



## ST5066 TDD approach for wideband HF transmissions

HFIA MEETING, SAN DIEGO, FEB. 17<sup>TH</sup> 2016

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# Presentation Outline

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## Context

- Thoughts on a new “ARQ” for wideband transmissions
- ALAP/ASAP strategy (reminder)

## D-PDU recommended size analysis

## First implementation results

## Conclusions

# Context (1/3)

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## Wideband HF waveforms will not only offer higher throughput/better resilience, they will also

- Request a more efficient & reactive link management
  - Ex: waiting for 127,5s an ack is not adapted to a 100 kb/s link providing IP connectivity
- Necessitate a more complex waveform management (2D as in modulation & bandwidth, not only 1D with modulation only)

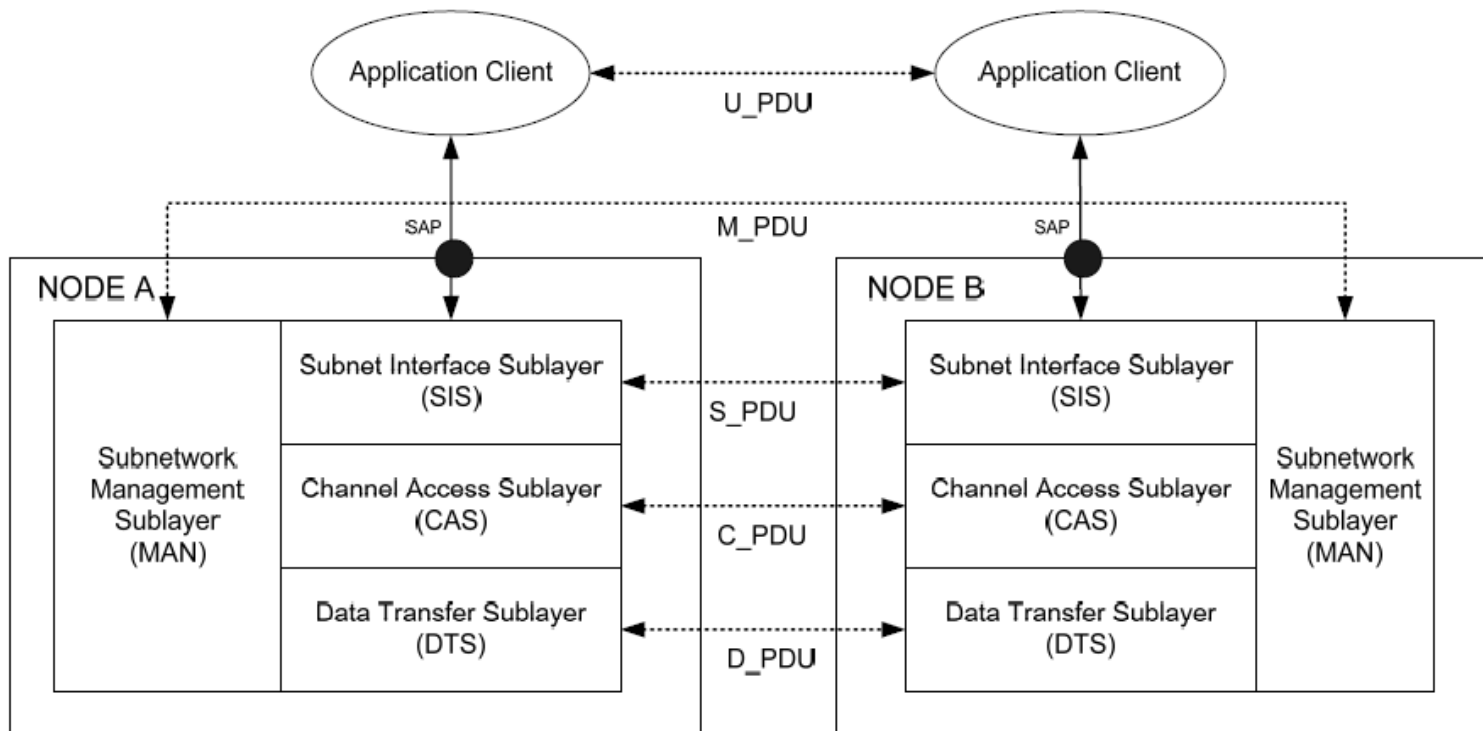
## High throughputs necessitate good SNR ... which can be obtained in particular if the tuning on the channel conditions is efficient

- the modem has more information on the link than the red ARQ stack
  - Ex : fine channel estimation
- working at modem level will allow a greater reactivity
- the ARQ can anyway provide to the modem its own quality metric if necessary

# Context (2/3)

## Consequence: evolution of ST5066 strategy (DTS role) ...

- 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

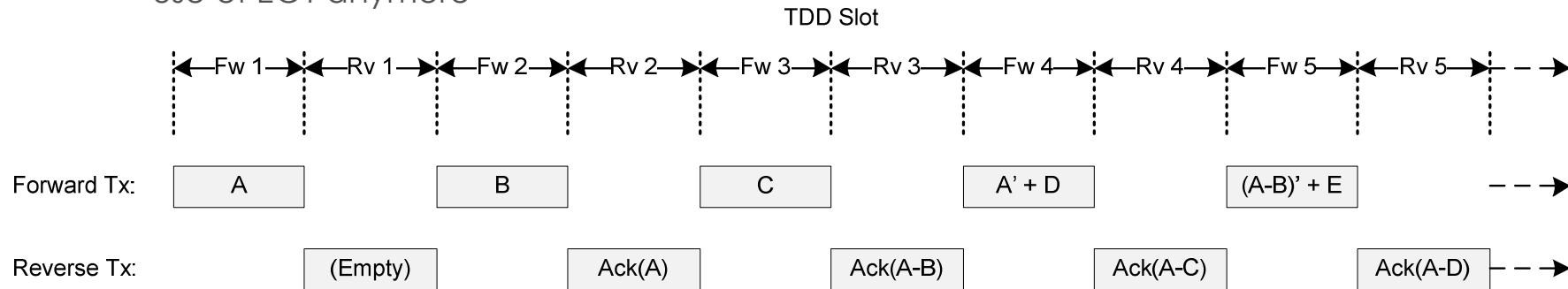


# Context (3/3)

## ... and evolution from PTT (alternate) to TDD for better reactivity

➤ Two approaches evaluated (see Feb. 2015 presentation):

- ALAP : traditional ARQ 5066 approach - acks sent when EOT is reached
- ASAP : follow strategy adopted in V/U band (similar throughputs) to ensure benefit of lower latency and inherent robustness to acks losses – acks sent as soon as possible – no use of EOT anymore



➤ Obtained results : a better solution with ASAP

Monitored parameter	Chat @3200 bps	Chat @128000 bps	SMTP/FTP/HTTP @3200 bps	SMTP/FTP/HTTP @128000 bps
Throughput	ALAP (small margin)	ASAP	Equivalent	ASAP
Best latency	ASAP (big margin)	ASAP	ASAP	ASAP
<b>Overall best strategy for the scenario</b>	<b>ASAP</b>	<b>ASAP</b>	<b>ASAP</b>	<b>ASAP</b>

# Study of the optimal C-PDU size

**Goal: determine the optimum C-PDU segment size that maximises throughput for each data rate and interleaver length combination**

➤ Considered scenarios

Application type	Configuration	Payload
<b>Chat</b>	Data direction: Forward & Reverse TDD Scheme: 1:1 Forward Data Rate: 3200 – 128000 bps Reverse Data Rate: Match forward data rate. Ack's Can Be Lost: Yes	256kB
<b>SMTP/FTP/HTTP</b>	Data direction: Forward only TDD Schema: 9:1 Forward Data Rate: 3200 – 128000 bps Reverse Data Rate: 3200 bps (fixed) Ack's Can Be Lost: No	2MB

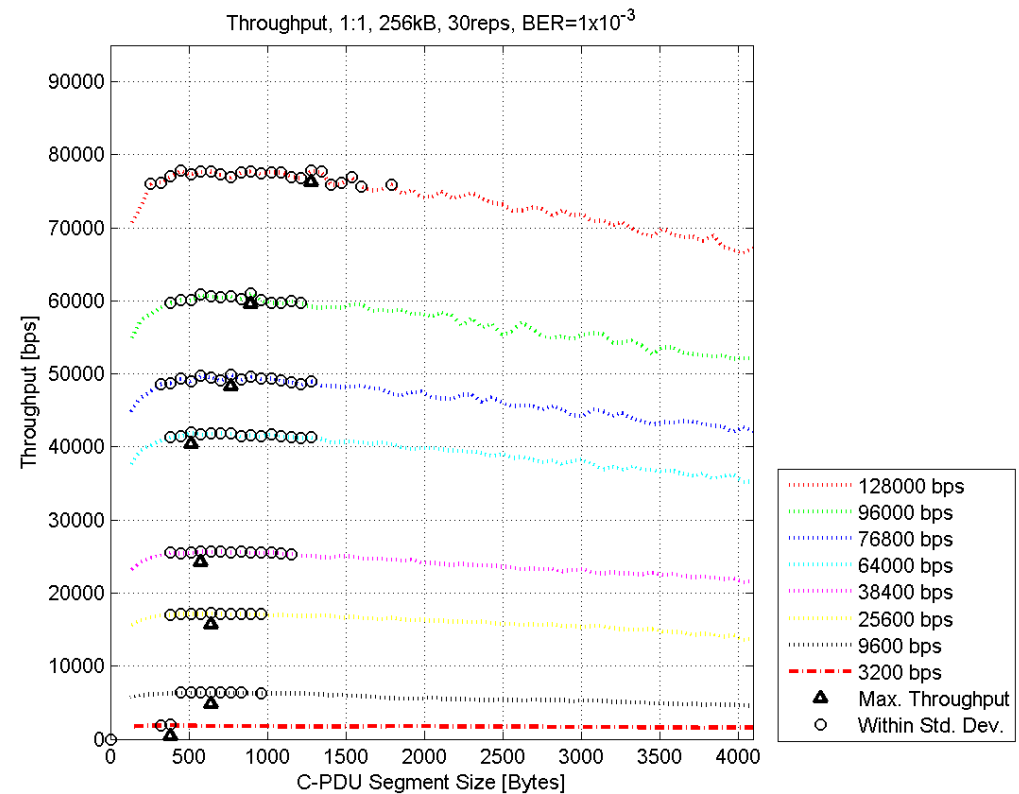
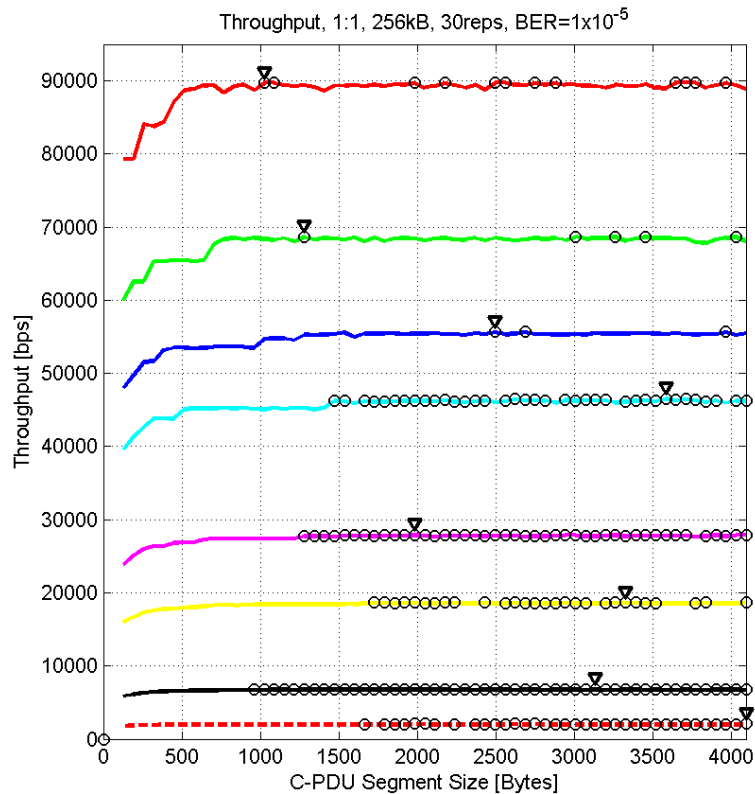
➤ NB : window of anticipation : 2048 (similar to 2054 proposal made by Harris)

➤ DPDU frame format with new extensions as proposed by Harris

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# Study of the optimal C-PDU size

## CHAT scenario : Throughput as a function of C-PDU segment size for BER=10<sup>-3</sup> / 10<sup>-5</sup>

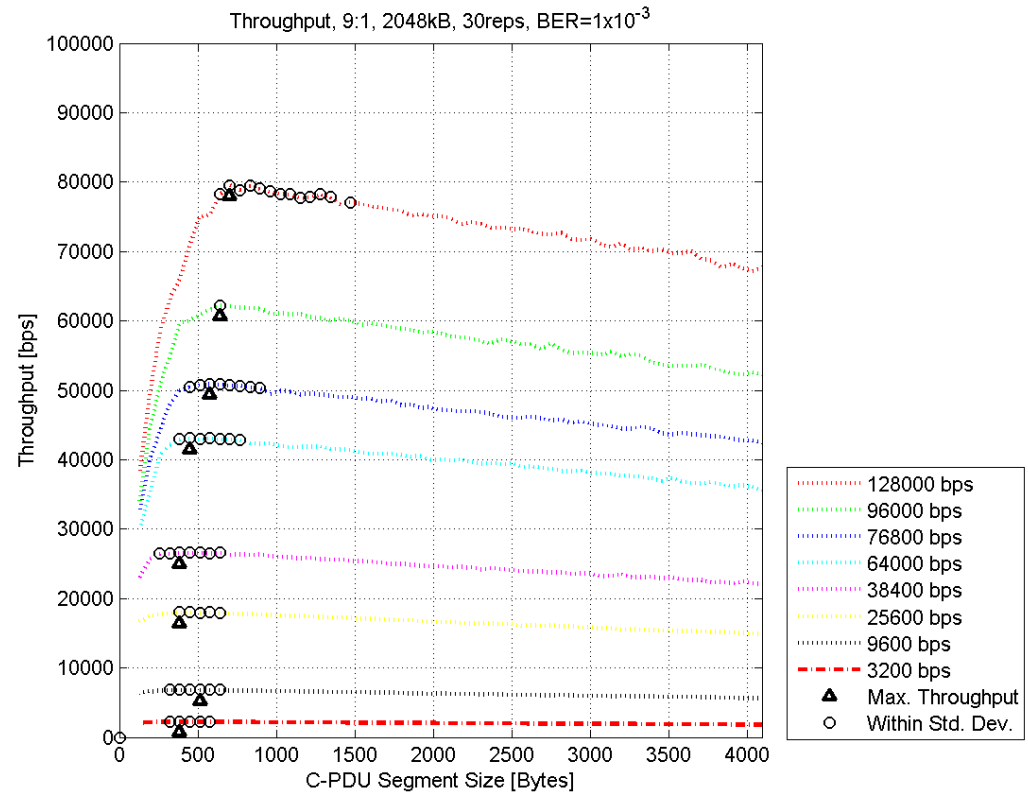
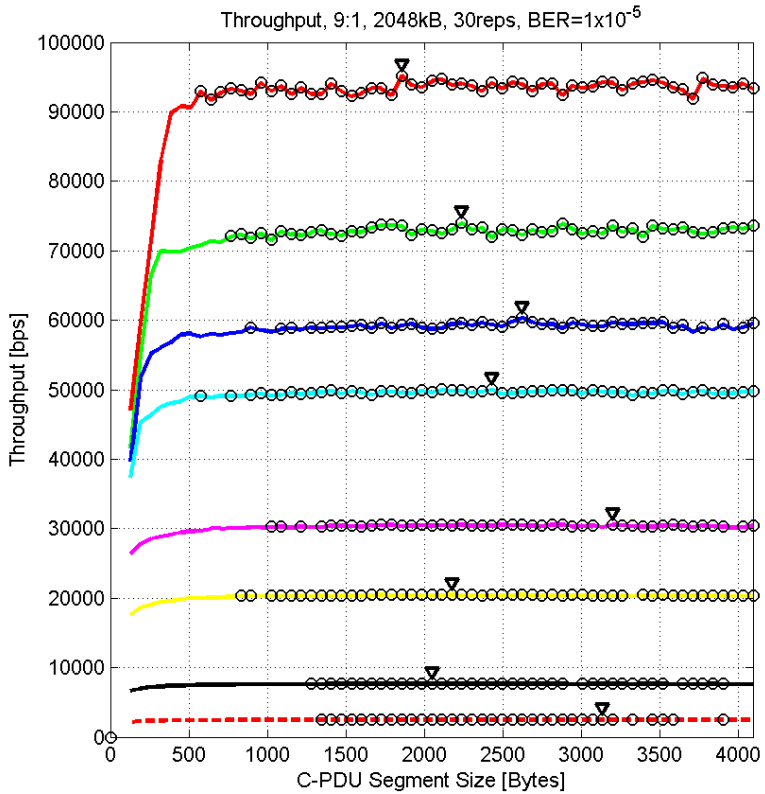


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# Study of the optimal C-PDU size

## SMTP/FTP/HTTP scenario : Throughput as a function of C-PDU segment size for BER=10<sup>-3</sup> / 10<sup>-5</sup>

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- 128000 bps
- 96000 bps
- 76800 bps
- 64000 bps
- 38400 bps
- 25600 bps
- 9600 bps
- 3200 bps
- ▲ Max. Throughput
- Within Std. Dev.

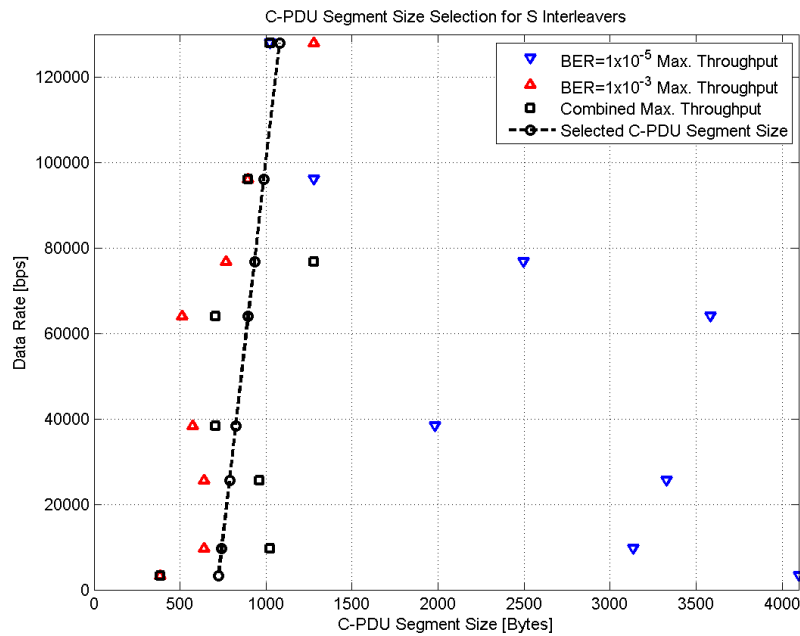


# Study of the optimal C-PDU size

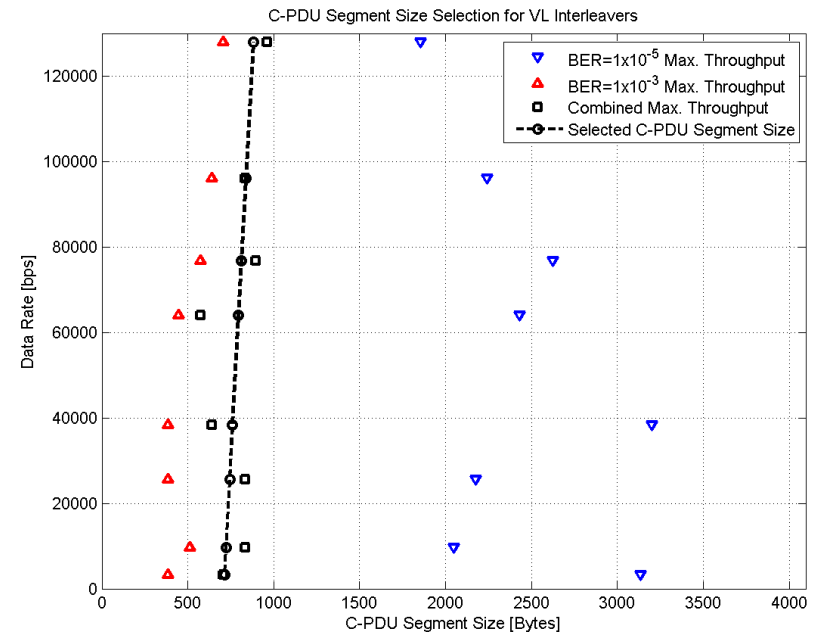
## Obtained optima for both scenarios

- C-PDU optimum for BER=10<sup>-3</sup>, 10<sup>-5</sup> and combination
- Linear approximation of Combined max throughput C-PDU optimal value

(CHAT scenario)



(SMTP/FTP/HMTP scenario)



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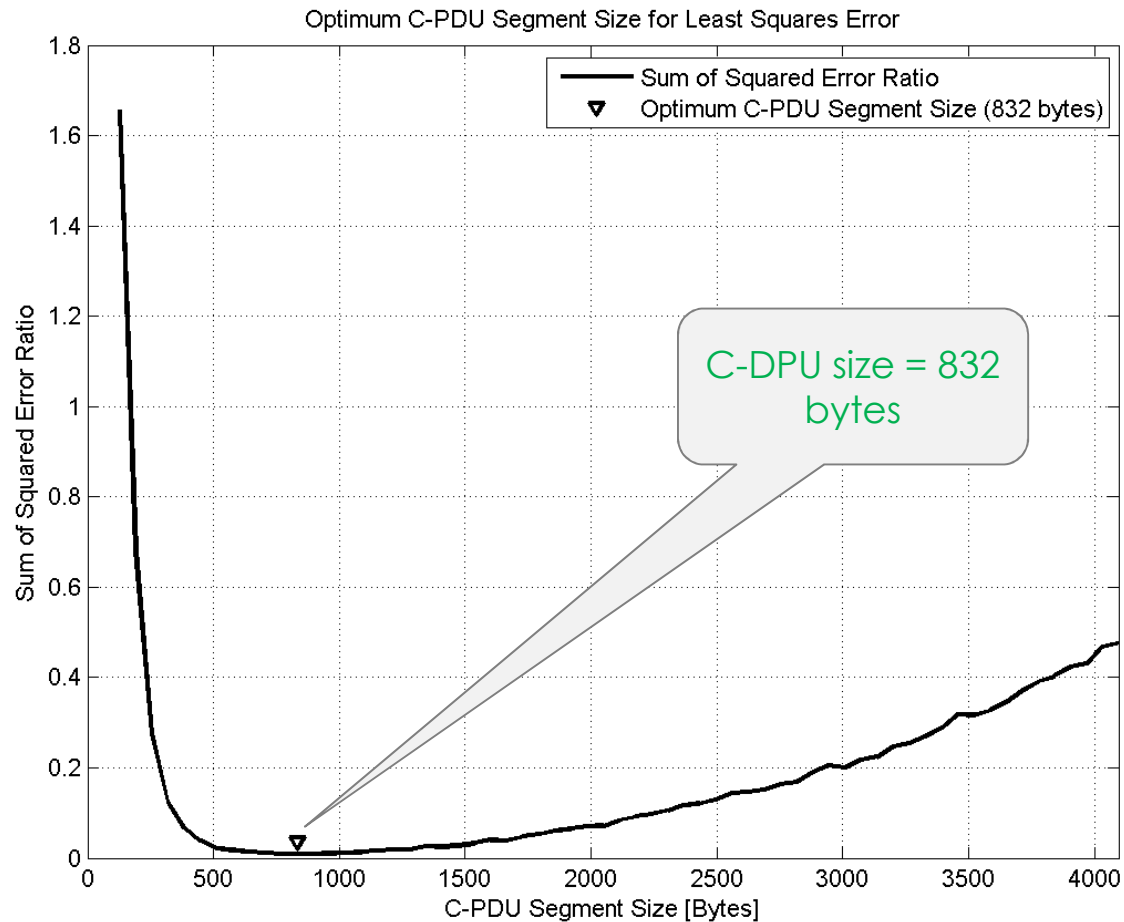
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# Study of the optimal C-PDU size

## Deriving overall optima: best constant size

➤ For all considered bitrates and scenarios

$$SSER(c) = \sum_{d \in D} \sum_{d \in U} \left[ \frac{T_{MAX}(u, d) - T(u, d, c)}{T_{MAX}(u, d)} \right]$$



# Study of the optimal C-PDU size:

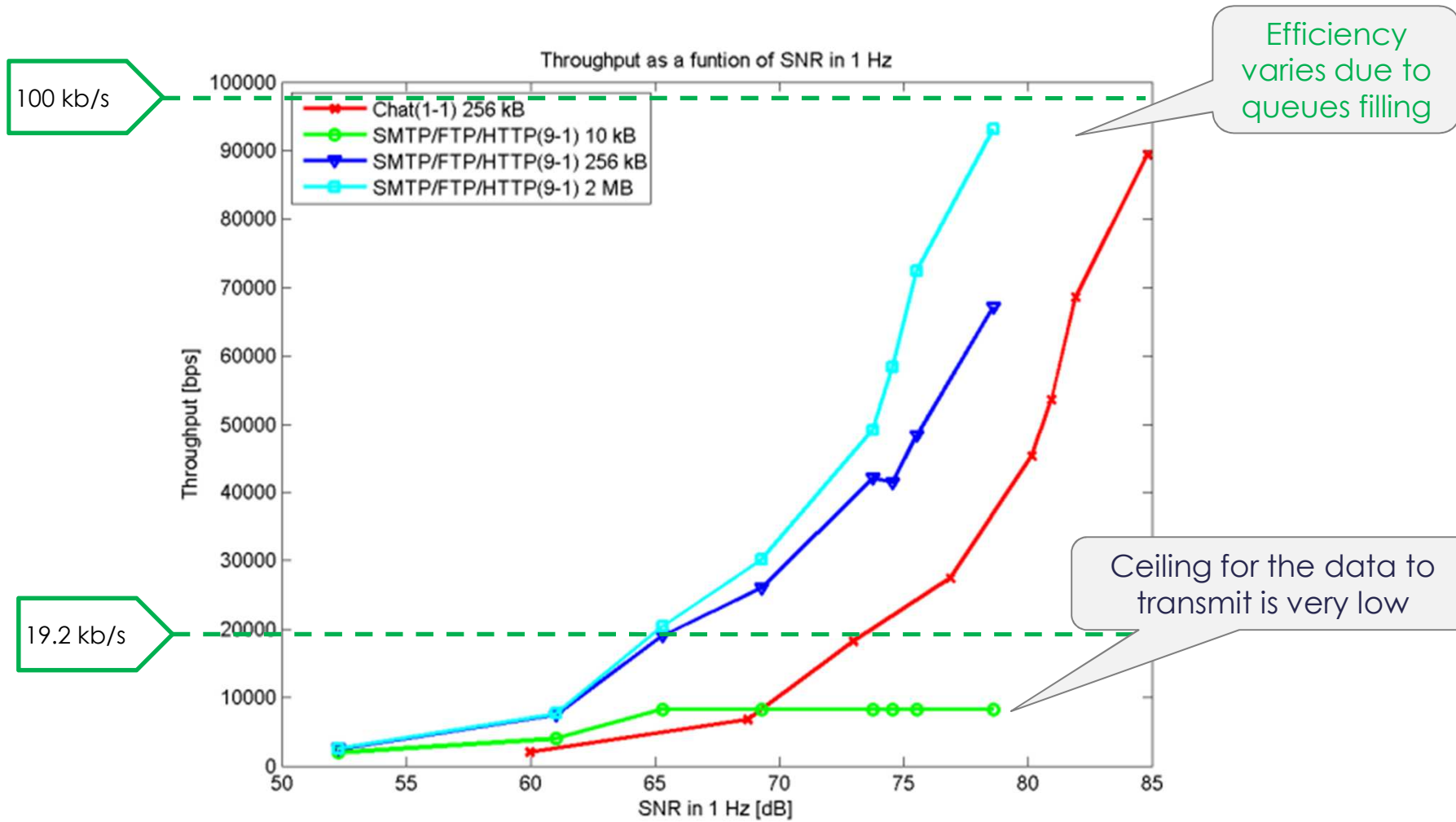
## Rationale

- Variation of throughput performance < 5% (worst case, short interleaver) and < 3.4% (worst case, VL interleaver) when using C-PDU constant vs. optimal one ... and often similar !
- Higher layer constraints:
  - The ARQ stack indicates the U-PDU when the client bind to the ARQ stack .. and the U-PDU size remains constant for the duration of the session
  - U-PDU can be split over multiple D-PDUs but not the contrary → It is desirable that the U-PDU size to be is an integer multiple of the C-PDU segment size, plus six bytes.

➔ **Recommandation is to use a constant C-PDU segment size matched with the U-PDU size**

# Obtained overall throughputs (simulations)

## Throughput expressed vs. SNR in 1Hz obtained for a C-PDU of size 832 bytes



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Reaching 100kb/s useful (taking into account acks TDD scheme ...)

# « Live » : test results

## SALAMANDRE Set-up

- HF XL demonstrator
- ST5066 TDD implementation
- Overall MMI to supervise

Station locale : Station Celle  
Etat ARQ : Offline

Choix de la configuration

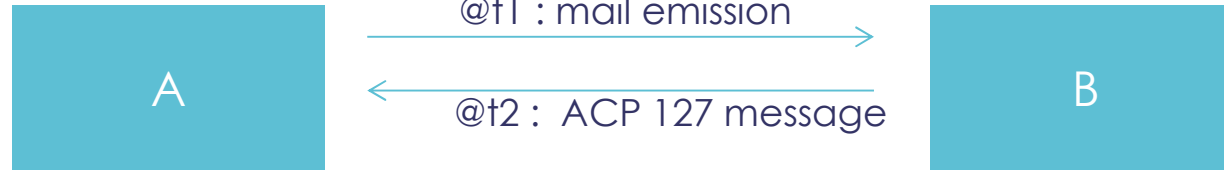
Nom	Type	Cognitivité (LB)	Profil TDD (LB)	Forme d'onde (BE)	Entrelaceur (BE)	Débit (BE)
Rx_High_DataRate	LB	Autonome	9s / 1.5s	-	-	-
NB_4539_4800_US	BE	-	-	4539	Ultra court	4800 bps
Rx_HD_Careful	LB	Autonome	1.5s / 9s	-	-	-
NB_4539_9600_S	BE	-	-	4539	Court	9600 bps
Interactive	LB	Autonome	1.5s / 1.5s	-	-	-
NB_MIL110C	BE	-	-	MIL110C	Moyen	4800 bps
Tx/Rx_High_Data_Rate	LB	Prévision	9s / 9s	-	-	-
Interactive	LB	Prévision	1.5s / 1.5s	-	-	-
Interactive_Reac	LB	Réactualisation	1.5s / 1.5s	-	-	-
NB_4539_3200_VL	BE	-	-	4539	Très Long	3200 bps
NB_4539_6400_L	BE	-	-	4539	Long	6400 bps
NB_4539_6400_VS	BE	-	-	4539	Très Court	6400 bps
Tx/Rx_HD	LB	Autonome	9s / 9s	-	-	-



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# First example: interest of TDD for bidirectional exchanges

## Use case:



The screenshot displays the ARQ 5066 XL MMI [2.0.2.0] software interface. The main window features the SALAMANDRE logo and a table titled "TX appel ALE" showing transmission parameters for various frequencies. Other windows include "ACP127 MMI (New Message)" and "ARQ 5066 XL MMI [2.0.2.0]".

Station distante	Mode	Mode Moteur Cognitif	Voie de réception	Lien ALE
2904	LB	Autonome	XL	CNX: TX Appel ...
2968	O	50 %	-90 dB	-80 dB
3204	O	50 %	-90 dB	-80 dB
3264	O	50 %	-90 dB	-80 dB
3276	O	50 %	-90 dB	-80 dB
3288	O	50 %	-90 dB	-80 dB
3294	O	50 %	-90 dB	-80 dB
3378	O	50 %	-90 dB	-80 dB
3384	O	50 %	-90 dB	-80 dB
3449	O	50 %	-90 dB	-80 dB
4008	O	50 %	-90 dB	-80 dB
4658	O	50 %	-90 dB	-80 dB

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# Second example: interest of interactivity

Use case:



The screenshot shows a desktop environment with two main windows. On the left is the 'THALES JPIP CLIENT' window, which features a video feed of a ship with the hull number 'D615'. To the right of the video are control buttons: CONNECT, START VIDEO TRANSFERT, STOP VIDEO TRANSFERT, START JPIP TRANSFERT, STOP JPIP TRANSFERT, and SAVE DISPLAY. Below these are dropdown menus for 'File for JPIP Transmission' (containing Rafale.j2k, fregate.j2k, Paris.j2k) and 'File received by video transmission'. A progress bar shows 66% completion. At the bottom of the client window are '+', 'RESET', and '-' buttons. On the right is a web browser window titled 'Station locale : Station Cholet' with the address bar showing 'http://station1/rafale.jp'. The browser displays a high-resolution image of a Rafale fighter jet in flight. At the bottom of the desktop, there is a status bar with modulation options: 'Non applicable BPSK 8PSK 32QAM' and 'QPSK+B4 QPSK 16QAM 64QAM'. Two buttons, 'RACC' and 'Dégradation de canal', are also visible.

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# Conclusions

## Proposal for an evolution of STANAG 5066

- Introducing TDD mode with ASAP strategy
- Introducing a simplification of the DTS layer role by transferring DRC to the Modem part
- Using a fixed C-PDU size (aligned with U-DPU one)

## Demonstrator under integration

- Streams treated by priority
- Bi-directional data transmission with urgent messages dispatched without waiting for the 127.5 s window end (or max FSN)

This evolution proposal for ST5066 is being integrated within the SALAMANDRE project demonstrator.



# THALES

SALAMANDRE



If you have any questions

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With grateful thanks to our colleagues  
from SALAMANDRE project

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# Simulations: analysing the proposed approach

## 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

