Reliable Synchronization for 5G

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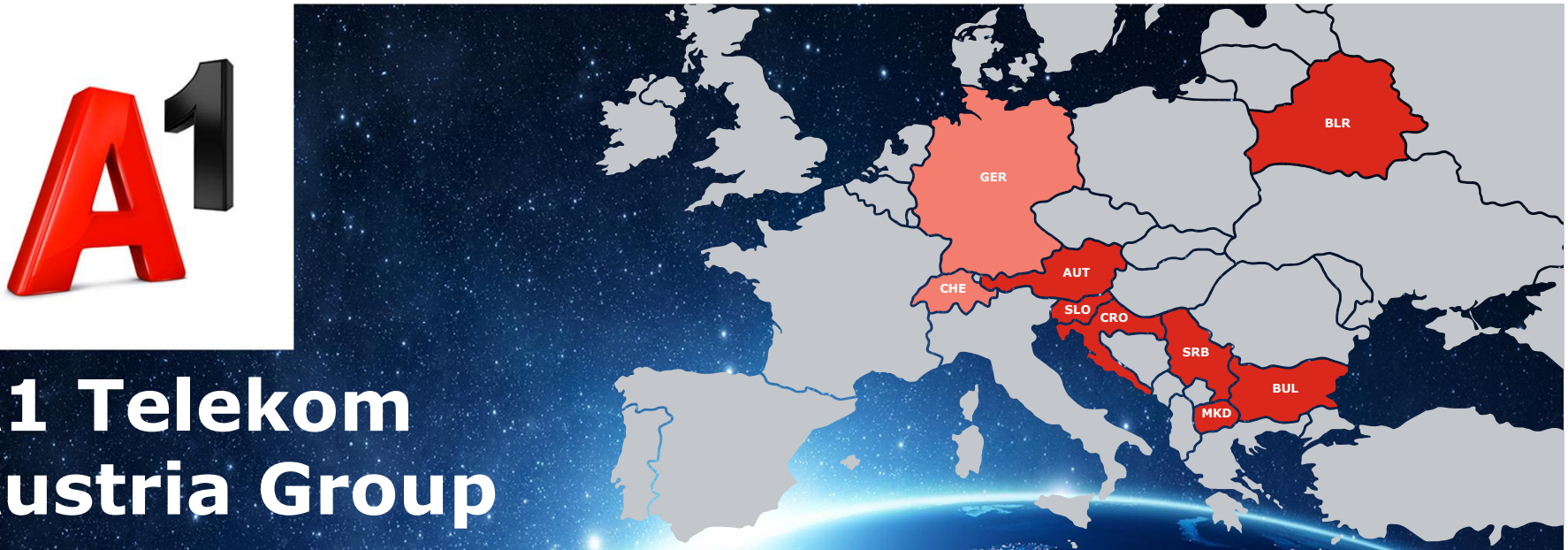
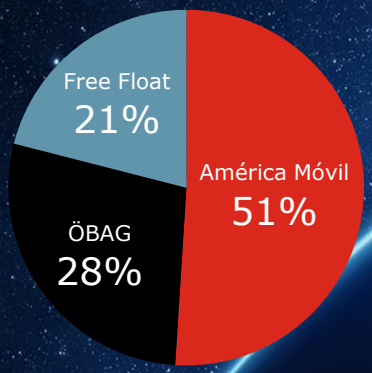
A1 Telekom Austria Group





Shareholder Structure

4.57 bn
Total revenues; financial year 2019

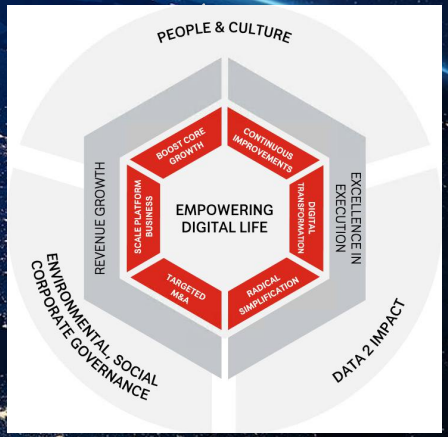
1.56 bn
EDITDA in the financial year 2019

25 mn
Customers in seven core markets

18,344
Employees as of year-end 2019

AUT A1 Austria: around 60% of the Group's total revenues.

A1 Digital: digital transformation in the core markets as well as in Germany and Switzerland.



Motivation

Frequency synchronisation:

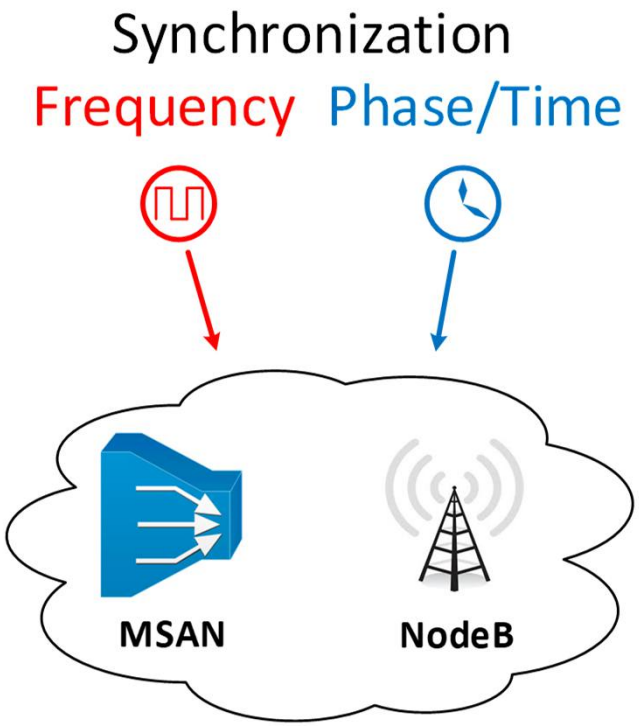
- for MSAN, 2G/3G NodeB and legacy equipment
- requirement for MSAN and RAN: SSU-A quality

Phase/Time synchronisation:

- requirement for 4G (LTE Advanced) and 5G (early implementations):
  - max. ±1.1 µs network equipment budget i.e. |TE| at NodeB input (acc. ITU-T Rec. G.8271.1)
  - Clock Class 6 or 7 acc. ITU-T Rec. G.8275.1
- requirement from regulator: max. deviation ±1.5 µs from UTC at air interface

Synchronisation is critical infrastructure!

- reliable, high availability (no outages)
- highly redundant and fail-save



Futureproof solutions!

Existing Frequency Synchronization

Source:

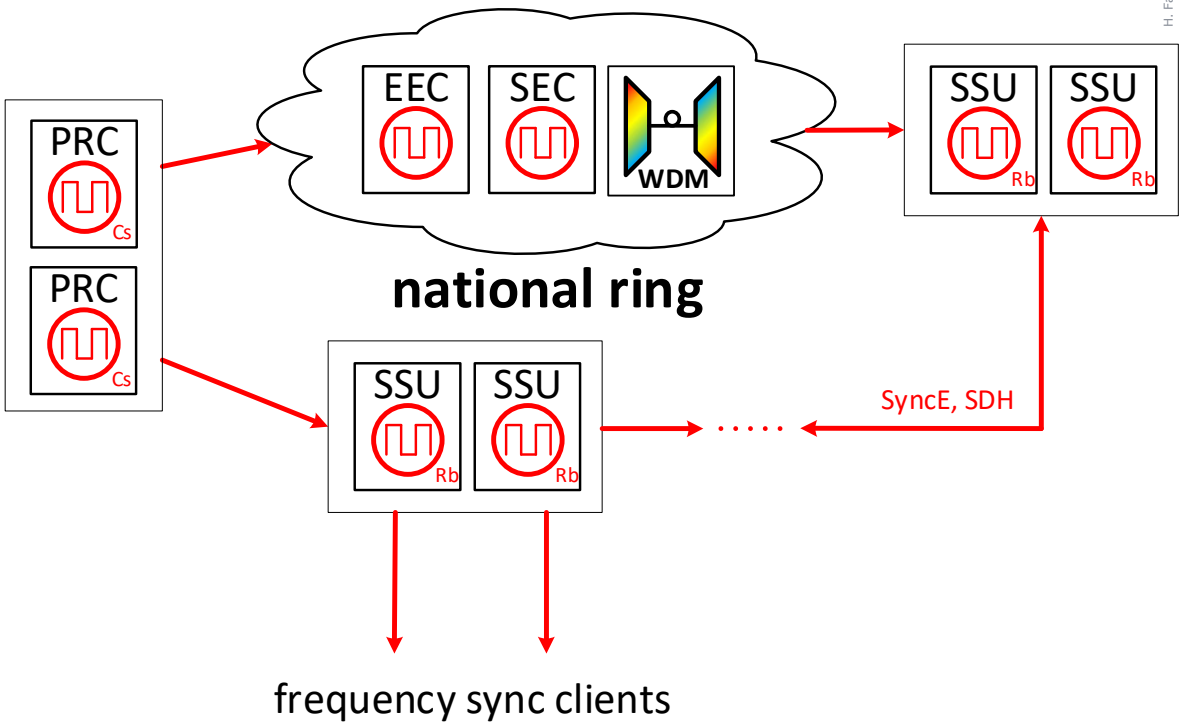
- Atomic Clocks (PRC)

SSU:

- GPS for redundancy
- Rb for holdover

Transport: OSI Layer 1

- 10 MHz (Coaxial)
- 2 Mbit/s / SDH
- Synchronous Ethernet (SyncE) with SSM for redundancy



Additional Phase Synchronization

Implementation:

- PTP (IEEE 1588v2) over Ethernet
- Profile G.8275.1 (full timing support)

Resiliency:

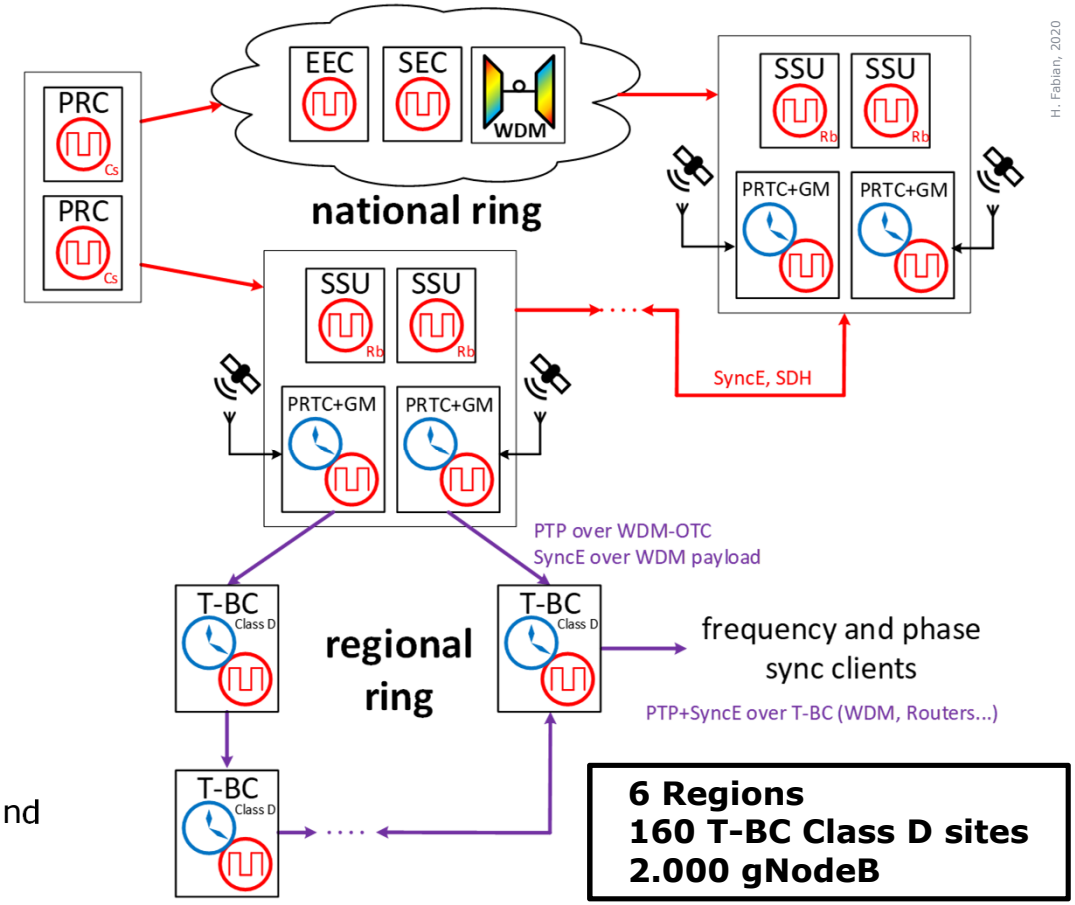
- separate frequency (Layer 1) and phase synchronization (Layer 2)
- „frequency-assisted phase holdover"

Quality (in faultless condition):

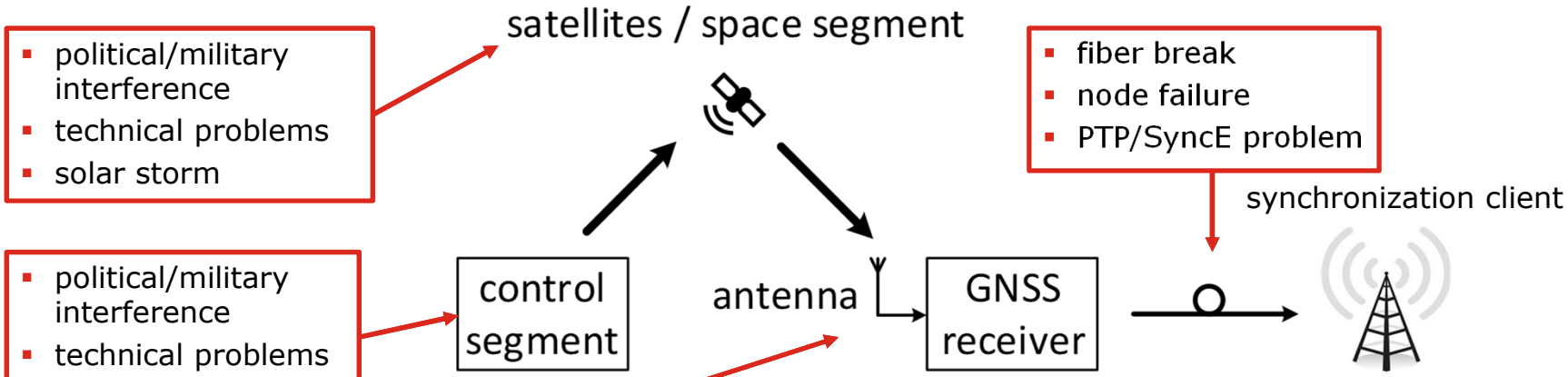
- <100 ns |TE| @ T-BC Class D site
- <500 ns |TE| @ sync client input

Challenges:

- Ring-Protection for Layer 1 frequency and Layer 2 phase synchronization



Challenges with GNSS, PTP, SyncE...

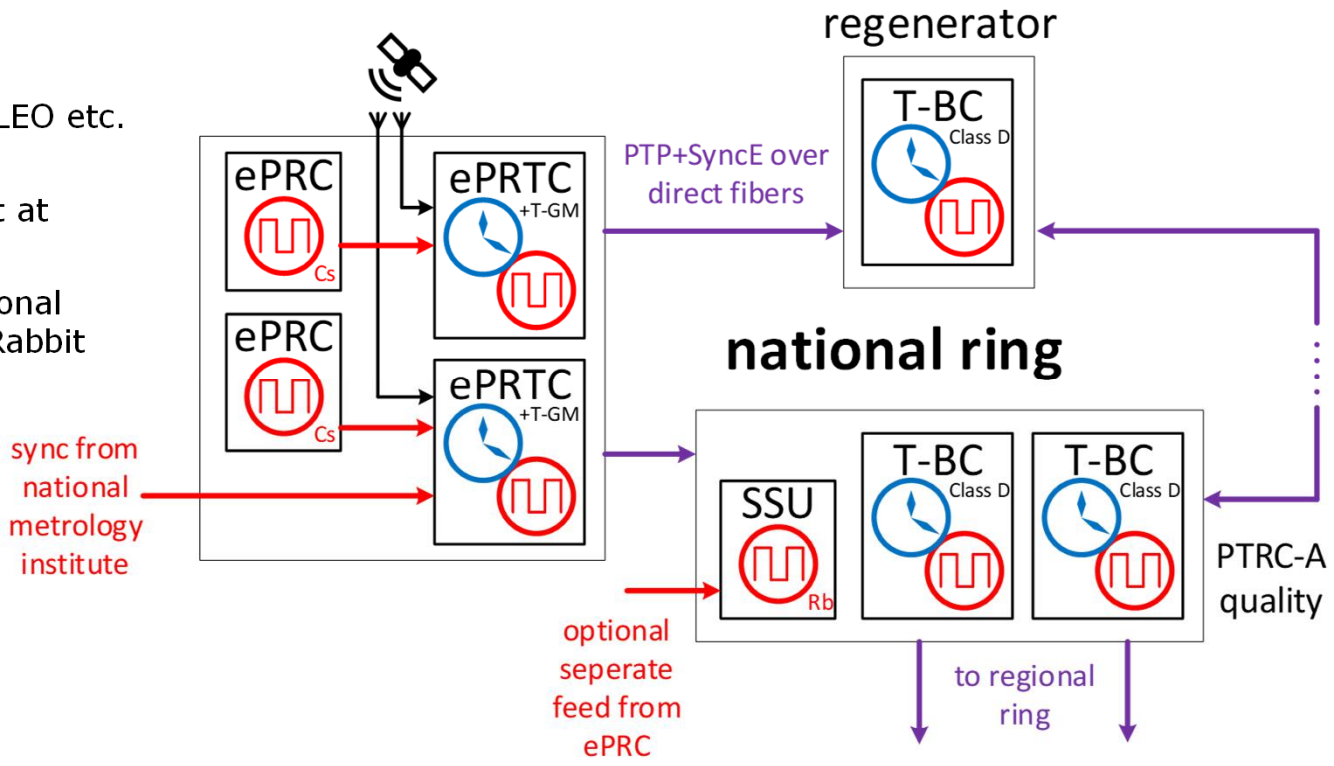


- satellite-independent phase/time source
- GNSS firewalls
- in-service measurement of sync quality
- separate frequency and phase synchronization
- PTP/SyncE protection or restoration
- independence from other technologies (IP/MPLS, WDM...)

Future Concept: National Frequency-, Phase- and Time-Synchronization

Open questions:

- Firewall for GPS/GALILEO etc. to detect spoofing
- Selection of best input at ePRTC
- Sync quality over national distances? (→ White Rabbit needed?)
- protection against double failures?
- ...



Our wishes to manufacturers and standardization

- **resiliency and protection** against system failures, line interruptions, desasters/crisis (→ e.g. GNSS outage)
- **redundancy** (e.g. for Layer 1 and 2 synchronization simultaneously together with fall-back scenario or "hybrid mode" for PTP outage but SyncE still present)
- **ePRTC with selection/averaging** from several sync sources
- **in-service quality measurements** and indications

- **high quality and "carrier grade" sync components** (ePRC, ePRTC, PRTC, T-GM, T-BC)
- reliable, simple and high-performance **network management system**
- **security** (e.g. master/slave authentication in PTP)
- **future-proof concepts** (to be able to fulfill future e.g. 5G requirements without building a completely new sync network every few years)

The market offers good components and concepts but no single best solution.

Acronyms and Abbreviations

4G	…	fourth generation technology standard for cellular networks
5G	…	fifth generation technology standard for cellular networks
Cs	…	Cesium (oscillator)
EEC	…	Ethernet Equipment Clock
ePRTC	…	Enhanced Primary Reference Time Clock
gNodeB	…	5G 'Next Generation Node B‘
GNSS	…	Global Navigation Satellite System
GPS	…	Global Positioning System
IEEE	…	Institute of Electrical and Electronics Engineers
IP	…	Internet Protocol
ITU	…	International Telecommunication Union
ITU-T	…	ITU Telecommunication Standardization Sector
LTE	…	“Long-Term Evolution” → 4G
MPLS	…	Multiprotocol Label Switching
MSAN	…	Multi-service access node
NodeB	…	3G/4G/5G base station
OTC	…	Optical Timing Channel
PRC	…	Primary Reference Clock
PRTC	…	Primary Reference Time Clock
PTP	…	Precision Time Protocol (IEEE 1588v2 1988)
RAN	…	Radio Access Network
Rb	…	Rubidium (oscillator)
SDH	…	Synchronous Digital Hierarchy
SEC	…	Synchronous Equipment Clock
SSM	…	Synchronization Supply Unit
SSU	…	Synchronization Status Message
SyncE	…	Synchronous Ethernet
T-BC	…	Telecom Boundary Clock
T-GM	…	Telekom Grandmaster
T-TC	…	Telecom Transparent Clock
T-TSC	…	Telecom Time Slave Clock
TE	…	Time Error
UTC	…	Coordinated Universal Time
WDM	…	Wavelength Division Multiplexing

Thank you

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