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B21C: Results and Recommendations of Synchronization over Video Transport Network Study

ITSF 2009

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B21C PROJECT

- Broadcast for the 21st Century
- Propose broadcast standard in order to facilitate the deployment and early adoption of application terminal for all types of transfer medium:

Ground fixed enhanced:	DVB – T2
Satellites for handheld terminals:	DVB – SH
Ground for mobile terminals:	DVB – H

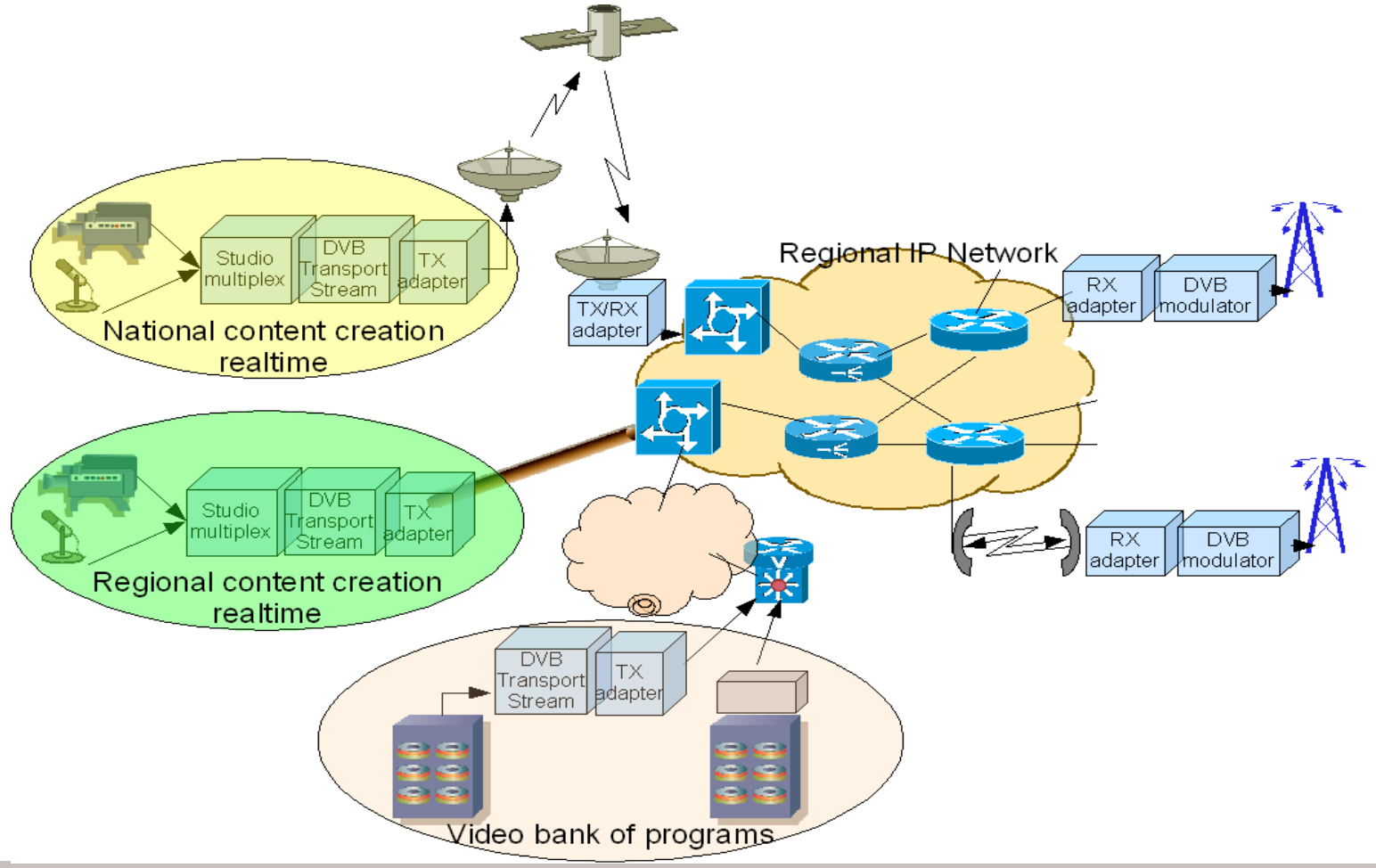
- Theoretical studies, simulations, network definition, trials, standardization proposals
- 35 European partners: industrial companies, network operators, universities & research centers over 9 countries

B21C Synchronization for the broadcast network

- Addressed in WP2 with Task Force 207
- Main targets:
  - Find an innovative synchronization solution to deliver Time & Frequency references to all transmission sites by using installed architectures
  - Identification and description of a cost-optimized, secured, fitting performance solution delivering synchronization over existing transport network
  - Suggested architectures are evaluated in terms of cost (LCC) and performances ratio
- Manufacturing and lab / trial testing of a demonstrator
- Recommendations will be transferred to DVB Forum

Video content dissemination to transmission sites

- Aggregation of multiple medias:



SFN delivery synchronization issue

- Drivers:
  - Minimal use of spectrum for high definition services (HDTV)
  - Minimize echoes interference
  - Mobiles roaming without extra management

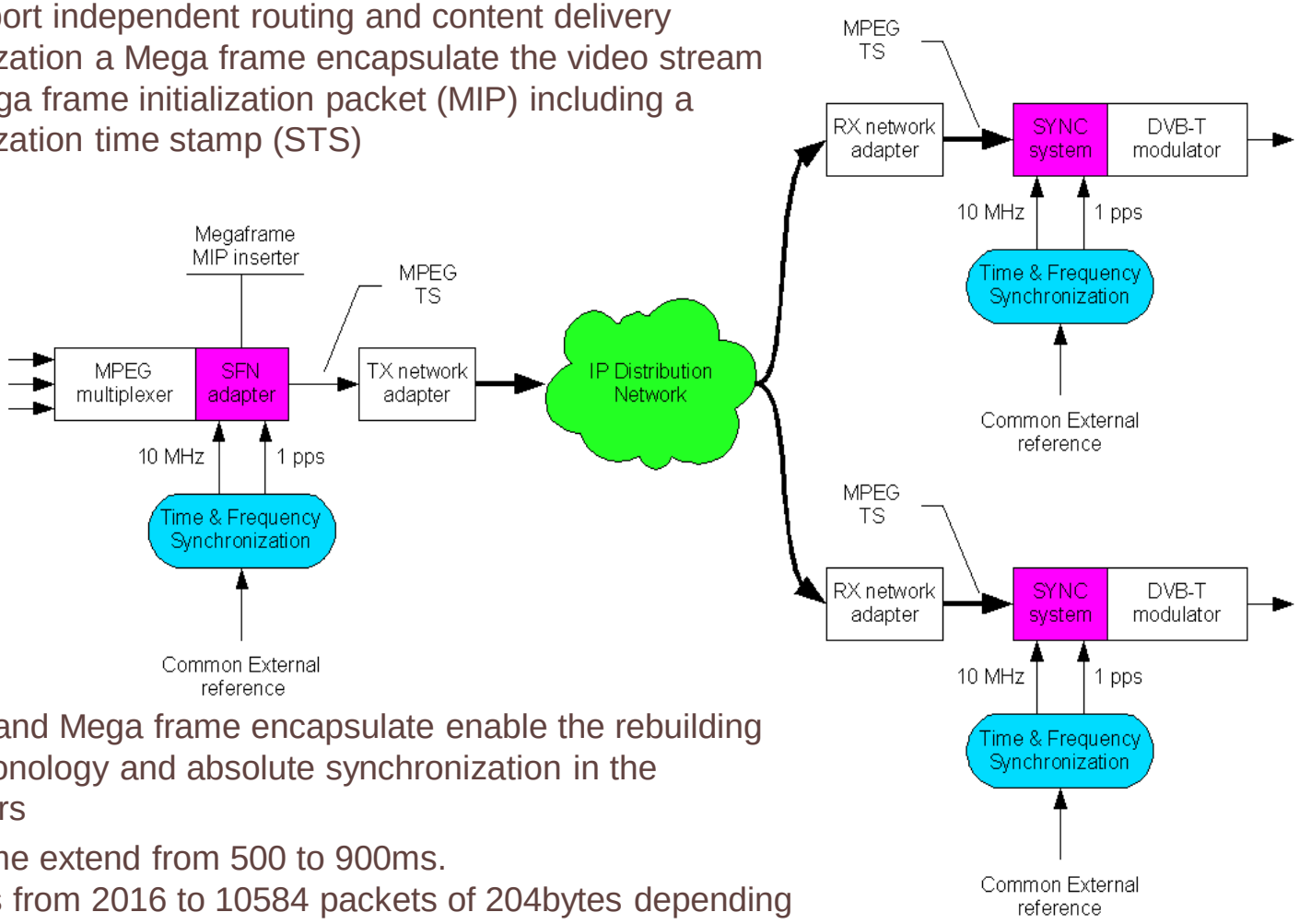
- Technical features:
  - CODFM modulation of radio emission and inter-channel cross talk avoidance require carriers accuracy **ΔF/F < 1.10-9**
  - Same content shall be delivered at the same time on the air from all the SFN area transmitters. The minimum synchronization accuracy is dependant of the coding scheme and the guard interval related to the coverage area.

    Synchronization source shall be accurate to 1/10 the guard interval.
    General agreement for **1µs** accuracy source

GI duration	Modulation
224 µs	8k 1/2
112 µs	8k 1/4
56 µs	8k 1/8
28 µs	8K 1/32

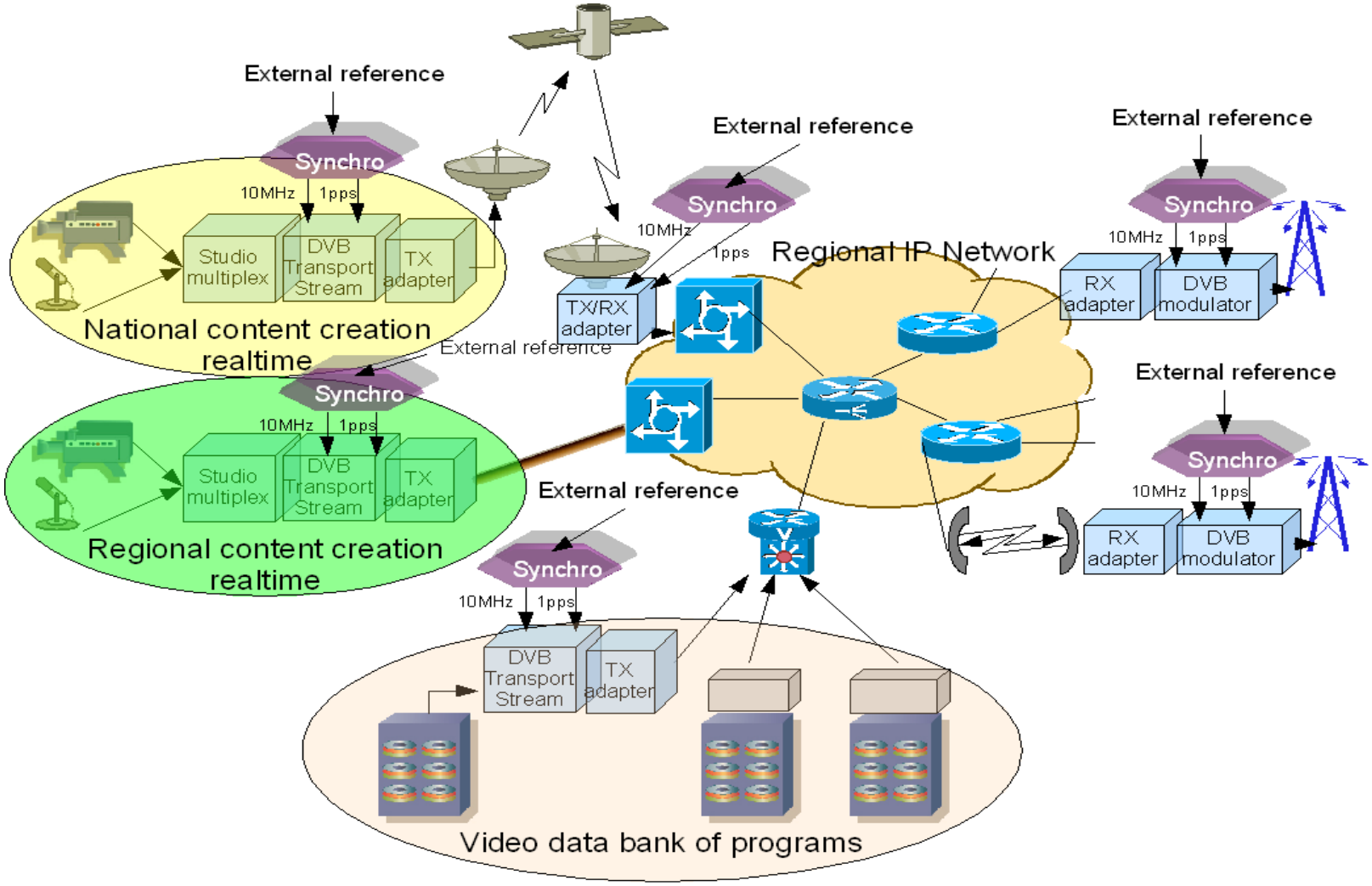
SFN delivery synchronization issue

- For transport independent routing and content delivery synchronization a Mega frame encapsulate the video stream with a mega frame initialization packet (MIP) including a synchronization time stamp (STS)



- The STS and Mega frame encapsulate enable the rebuilding of the chronology and absolute synchronization in the transmitters
- Mega frame extend from 500 to 900ms.
  It contains from 2016 to 10584 packets of 204bytes depending on modulation efficiency, modulation rate and FEC

Synchronization spread over delivery network



Legacy GPS synchronization source alternative

- PTP: IEEE1588v2

– **Pro's:**

- Time stamp distribution with unitary path compensation.
- Network elements delay and jitter shall be removed if boundary or transparent clock are implemented.
- Constant propagation path asymmetry can be compensated.
- Time transfer performances expected over MAN ~1µs
- Syntonization capabilities are compatible with integration time.
- High pressure from industry to rush maturity.

– **Con's:**

- Legacy Network elements jitter shall be mitigated with non standardized filtering.
- Path switch shall disrupt synchronization accuracy.
- Variation on traffic load shall produce non stationary path asymmetry that cannot be mitigated.

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Network synchronization and timing transfer capabilities analysis

- Approach: Segmentation of the distribution network
- The synchronization traffic shall use the same path than content
  - Content delivery and synchronization service remains consistent, no separate disruptions to manage.
  - Enhanced availability and lower the monitoring cost on operation
- Some external common references shall remain to maintain network segments to be interoperable and avoid interference with other network implementations
- 2 main segments :
  - Long range transfer
    - Sub segments :
      - Satellite link
      - Wired WAN
  - Metropolitan area or regional transfer

Satellite link synchronization transfer capability

- Satellite links use geosynchronous SV that provide about 250ms path delay.
- Satellite forwarding payload are computing error correction. It introduce a queue latency that is not stationary. Variation in latency is up to ms.
- Satellite downlink receivers are in open sky view, so they are as well fed with GNSS signals in proper receiving conditions.
- Conclusion:
  This is not the place to remove GPS synchronization references, there is no added value for that.

WAN network synchronization capabilities

- Broadcast operators that monitor the QoS of the end to end service from content delivery centers to on the air signals are relying on leased telecom links for long distance transfer.
  - Specific low layer services shall not be mandate.
  - Quality of synchronization services in those network path are not generic compatible with IEEE1588v2 packets accurate transit.
- To maintain transit coherency, Virtual Private LAN Services (VPLS) is used including MultiProtocol Label Switching (MPLS) services.
- To avoid packet queuing collision, operators are maintaining path load average < 50% of maximum bandwidth.
- Video packet traffic load is not constant in short term due to MPEG coding compression algorithm.

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WAN synchronization capabilities: trials

- Conditions:

- Fiber network ring made of 9 optical segments and 9 switches.
- Physical path length about 2400 km.
- A traffic load of 50% was set on some path and 0% on others.
- A added test traffic is introduced in 100Mbit/s interface of 100packets/s 64bytes.
- 3 level of QoS are explored using the differentiated services field with DiffSer Code Point (DSCP) implementation in the Type of Service (ToS) byte.
  - Best Effort (H1)
  - Expedited Forwarding (EF)
  - Layer 1 direct access (L1)
- Measurements of path delay are collected for 2 hours on each path.
- Average network latency is measured every second.
- Maximum and minimum latency are cumulated over time.
- Minimum latency difference is measured comparing same QoS over 0% and 50% loaded path. Physical route and switch are the same on both path.

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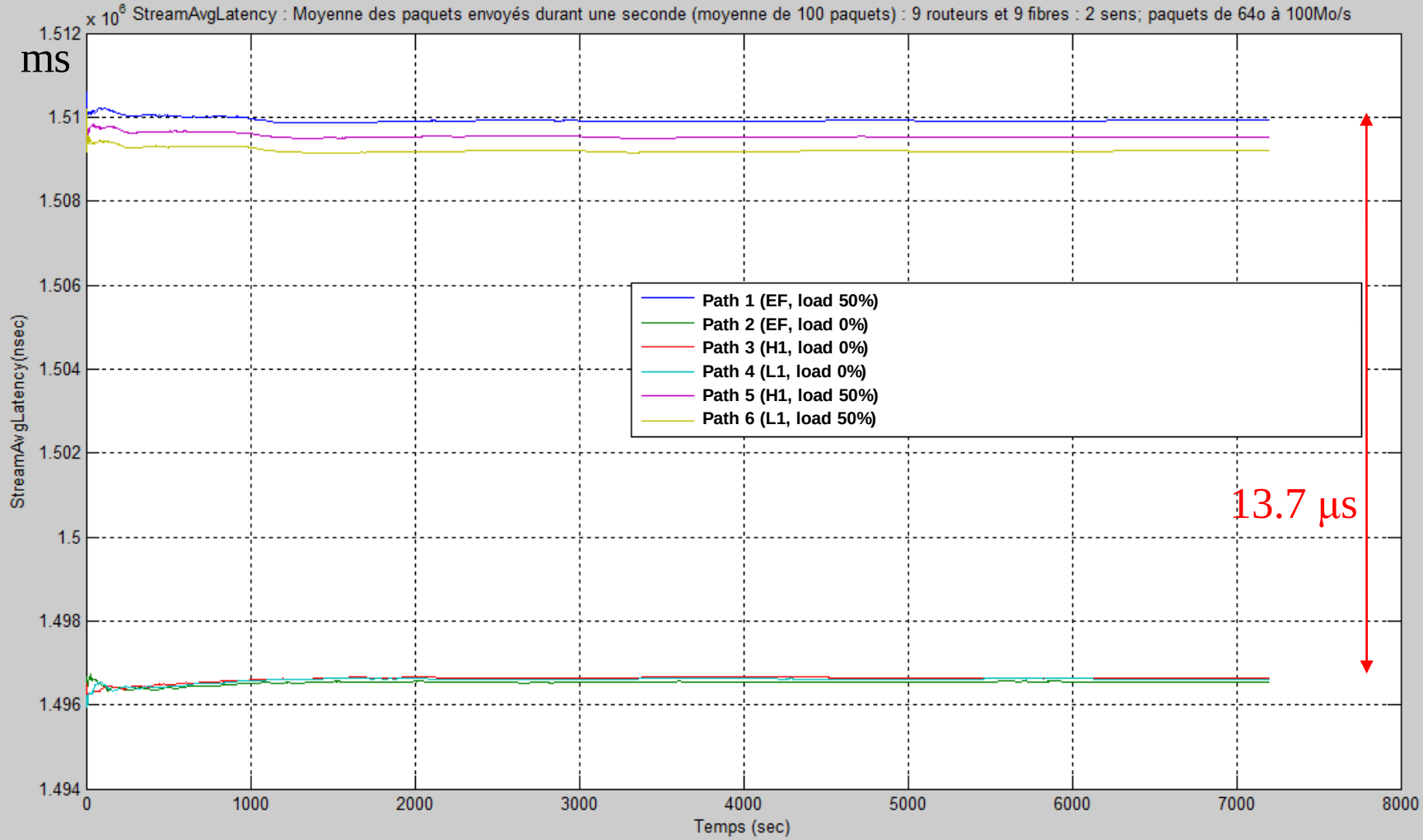
Wired WAN synchronization capabilities: average packet latency



Wired WAN synchronization capabilities: trials results

- Average latency is about 1.5 ms
- Variation of average latency vs load is < 13.7 µs
  This variation vs load is only affected < 1 µs per service priority
- Variation of minimum latency vs load is < 3.9 µs
  No long term influence of service priority
- Variation of maximum latency vs load is
  16 µs with EF priority
  10 µs with Best Effort priority
  6 µs with direct L1 access

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WAN synchronization capabilities: discussion

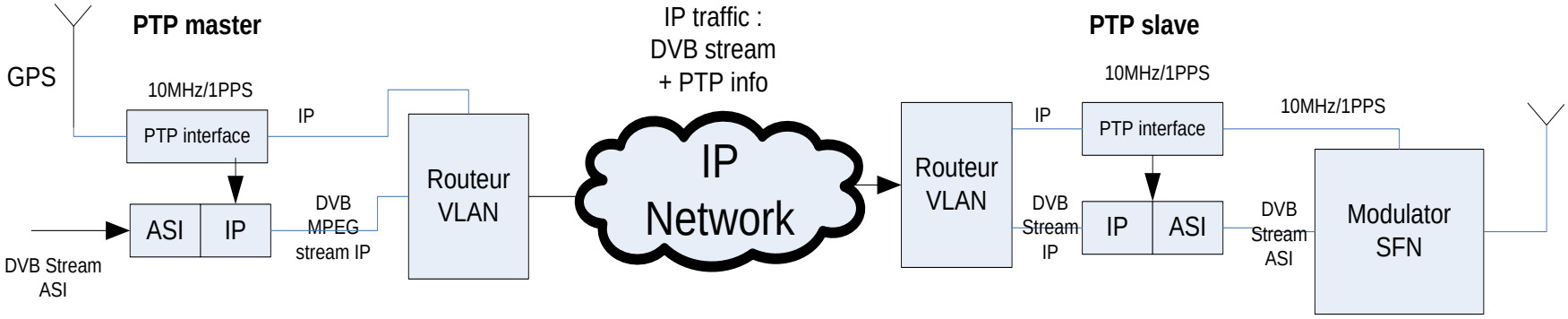
- Since video stream is not stationary, short term variation of latency are non predictable.
- So statistic on the traffic are also not predictable.
- Only very long term mitigation shall enable to reach 1 µs target of accuracy.
- Long term mitigation will be disrupted by path switching events on the WAN.
- So the QoS of the Synchronization will be out of range of availability constraint, unless very high stability local oscillator are included.
- This may not compete with GNSS clocks

MAN network synchronization capabilities

- Broadcast operators are in some place relying on leased telecom links for regional distance transfer. It extends up to 6 hops.
  - Specific low layer services shall not be mandate.
  - Quality of synchronization services in those network path are not generic compatible with IEEE1588v2 packets accurate transit.
- To maintain transit coherency, Virtual Private LAN Services (VPLS) is used including MultiProtocol Label Switching (MPLS) services.
- To avoid packet queuing collision, operators are maintaining path load average < 50% of maximum bandwidth.
- Video packet traffic load is not constant in short term due to MPEG coding compression algorithm.
- Lasts Hops (<3) are on the broadcast operator full operation.

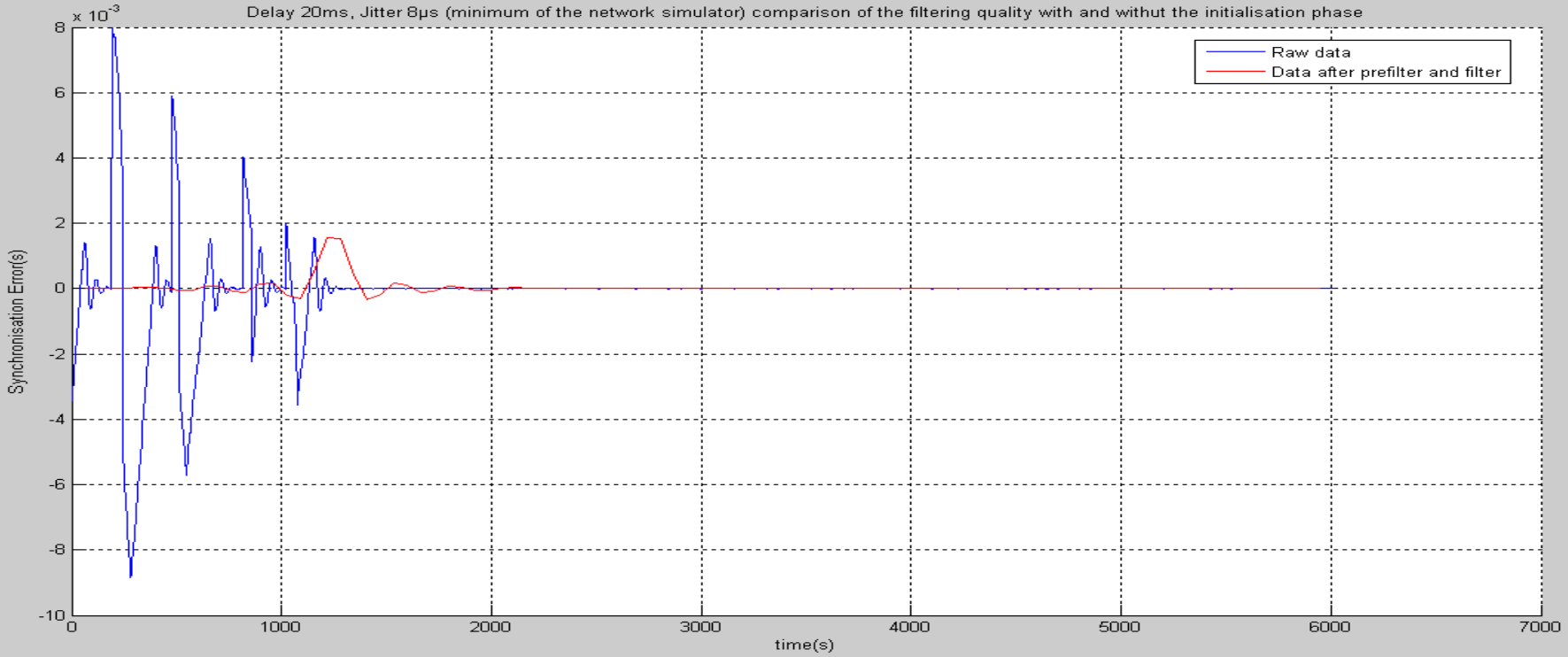
MAN network synchronization capabilities: Trials

- Trial 1 for maximum extension capability test with legacy Network Elements (non IEEE1588v2)
- Trial 2 for limited extension capability (< 3 hops) with legacy Network Elements (non IEEE1588v2)
- Laboratory network platform with real termination equipments and simulated network path.
- Injected traffic is UDP / Multicast



MAN synchronization capabilities : maximum extension legacy NE

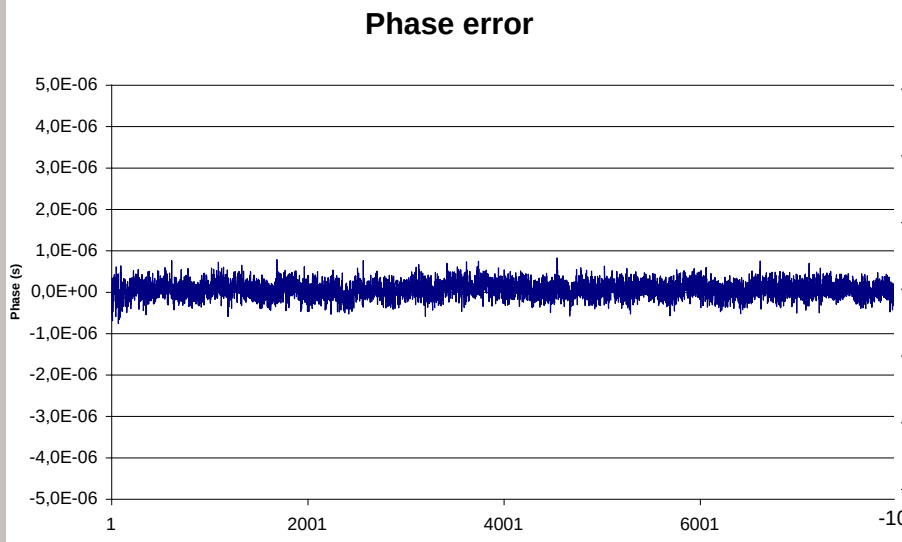
- Injected network behavior: Delay 20ms, Jitter 8µs

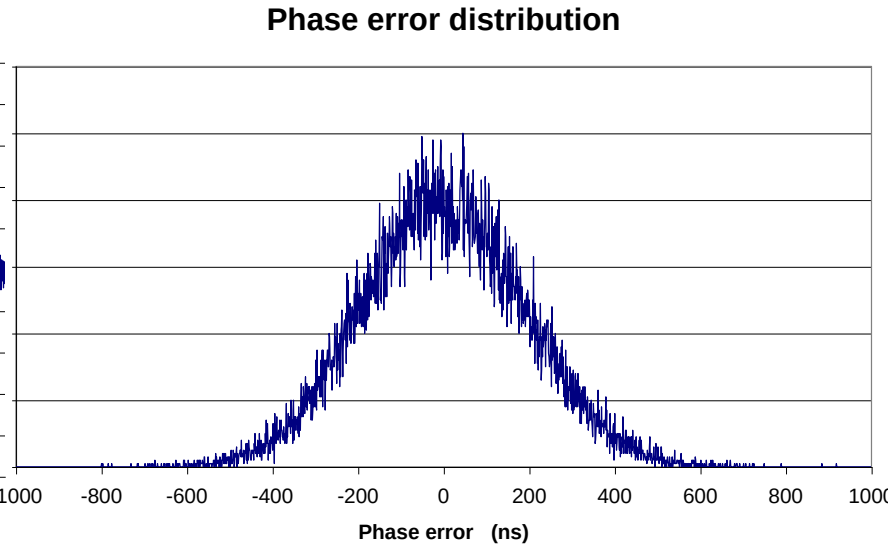


- Very long integration time mandatory to reach 1 µs accuracy
- Remaining sensitivity to load variation much higher than 1 µs

MAN synchronization capabilities : limited extension legacy NE

- Injected network behavior: Delay 22 µs, Jitter 1.5 µs (2 hops)





- Filtered output phase error is < 600 ns with short integration
- Can react to route path switching
- Remaining asymmetry to load > 2 µs (not shown)

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MAN synchronization capabilities: discussion

- Same conclusion than for WAN network when broadcast operator lease some part of the network : it is not a competitive solution.
- NE transparent clock for IEEE1588v2 enable the compensation of the latency variation vs load inside the switches.
- So remaining asymmetry variation will be compatible with expectation for hops ≤ 6
- As well as integration time can be minimized and then compatible with route path switching.
- So this solution is to be competitive with GNSS master clocks (excluding the cost of NE to be renewed.
- For 1hop only (last connection), legacy NE can be dealt with careful asymmetry variation mitigation: some experiments shall confirm that later. Remaining asymmetry is in the 2 µs range.

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Synchronization architecture recommendations

- Long range with satellite link : Master clock GPS source on the head end, Master clocks at regional network gateways or transmitters ends.
- Long range with physical link (optical, copper) : Master clock GPS source at network ends.
- Medium range with microwave or physical link, up to 6 hops : Master clock GPS source at network head end, transparent clocks through network path, slave clocks at transmitters ends.
- Last hop with microwave or physical link: Master clock GPS source or IEEE1588v2, legacy network elements (to be calibrated for asymmetry), slave clocks at transmitters ends.

- Thanks for support from:

CELTIC
Telecommunication Solutions

DVB
Digital Video Broadcasting

B21C

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Open Questions ?