ST5066 strategies for high data rate HF transmissions

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Context

◆ **Purpose of an "ARQ" for wideband transmissions**

◆ **System considerations**

Thoughts on a good strategy for HF wideband waveforms

Simulations and preliminary Results

Conclusions

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Evolution currently proposed for new HF wideband solutions (with contiguous or possibly non-contiguous strategies)

◆ **MIL STD 188-110C app. D**

◆ **HF XL approach**

  ○ evolution of ST4539 (appendix H proposal currently under review)

  ○ evolution of ALE/ALM (denoted ALE 4G) based on wideband reception, refer preliminary results presented during at HFIA Feb 2104

  ○ ... and also higher layer: evolution of DRC, ARQ …

Wideband HF solutions (110C, HFXL) allows to reach much higher PHY layer throughputs, but are not well managed by data link layer as per current version of STANAG 5066

◆ **Already discussed in this forum of the window of anticipation, DPDU size …**

But other questions should also be raised

◆ **Adequation of ST5066 almost as is to higher date rates**

◆ **Possible impact of targeted applications for wideband HF**

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From a system point of view, wideband HF waveforms will be interesting if they permit:

◆ **More efficient link management (more reactivity, automatic choices, …)**

◆ **Wider use of modern applications (IP over HF: chat, big emails, file transfers, …), in particular thanks to high data rate <u>at the user level</u>**

Changes / key element: adaptability

◆ **Wideband waveforms management is 2D instead of 1D as before: modulation & bandwidth**

- The modem information should be used to decide of the link management more than an ARQ stack in the red part of the waveform

- Working at modem level will allow a greater reactivity which will allow to operate with a smaller margin (hence permit to reach the high SNR needed for wideband HF solutions)

◆ **Reactivity implies however feedback information**

- 127,5s is a long time to wait for information to adapt the circuit …

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Considered strategy for ST5066 evolution :

◆ **Maintain SIS role**

◆ **Maintain CAS role (with wideband ALE management capability, as proposed for instance in Feb. 2014)**

◆ **Simplify DTS role by transferring DRC to the Modem part**
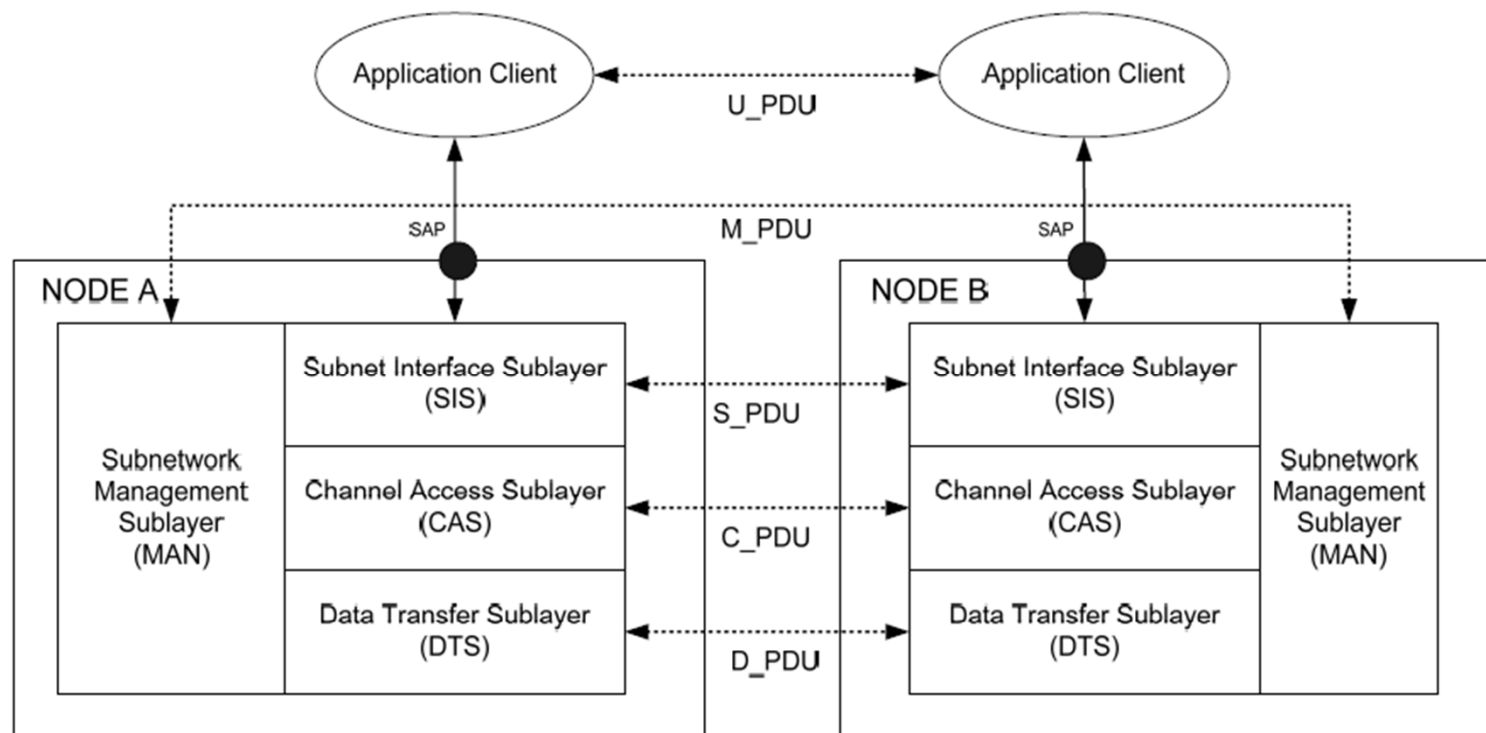
Main change we are recommanding: DRC to be dealt by the modem, in the black

Further possible evolution: adopting a TDD approach

- ◆ **To ensure that the Modem (managing the link) will have sufficient information to adapt when necessary**

- ◆ **To improve user experience with applications tolerating only low latency (eg. Chat, web browsing, …)**

- ◆ **Ultimately, for easier operations in multi-users schemes**

HF XL has been thought as a TDD scheme for these reasons. Benefits at application level are:

- ◆ **lower latency of individual DPDUs (➔ food for applications such as chat, IoD, …)**

- ◆ **Inherent robustness to acks losses, due to frequent transmissions of selective acks**

Balance the cost of more acks/signalling … to the cost of losts packets due to bad adaptation, or too large margins taken in selecting the used data rate

Simulations: analysing the proposed approach

Simulation conditions: frames format

◆ **Considered frames: evolution of basic ST5066 frames to new formats (highlighted fields) as per E. Koski proposal**

DATA-Only

Sync	D-PDU Type	EOW	EOT	Address Size	Header Size	Source & Destination Adresses	Flags	User Data Size	Frame Sequence Number	Header CRC	User Data	User Data CRC
2 bytes	4 bits	12 bits	1 byte	3 bits	5 bits	1 to 7 bytes	6 bits	10 bits (12 bits)	1 byte (12 bits)	2 bytes	1 to 1023 bytes (1 to 2054 bytes)	4 bytes

ACK-Only

Sync	D-PDU Type	EOW	EOT	Address Size	Header Size	Source & Destination Adresses	Lower Window Edge	Selective Acks	Header CRC
2 bytes	4 bits	12 bits	1 byte	3 bits	5 bits (9 bits)	1 to 7 bytes	1 byte (12 bits)	0 to 16 bytes (0 to 256 bytes)	2 bytes

DATA-ACK

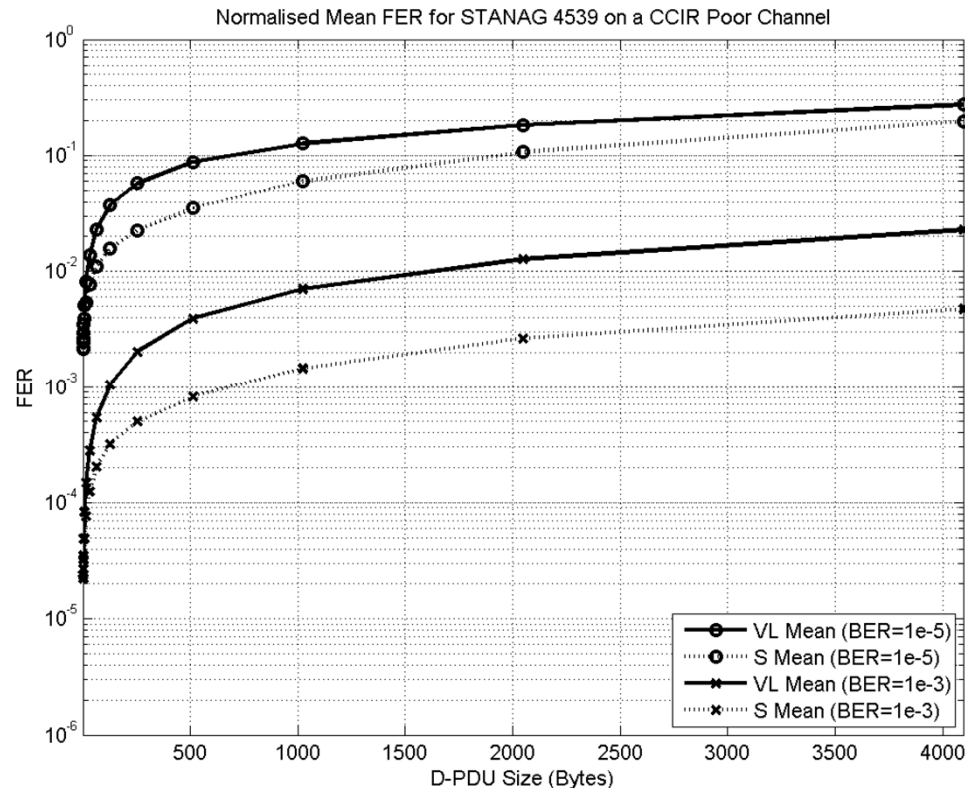| Sync	D-PDU Type	EOW	EOT	Address Size	Header Size	Source & Destination Adresses	Flags	User Data Size	Frame Sequence Number	Lower Window Edge	Selective Acks	Header CRC	User Data	User Data CRC
2 bytes	4 bits	12 bits	1 byte	3 bits	5 bits (9 bits)	1 to 7 bytes	6 bits	10 bits (12 bits)	1 byte (12 bits)	1 byte (12 bits)	0 to 16 bytes (0 to 256 bytes)	2 bytes	1 to 1023 bytes (1 to 2054 bytes)	4 bytes

Legend:

☐ General field

☐ Field considered for wideband adaptation

( ) Proposed adaptation

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Simulation conditions: channel FER

◆ **For sake of simplicity, the wideband data rates are considered to have similar characteristics as their narrow band unitary 3kHz channel versions (ie. no gain considered from diversity, corresponding to worst case).**

➔ **FER derived with reference in CCIR Poor conditions**

Normalised Mean FER for STANAG 4539 on a CCIR Poor Channel

Feb. 13th, 2014 / TH/TCS/RCP/DT/cl,14/0002/PRE
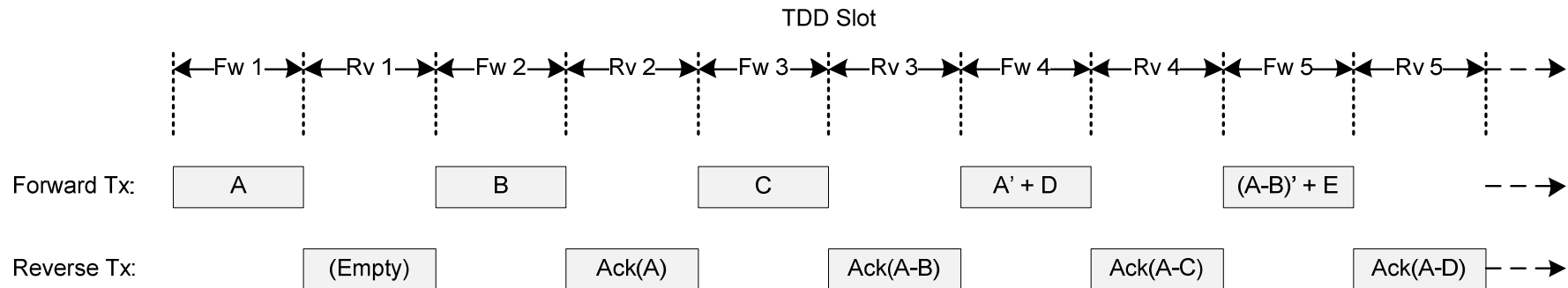
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Simulation conditions: scenarios

◆ **Two different scenarios have been considered: one symmetrical with low latency constraints, and one asymmetrical with high throughput in forward direction**

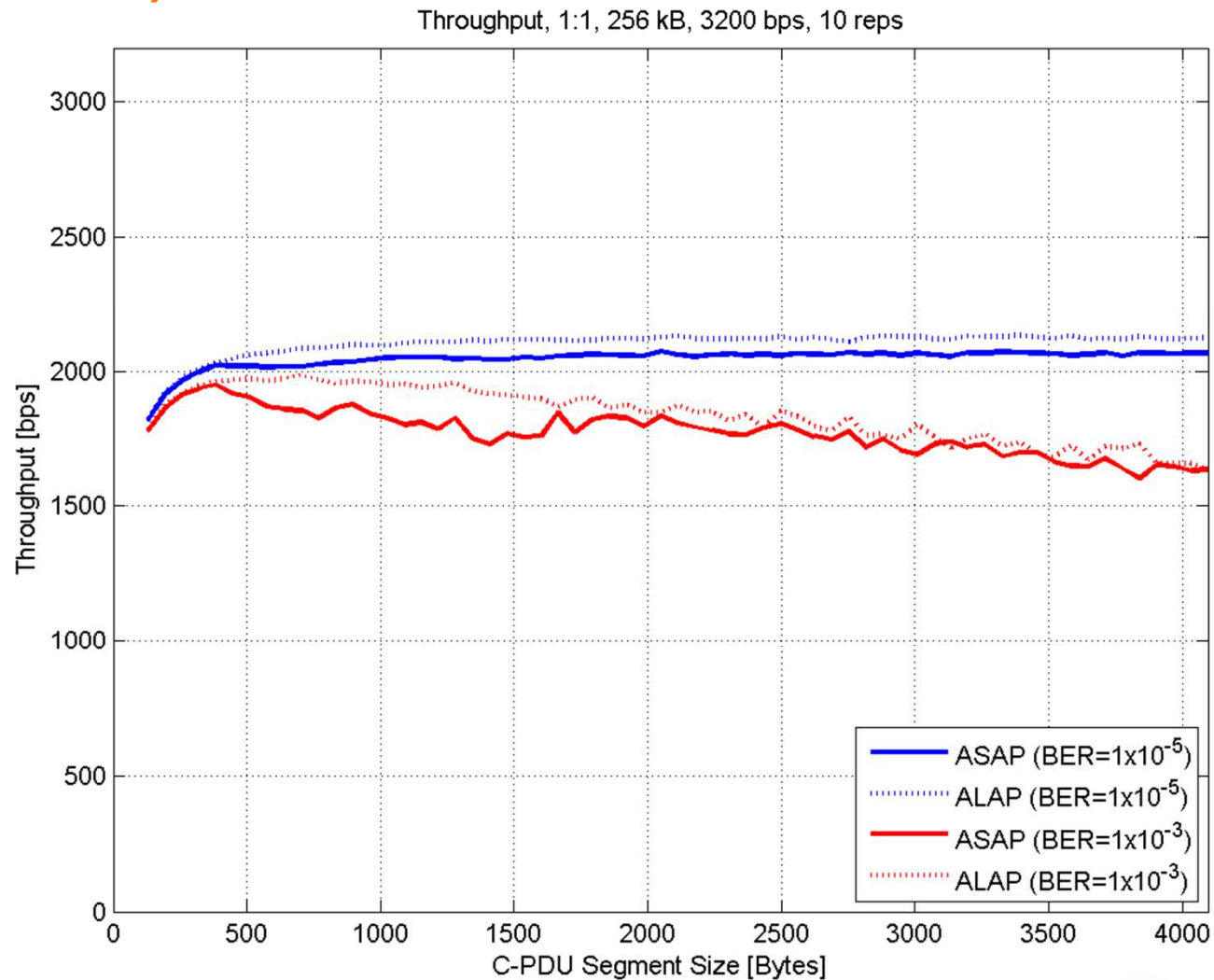|			
Chat	Data direction: TDD Scheme: Forward Data Rate: Reverse Data Rate: rate. Ack's Can Be Lost:	Forward & Reverse 1:1 3200 – 128000 bps Match forward data Yes	**256**
SMTP/FTP/HTTP	Data direction: TDD Schema: Forward Data Rate: Reverse Data Rate: Ack's Can Be Lost:	Forward only 9:1 3200 – 128000 bps 3200 bps (fixed) No	**2048**

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First analysis : comparing use of TDD vs. classic 5066 approach

◆ **HF XL TDD principle (ASAP strategy : acks sent as soon as possible)**

TDD Slot

←Fw 1→ ←Rv 1→ ←Fw 2→ ←Rv 2→ ←Fw 3→ ←Rv 3→ ←Fw 4→ ←Rv 4→ ←Fw 5→ ←Rv 5→ – – →

Forward Tx:	A	B	C	A' + D	(A-B)' + E	– – →

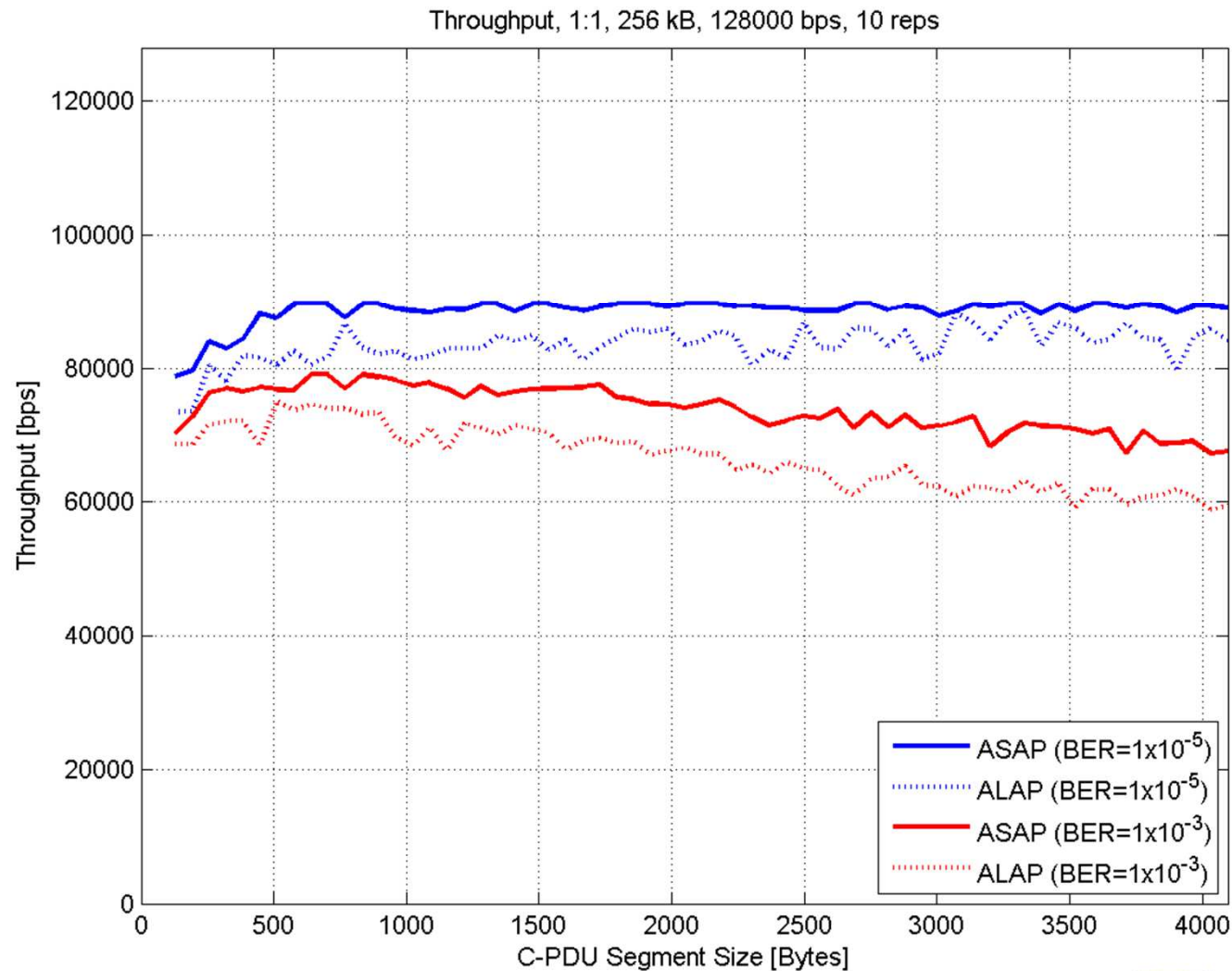| Reverse Tx:	(Empty)	Ack(A)	Ack(A-B)	Ack(A-C)	Ack(A-D)	– – →

◆ **As in narrow band: acks sent when EOT is reached, either because end of anticipation window or max forward transmission time (ALAP strategy; acks sent as late as possible)**
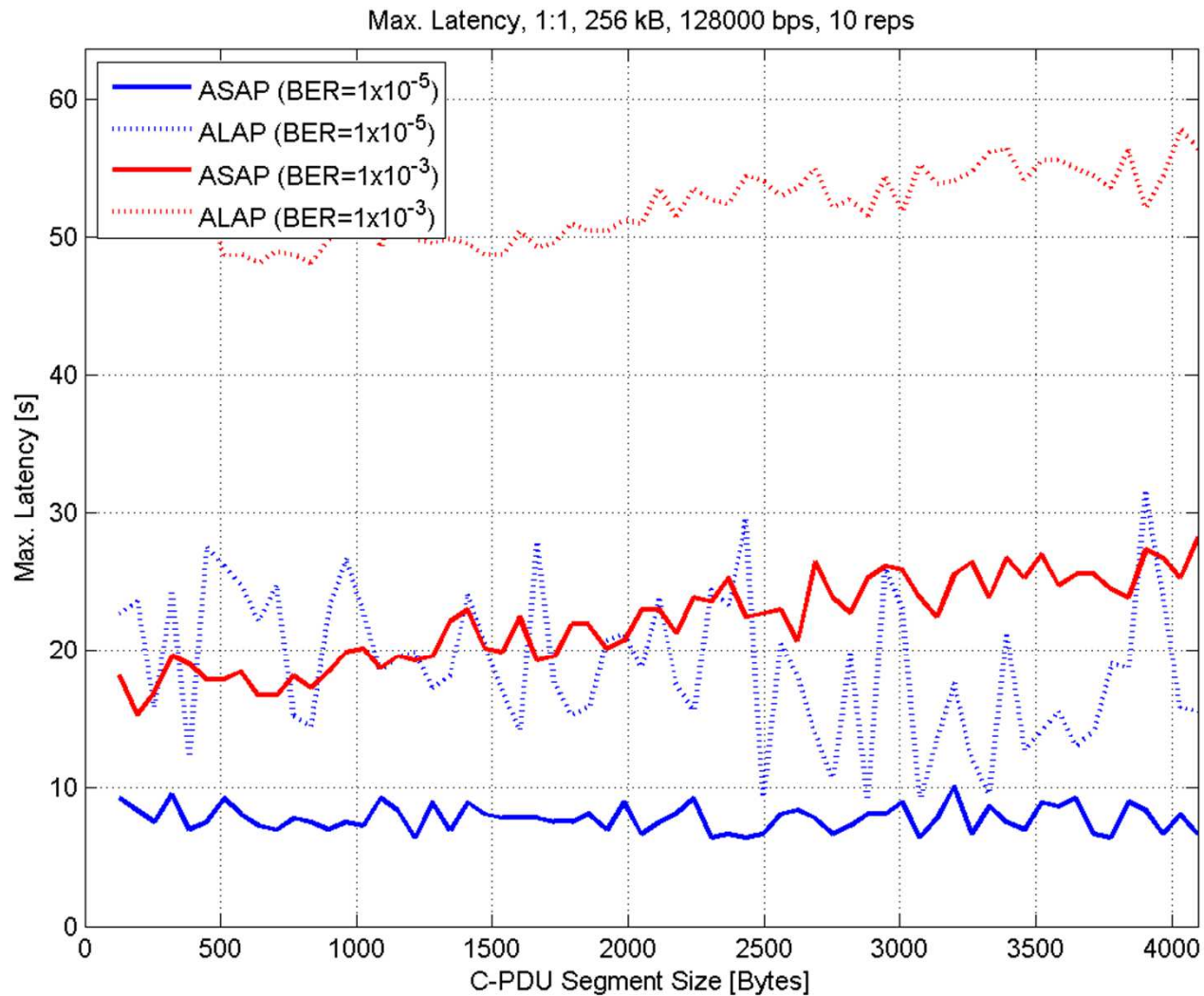
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Obtained results for chat scenario – throughput (comparison for low data rate)

◆

Throughput, 1:1, 256 kB, 3200 bps, 10 reps

Legend:
- ASAP (BER=1×10^{-5})
- ALAP (BER=1×10^{-5})
- ASAP (BER=1×10^{-3})
- ALAP (BER=1×10^{-3})

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Obtained results for chat scenario - throughput

◆

Throughput, 1:1, 256 kB, 128000 bps, 10 reps

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Obtained results for chat scenario - latency

◆

Max. Latency, 1:1, 256 kB, 128000 bps, 10 reps

Legend:
- ASAP (BER=1×10^{-5})
- ALAP (BER=1×10^{-5})
- ASAP (BER=1×10^{-3})
- ALAP (BER=1×10^{-3})

X-axis: C-PDU Segment Size [Bytes]
Y-axis: Max. Latency [s]
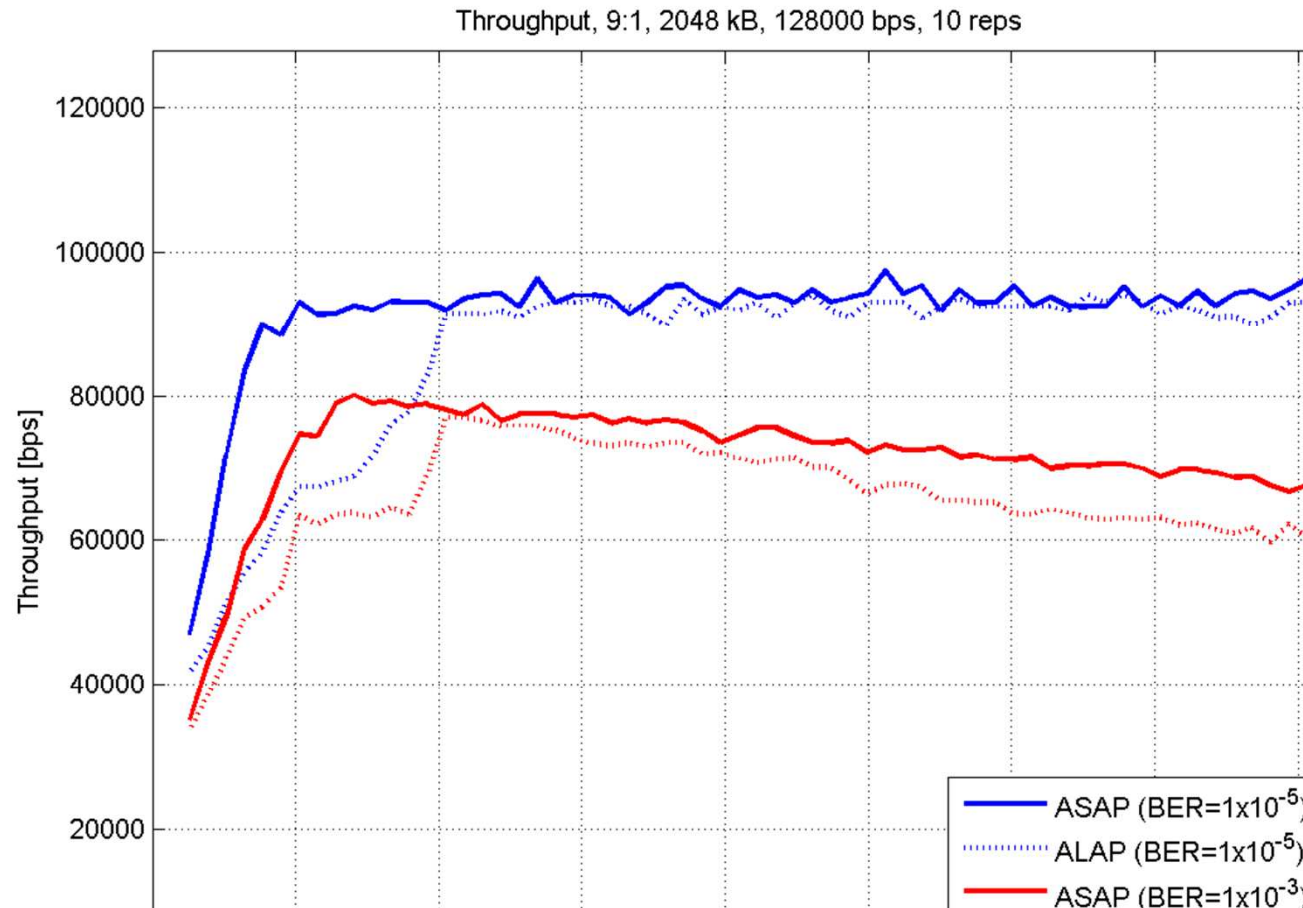
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Obtained results for SMTP/FTP/HTTP scenario – throughput (comparison for low data rate)

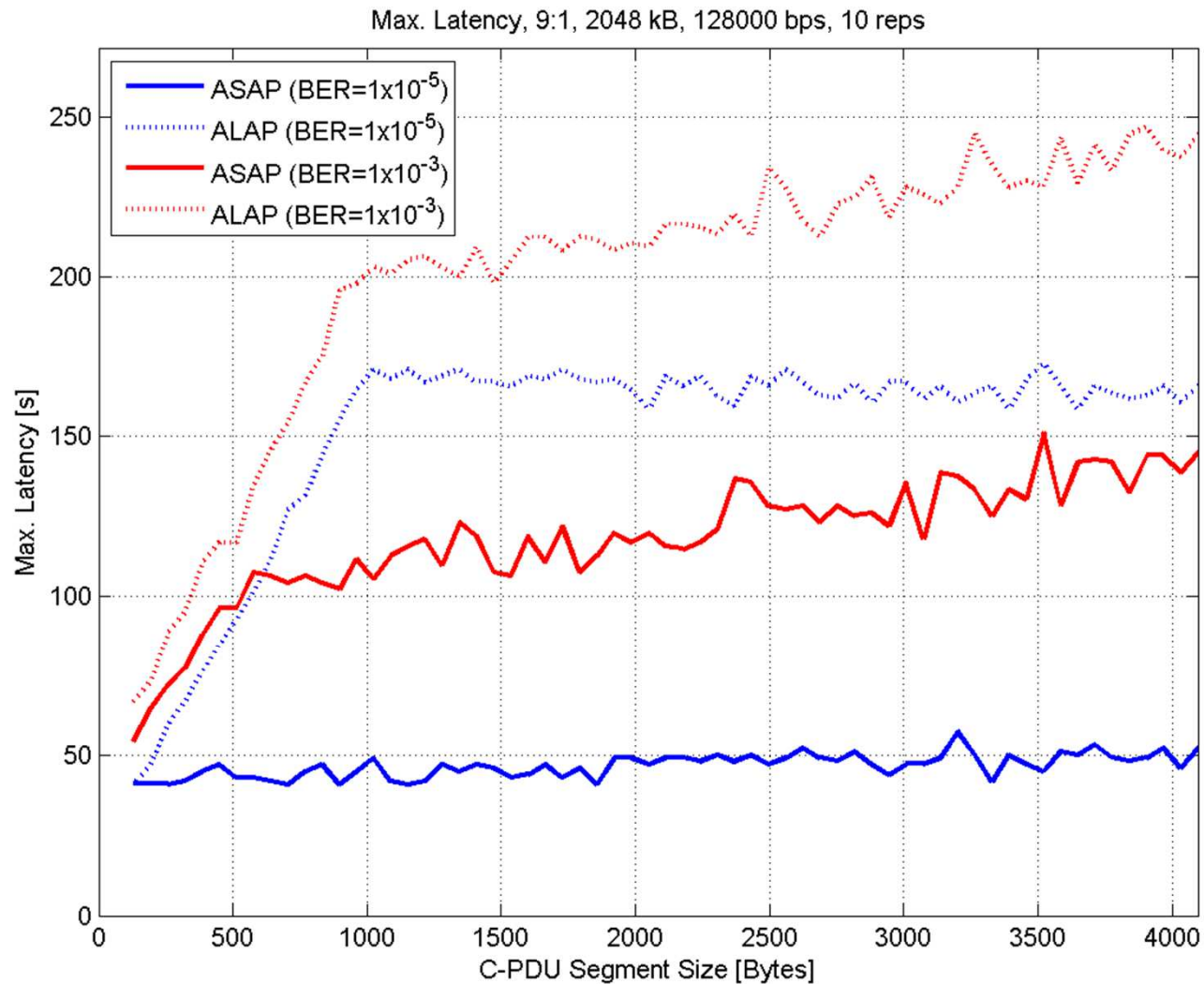Throughput, 9:1, 2048 kB, 3200 bps, 10 reps

Legend:
- ASAP (BER=1×10^{-5})
- ALAP (BER=1×10^{-5})
- ASAP (BER=1×10^{-3})
- ALAP (BER=1×10^{-3})

X-axis: C-PDU Segment Size [Bytes]
Y-axis: Throughput [bps]

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Obtained results for SMTP/FTP/HTTP scenario – throughput

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Throughput, 9:1, 2048 kB, 128000 bps, 10 reps

Legend:
- ASAP (BER=1×10^{-5})
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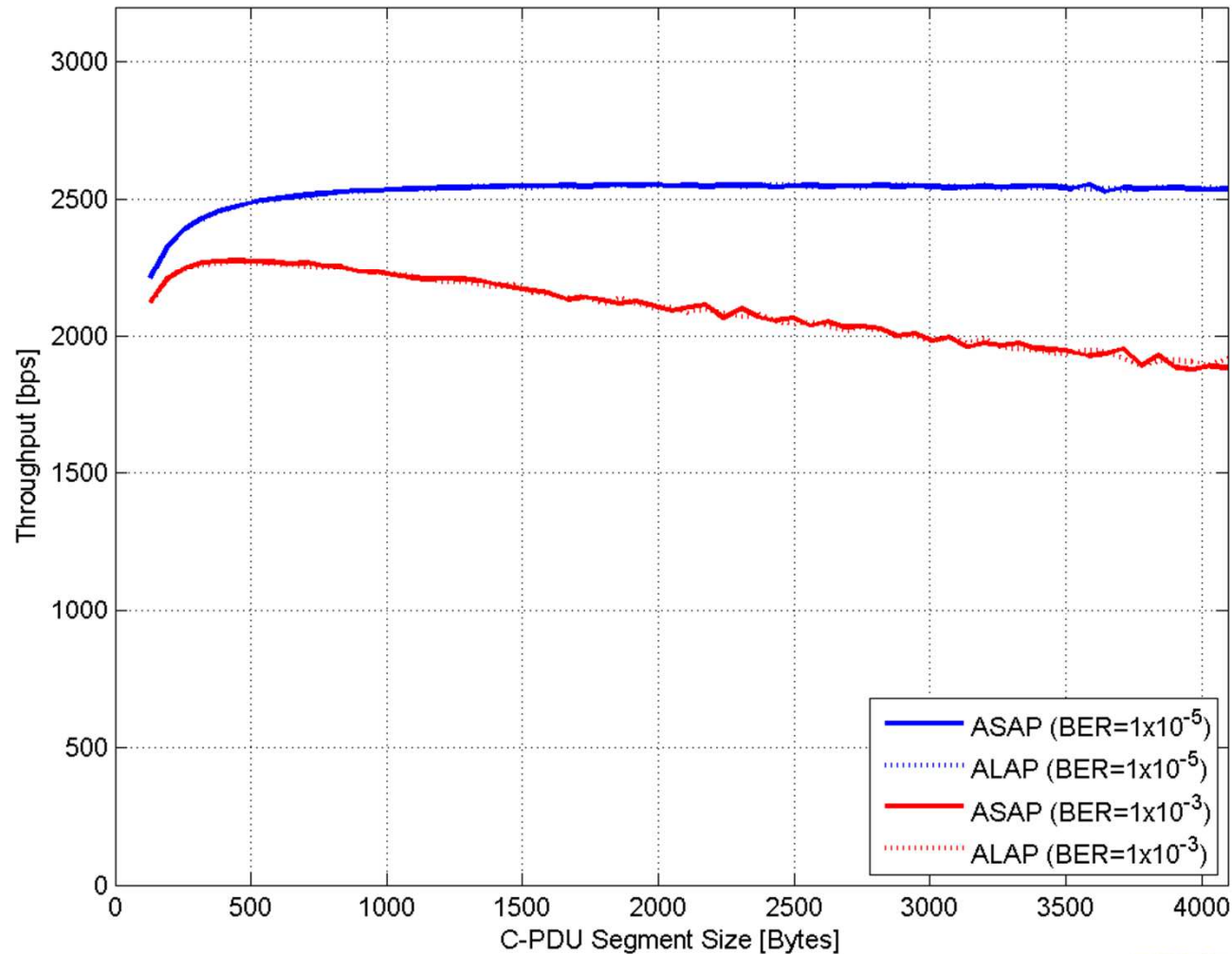
The ASAP TDD strategy is clearly more efficient for high date rates and should consequently be used.

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Obtained results for SMTP/FTP/HTTP scenario - latency

◆

Max. Latency, 9:1, 2048 kB, 128000 bps, 10 reps

Legend:
- ASAP (BER=1×10^{-5})
- ALAP (BER=1×10^{-5})
- ASAP (BER=1×10^{-3})
- ALAP (BER=1×10^{-3})

Y-axis: Max. Latency [s]
X-axis: C-PDU Segment Size [Bytes]

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Second analysis (on-going work) : select optimal DPDU size for various bit rates

♦ **Varying the DPDU size for two average BER values: 10^{-3} and 10^{-5}**

♦ **Finding the optimal segment size considering the two values, for better robustness to channel conditions variations**

Throughput, 1:1, 256kB, 30reps, BER=1x10^{-3}
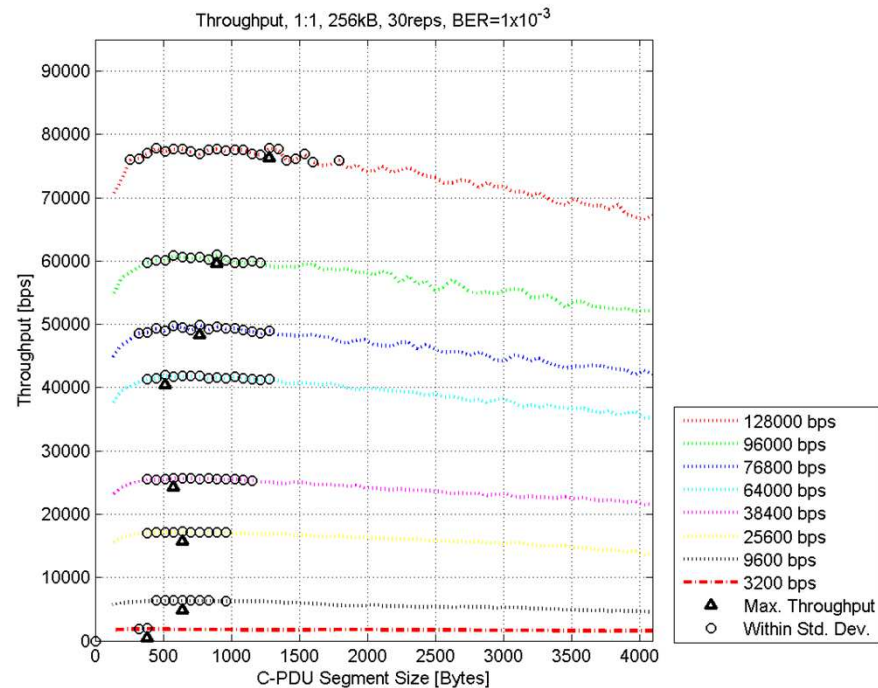
On-going work, that will allow us to recommend a DPDU size for each throughput and interleaver

Evolution of ST 5066 as the interoperability standard for wideband HF implies to reassess the standard and at minima adapt it so as to ensure that

◆ the needed efficiency of the procedure allow take advantage of the high data rate physical layer(s) introduced with wideband modems

◆ the end user applications requirements are met (e.g. limited latency, …)

ST 5066 needed evolutions appear not to be so numerous

◆ (almost?) no change on higher layers but move DRC procedure to modem part to be more efficient

◆ recommended : switch to TDD approach

➔ independent of the PHY layer choices, these modifications can be used for any wideband HF waveform

Next steps

◆ **Confirm** use of new frames for High Data Rate, and optimal DPDU size (incl. taking into account higher layers)

THALES welcomes comments on this presentation and on its proposed scheme, that will be implemented within French MoD programme SALAMANDRE

Thanks for your attention

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with grateful thanks to our colleagues
from SALAMANDRE project

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