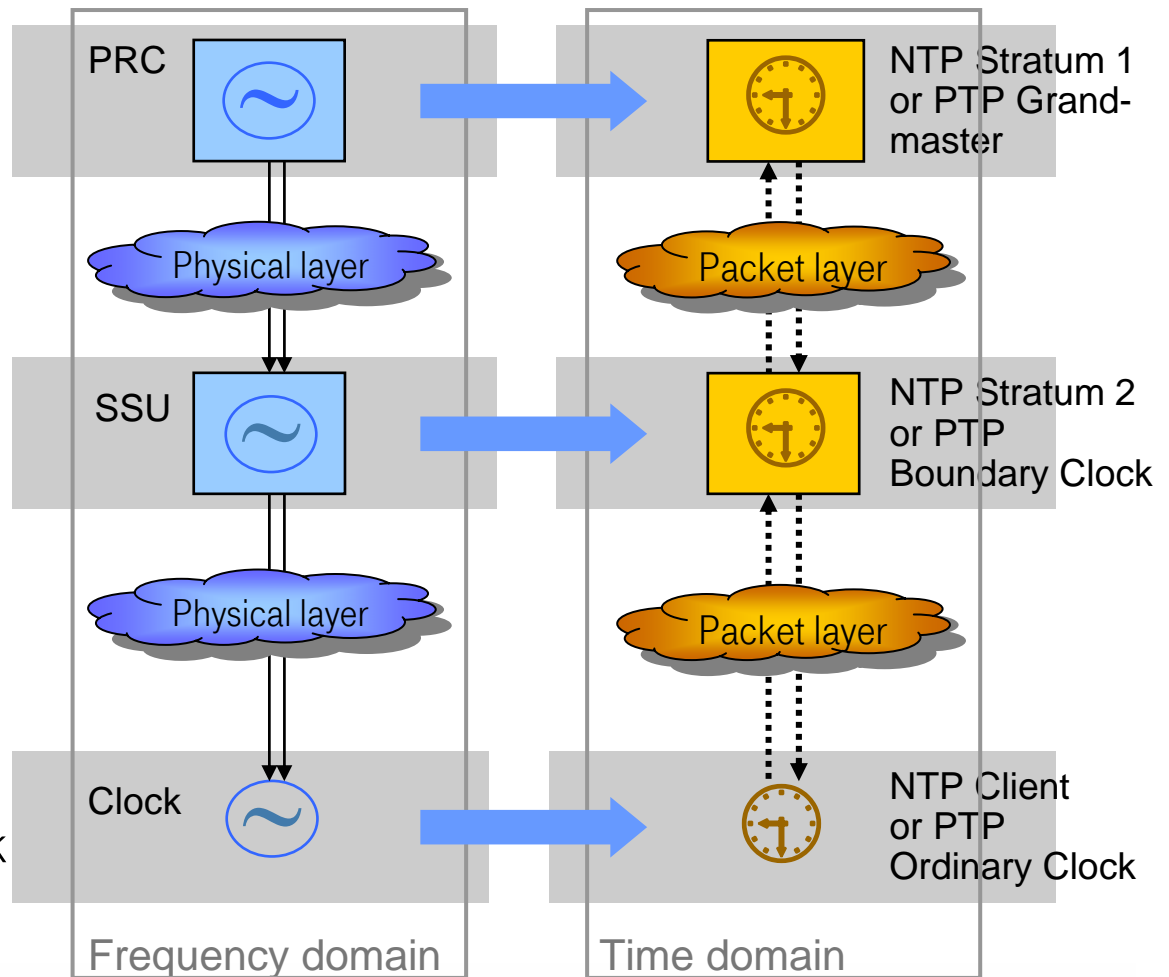
- Frequency is supplied by a synchronization network
- Time is supplied separately by NTP or PTP



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## ⑥ 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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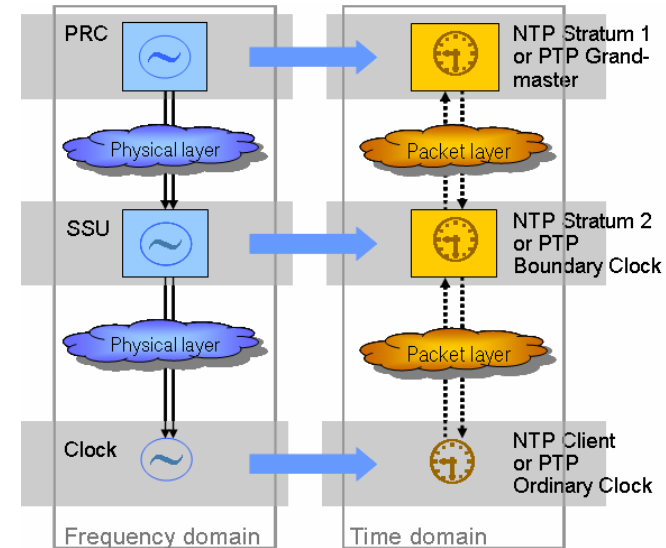
## ⑥ Frequency and time synchronization belong together

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

