ITSF 2007
overview of future sync applications and architecture challenges

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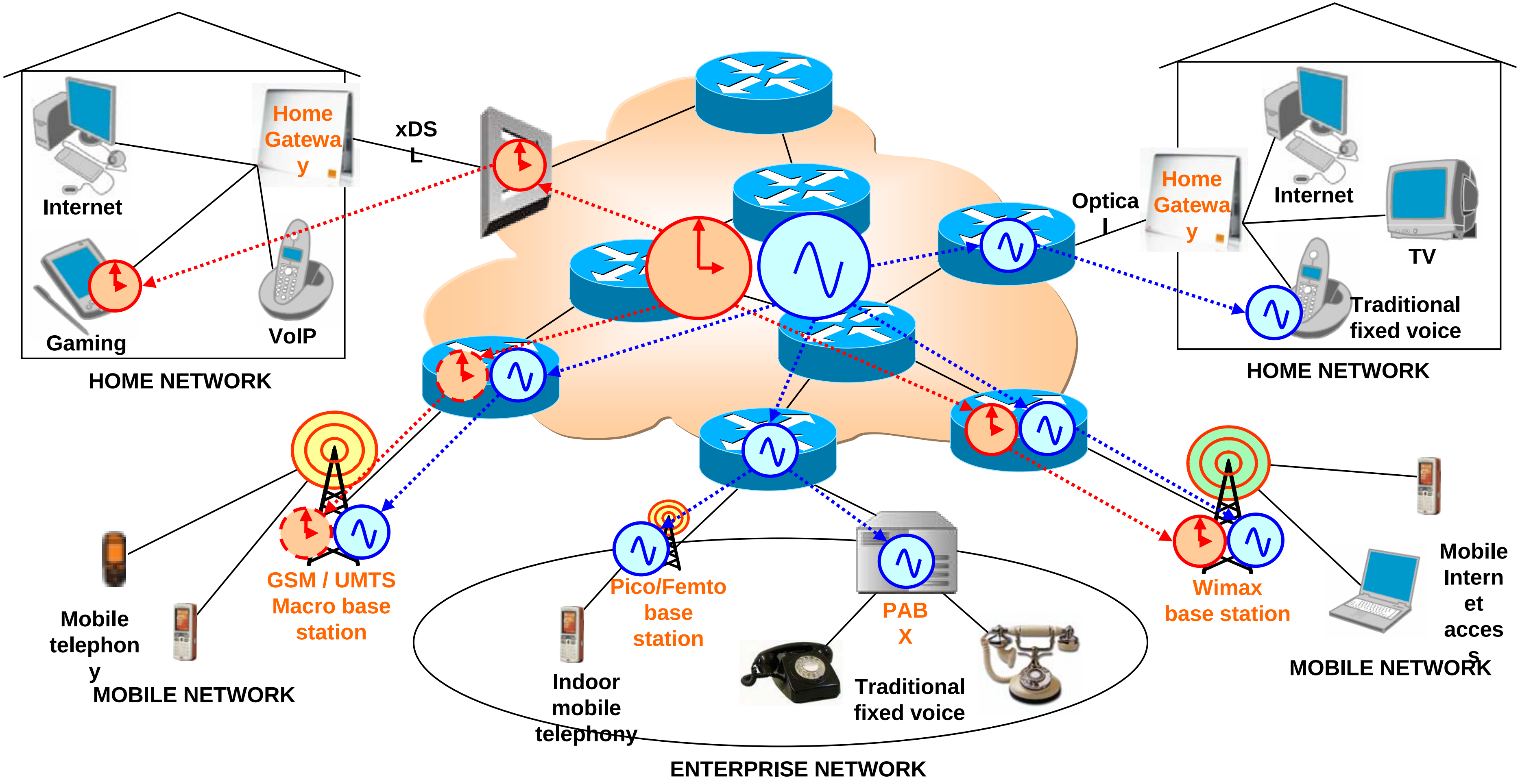
agenda

Meaning of the wording used in this presentation

- Synchronization in frequency
  Delivery of a common reference rhythm to a set of equipments, within the limits of a given accuracy and stability (equivalent to syntonization)
- Synchronization in phase
  Delivery of a phase instant to a set of equipments, which has to be aligned within a given accuracy. No time-of-day information, just a "pps" like signal. Can have an absolute reference (e.g. traceability to UTC), or a relative/local reference.
- Synchronization in time
  Delivery of a time-of-day information to a set of equipments, within the limits of a given accuracy. Can have an absolute reference (e.g. traceability to UTC), or a relative/local reference.


future sync applications

Synchronization for an integrated operator



- Objective of the paper: provide an overview of the synchronization issues from an operator perspective

Synchronization in frequency: main future requirements…

- Traditional "legacy" TDM requirements
  - Legacy equipments will last in the network still for a while…
  - Mainly, **compliance with ITU-T G.823 for stability & G.811 for accuracy**
  - For **buffer dimensioning** (minimize the size of buffers in order to minimize the delay)
  - Examples: PABX interconnection, traditional voice equipments, etc…

- Synchronization of the base stations
  - Several cases, depending on the size of the cells (macro, pico, femto)
  - Requirement for **air interface: 50 ppb for macro cells, 100 ppb for micro cells** in term of accuracy, same **stability over a short period (0.667 ms)**
  - **No clear requirement for network interface** of the base stations, only reference to ITU-T recommendations, but several designs exist depending on the manufacturer, leading to different synchronization tolerances
  - Mainly in order to avoid radio interferences and to enable smooth **handover** operations
  - Key point: no strong need for G.811 traceability, requirement is therefore relaxed according to traditional ones (not necessarily a need to have a "tight lock" to a reference signal)

- Equipments involved in a synchronization chain
  - An equipment which has no requirement to be synchronized could however be involved in a synchronization chain distribution, and must in this case be able to deliver sync

…the new thing is that the requirements remain the same!

- As we can see, the key issue in the future is not the need for more stringent performances for synchronization in frequency…

- …but rather how to be able to **maintain the level of performances we had in the past** as far as we are switching to new technologies

  - **quickly**…

    - at **low cost**…

      - and with enough **simplicity and reliability**!

Synchronization in phase and time: main future requirements…

- Traditional update of time-of-day in the network equipments
  - Target accuracy: **better than the second**
  - Type of application: generation of log files, billing, etc…
  - NTP do the job very well, widely used in telecom world

- Synchronization of probes for network metrology
  - Target accuracy: depends on the context, but **often better than the millisecond**
  - Used for measurements of the network (e.g. IP metrics)
  - Are technologies like NTP or IEEE 1588 always able to provide such performances?

- Emerging need for accurate phase alignment for mobile applications
  - Mainly TDD technologies, like UMTS LTE, Wimax, DVB, etc…
  - Target accuracy: **better than the microsecond**
  - Note that the **requirement is for phase**, not time
  - Only available solution today: GPS
  - Work has to be done to propose an alternative to GPS (on going within ITU-T Q13/15)

…the real challenge is here!

- Contrary to synchronization in frequency, telecom networks are not able to provide "natively" such accurate synchronization in phase or time
- Existing protocols, like NTP or IEEE 1588, needs anyway important adaptations to be able to address such requirements over wide networks
- Improvement of a technology like Synchronous Ethernet is also an option to be considered
- **The real challenge is here**, since sub-microseconds requirement is very stringent, leading to consider the physical layer and the potential issues related to it (temperature variations, links asymmetry, etc…)

What about future services not already defined?

- Keep in mind that **future applications could require very stringent synchronization quality**
  - relaxing the sync performances is therefore no necessarily the best thing to do

- Moreover, high synchronization performances could enable to take benefits from an accurate synchronization in order to **improve the functioning of networks** (?)

- And to **improve the QoS of the services** (?)

- Key message: do not degrade too much the sync quality

considerations regarding potential solutions

Solutions to achieve synchronization in frequency over packets network

- Two main families for frequency delivery by the network:
  - Physical methods (Synchronous Ethernet)
  - Packets based methods (IEEE 1588, NTP, CES-like, etc…)

- External timing sources can also be considered as punctual solutions, for very specific cases, but definitely not as a main rule:
  - GPS
  - Radio signal
  - Synchronization service

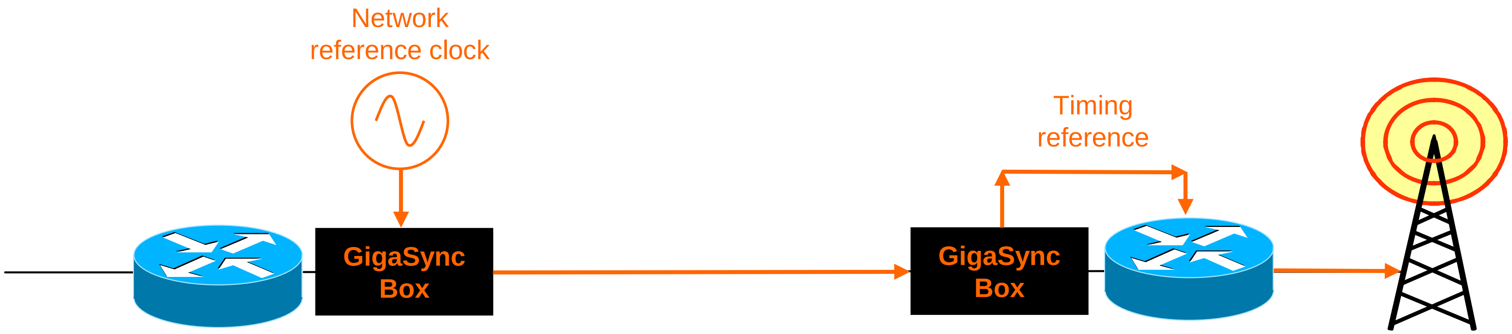
Focus on Synchronous Ethernet

- Advantages:
  - **Synchronous Ethernet is a standard** almost finalized (work within ITU-T Q13/15)
  - Provides a **high synchronization quality** equivalent to traditional TDM techniques
  - The **traffic variations have no impact** on the synchronization transport (independent of the traffic and the network topology)
  - **Robustness and reliability** of the mechanism
  - **Well-known monitoring and backup mechanisms**
  - **No bandwidth consumption**
  - Synchronous Ethernet solution **starts being natively available within the Ethernet equipments**

- Drawbacks:
  - Implies to have the **control on the physical layer of the network** (all the equipments in the synchronization chain must implement this method)
  - For particular cases, this is **not always possible in the short term** (e.g. in case of leased bandwidth at the layer 2/3 only)
  - **Hardware modification necessary** in all the network equipments of the synchronization chain

- Temporary solutions based on Synchronous Ethernet exist…

GigaSync boxes based on Synchronous Ethernet



- GigaSync external boxes co-developped by FT with Gillam-FEi
- Functionality: enable to **"upgrade" legacy Ethernet switches with Synchronous Ethernet capacity**, with a full transparency to the Ethernet data traffic
- Examples of applications:
  - Synchronization of base stations
  - TDM circuit emulation

Focus on Packets based methods (end-to-end)

- Advantages:
  - **Transparency to the network** (timing flows can cross different types of networks)
  - **No need to have the control on physical layer** (legacy asynchronous Ethernet switches don't need to be upgraded)
  - Therefore, this kind of **solution is quite flexible**, especially when the control over the physical layer of network is not possible (e.g. leased lines)
  - **No hardware modification** in the network equipments

- Drawbacks:
  - As far as synchronization is carried with the data traffic, synchronization is impacted by the data traffic
  - **Strong impact of the network load** on the synchronization quality (especially the load variations, leading to Packet Delay Variation)
  - Requires to **engineer correctly the packets network** (e.g. small number of switches, type of switches, priorization, …) and probably to **monitor the PDV**, but…
  - …**How a packets network has to be correctly engineered is not yet clearly defined:**
    - The **metrics of packets networks** enabling to characterize the network and to compare one given implementation with another one are **not yet defined**
    - No standard recovery algorithm, only **proprietary solutions** regarding performances, no minimal quality guaranteed
  - **Long stabilization period before clock recovery** (often more than 30 min)
  - **Bandwidth consumption**
  - **Monitoring issues** with packets based methods (operational teams are not used to handle packet based methods)
  - Tests are not very encouraging for the moment

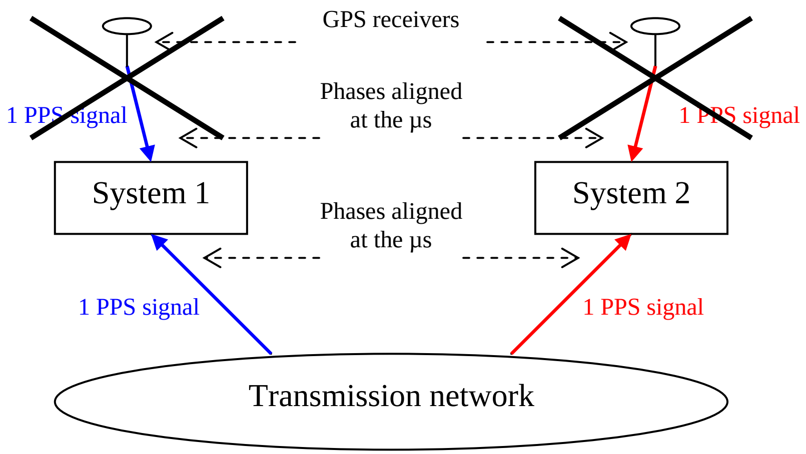
Solutions to achieve synchronization in frequency over packets network: FT vision

- **Synchronous Ethernet as the target technology** for most of the cases

- **Packets based methods as temporary solutions** for particular cases, but the use of a "standard communication protocol" is very important for interoperability
  - Once telecom profile(s) will be defined, IEEE 1588 will be a good candidate (ITU-T Q13/15 is working on that)
  - Need to work further on **PDV metrics** and to have a **better understanding of the algorithms** (definition of standard ones?), key points to be able to trust in these mechanisms
  - **Link-by-link solutions (e.g. IEEE 1588 BC or TC) have no real interest for frequency delivery** (this can be discussed for phase or time), since hardware modifications are required – let's use Synchronous Ethernet in this case

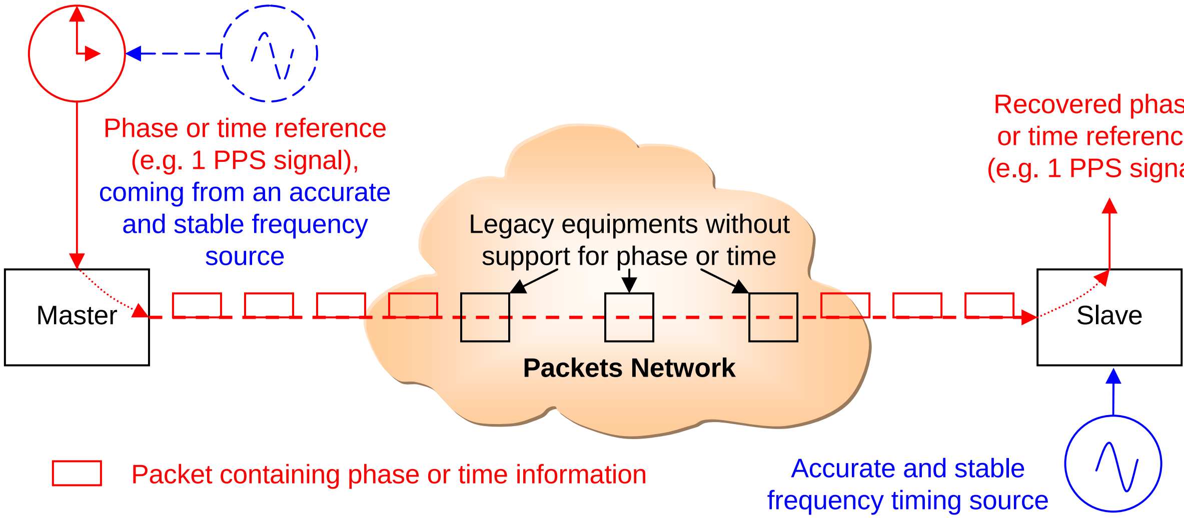
- Carrier grade equipments should be based at least on Synchronous Ethernet for synchronization aspects, and additionally, a packet based methods like IEEE 1588 could also be implemented

Considerations regarding the solutions to deliver accurate phase or time over a packet network



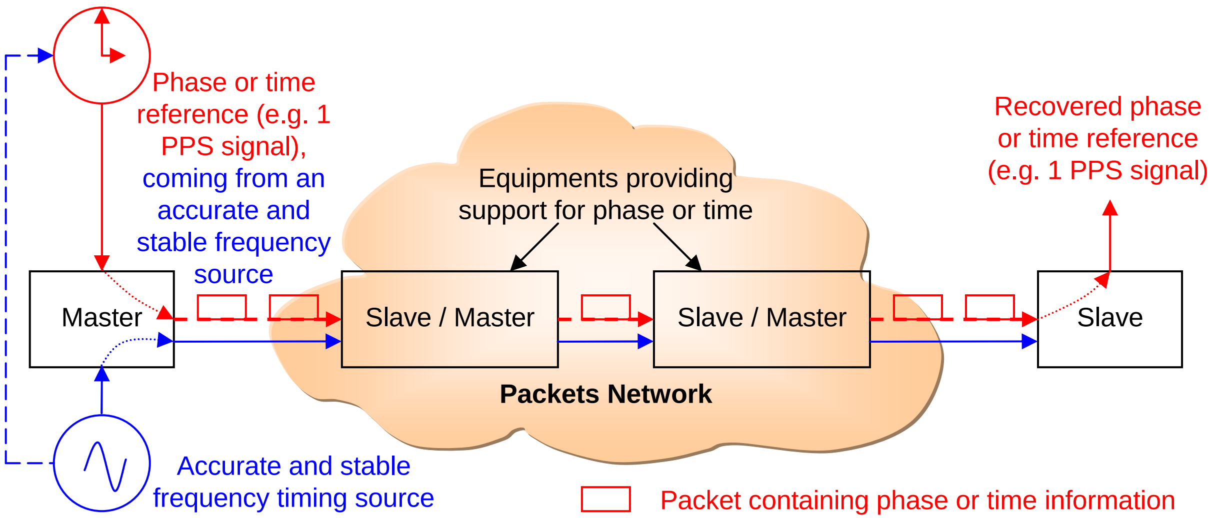
- Objective: **use of the network instead of GPS receivers** for the delivery of an accurate phase alignment (i.e. with a µs accuracy objective)
- The real challenge, since the requirements are particularly stringent…
- **Combination with a layer 1 frequency delivery**, like Synchronous Ethernet, will probably be required to address this requirement
  – Different options are possible for that, as we will see…

Considerations regarding "end-to-end" mode to deliver accurate phase or time synchronization



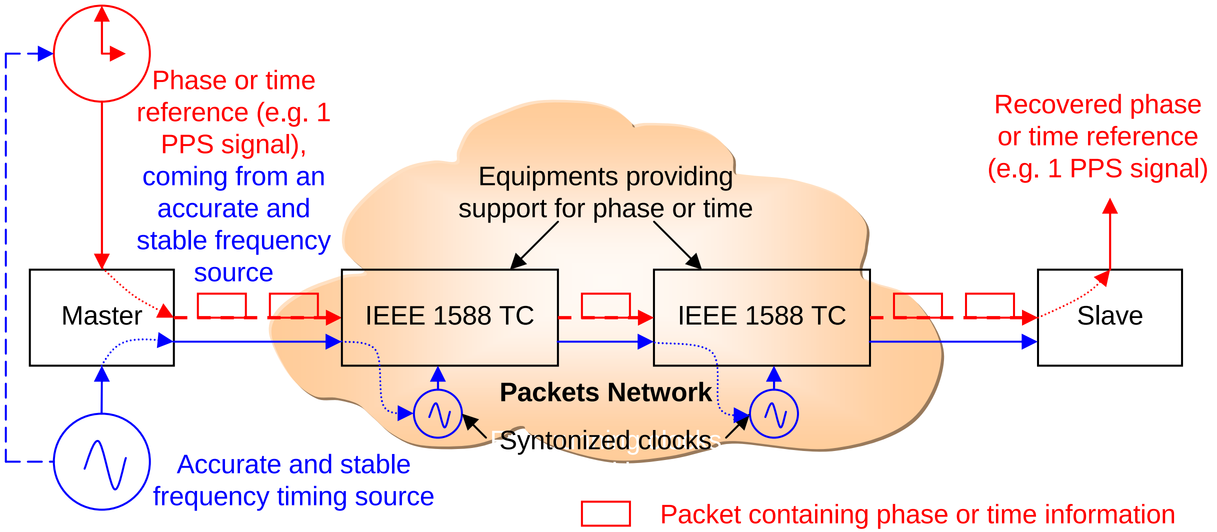
- Advantages:
  - The same as for the packet based methods for frequency
  - Flexibility and transparency to the network
  - The support of frequency at layer 1 will probably help to filter the delay asymmetry and the PDV, but does not fully solve this issue
- Drawbacks:
  - The same as for the packet based methods for frequency
  - Difficulties to filter the delay asymmetry and the PDV, even with the support of frequency at layer 1

Considerations regarding "link-by-link hierarchical" mode to deliver accurate phase or time synchronization



- Advantages:
  - Delay asymmetry and PDV are theoretically removed (if the link delays are constant)
  - Good scalability of the mechanism a priori (each intermediate node maintains its own timing reference)
  - The support of frequency at layer 1 will probably enable to reduce the recurrence of the slave updates, and therefore save bandwidth and simplify the mechanism
- Drawbacks:
  - Special hardware features need to be implemented in each intermediate node involved in the synchronization chain

Considerations regarding "link-by-link Transparent Clock" mode to deliver accurate phase or time synchronization



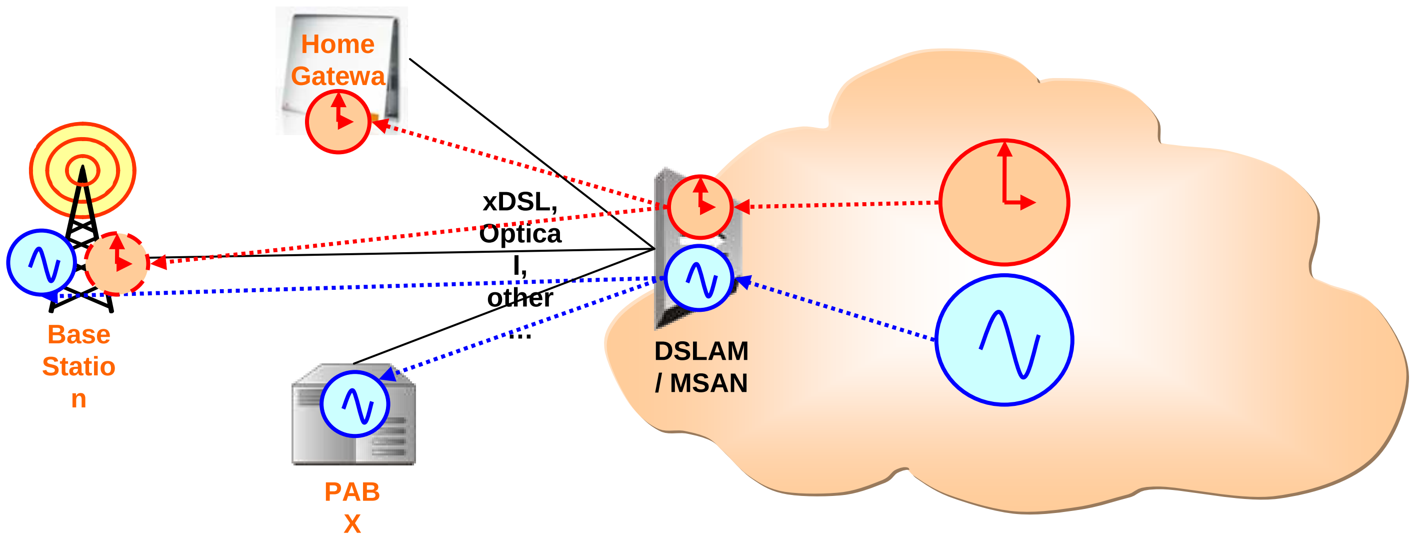
- Advantages:
  - Delay asymmetry and PDV are calculated and can be easily removed theoretically
  - The support of frequency at layer 1 will probably enable to improve the residence time calculation
- Drawbacks:
  - Special hardware features need to be implemented in each intermediate node involved in the synchronization chain
  - Bad scalability of the mechanism a priori (the intermediate node don't maintain any timing reference)


future architecture
challenges

Mobile backhauling and synchronization…

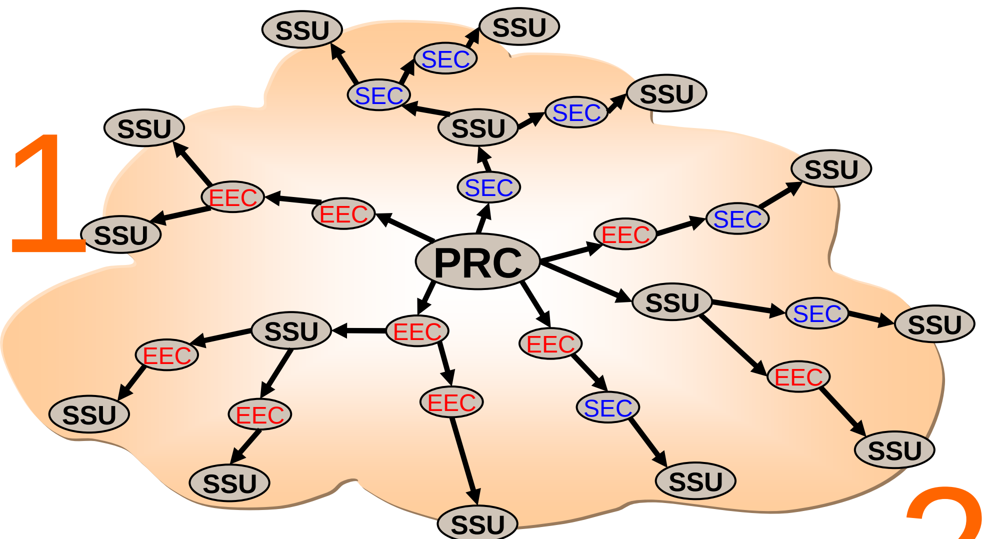
- The problem of the synchronization over a packets network impacts today **mainly the access**, and especially the **mobile backhauling**
  - For most of the cases, the core network will be impacted later
- In many cases, **switching from a TDM backhauling to an Ethernet or IP backhauling**, mainly for costs reduction purposes
- Several main cases can occur (for frequency delivery here):
  - **Control on the backhauling network**, and **new equipments to be deployed**
    - Synchronous Ethernet natively implemented in the equipments is the simplest and the most reliable solution
  - **Control on the backhauling network**, but **traditional Ethernet equipments already deployed** (without Synchronous Ethernet capacity)
    - Use of external Synchronous Ethernet boxes is possible as a temporary solution, waiting for the support for Synchronous Ethernet in the equipments
  - **No control on the backhauling network** (case of **leased lines**, where only bandwidth capacity is leased)
    - Use of packets based methods?
    - Risky, since the metrics related to PDV are not yet clearly defined…
    - Other solutions can also be envisaged

Synchronization and convergence…

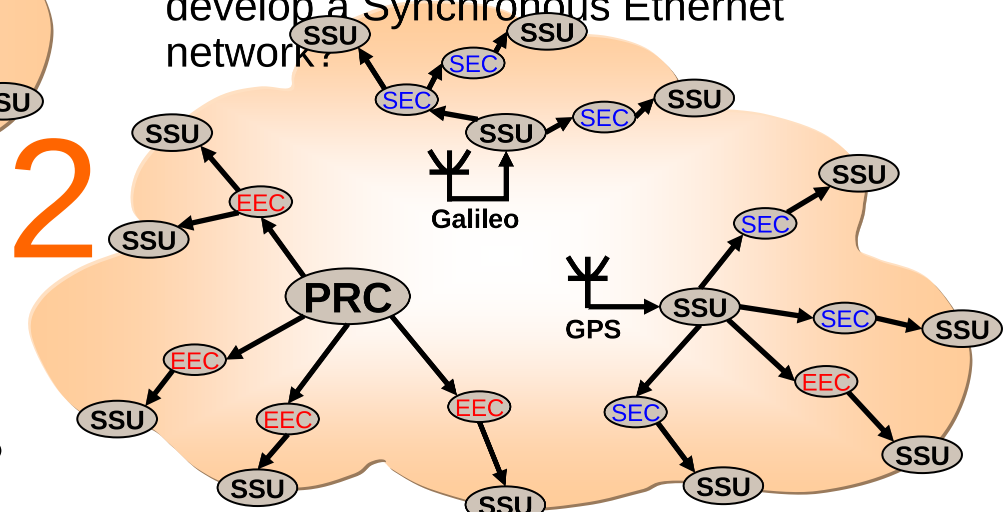


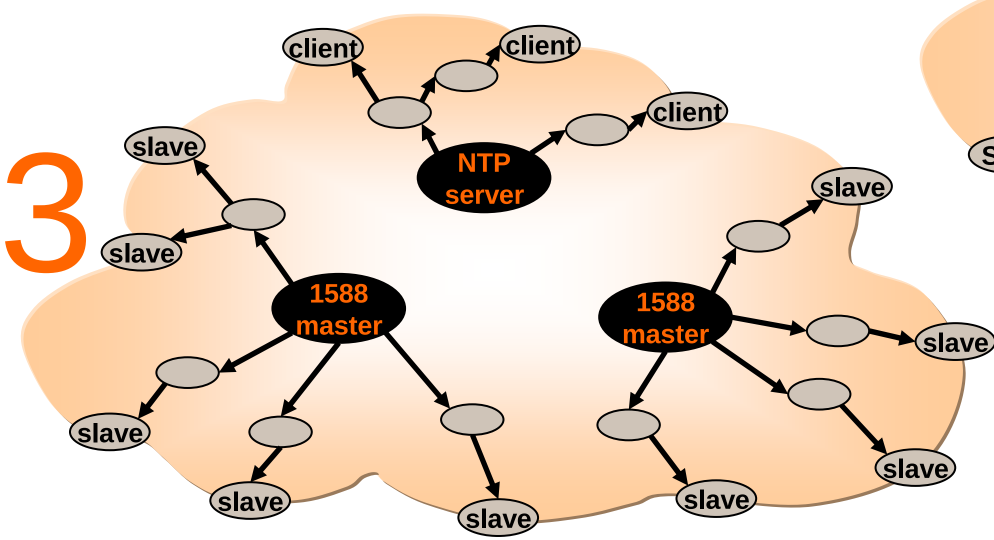
- Convergence implies to **share the same equipments for several applications or services**
  - It means that the synchronization quality must not be relaxed too much considering only one application, but the whole set of applications must be considered
- **DSLAM / MSAN is often a shared equipment** in a lot of architectures, the way it is synchronized is therefore essential
  - **Synchronous Ethernet to be implemented** for the network side for frequency
  - **NTR to be implemented** for the xDSL side for frequency delivery
  - Solutions to **carry accurate phase over xDSL links** is a important point to be studied for the future
- Synchronization over optical links (OTN, PON, etc…) and other technologies has to be taken into account, for both frequency and phase
  - Do not limit the problem to Ethernet networks, many other technologies are involved

Future synchronization network architectures…



- Centralized architecture, link-by-link **(1)**?
- Future architecture in line with what exists, i.e. hierarchical distribution of synchronization in frequency?
- Maintain an SDH network, and develop a Synchronous Ethernet network?





- Distributed architecture, link-by-link **(2)**?
- Use of GPS combined with Galileo?
- Distributed architecture, end-to-end **(3)**?
- Use of IEEE 1588 or NTP based solutions with synchronization islands?

…key drivers to choose the most relevant synchronization network architecture and technology

- technical economical studies
- state of the existing infrastructure
- flexibility of the architecture
- expected performances of the technology
- reliability of the technology
- availability of the technology
- interoperability of the technology
- knowledge and understanding of the technology
- monitoring
- backup

- **Mix of different architectures** is of course also possible (e.g. use of Synchronous Ethernet to provide frequency to NTP servers or IEEE 1588 masters)


conclusion

Conclusion, with an operator point of view…

- Synchronous Ethernet will definitely become the target technology for synchronization delivery over packets network, since accurate phase or time delivery will probably require such stable frequency delivery capacity
- Delivery of accurate phase and time by the network is one of the most important challenges in the next years
- Providing guarantees regarding the performances of packets based methods is a major topic, via the definition of PDV metrics, as well as a better understanding of the algorithms implemented

thank you

backup slides

Comparison of the requirements in term of MTIE