

Stratégies NOMA-MCM pour les Communications Véhiculaires 6G

Alain ALLOUIS, Iyad DAYOUB

Le 28/06/2024 à 11h10, à Compiègne

Workshop - Véhicules intelligents - Heudiasyc



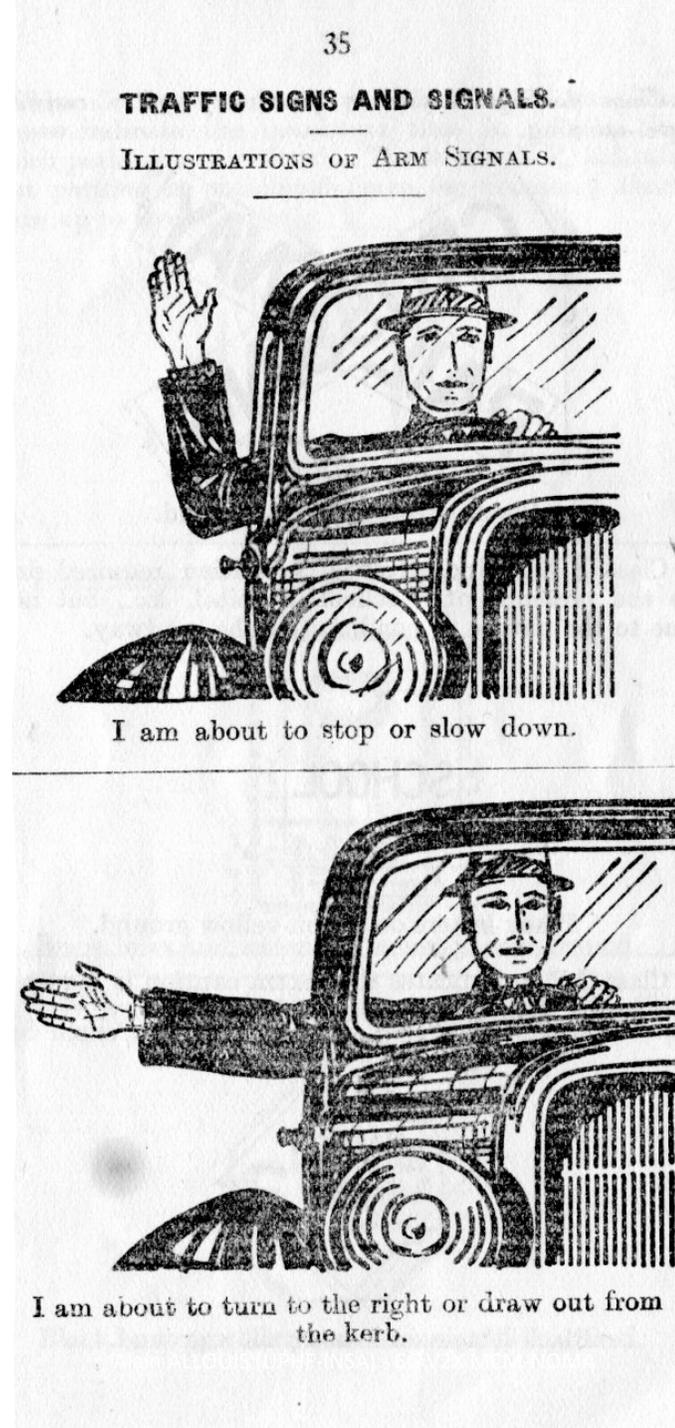
Ce travail a été réalisé en collaboration



Anecdote - Évolution des Communications dans les Transports



28/06/2024



Anecdote - Évolution des Communications dans les Transports

- Détroit (Michigan) 1921



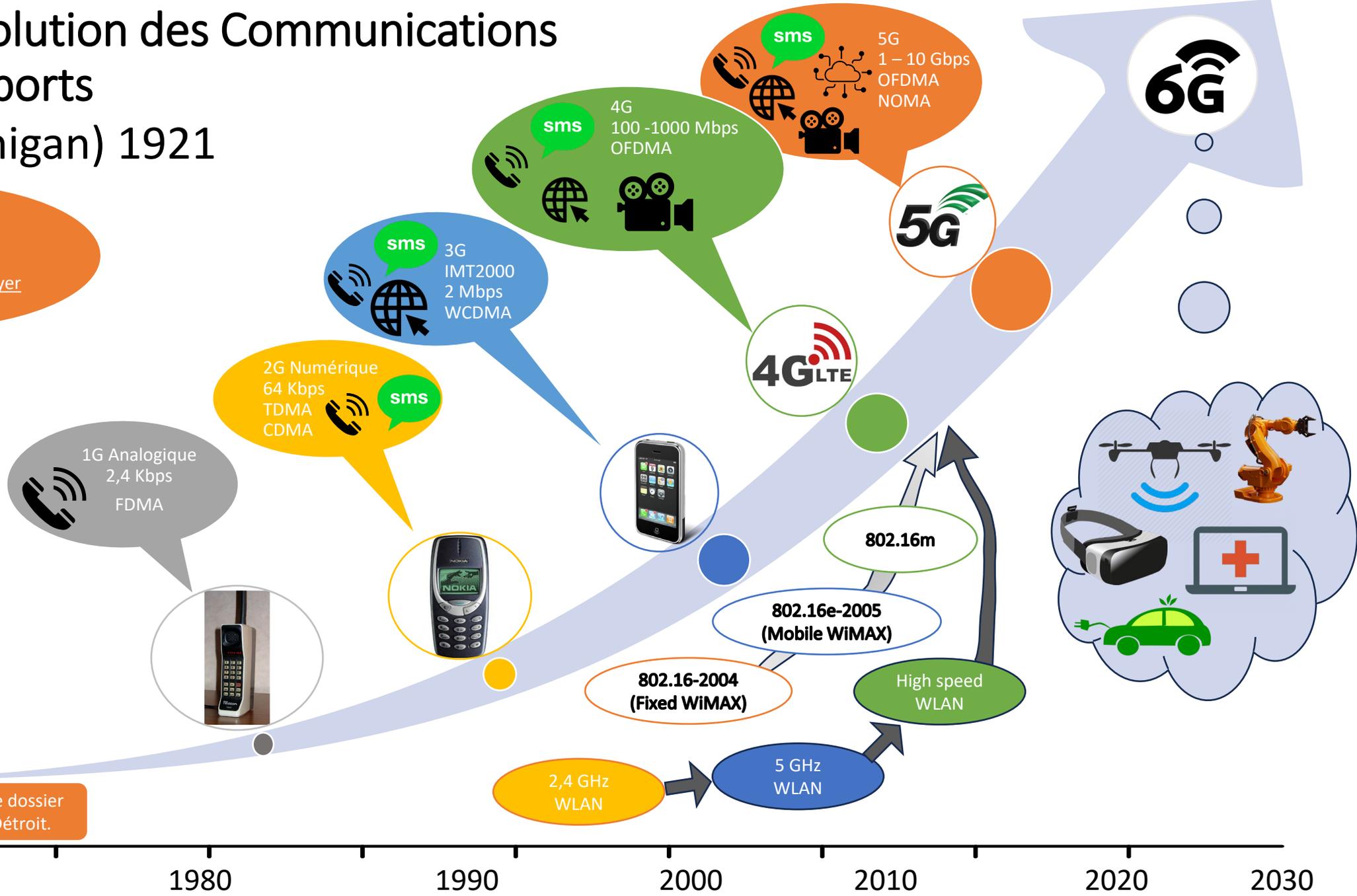
Anecdote - Évolution des Communications dans les Transports

- Détroit (Michigan) 1921

Aujourd'hui
NOMA , MCM et X-Layer



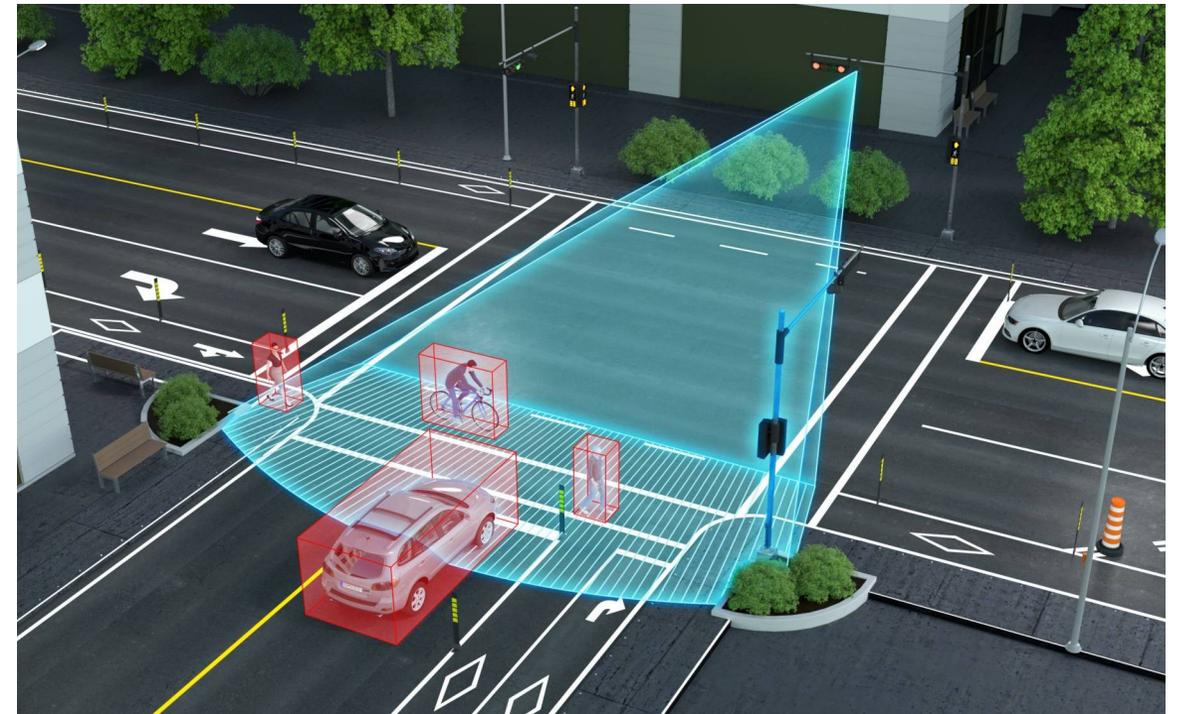
Récepteur radio installé sur le dossier d'une voiture de police de Détroit.



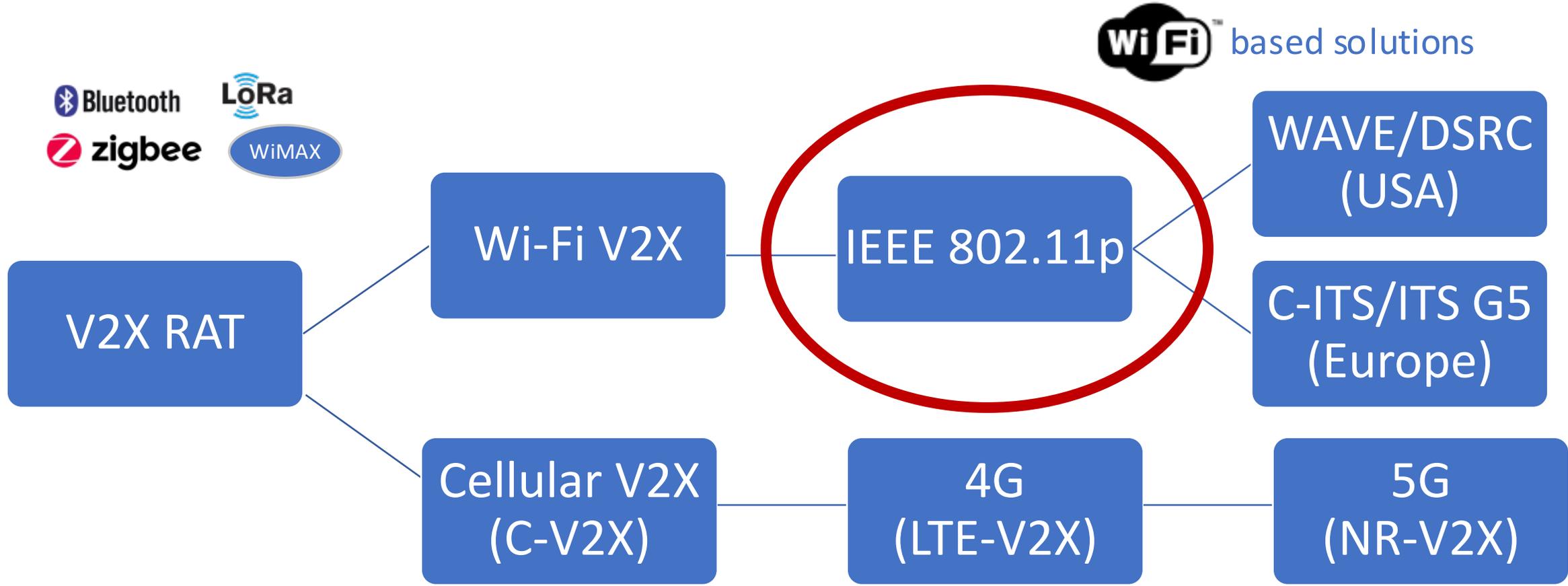
Plan de la présentation

- Introduction
- Aperçu de la Recherche
- Fondements des Communications Véhiculaires (V2X)
- Méthodologie 6G V2X et Technologies Associées
- Maximum Achievable Sum Rate in Downlink Multicarrier NOMA System
- Conception Cross-Couche PHY/MAC avec NOMA pour C-V2X
- Conclusion et Perspectives

Rôle de la Communication Véhiculaire dans les Transports Intelligents



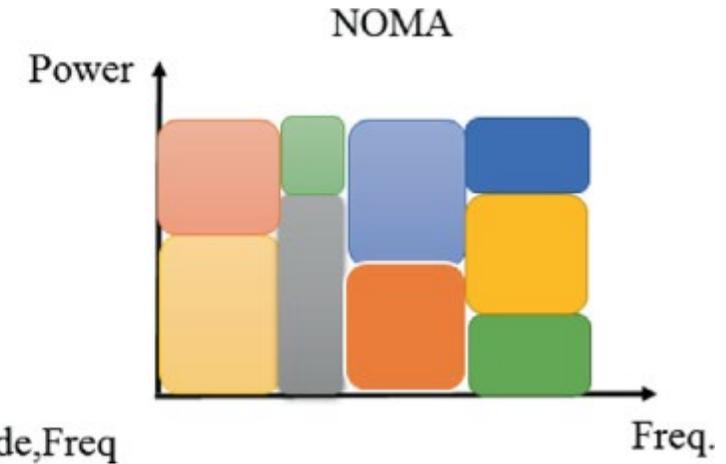
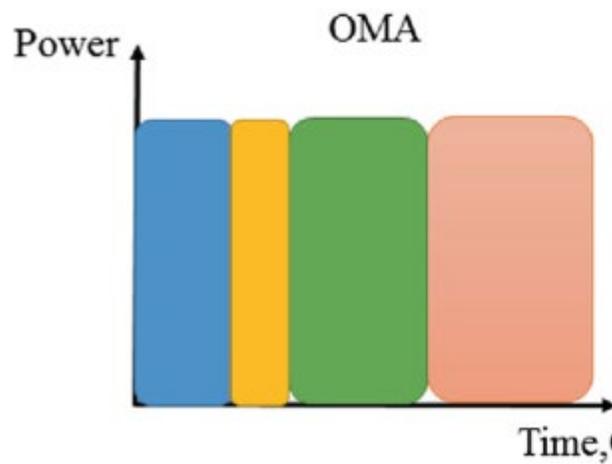
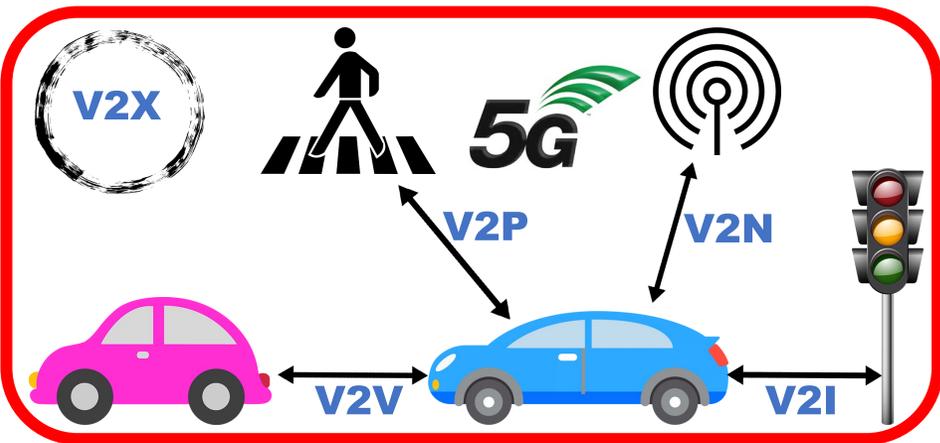
Transition de l'IEEE802.11p vers la Révolution 6G-V2X



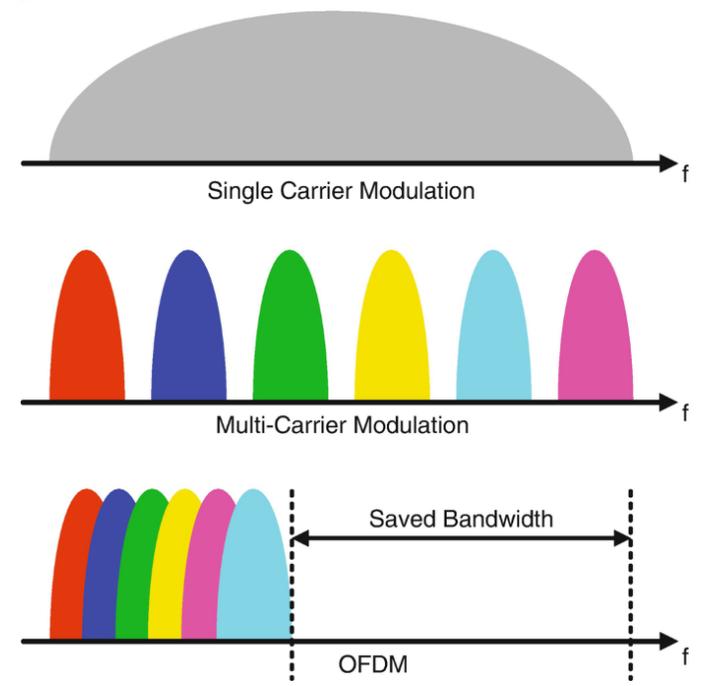
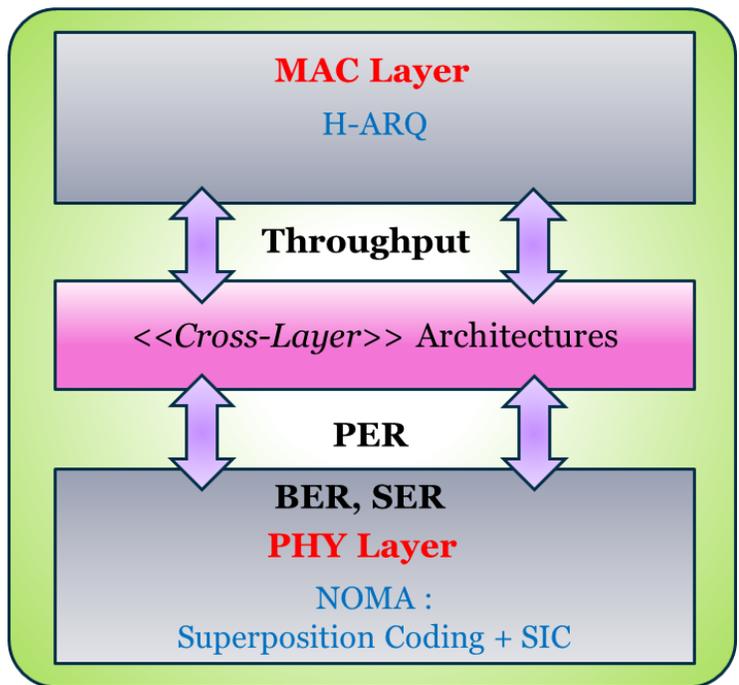
Spectrum reserved variable by country 5.77 – 5.85 GHz
Added in Japan 7.555-7.645 GHz

Axe de notre recherche

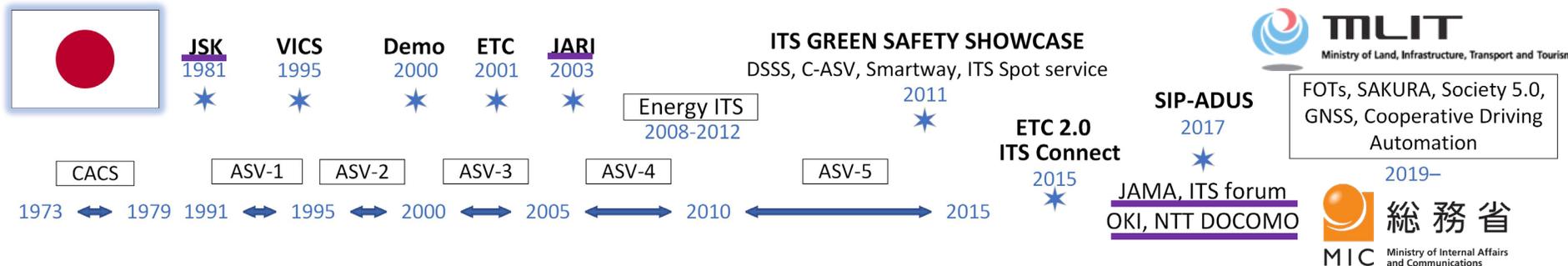
Exploration Avancée des Technologies 6G pour la Connectivité Véhicule-à-Tout (V2X) : Focus sur NOMA et MCM



Closed-form expression

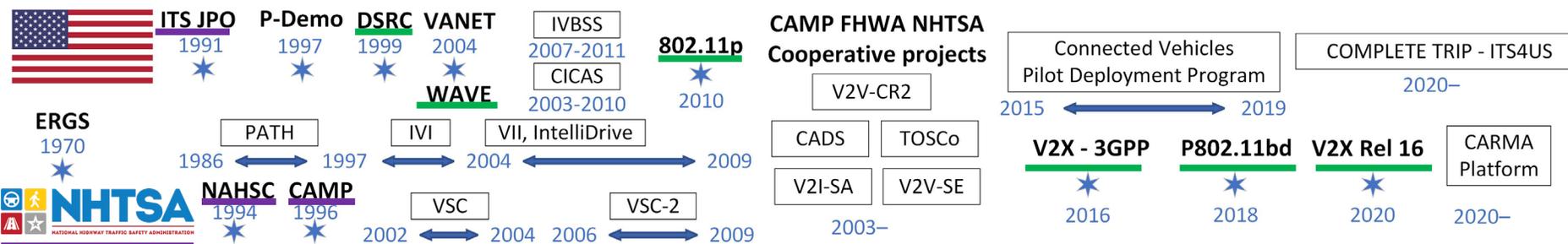


Plongée dans l'Histoire et la Pertinence des Communications V2X



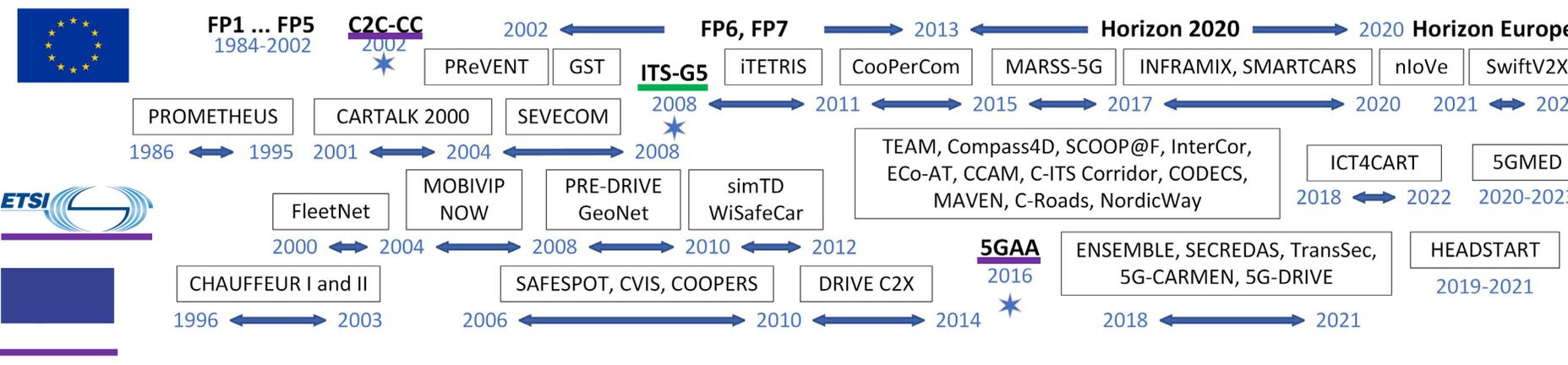
Ensemble de technologies : VANET, IoV, ...

Standard/Norme



Institutions, organisations et organismes de réglementation

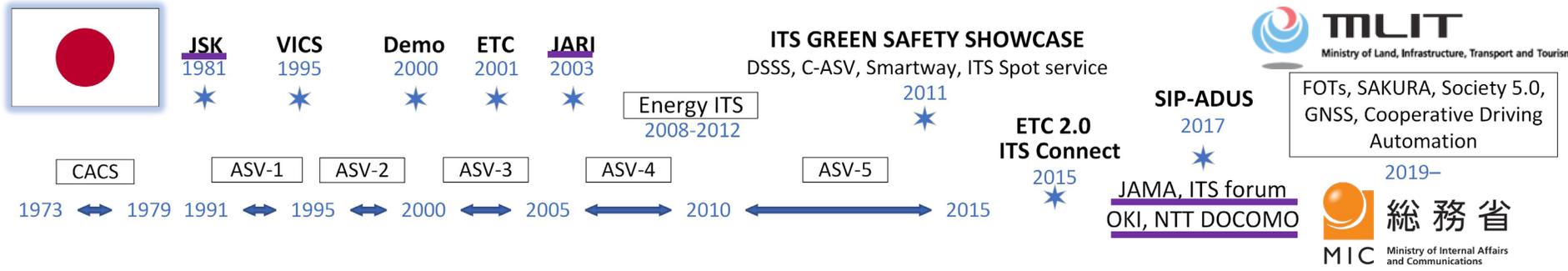
Projets



★ Event (Demo/Foundation)

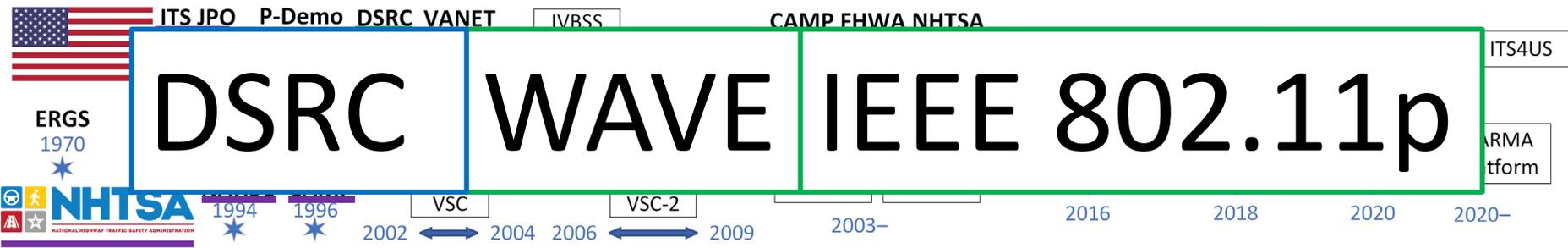
↔ Project period

Plongée dans l'Histoire et la Pertinence des Communications V2X



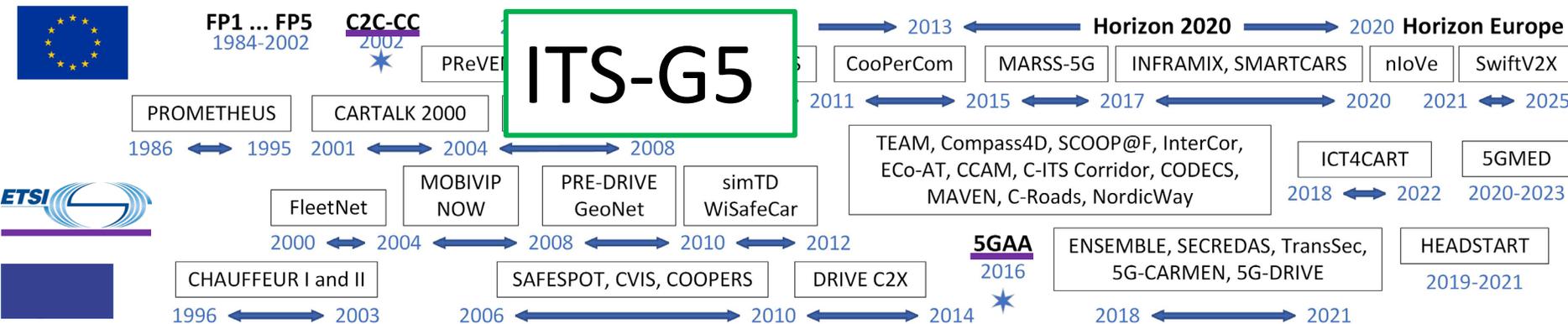
Ensemble de technologies : VANET, IoV, ...

Standard/Norme



Institutions, organisations et organismes de réglementation

Projets

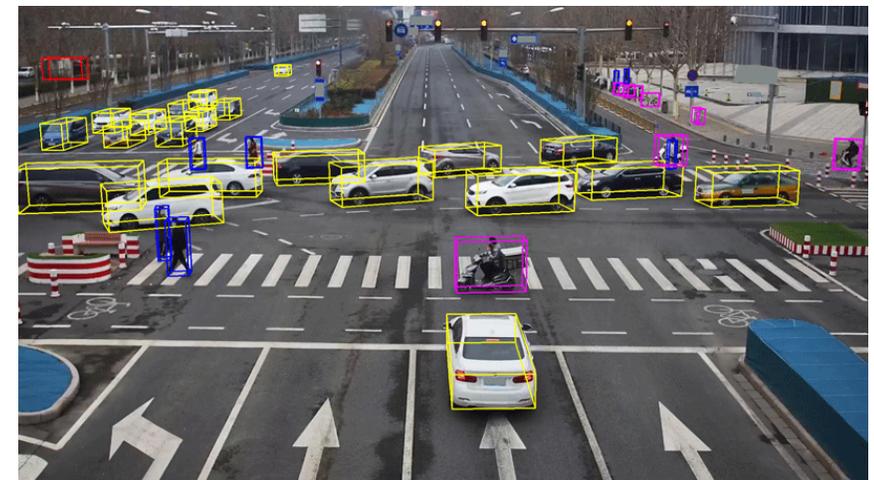
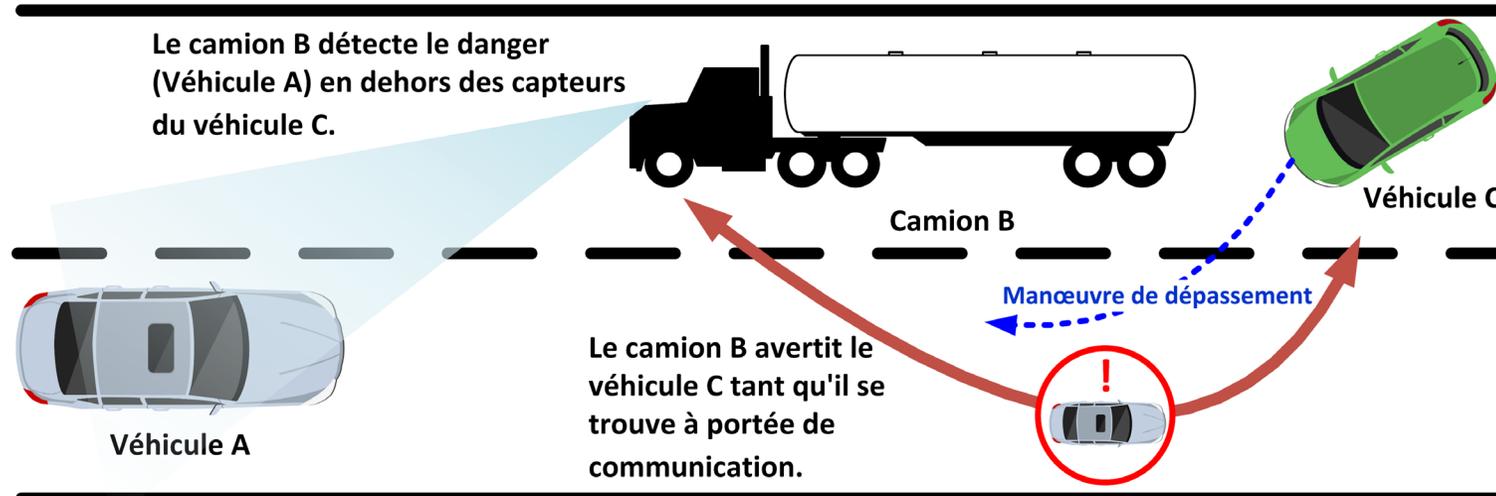
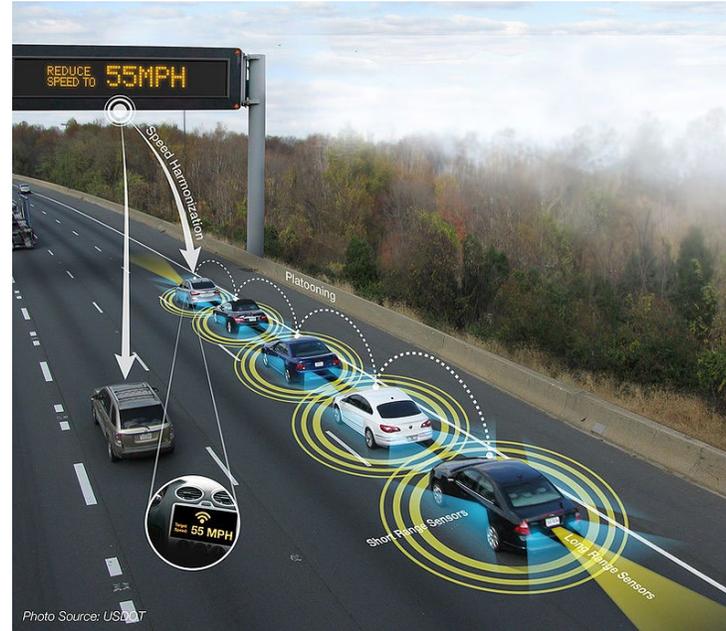


★ Event (Demo/Foundation) ↔ Project period

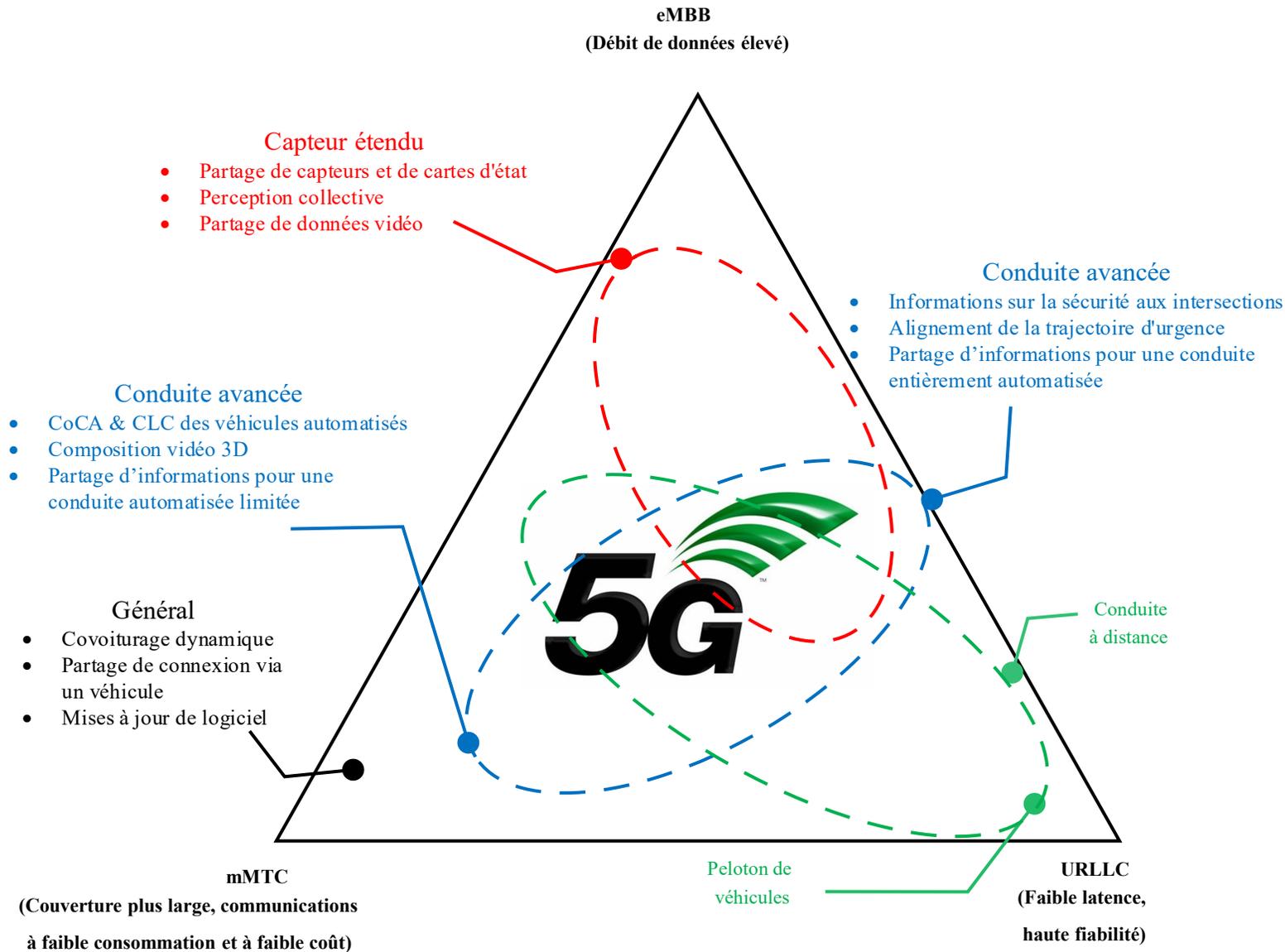
Analyse des Exigences des Cas d'Usage V2X

25 cas d'usage

- Peloton de véhicules,
- Conduite à distance,
- Capteurs étendus,
- Conduite avancée

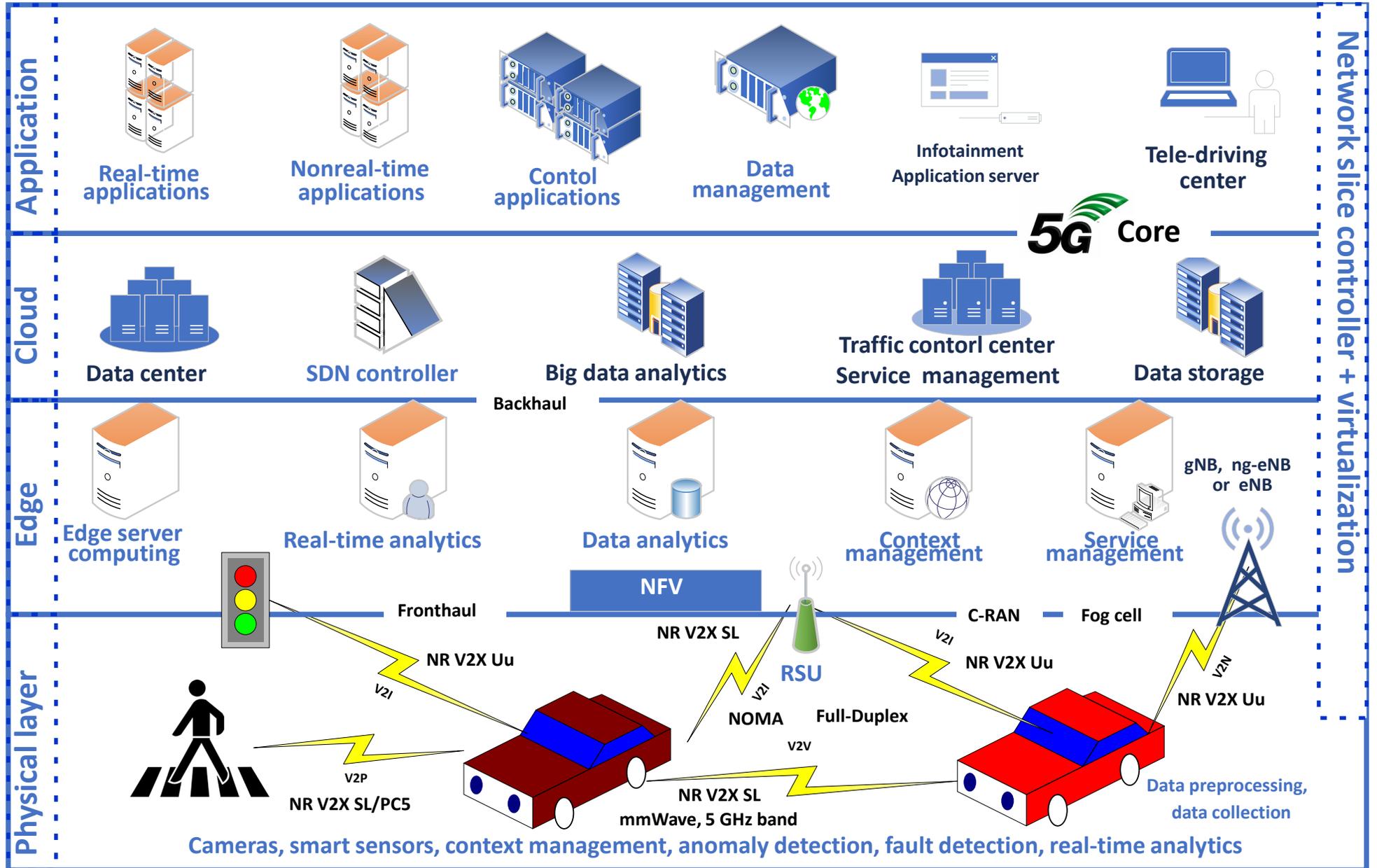


Cartographie des cas d'usage du V2X avec les trois piliers de la 5G



Technologies habilitantes et architecture hiérarchique 5G V2X

- Exigences
- Normes
- Directions
- Défis



On 5G-V2X Use Cases and Enabling Technologies: A Comprehensive Survey

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Full
Text Views

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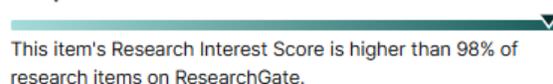


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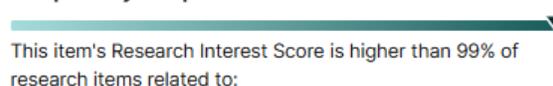
This item's Research Interest Score is higher than 98% of research items on ResearchGate.

Compared by date of publication



This item's Research Interest Score is higher than 99% of research items published in 2021.

Compared by discipline



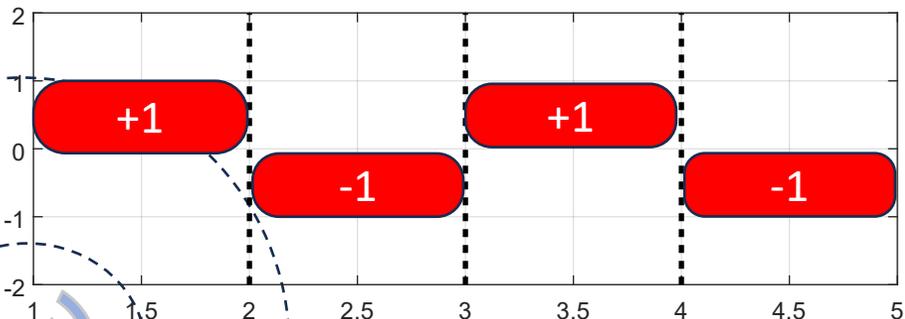
This item's Research Interest Score is higher than 99% of research items related to:

Communication Engineering



Le Rôle du NOMA dans les Communications V2X

Données de l'utilisateur 1 BPSK modulé



h_1

h_2

BS

1 émetteur/antenne

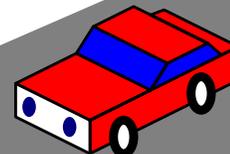
$P = 1$ watt

BPSK

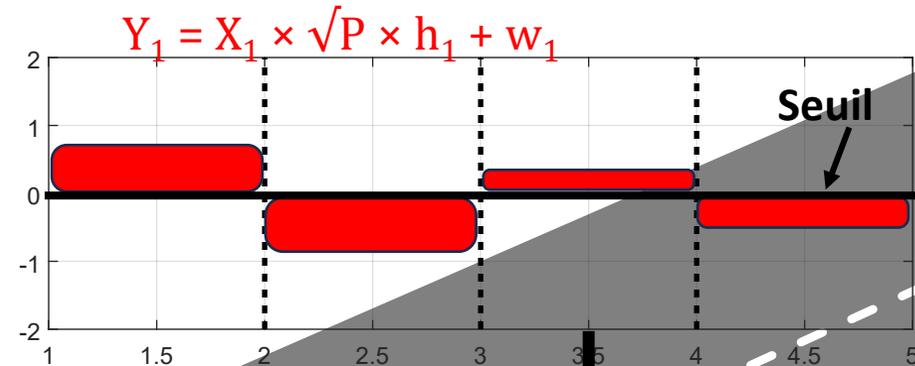
$$X_1 = +1 -1 +1 -1$$

$$X_2 = -1 +1 +1 -1$$

Utilisateur 2

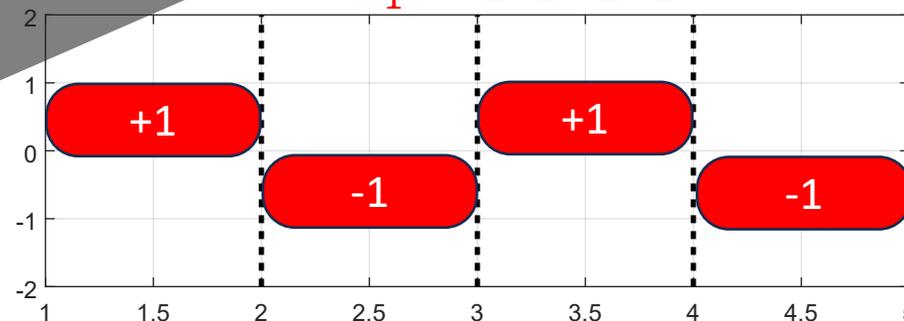


Utilisateur 1

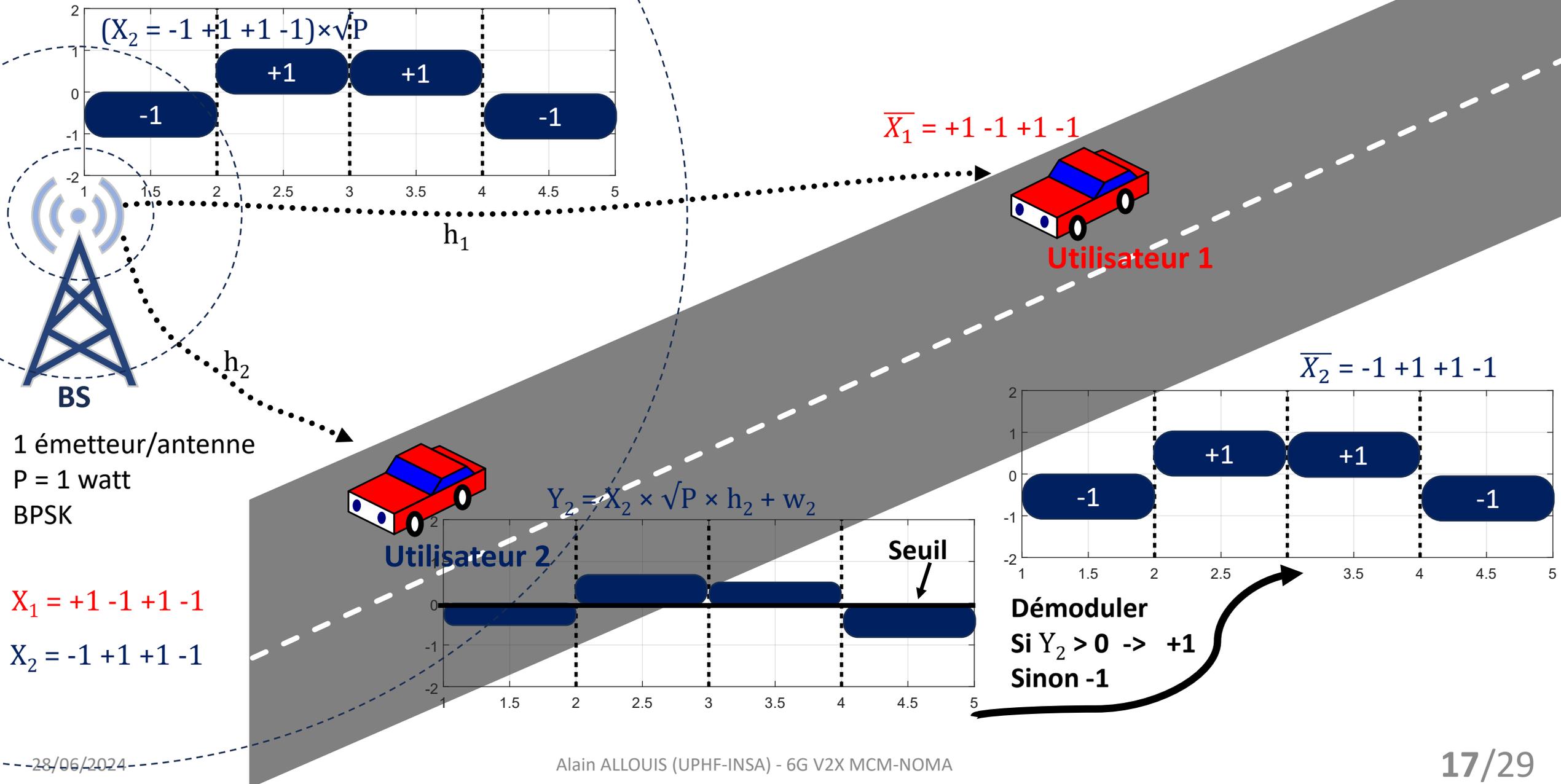


Démoduler
Si $Y_1 > 0 \rightarrow +1$
Sinon -1

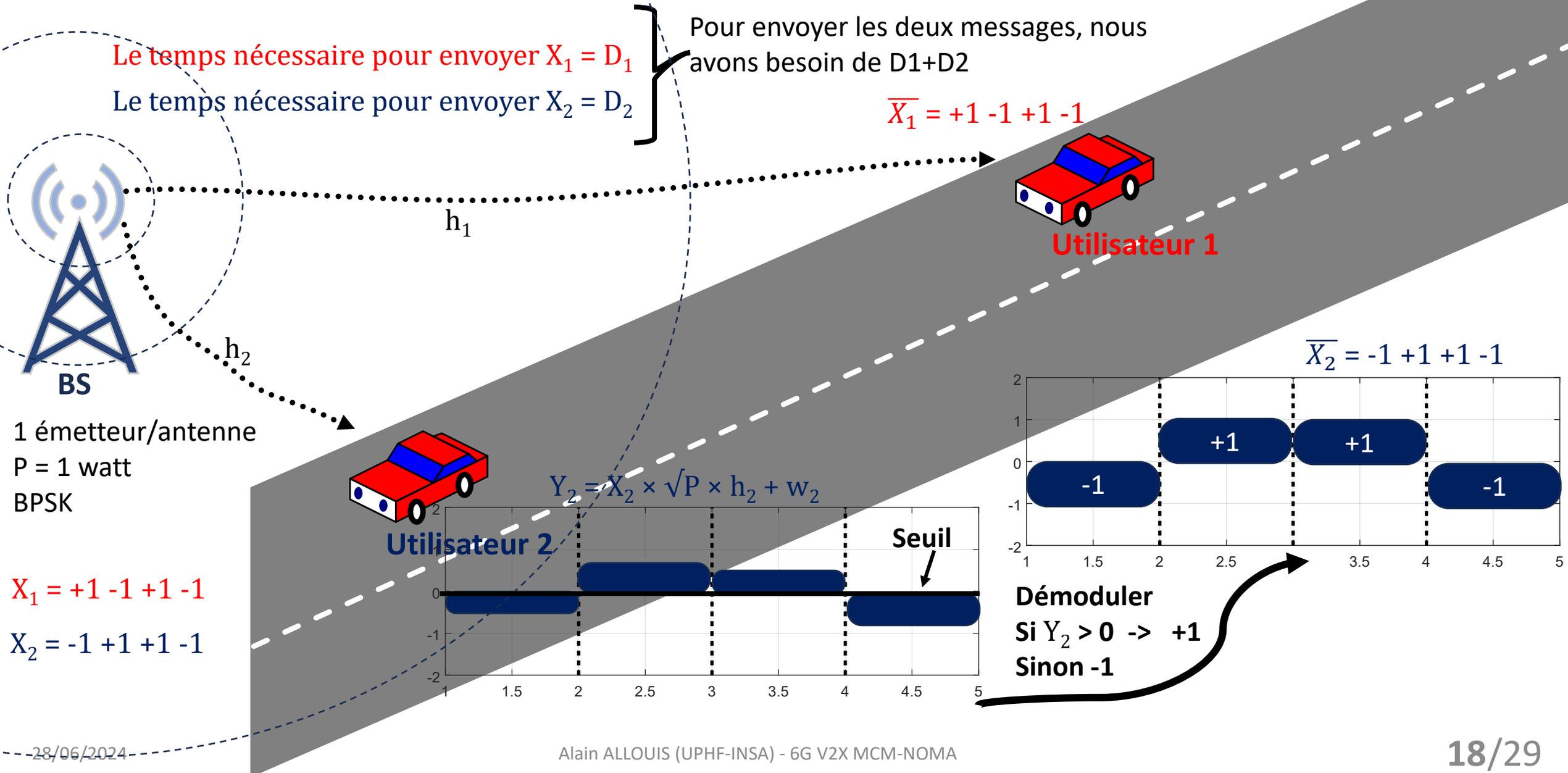
$$\bar{X}_1 = +1 -1 +1 -1$$



Le Rôle du NOMA dans les Communications V2X



Le Rôle du NOMA dans les Communications V2X



Le Rôle du NOMA dans les Communications V2X

Le temps nécessaire pour envoyer $X_1 = D_1$

Le temps nécessaire pour envoyer $X_2 = D_2$

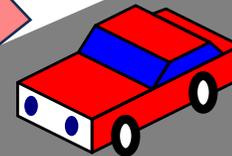
Pour envoyer les deux messages, nous avons besoin de $D_1 + D_2$



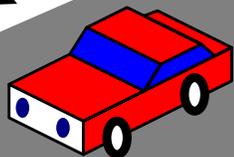
BS

h_1

h_2



Utilisateur 1



Utilisateur 2

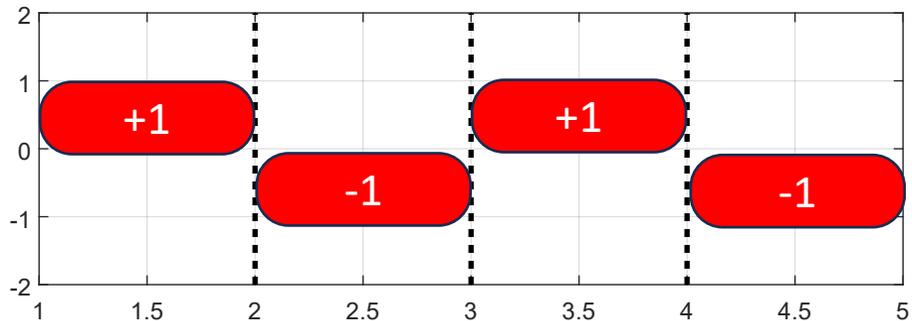
1 émetteur/antenne

$P = 1$ watt

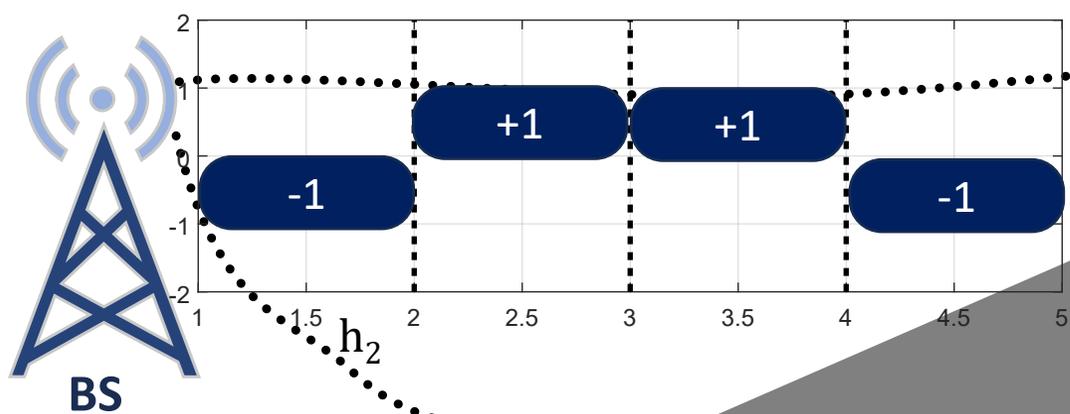
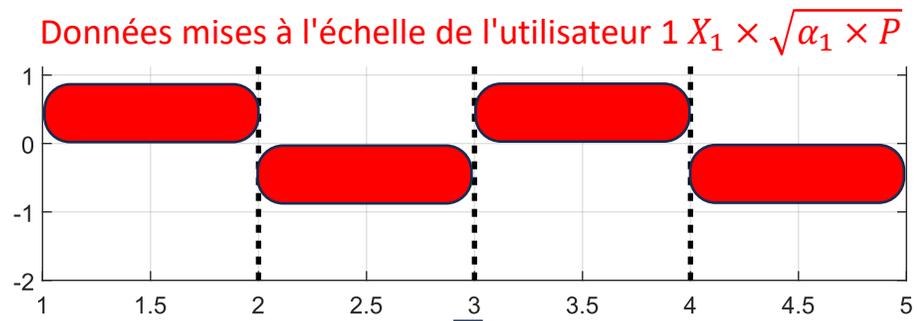
BPSK

$X_1 = +1 -1 +1 -1$

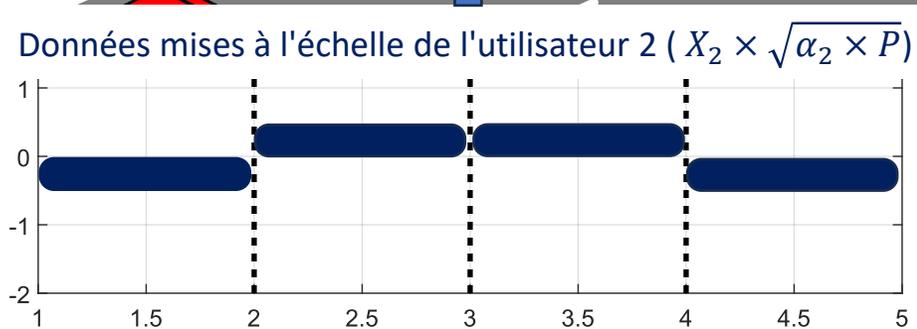
$X_2 = -1 +1 +1 -1$



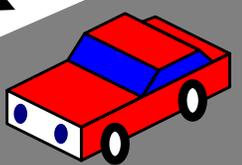
Superposition
 $\times \sqrt{\alpha_1 \times P}$



$\times \sqrt{\alpha_2 \times P}$



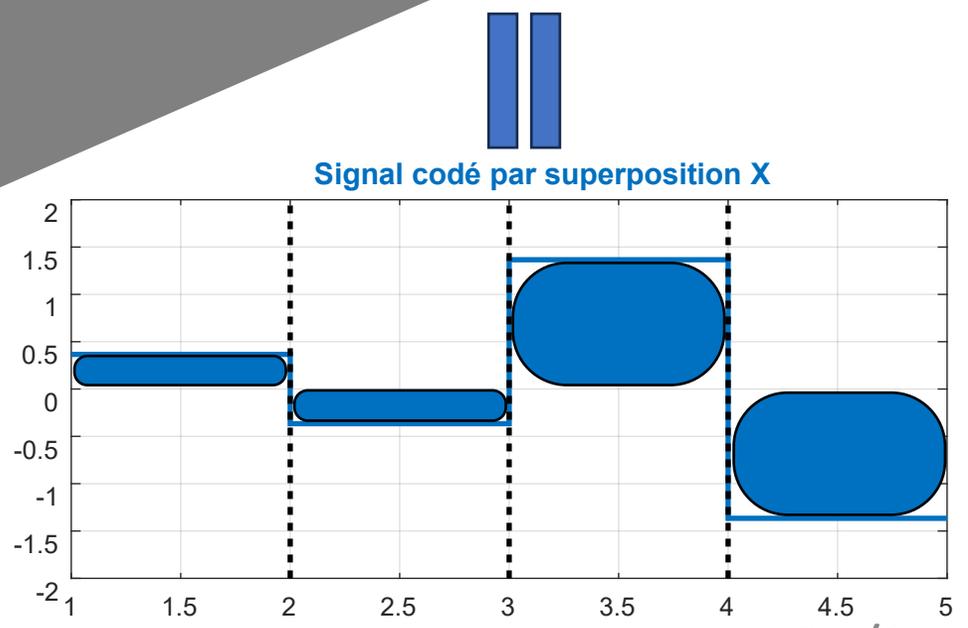
1 émetteur/antenne
 P = 1 watt
 BPSK

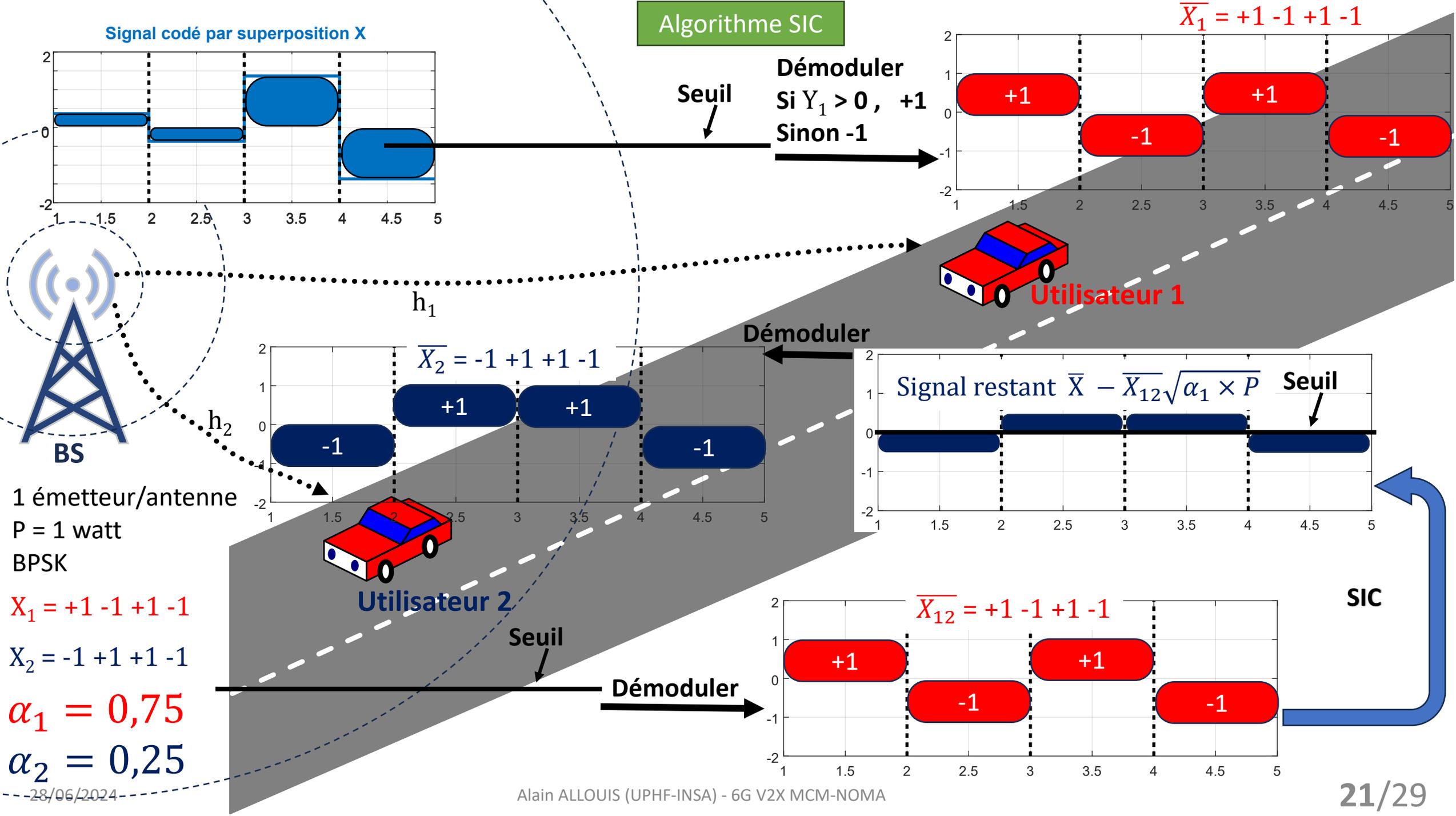


Utilisateur 2

$X_1 = +1 -1 +1 -1$
 $X_2 = -1 +1 +1 -1$

$\alpha_1 = 0,75$
 $\alpha_2 = 0,25$





Le débit total maximal réalisable pour un système MCM-NOMA à n utilisateurs

Maximum Sum Rate of MCM-NOMA in Future Vehicular Sensor Networks

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$$\begin{aligned}
 R^{\text{sum}} &= \frac{\gamma}{T} \sum_{U_i=U_0}^{U_{n-2}} \sum_{j=0}^{LK-1} \log_2 \left(\frac{\alpha_{U_i} \sigma^2 \sum_{i=0}^{N-1} [\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i \sum_{i=0}^{N-1} \overline{[\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i}}{\alpha_{U_j} \sigma^2 \sum_{m=0}^{LK-1} \left(\sum_{i=0}^{N-1} [\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i \sum_{i=0}^{N-1} \overline{[\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i} \right) - \alpha_{U_i} \sigma^2 \sum_{i=0}^{N-1} [\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i \sum_{i=0}^{N-1} \overline{[\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i} + P_\eta} \right) \\
 &\quad \times \left(1 + \frac{\alpha_{U_{n-1}} \sigma^2 \sum_{i=0}^{N-1} [\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i \sum_{i=0}^{N-1} \overline{[\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i}}{\alpha_{U_{n-1}} \sigma^2 \sum_{\substack{m=0 \\ m \neq j}}^{LK-1} \left(\sum_{i=0}^{N-1} [\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i \sum_{i=0}^{N-1} \overline{[\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i} \right) + P_\eta} \right) \\
 &\quad + \frac{\gamma}{T} \sum_{j=0}^{LK-1} \log_2 \left(1 + \frac{\alpha_{U_{n-1}} \sigma^2 \sum_{i=0}^{N-1} [\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i \sum_{i=0}^{N-1} \overline{[\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i}}{\alpha_{U_{n-1}} \sigma^2 \sum_{\substack{m=0 \\ m \neq j}}^{LK-1} \left(\sum_{i=0}^{N-1} [\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i \sum_{i=0}^{N-1} \overline{[\mathbf{g}_{u,v}]_i [\mathbf{q}_{l,k}]_i} \right) + P_\eta} \right).
 \end{aligned}$$



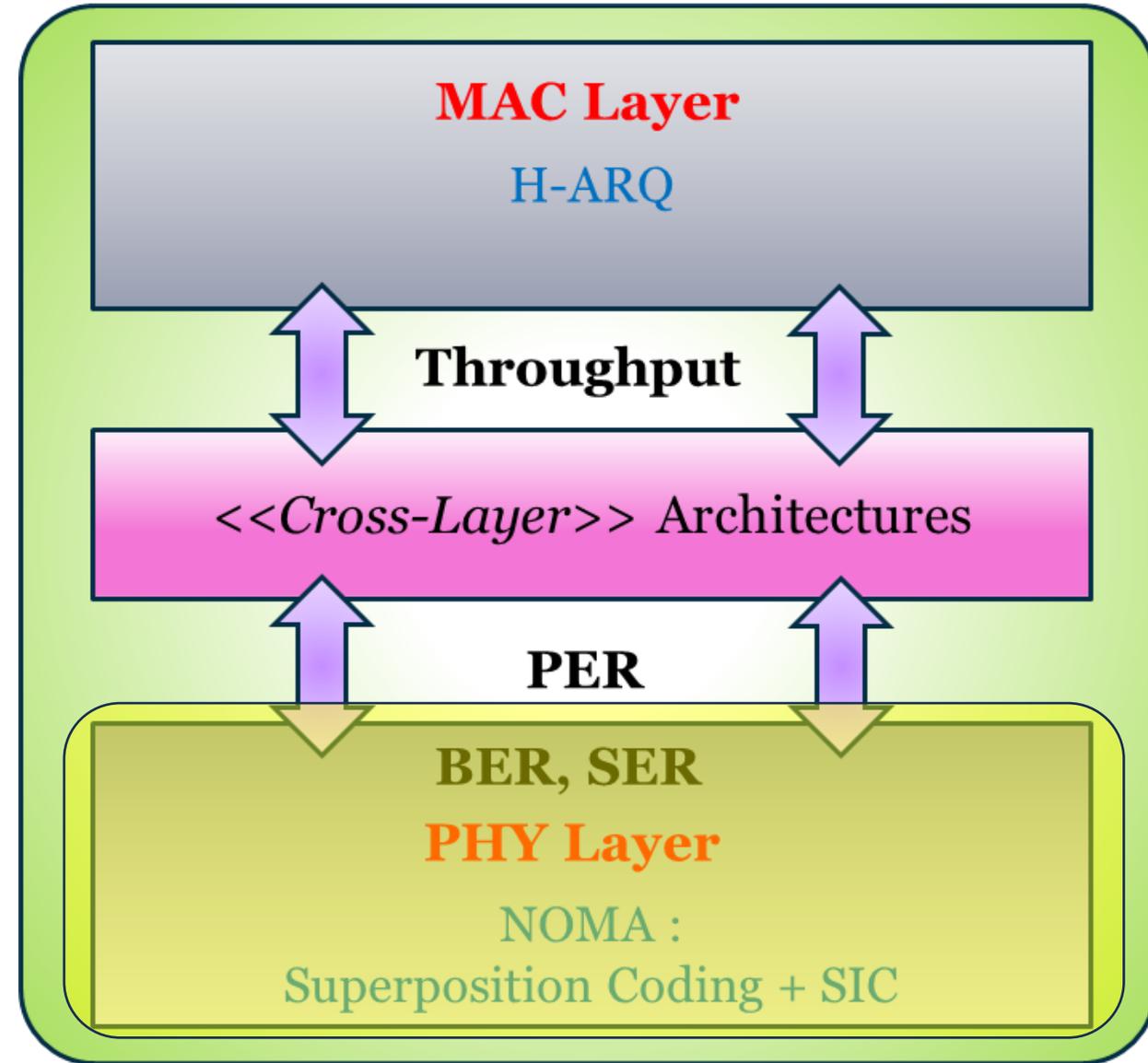
Conception multicouche PHY/MAC utilisant NOMA

$$R_{NOMA}^{sum} = \sum_{i=1}^N R_{i,NOMA}$$

$$R_{OMA}^{sum} = \sum_{i=1}^N R_{i,OMA}$$

$$R_1 = \log_2 \left(1 + \frac{\alpha_1 P |h_1|^2}{(\alpha_2 + \alpha_3 + \dots + \alpha_N) P |h_1|^2 + \sigma^2} \right)$$

$$R_2 = \log_2 \left(1 + \frac{\alpha_2 P |h_2|^2}{(\alpha_3 + \alpha_4 + \dots + \alpha_N) P |h_2|^2 + \sigma^2} \right)$$

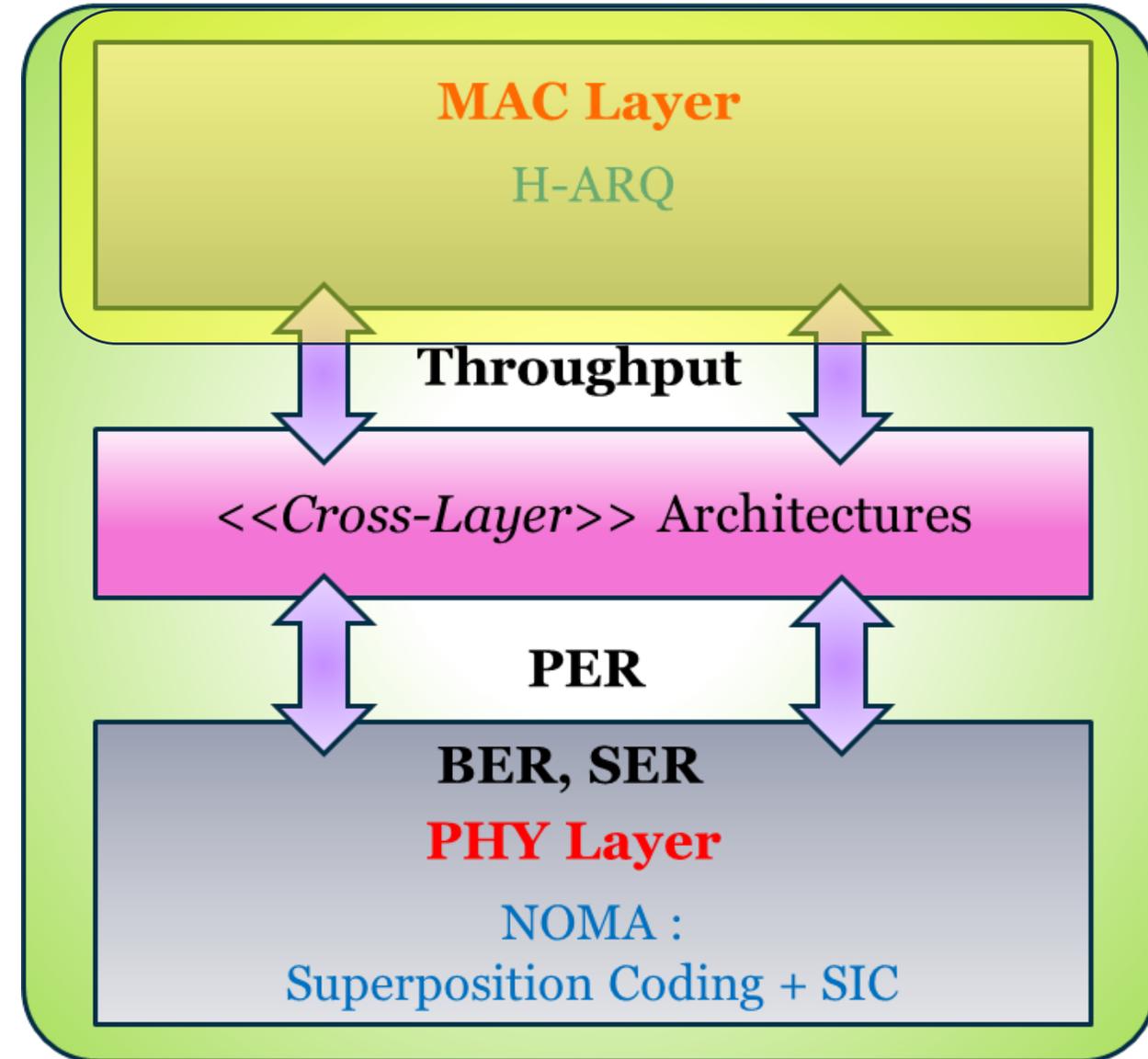


Conception multicouche PHY/MAC utilisant NOMA

$$SER_{BPSK}(i) = 0.5 \left(1 - \sqrt{\frac{\bar{\gamma}_s(i)}{1 + \bar{\gamma}_s(i)}} \right)$$

$$PER(i) = 1 - (1 - SER_{BPSK}(i))^L$$

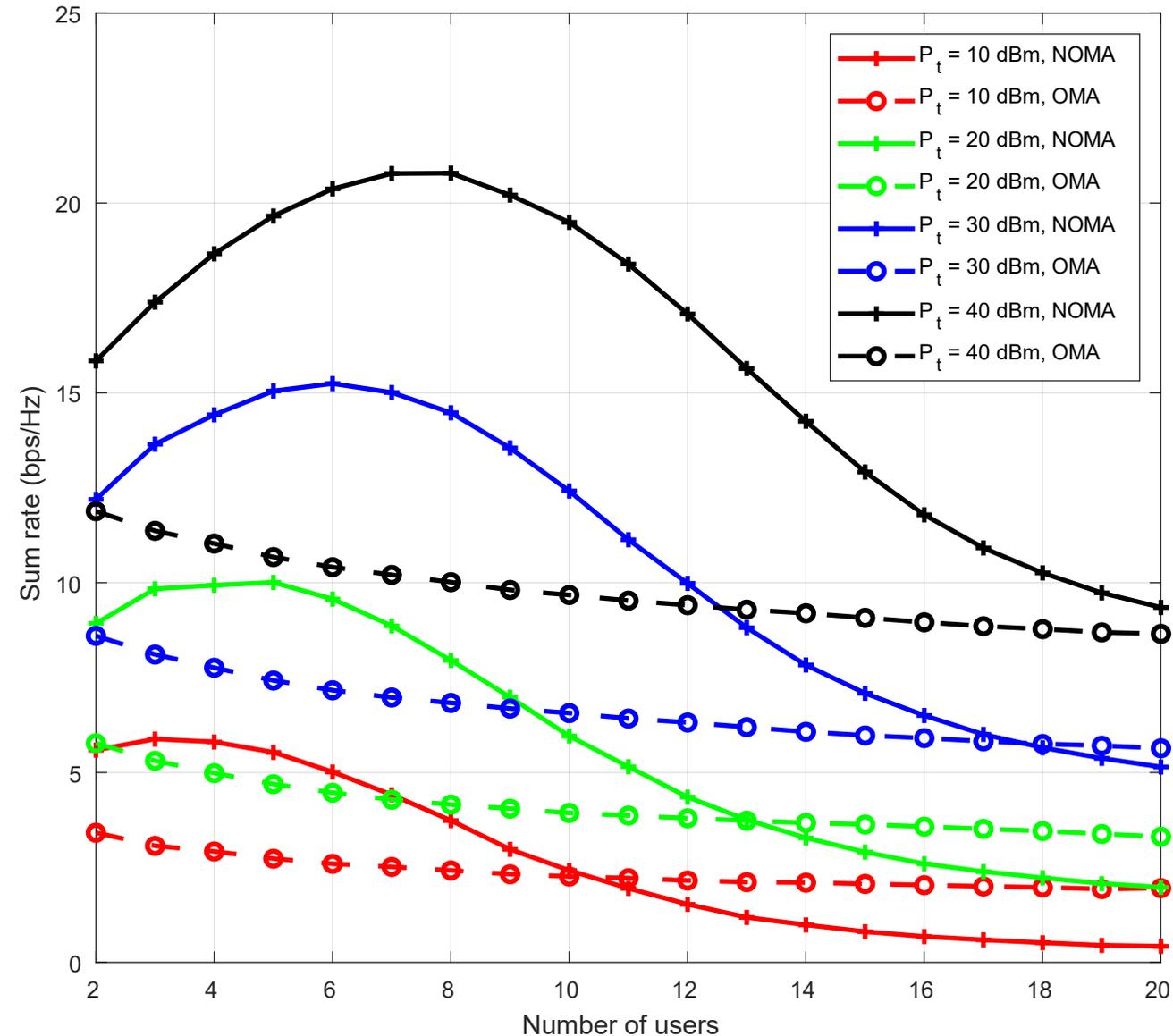
$$\eta(i) = (1 - PER(i))R(i)$$



Performances NOMA vs OMA, avec différentes puissances de transmission

- Interférences plus élevées chez les utilisateurs éloignés
- SIC chez les utilisateurs proches
- Points où OMA sera plus performant
- Points de chute

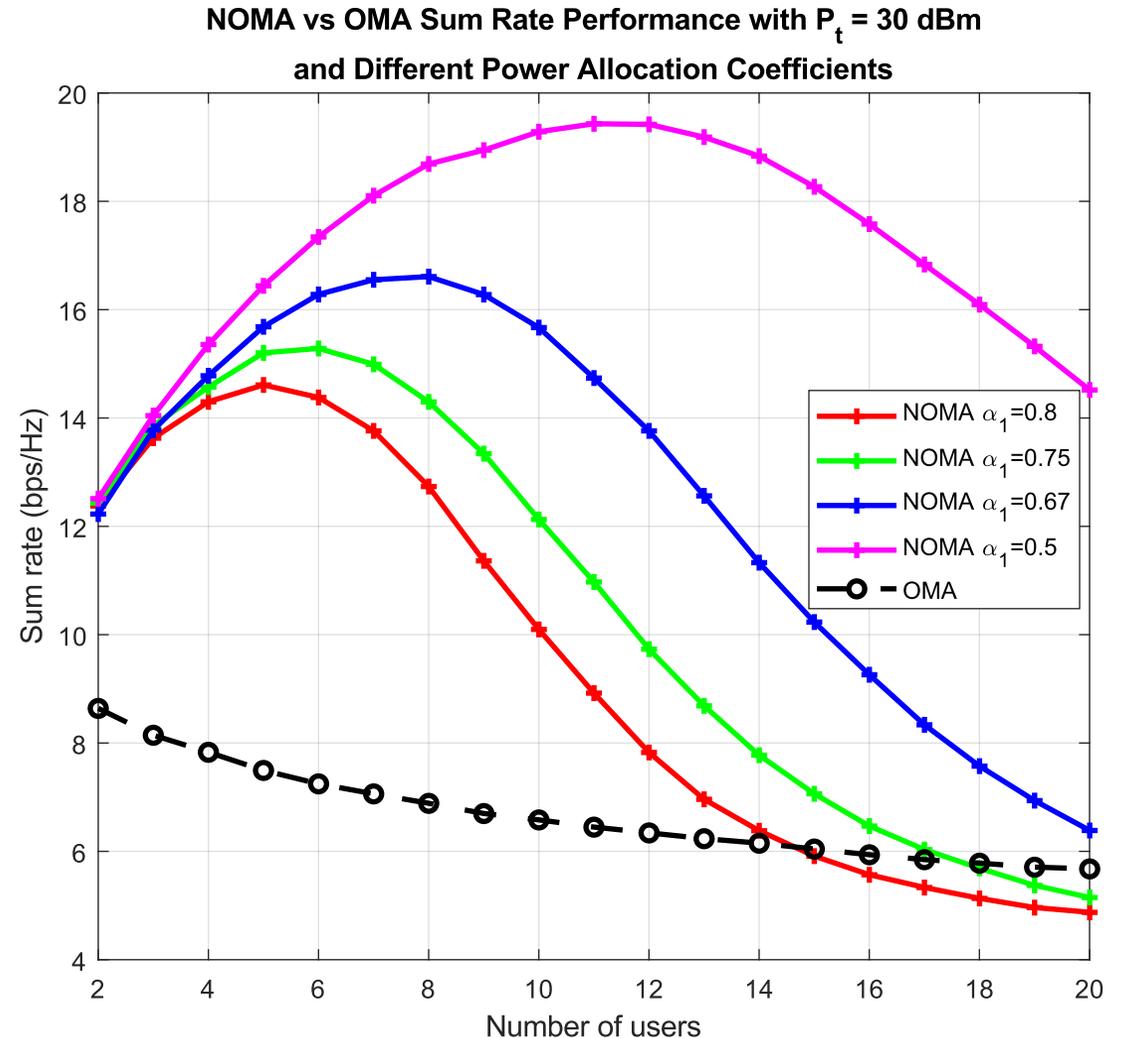
Impact des coefficients d'allocation de puissance ?



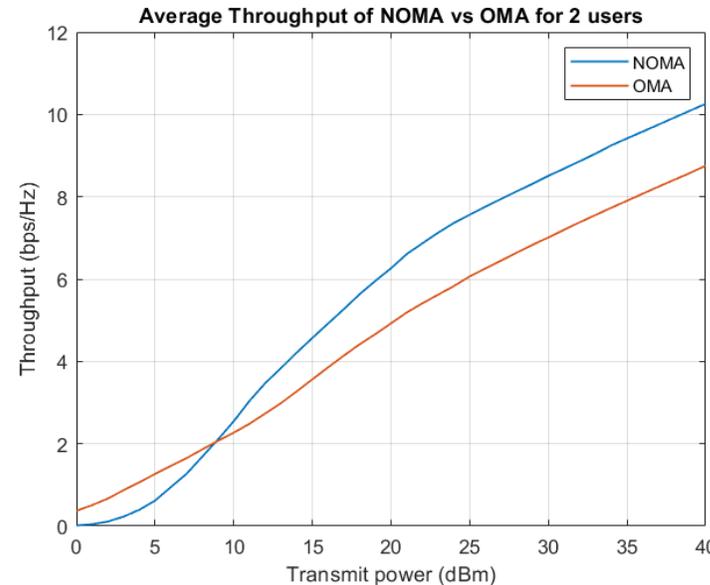
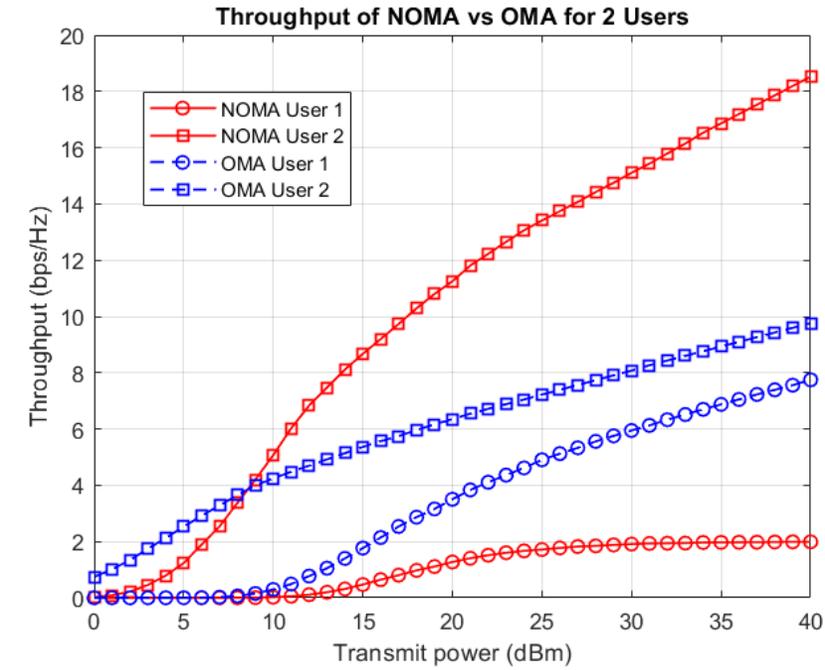
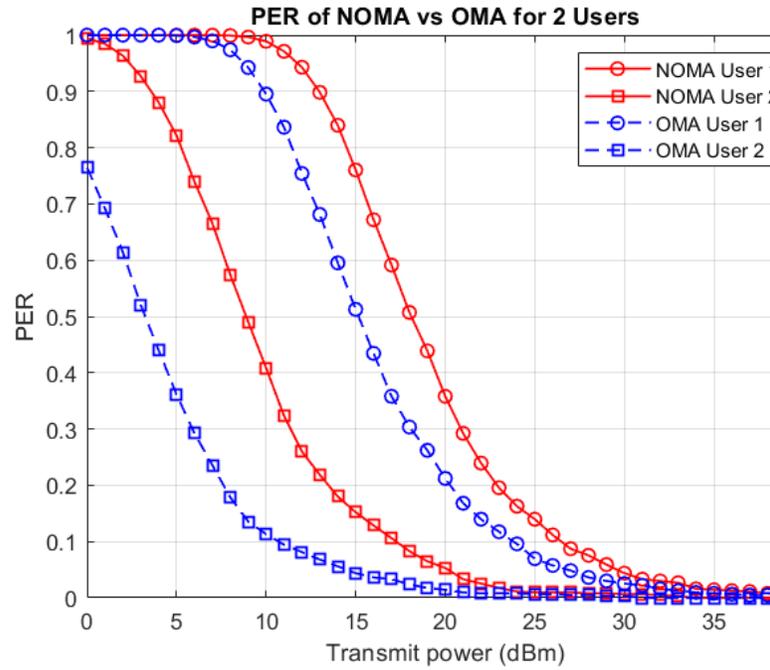
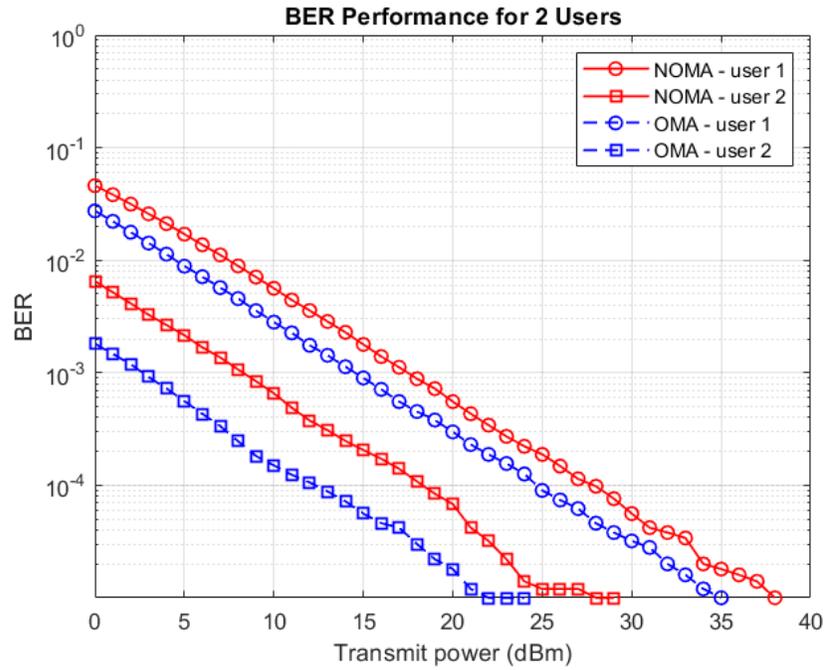
NOMA et OMA avec une puissance de transmission de 30 dBm et utilisant différents coefficients d'allocation de puissance

- utilisateurs éloignés ou faibles (α_1)
 $\alpha_1 = 0,8, 0,75, 0,67, 0,5$

Stratégie d'allocation de puissance fixe/dynamique

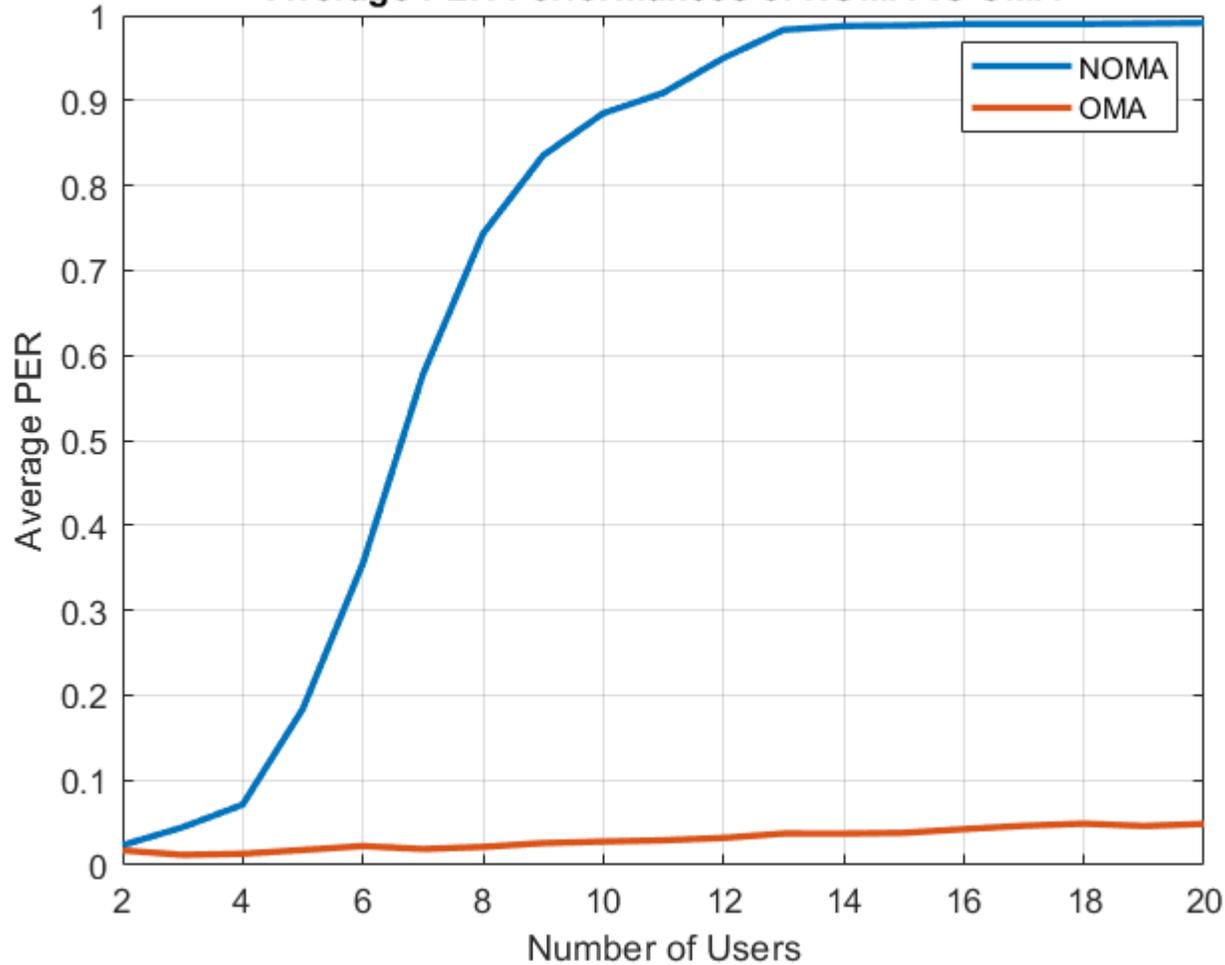


Performances de conception multicouches 2 utilisateurs

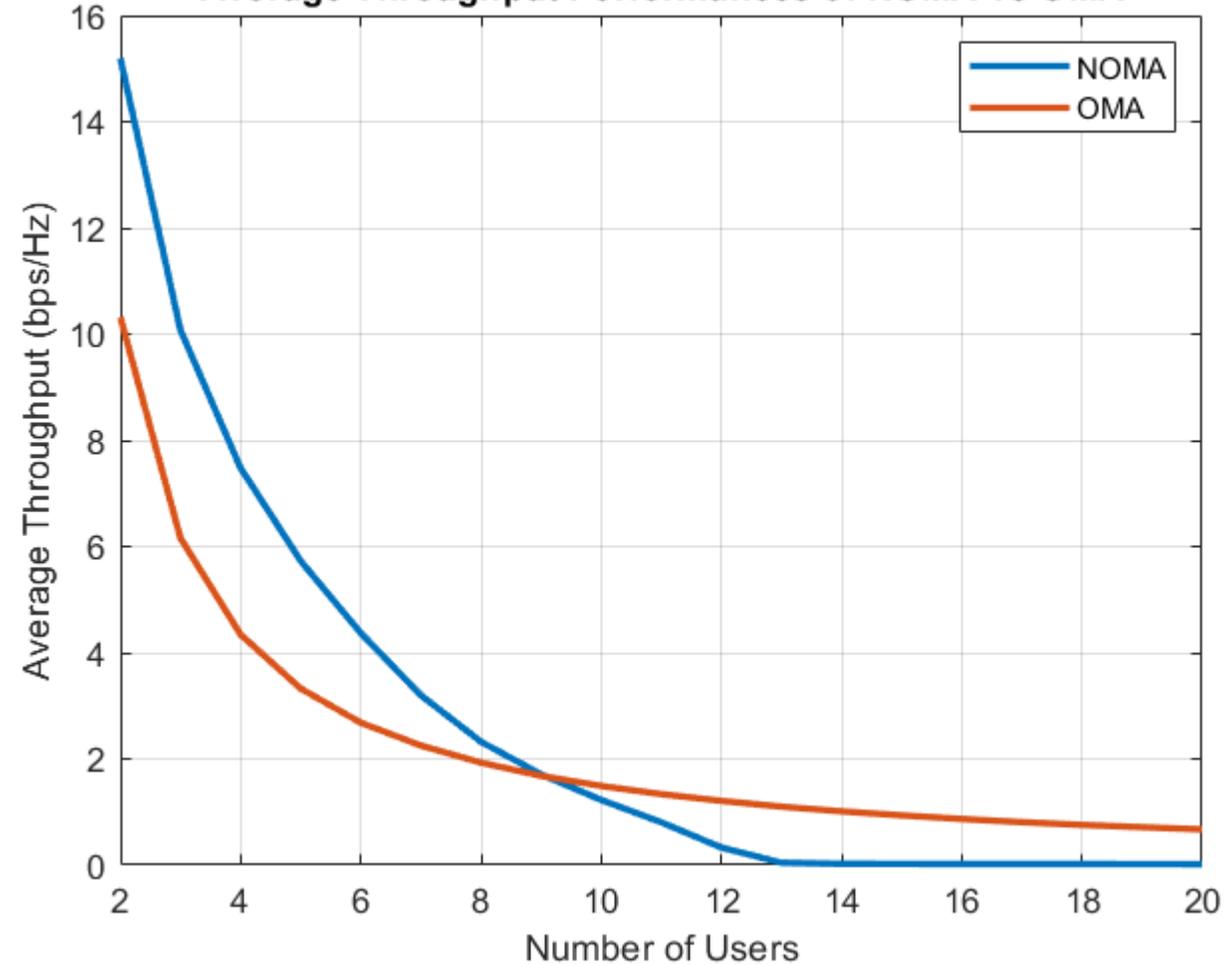


Performances de conception multicouches

Average PER Performances of NOMA vs OMA



Average Throughput Performances of NOMA vs OMA



Perspectives - Communications V2X et technologies 6G

- Relier la recherche aux cas d'usage standard
- Mieux exploiter l'IA, algorithmes d'allocation de ressources
lier différentes technologies d'accès radio, solutions hybrides
- Full Duplex, doubler l'efficacité spectrale et réduire la latence
l'allocation dynamique du spectre et
« small cells » 6G-V2X.

