ST5066 TDD approach for wideband HF transmissions

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Presentation Outline

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)

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)

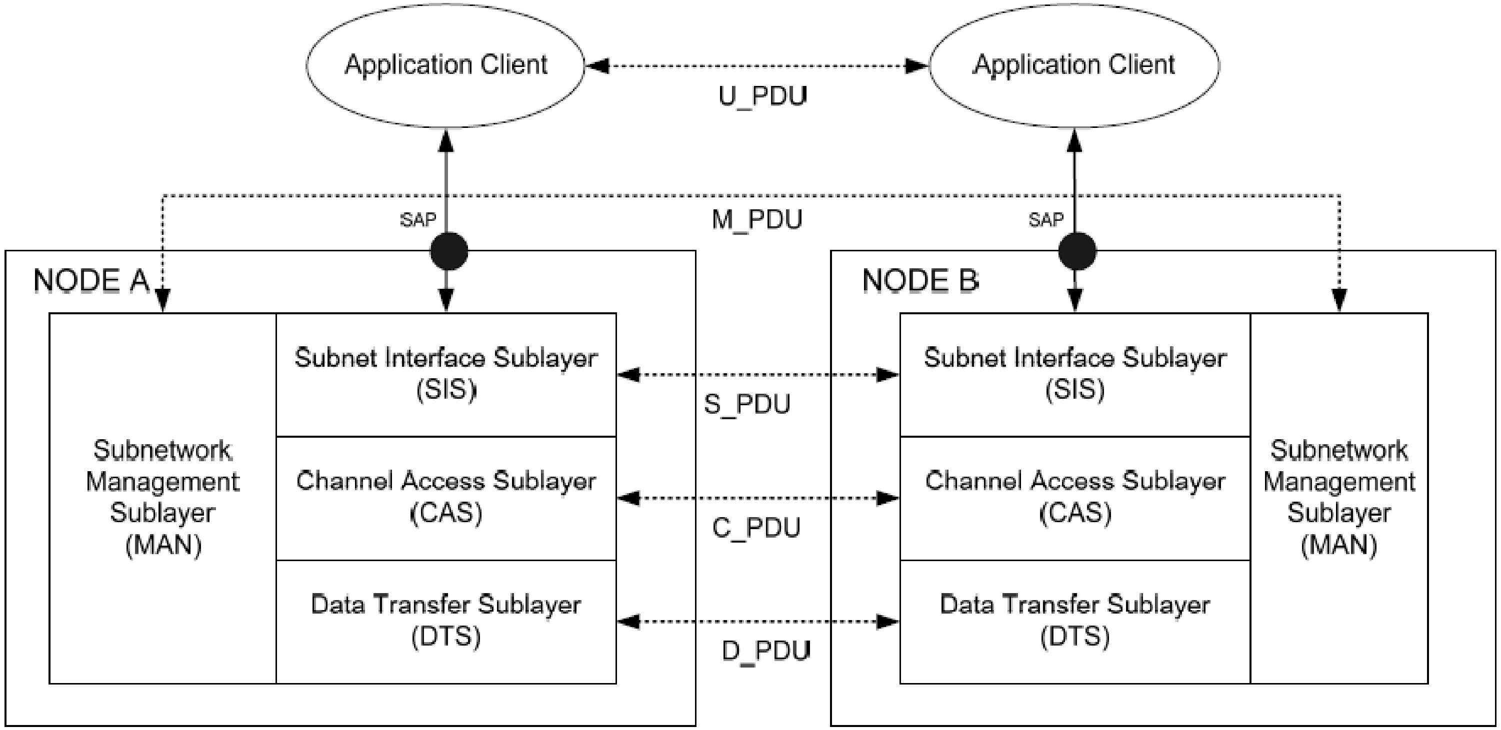
High throughputs necessitate good SNR … which can be obtained in particular if the tuning on the channel conditions is efficient

- 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



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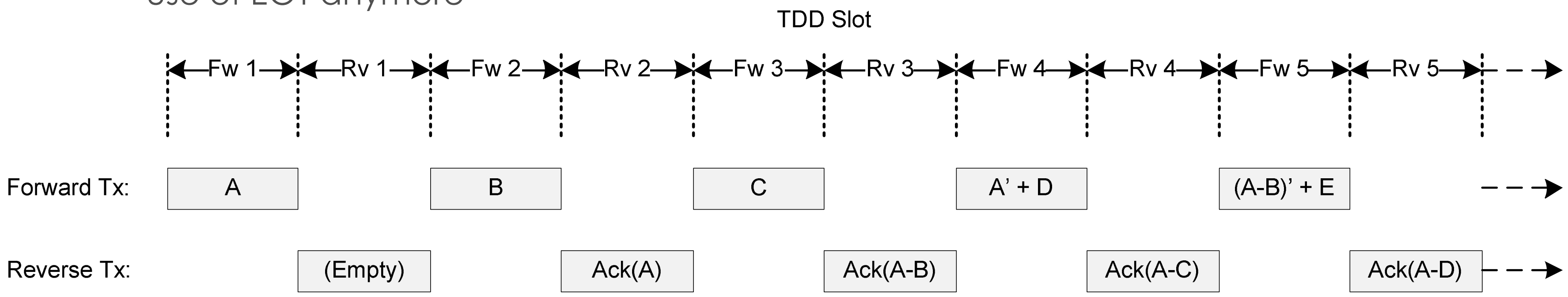
Context (3/3)

… 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 : <u>a better solution with ASAP</u>

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
Overall best strategy for the scenario	**ASAP**	**ASAP**	**ASAP**	**ASAP**

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

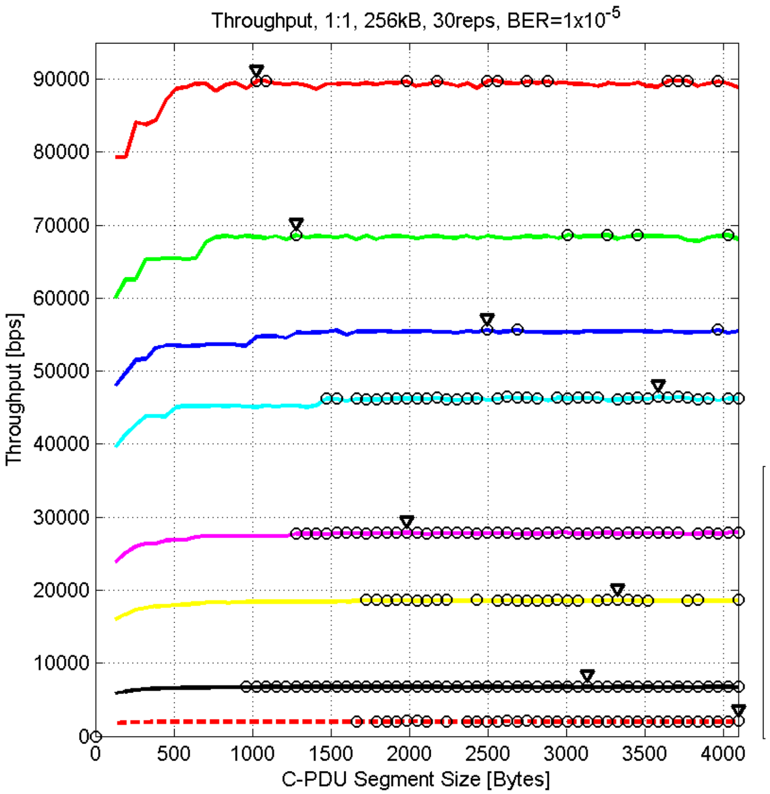
- Considered scenarios

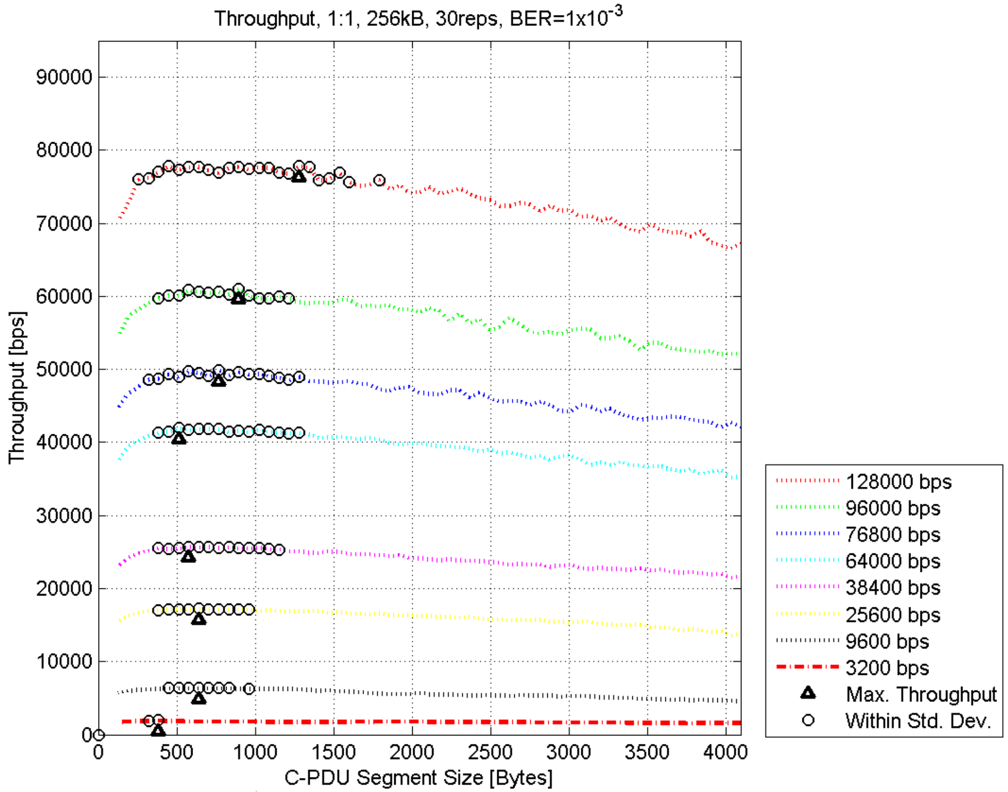
Application type	Configuration	Payload
Chat	Data direction: Forward & Reverse TDD Scheme: 1:1 Forward Data Rate: 3200 – 128000 bps Reverse Data Rate: Match forward data rate. Ack's Can Be Lost: Yes	256kB
SMTP/FTP/HTTP	Data direction: Forward only TDD Schema: 9:1 Forward Data Rate: 3200 – 128000 bps Reverse 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

Study of the optimal C-PDU size

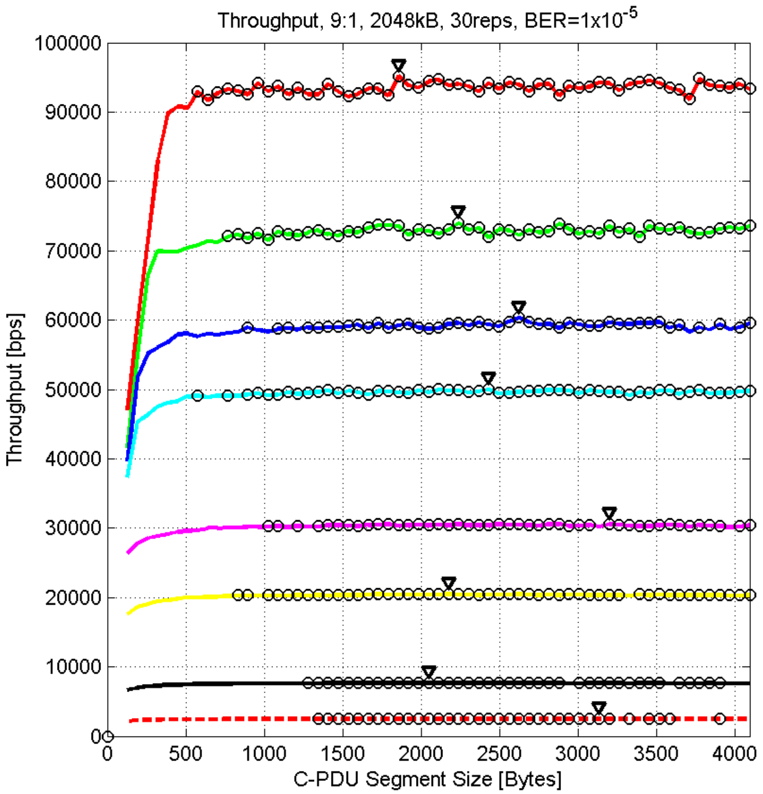
CHAT scenario : Throughput as a function of C-PDU segment size for BER=10^{-3} / 10^{-5}

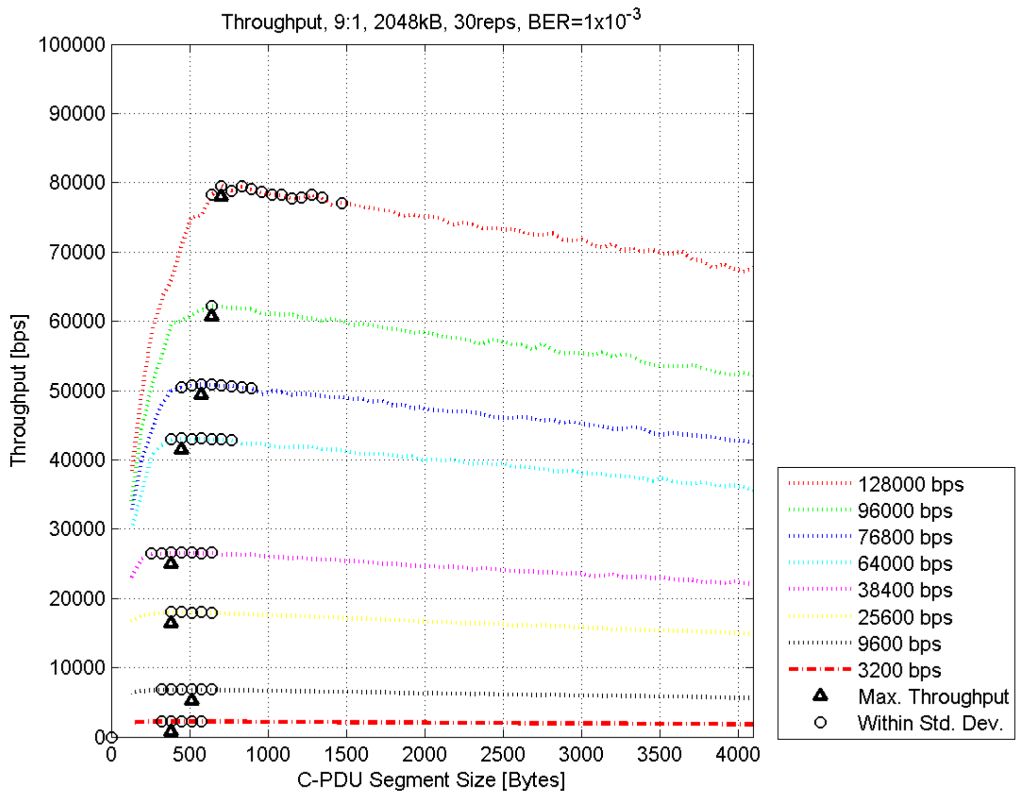




Study of the optimal C-PDU size

SMTP/FTP/HTTP scenario : Throughput as a function of C-PDU segment size for BER=10^{-3} / 10^{-5}



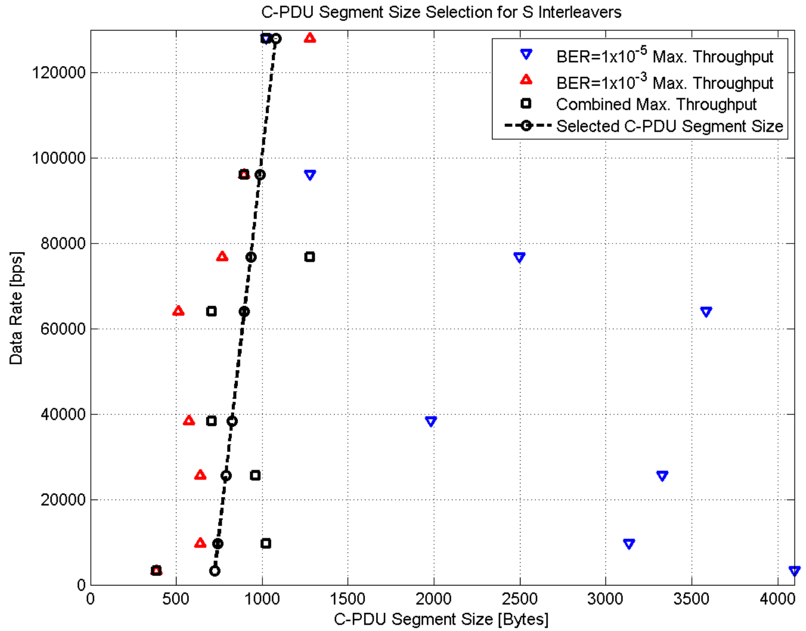


Study of the optimal C-PDU size

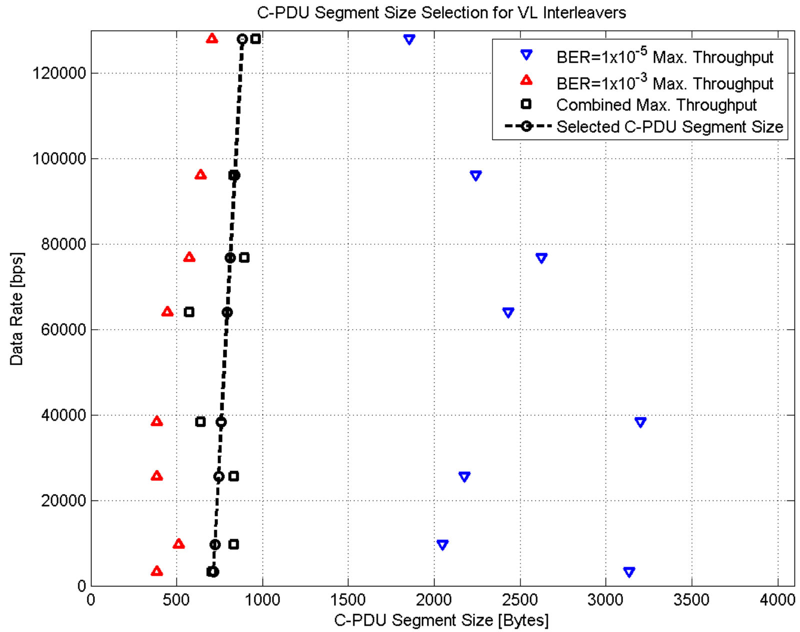
Obtained optima for both scenarios

- C-PDU optimum for BER=10^{-3}, 10^{-5} and combination
- Linear approximation of Combined max throughput C-PDU optimal value

(CHAT scenario)



(SMTP/FTP/HMTP scenario)



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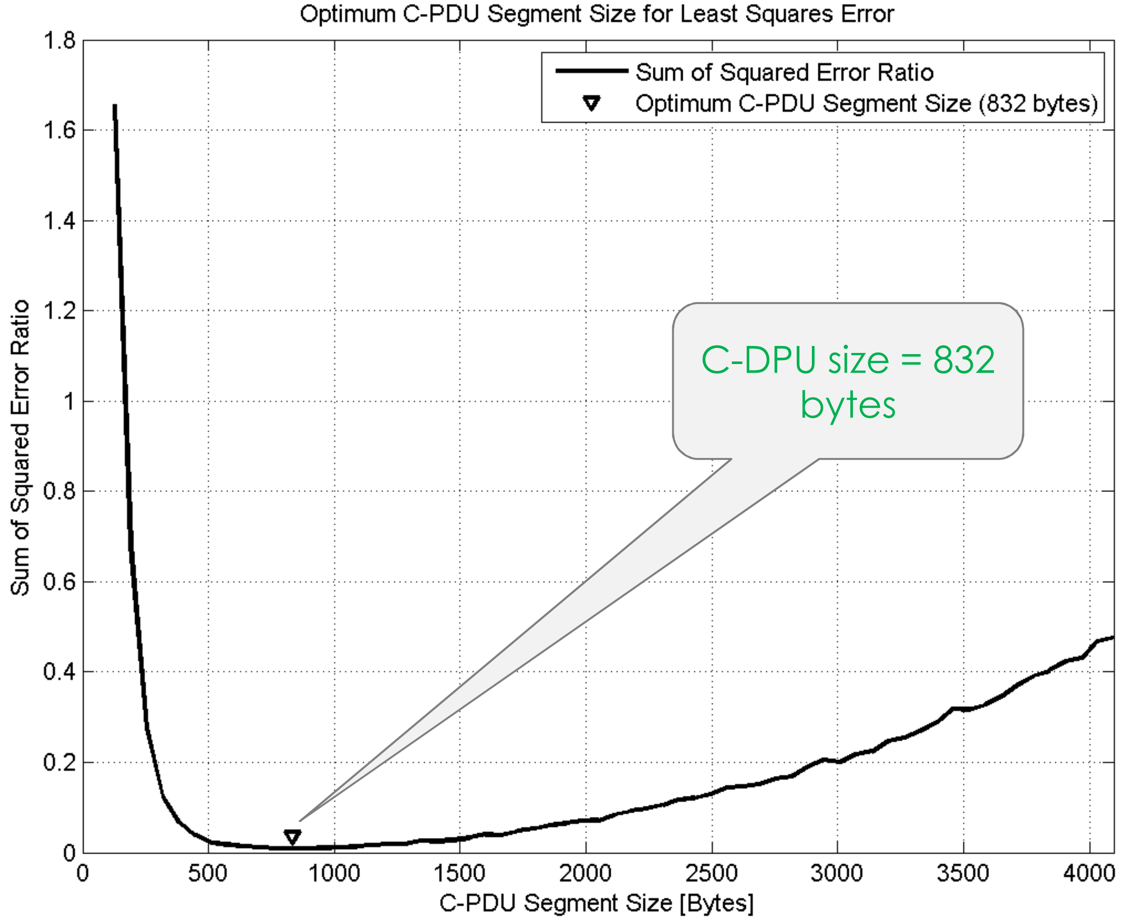
Study of the optimal C-PDU size

Deriving overall optima: best constant size

- For all considered bitrates and scenarios

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



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Study of the optimal C-PDU size:

Rationale

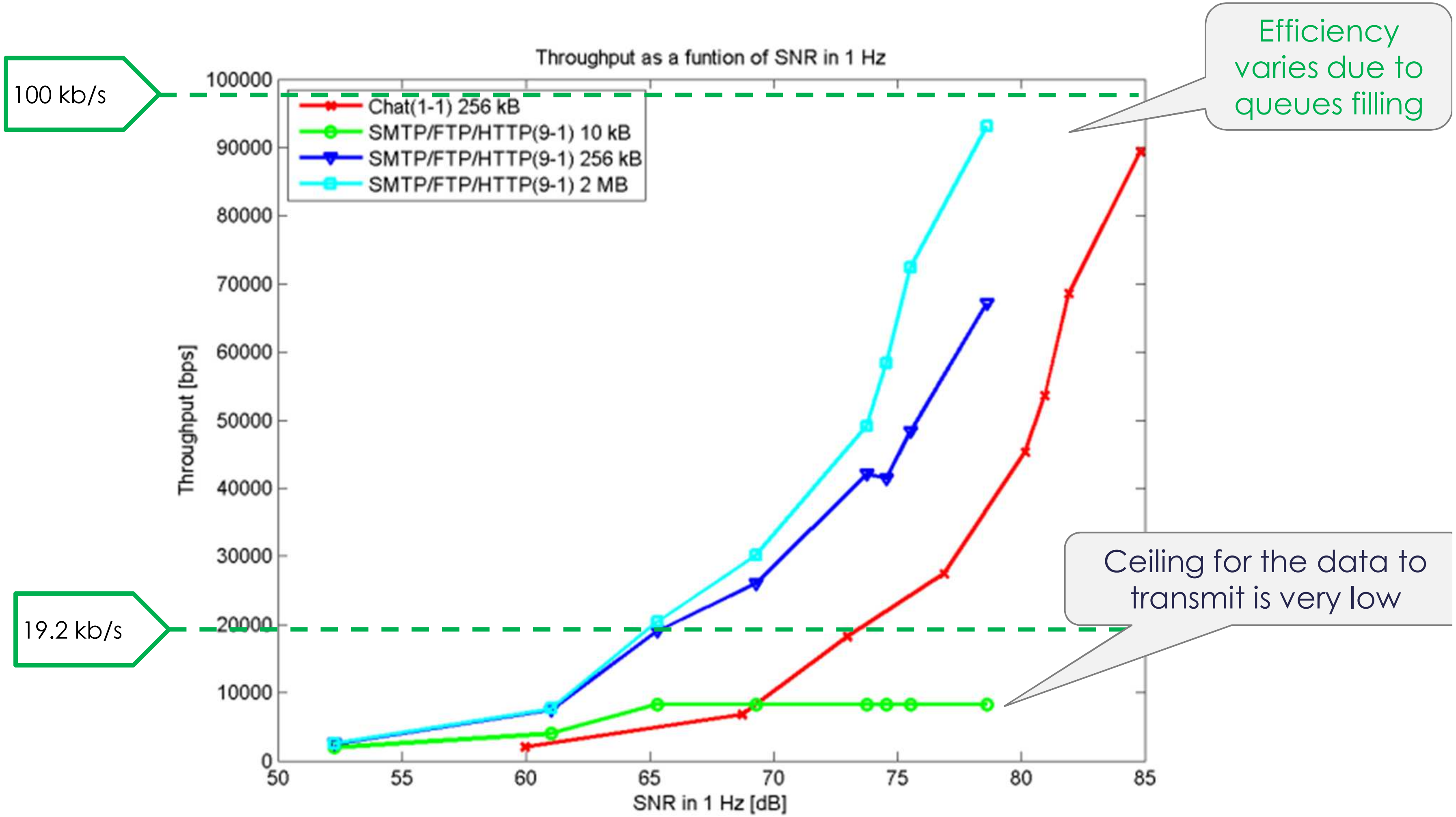
- Variation of throughput performance < 5% (worst case, short interleaver) and <3.4% (worst case, VL interleaver) when using C-PDU constant vs. optimal one … and often similar !

- 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

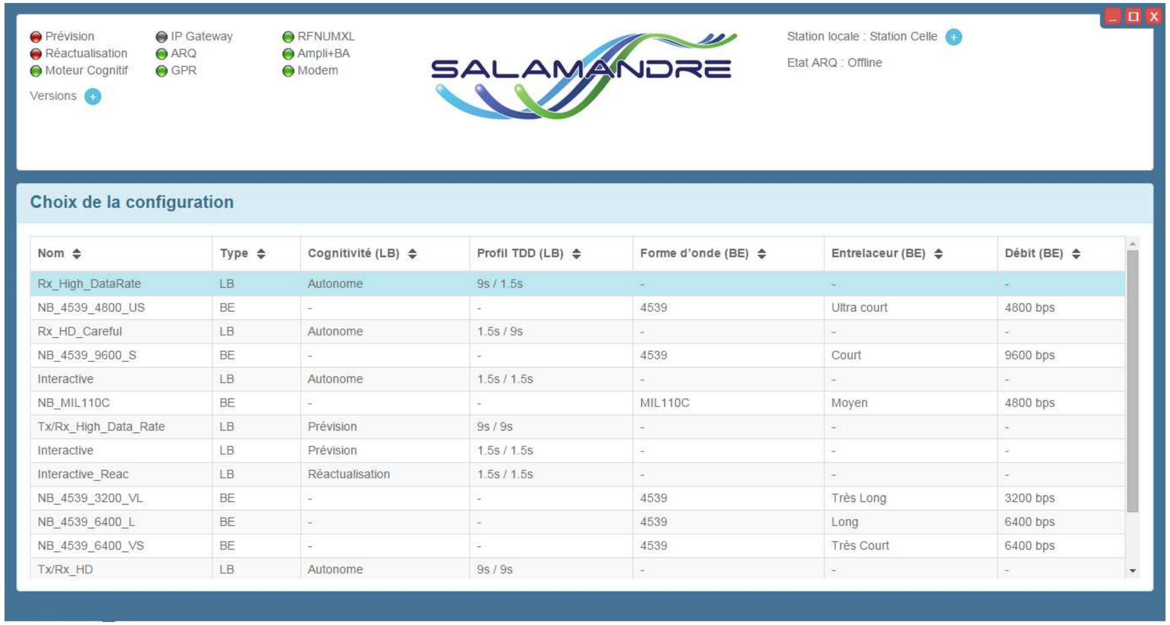


Reaching 100kb/s useful (taking into account acks TDD scheme …)

« Live » : test results

SALAMANDRE Set-up

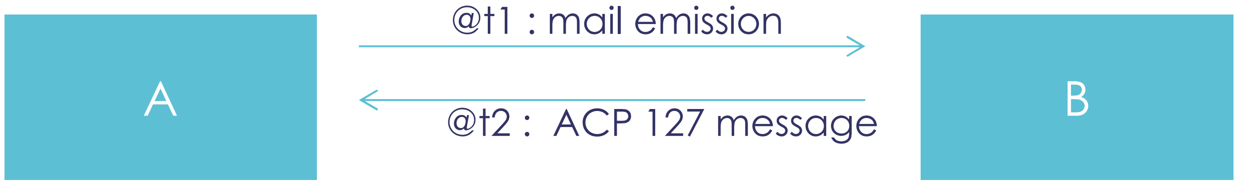
- HF XL demonstrator
- ST5066 TDD implementation
- Overall MMI to supervise

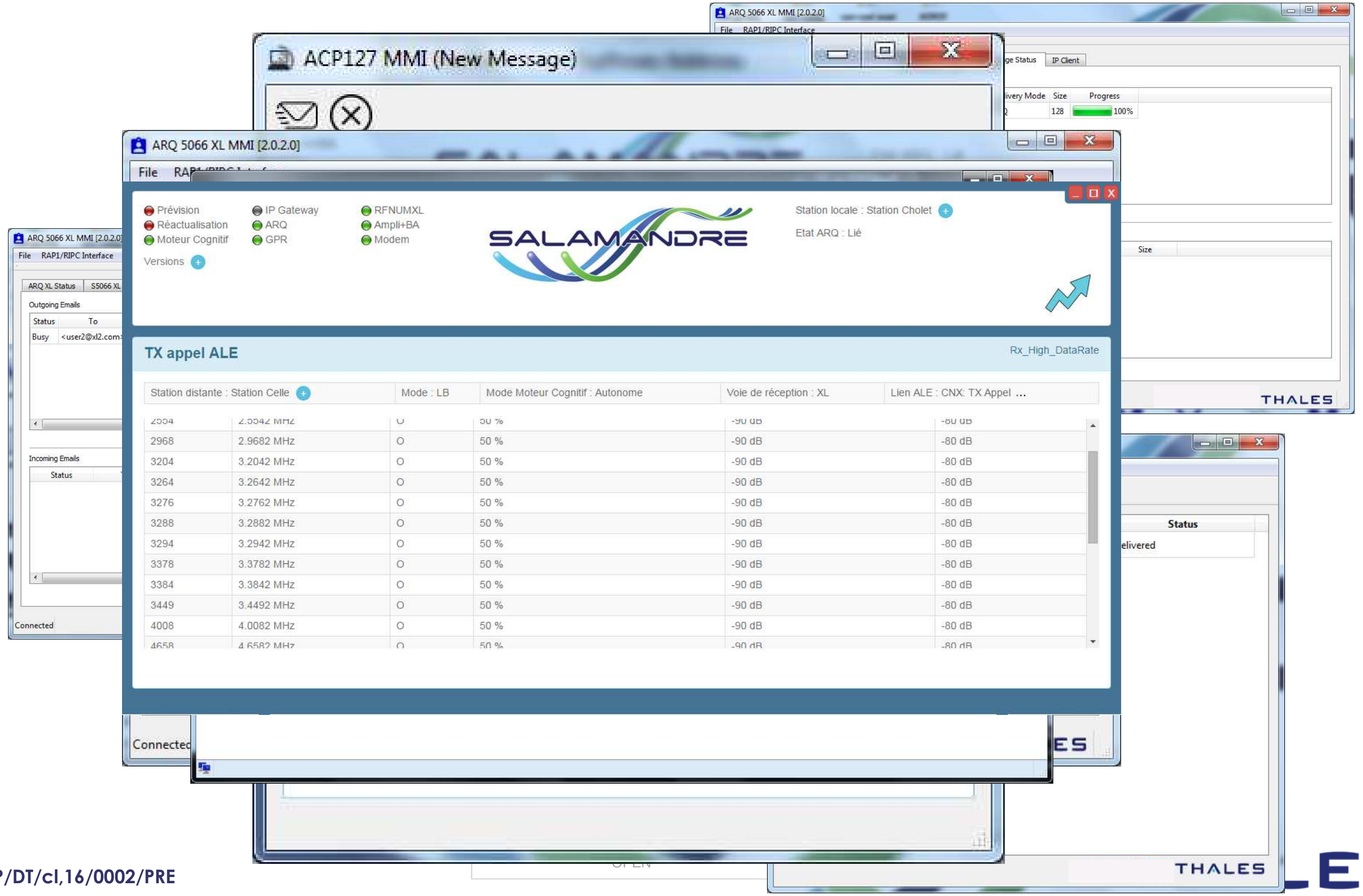


Nom	Type	Cognitivité (LB)	Profil TDD (LB)	Forme d'onde (BE)	Entrelaceur (BE)	Débit (BE)
Rx_High_DataRate	LB	Autonome	9s / 1.5s	-	-	-
NB_4539_4800_US	BE	-	-	4539	Ultra court	4800 bps
Rx_HD_Careful	LB	Autonome	1.5s / 9s	-	-	-
NB_4539_9600_S	BE	-	-	4539	Court	9600 bps
Interactive	LB	Autonome	1.5s / 1.5s	-	-	-
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	-	-	-

First example: interest of TDD for bidirectional exchanges

Use case:





Second example: interest of interactivity

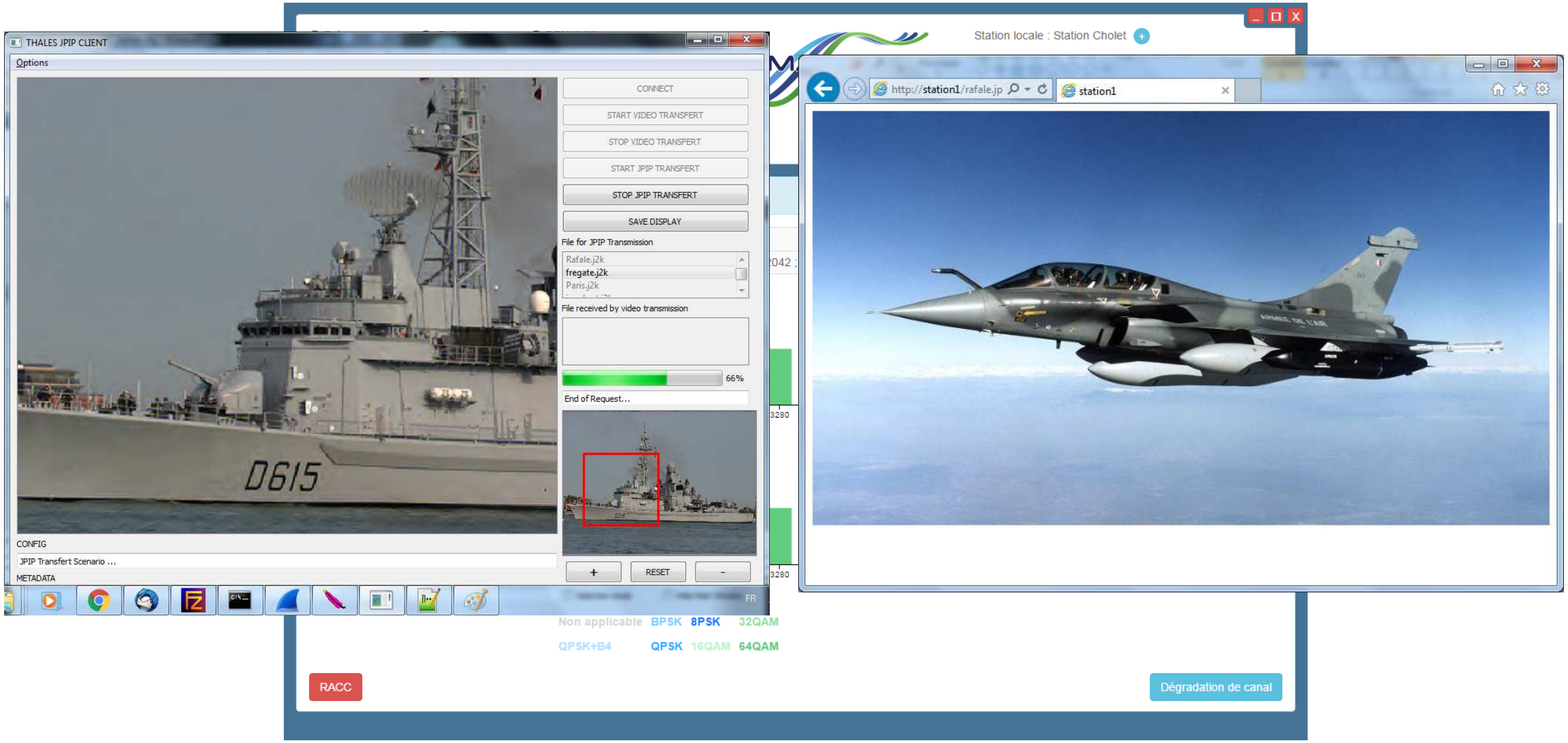
Use case:

A

IOD of A on server B →

← Web server access from B on server A

B



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.

If you have any questions

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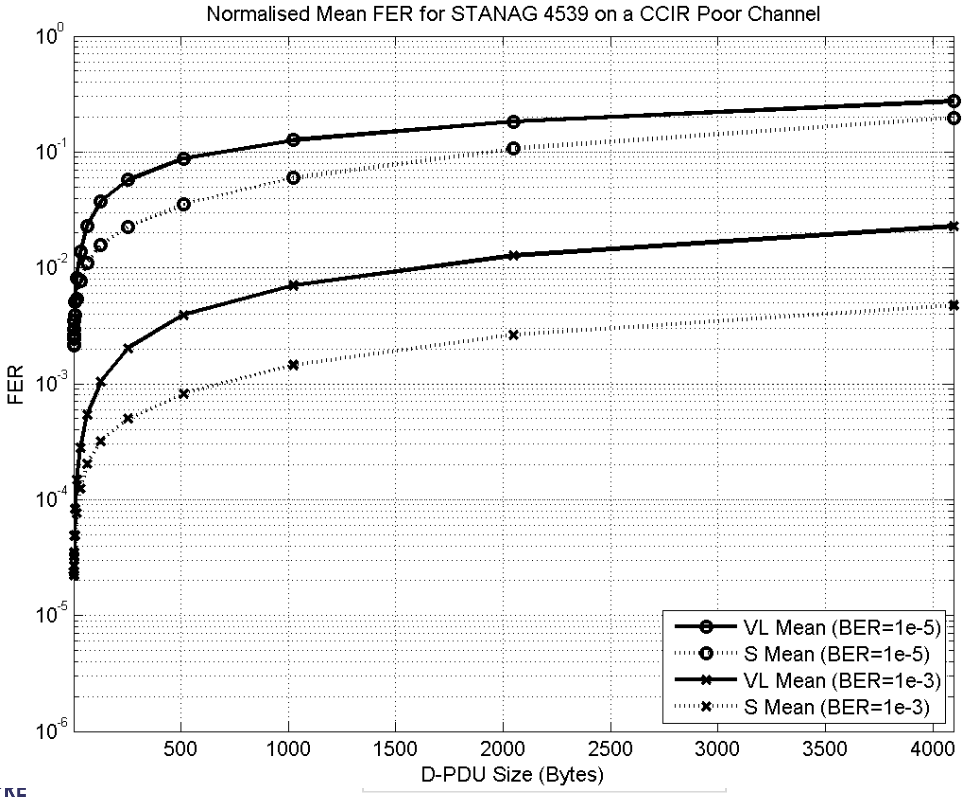
With grateful thanks to our colleagues
from SALAMANDRE project

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



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