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Smooth Evolution Path from Legacy to NGN Synchronization

Dominik Schneuwly

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Outline

- Drivers of the evolution
- Dimensions of the evolution
- Evolution starting points
- Evolution phases and end points
- Evolution path examples
- Conclusions

Driver of the evolution

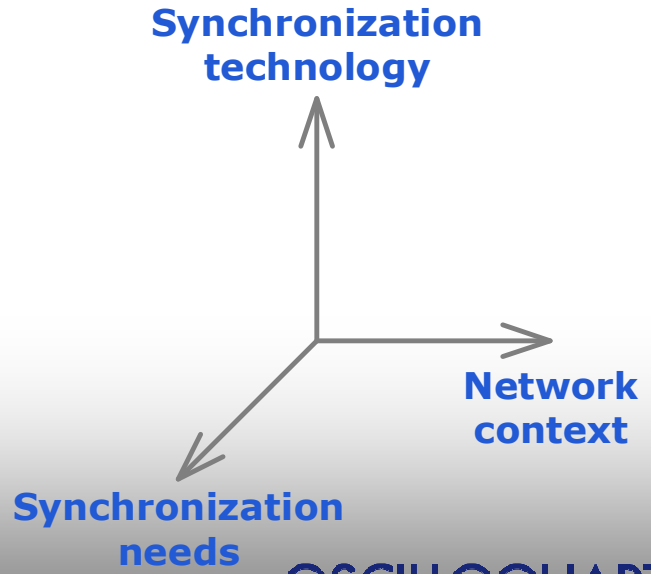
- Network technology evolution from TDM to packet-switched networks, and from fixed to fixed & mobile end sytems

- Synchronization in the past:
  - Driver: TDM switching (telephony) and transmission (SDH)
  - Reasons: limit under- and overflowing of frame buffers, allow crossconnecting (SDH)
  - Requirements: frequency, accuracy $1 \cdot 10^{-11}$ (relative freq. acc.)

- Synchronization at present and in the future:
  - Driver: mobile base stations, e.g. 2G BTS, 3G Node B, 4G eNB
  - Reasons: successful call handover
    efficient use of sparse spectrum & channel capacity
    etc.
  - Requirements: frequency (1.6E-8) and phase (1.5 µs → hundreds ns)

Dimensions of the evolution

- Change in synchronization needs
  - Old: frequency for the entire network (1E-11)
  - New: frequency (1.6E-8) and phase (1.5 µs → hundreds ns) for the network edge
- Change in network technology
  - Old: TDM networks (PDH, SDH)
  - New: packet-switched networks
    - Ethernet, Synchronous Ethernet (SyncE)
    - IP, IP/MPLS
    - Etc.
- Change in synchronization technology
  - Old: SDH/SONET, E1/T1 over PDH
  - New: SyncE, PTP (IEEE 1588 v2)



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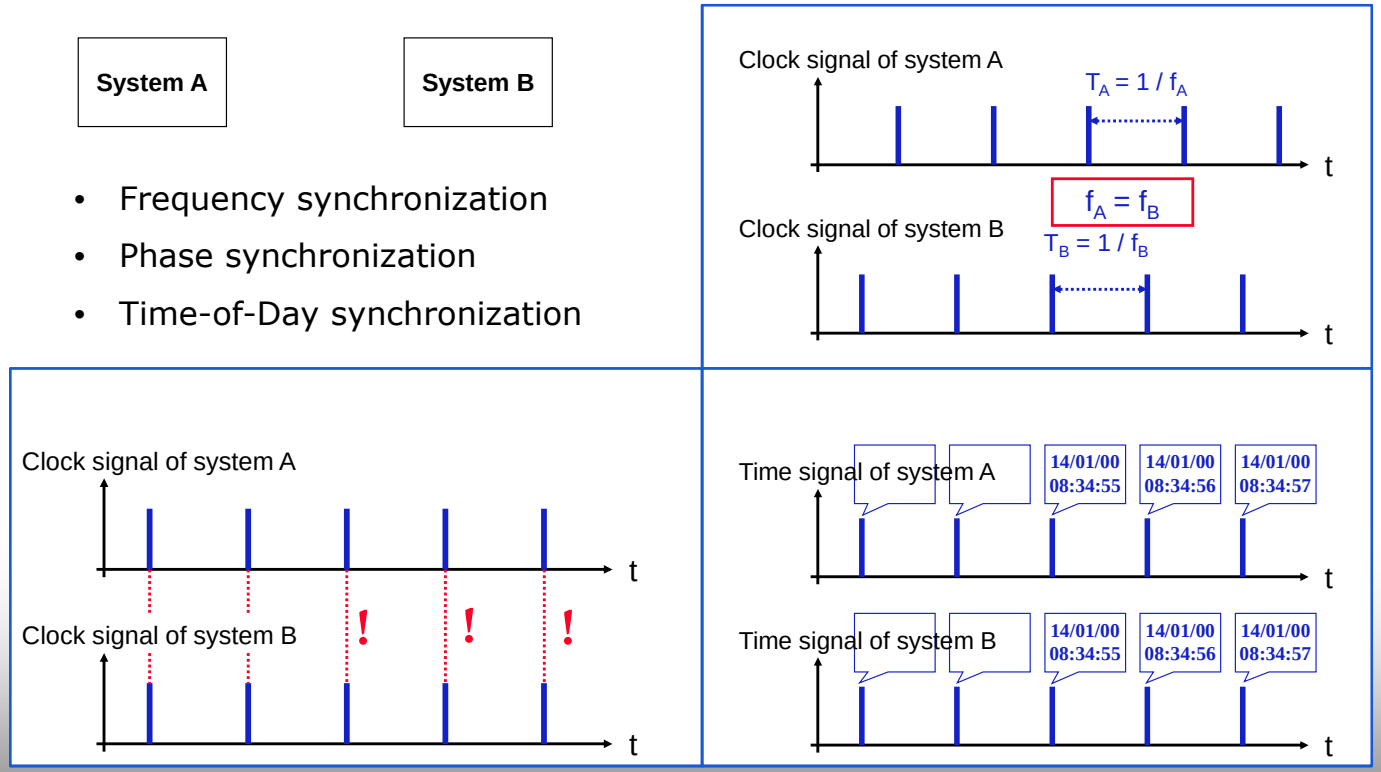
Once more: frequency, phase and time-of-day



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Frequency and phase synch. requirements

Application	Radio Interface		Backhaul	
	Frequency	Phase	Frequency	Phase
CDMA 2000	±50ppb	±3 to 10µs	GPS	GPS
GSM	±50ppb	n/a	±16ppb	n/a
WCDMA	±50ppb	n/a	±16ppb	n/a
LTE (FDD)	±50ppb	n/a	±16ppb	n/a
LTE (TDD)	±50ppb	±1.5µs	±16ppb	±1.1µs
LTE-A MBMS	±50ppb	±1 to 5µs	±16ppb	±1µs (G.8271)
LTE-A CoMP LTE-A CoMP JT	±50ppb	±1 to 5µs ± 0.5µs	±16ppb	±1.1µs < 0.5µs (?)
LTE-A eICIC	±50ppb	±1 to 3µs	±16ppb	±1.1µs

MBMS: Multimedia Broadcast Multicast Services CoMP: Coordinated Multipoint
eICIC: enhanced Inter-Cell Interference Coordination JT: Joint Transmission

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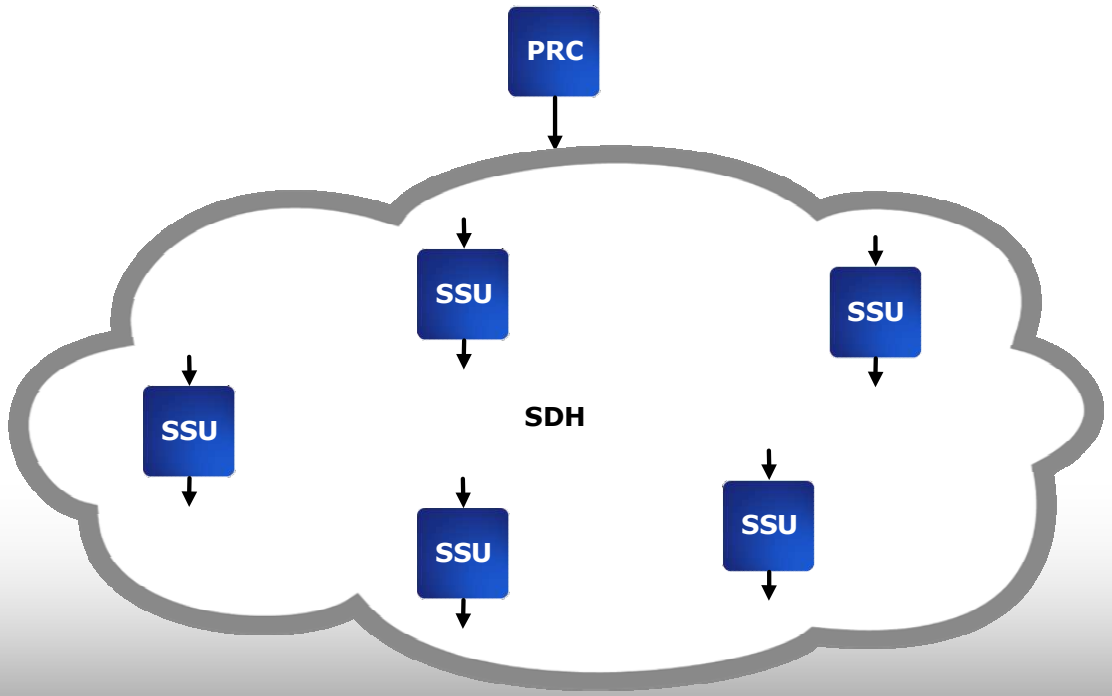
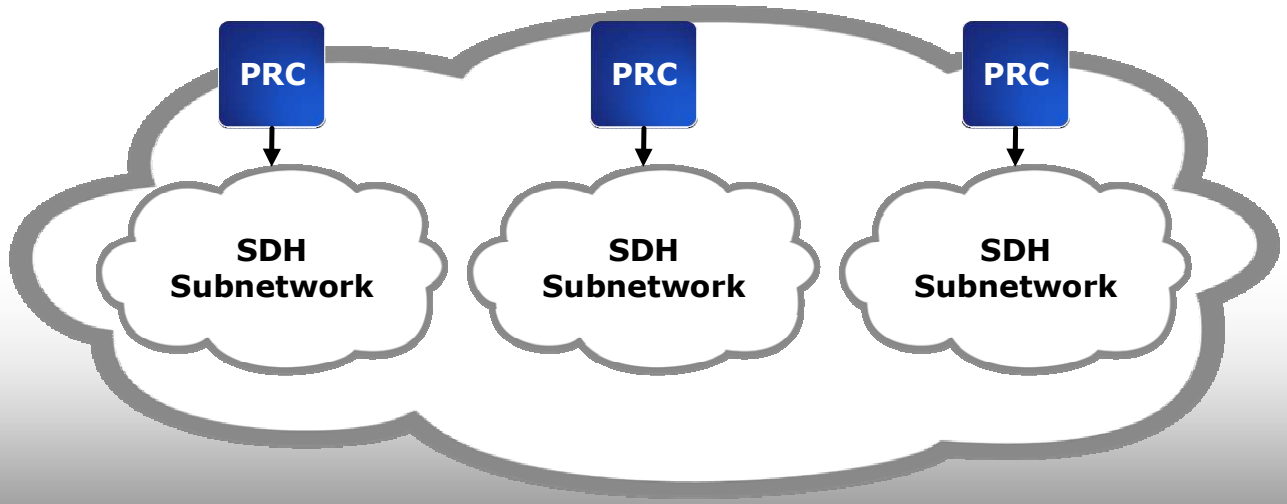
Starting point 1: central PRC

- Frequency synchronization with accuracy = 1E-11
- Generation: central PRC, typically atomic Cesium clock
- Distribution: SDH, physical layer; sometimes E1/T1 in «last mile»



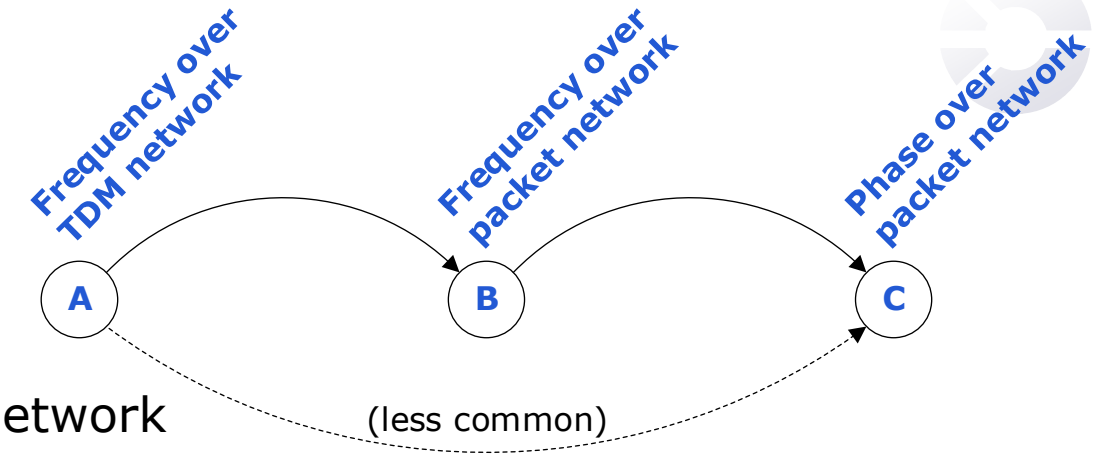
Starting point 2: distributed PRCs

- Frequency synchronization with accuracy = 1E-11
- Generation: distributed PRCs, typically GNSS receivers
- Distribution: SDH, physical layer; sometimes E1/T1 in «last mile»



Transition phases

- Main transition phases:



- A: Frequency over TDM network
  - SDH/SONET
- B: Frequency over packet network
  - SyncE
  - PTP / No Timing Support (G.8265.1)
- C: Phase over packet network
  - PTP / Full Timing Support (G.8275.1) with SyncE
  - PTP / Full Timing Support (G.8275.1) without SyncE (ITU-T: «ffs»)
  - PTP / Assisted Partial Timing Support (G.8275.2)

Many evolution scenarios

Transition A → B

B / A	SDH & PDH
SyncE	X
G.8265.1	X

Transition B → C

C / B	SyncE	G.8265.1
G.8275.1	X	X
G.8275.2	X	X

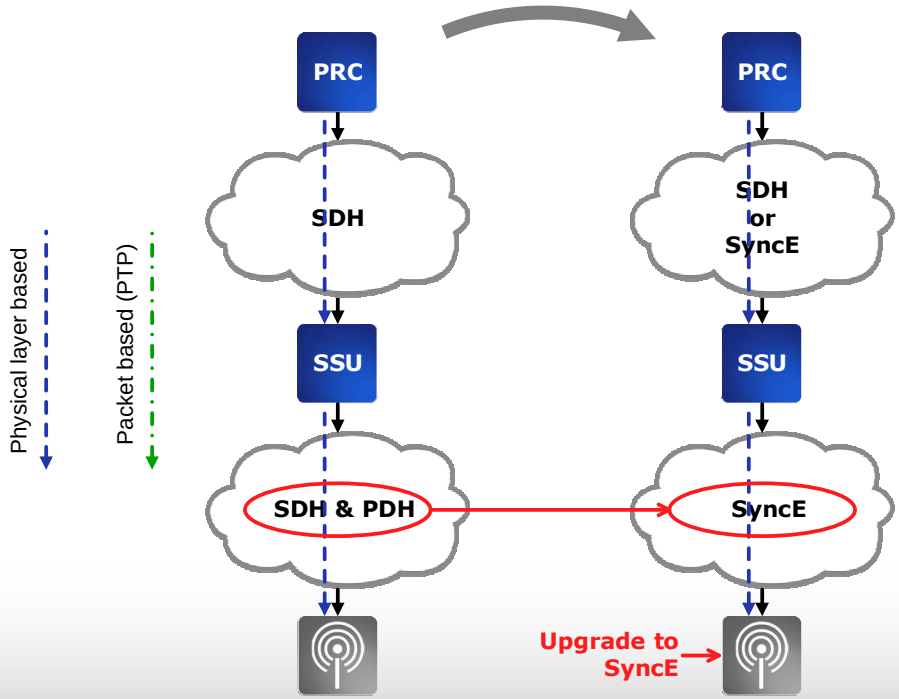
Transitions A → B → C:

SDH & PDH → SyncE → G.8275.1
SDH & PDH → SyncE → G.8275.2
SDH & PDH → G.8265.1 → G.8275.1
SDH & PDH → G.8265.1 → G.8275.2

There are more evolution scenarios than that!

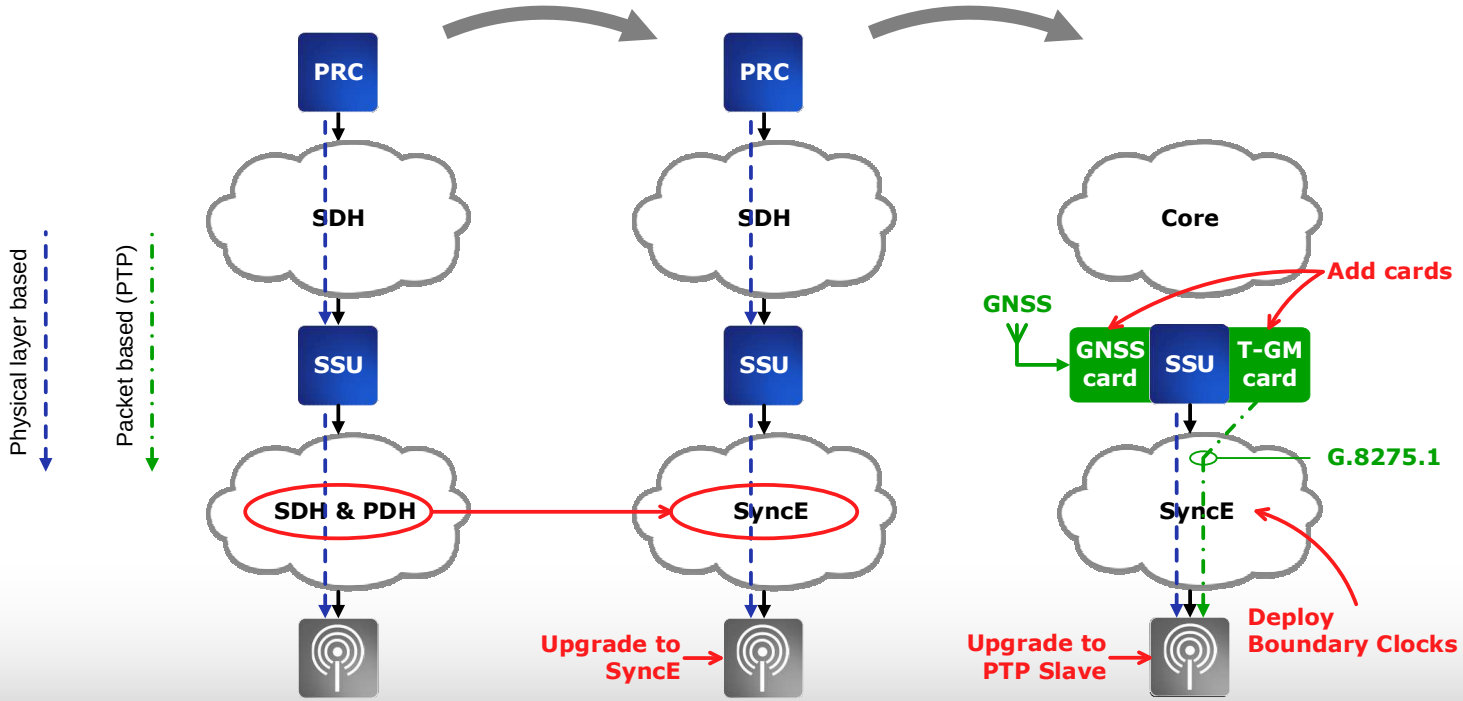
- Already mentioned: Starting point (SDH & PDH) can be with centralized or with decentralized PRCs
- There are multiple mobile systems (2G, 3G, 4G); evolution scenarios may be different for each of them
- Multiple network ownerships (mobile operator, transport provider, etc.)
- Networks with equiment from multiple vendors: different equipment roadmaps
- Some operators use CES/PWE for their 2G BTS (PDH over packet network)
- And we haven't mentioned WDM systems in conjunction with phase synchronization …
- Etc., etc.

Evolution example 1a: SDH & PDH → SyncE → G.8275.1



Leverage existing PRC and SSUs

Evolution example 1a: SDH & PDH → SyncE → G.8275.1



Leverage existing PRC and SSUs, just add cards to SSUs for phase

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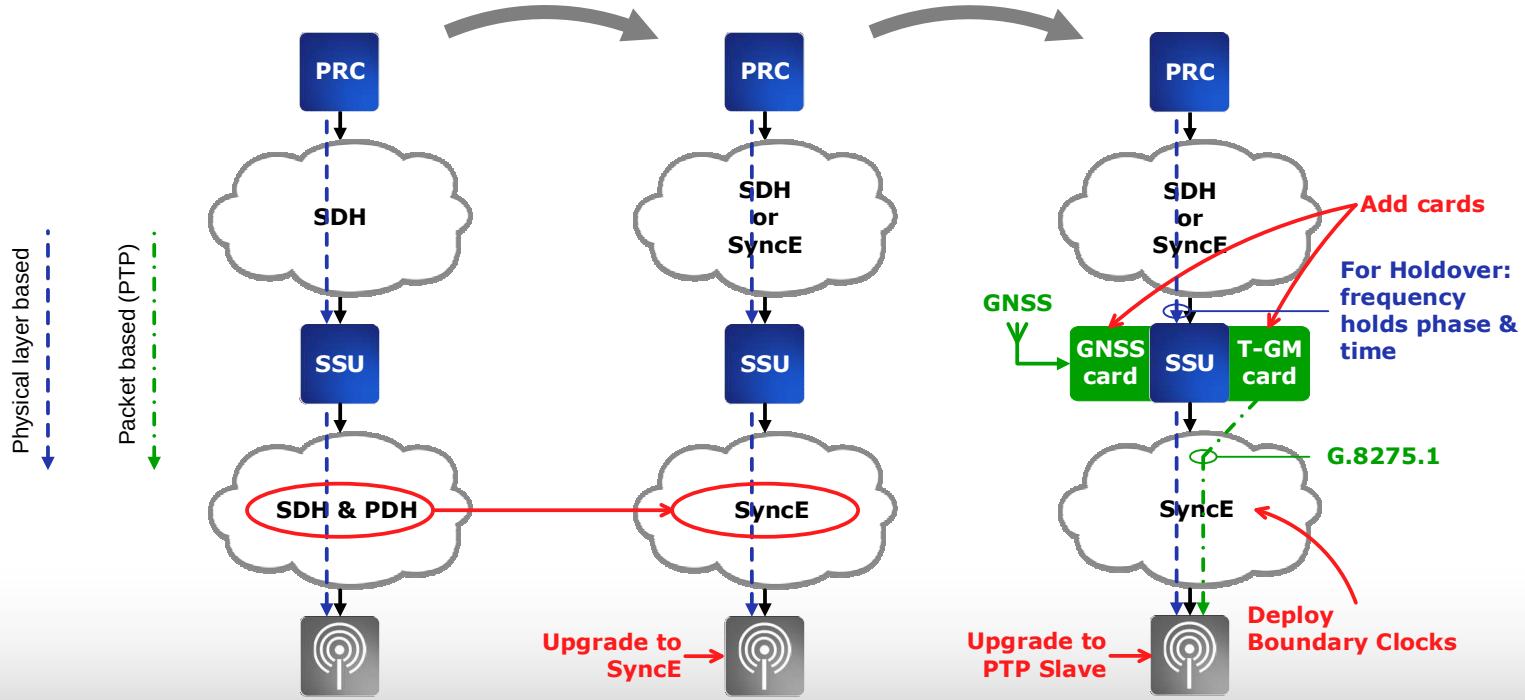
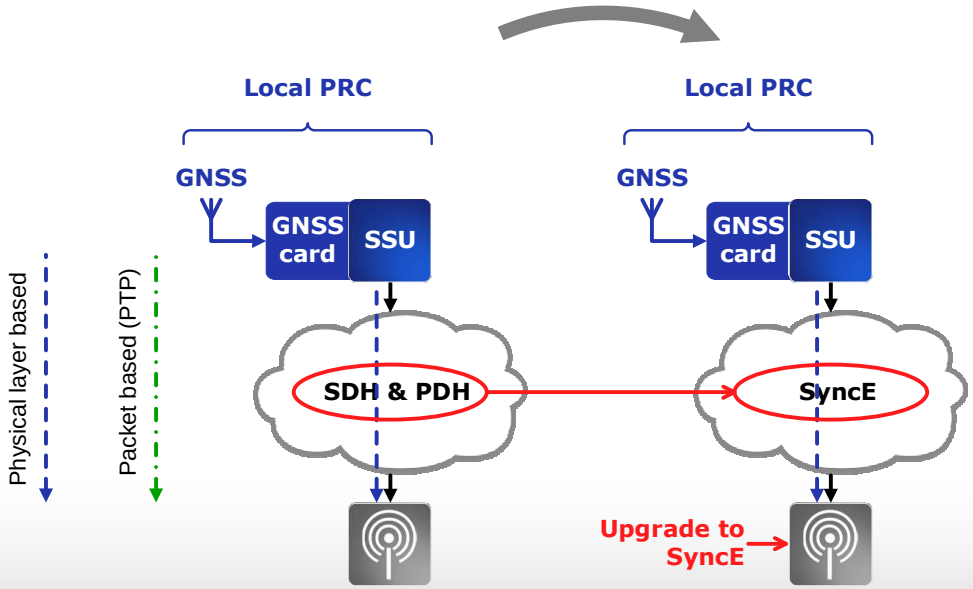
Evolution example 1b: keep PRC for phase holdover



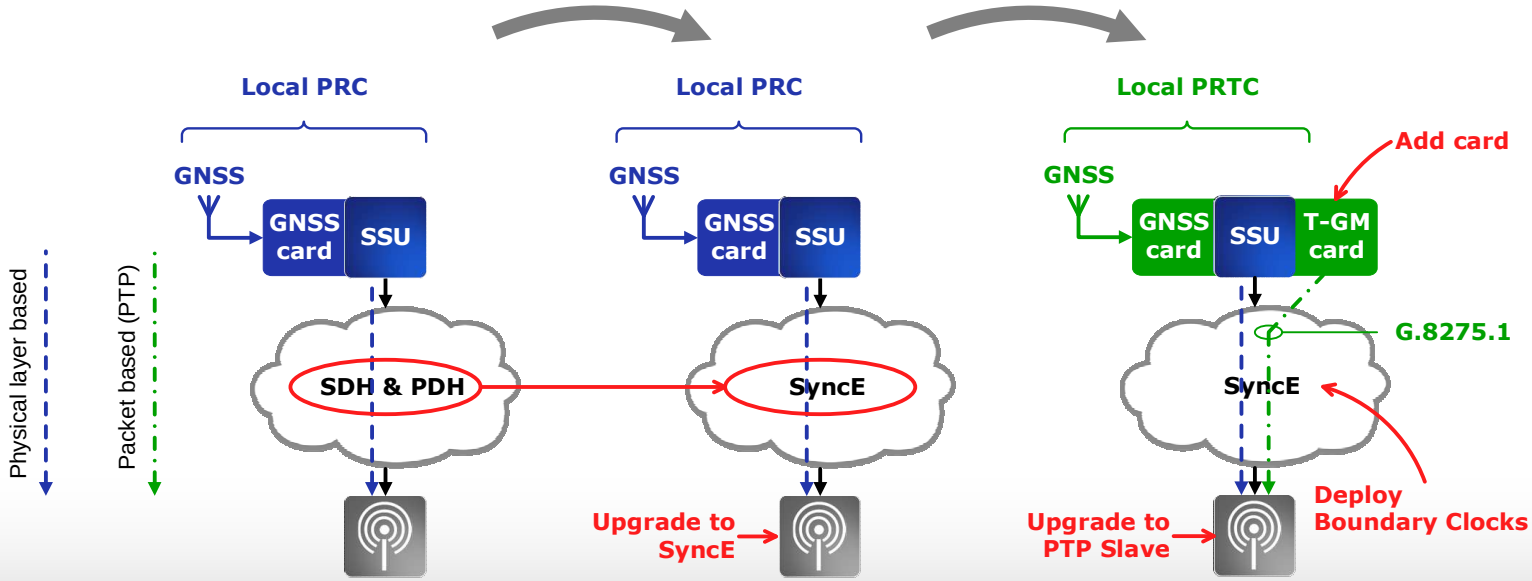
Leverage existing PRC and SSUs, just add cards to SSUs for phase

Evolution example 1c: starting with decentralized PRCs



Leverage existing GNSS/SSUs, just add T-GM card to SSUs for phase

Evolution example 1c: starting with decentralized PRCs



Leverage existing GNSS/SSUs, just add T-GM card to SSUs for phase

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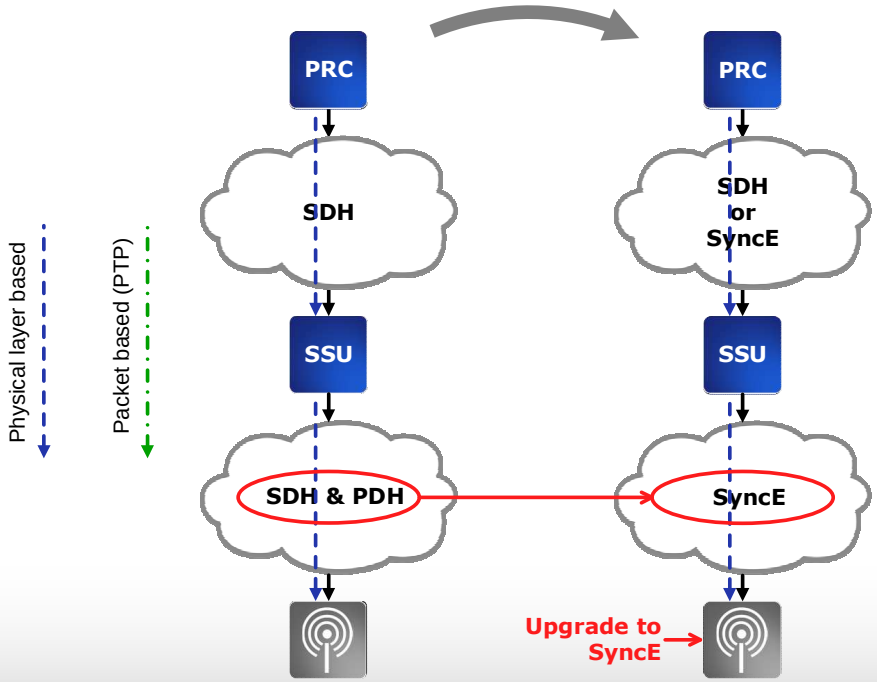
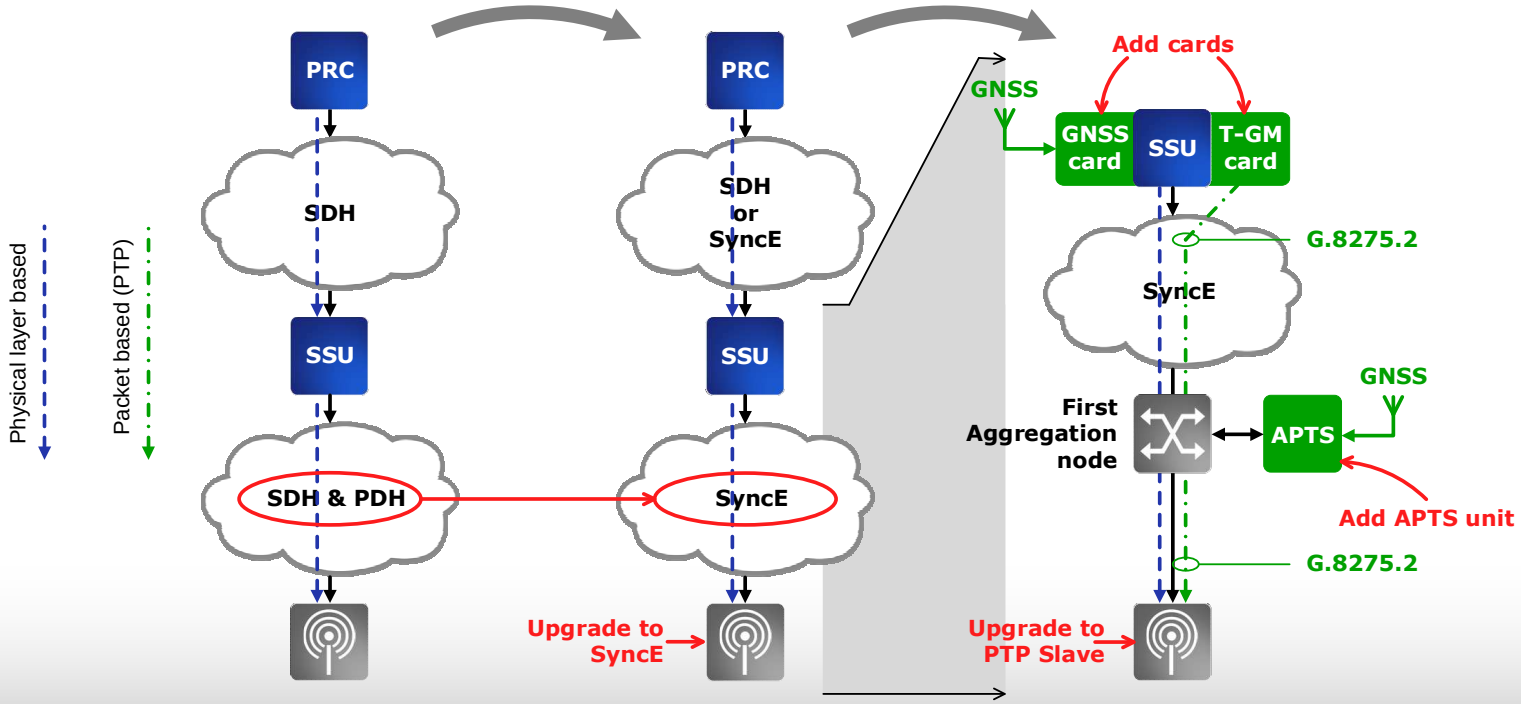
Evolution example 2a: SDH & PDH → SyncE → G.8275.2



Add cards to SSUs and add small APTS units for phase

Evolution example 2a: SDH & PDH → SyncE → G.8275.2



Add cards to SSUs and add small APTS units for phase

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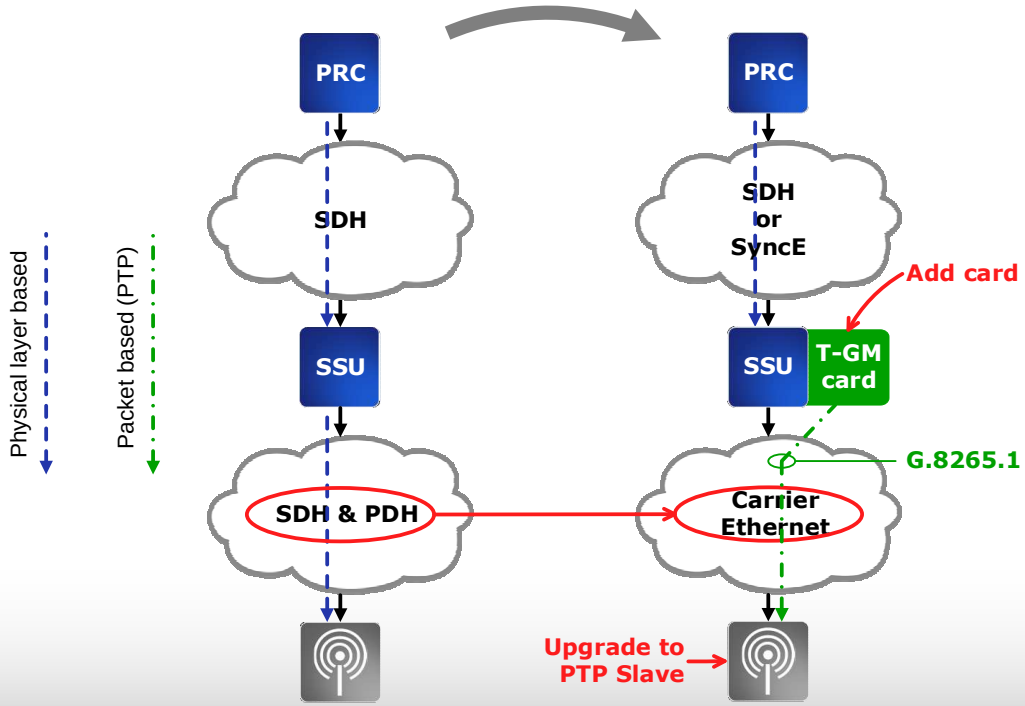
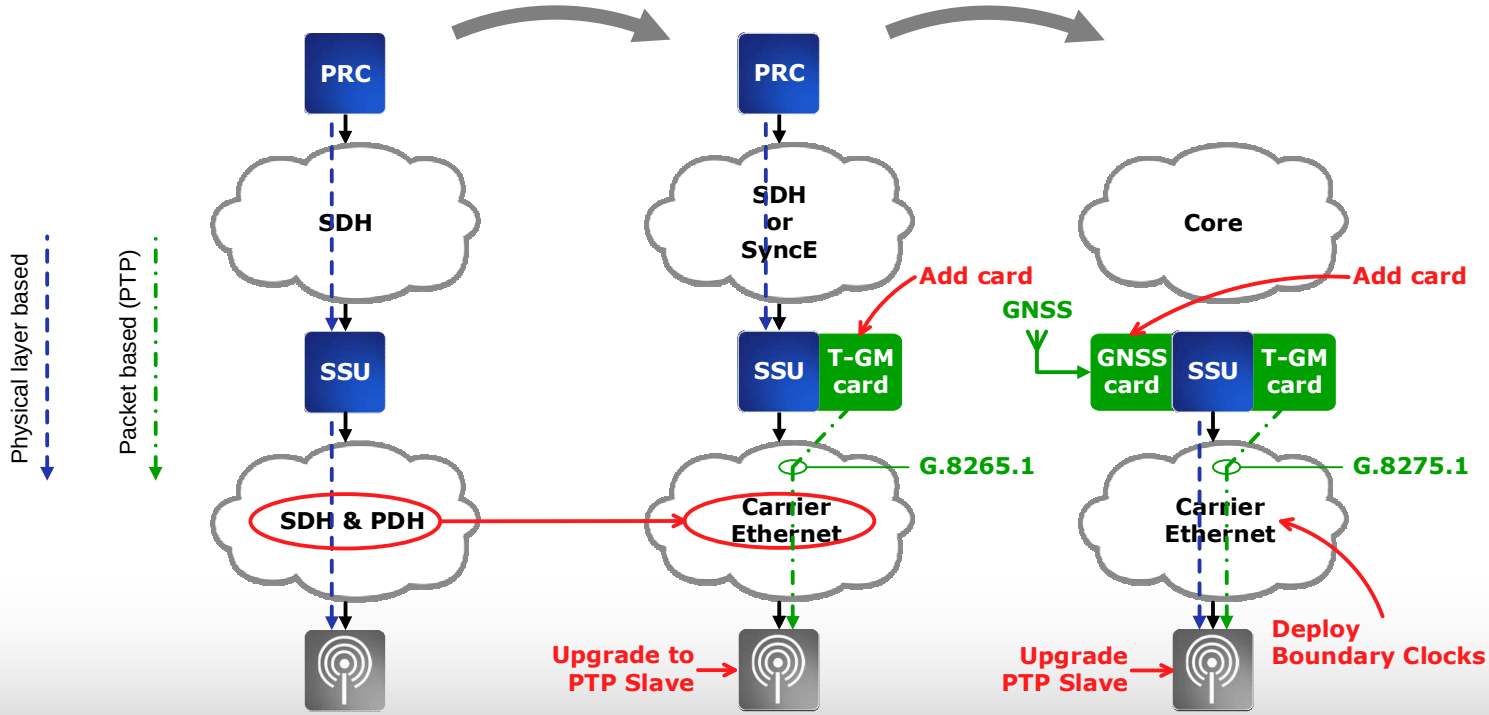
Evolution example 3a: SDH & PDH → G.8265.1 → G.8275.1



Leverage existing PRC and SSUs, just add cards to SSUs for phase

Evolution example 3a: SDH & PDH → G.8265.1 → G.8275.1



Leverage existing PRC and SSUs, just add cards to SSUs for phase

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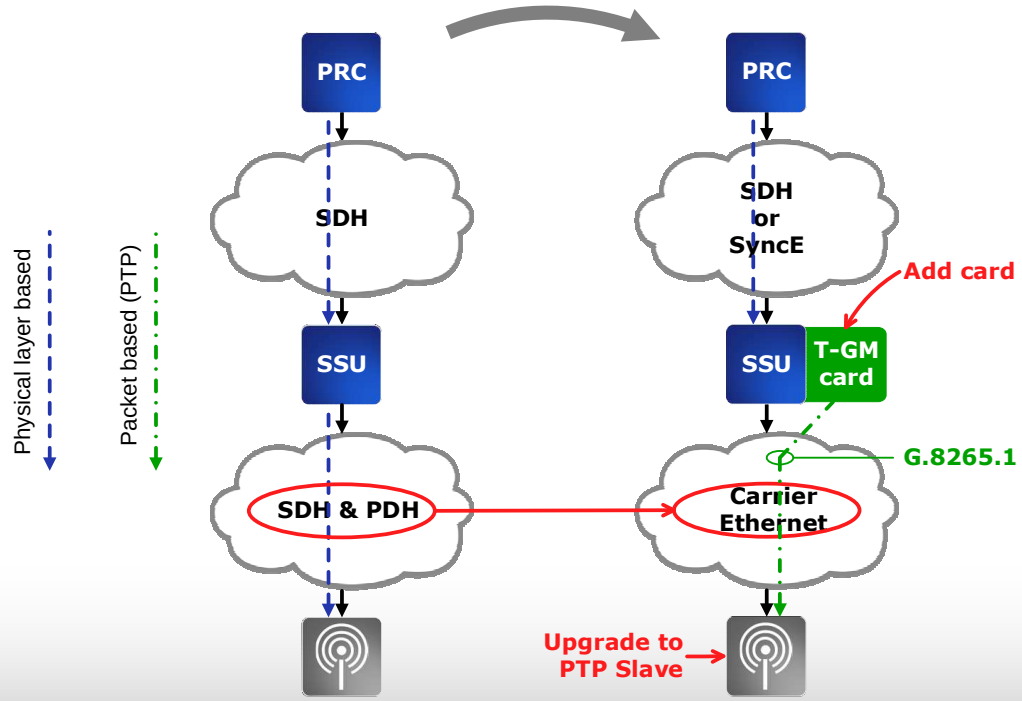
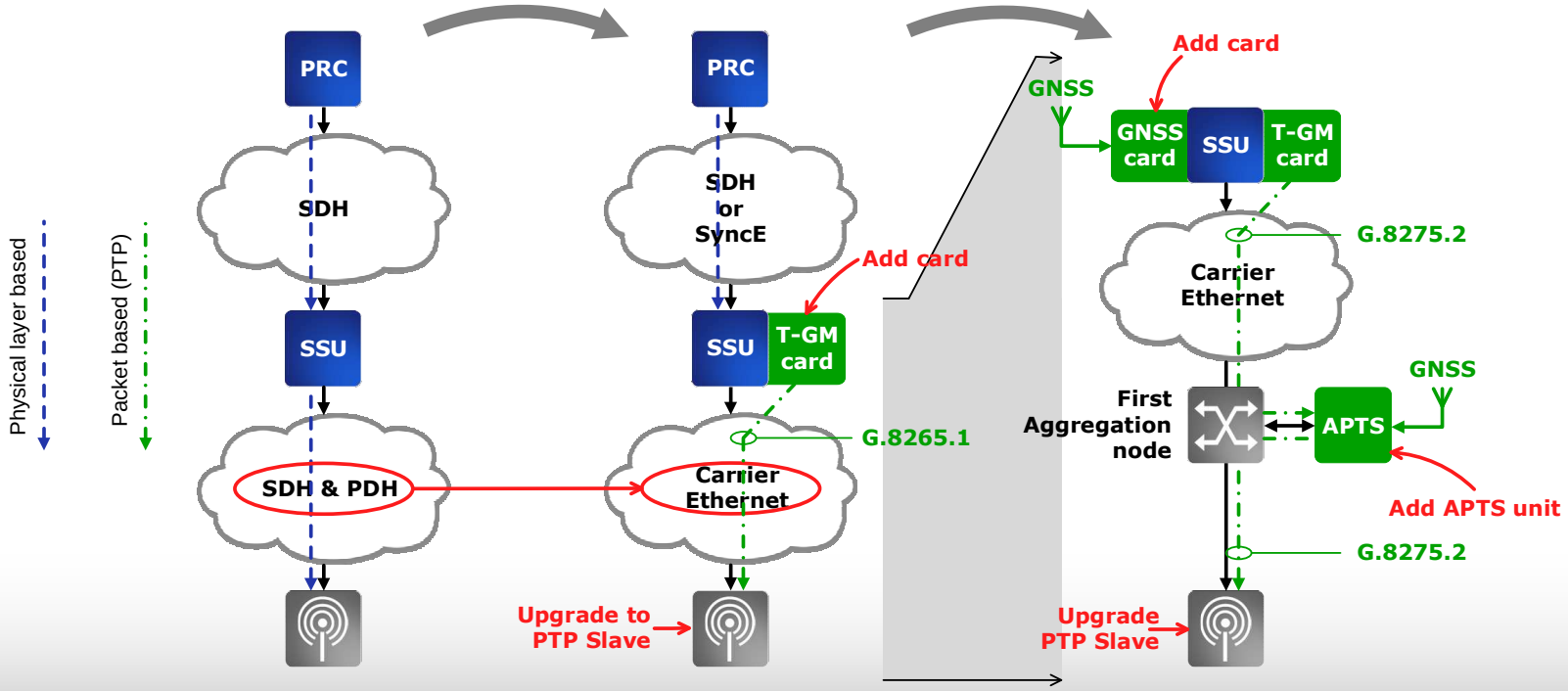
Evolution example 4a: SDH & PDH → G.8265.1 → G.8275.2



Add cards to SSUs and add small APTS units for phase

Evolution example 4a: SDH & PDH → G.8265.1 → G.8275.2



Add cards to SSUs and add small APTS units for phase

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Conclusions

- Evolution is driven by changes in synchronization needs, network context and synchronization technologies
- There are many possible evolution scenarios
- Leveraging existing SSUs and PRCs is possible with many evolution scenarios
- Within these scenarios, evolution requires addition on T-GM cards in SSUs, and possibly addition of small APTS units
- Chosen evolution path has important impact on CAPEX
- Optimal planning of the evolution path is a must

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Thank you

schneuwly@oscilloquartz.com
info@advaoptical.com