ConnRAD – Connectivity and Resilience for Automated Driving

Final Presentation   **23.10.2025**

ConnRAD
Connectivity & Resilience for automated
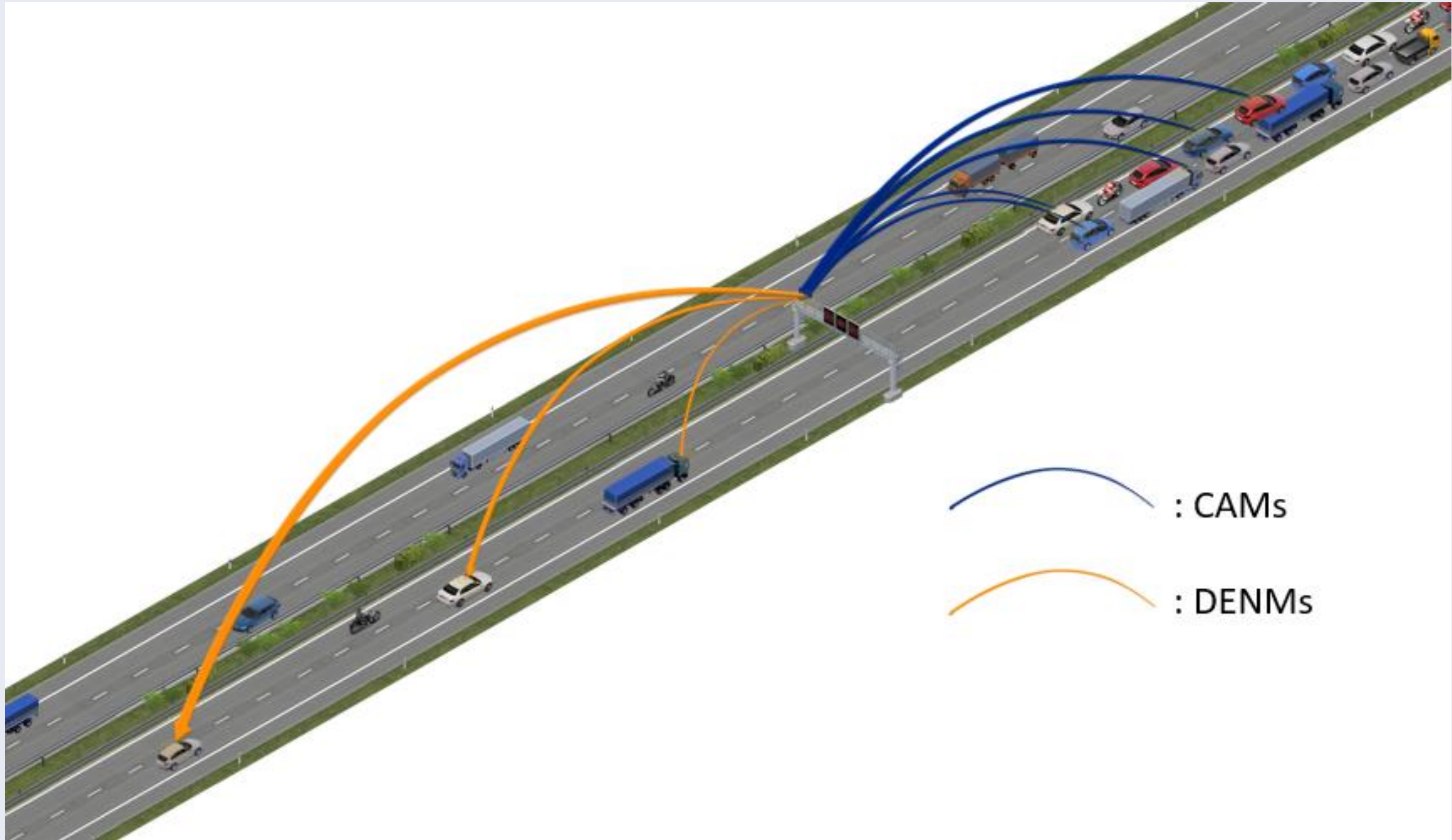Driving Functions in Germany

RF-Fingerprinting for fast Authentication in V2X

Simulation of RF-Transceiver for Fingerprinting – A Feasibility Study

Franz Dielacher, Hans-Dieter Wohlmuth, Patrick Weissensteiner, Infineon Technologies AG (IFAG)
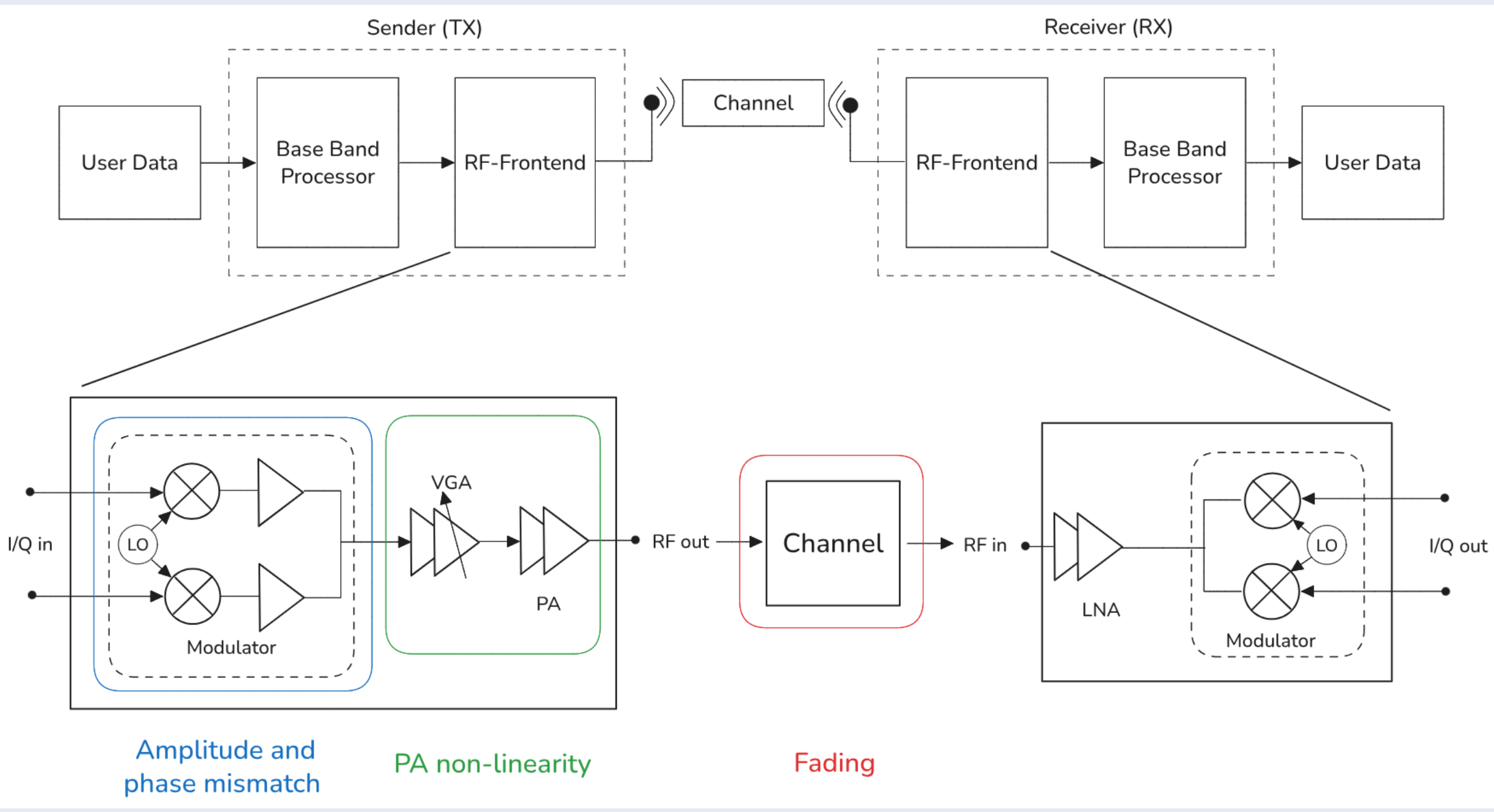
Reliable and trustworthy event-notification via V2X

- Traffic jam detection by incoming V2X messages (CAMs for vehicles within traffic jam)
- → Need for trustworthy and low-latency message authentication

- : CAMs
- : DENMs

System model

- RF-Frontend suffers from intrinsic impairments which can be exploited for transmitter identification.
- Channel estimation would eliminate impairments.
- **Hypothesis:** channel has a high influence, which makes fingerprinting with impairments not feasible.
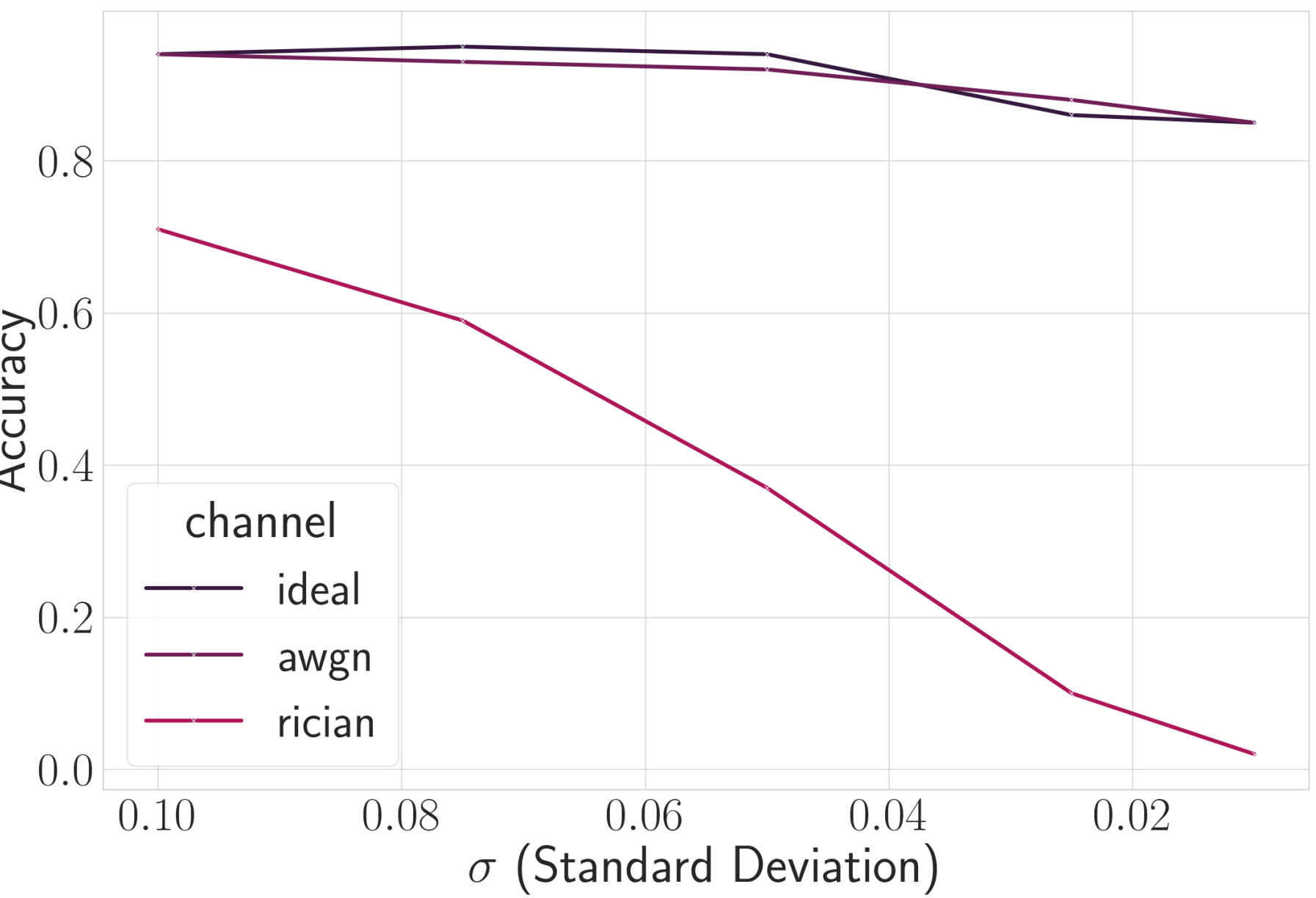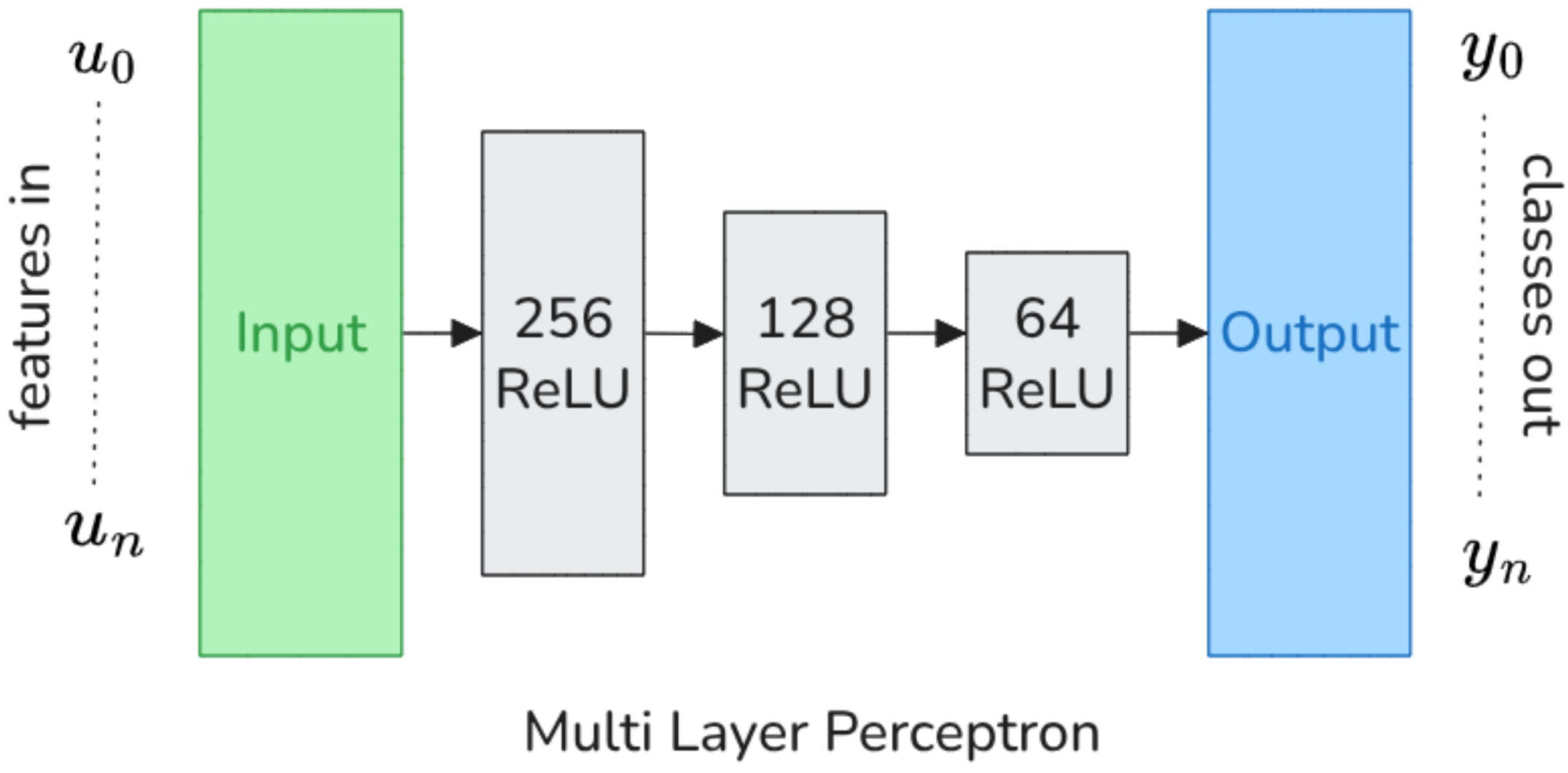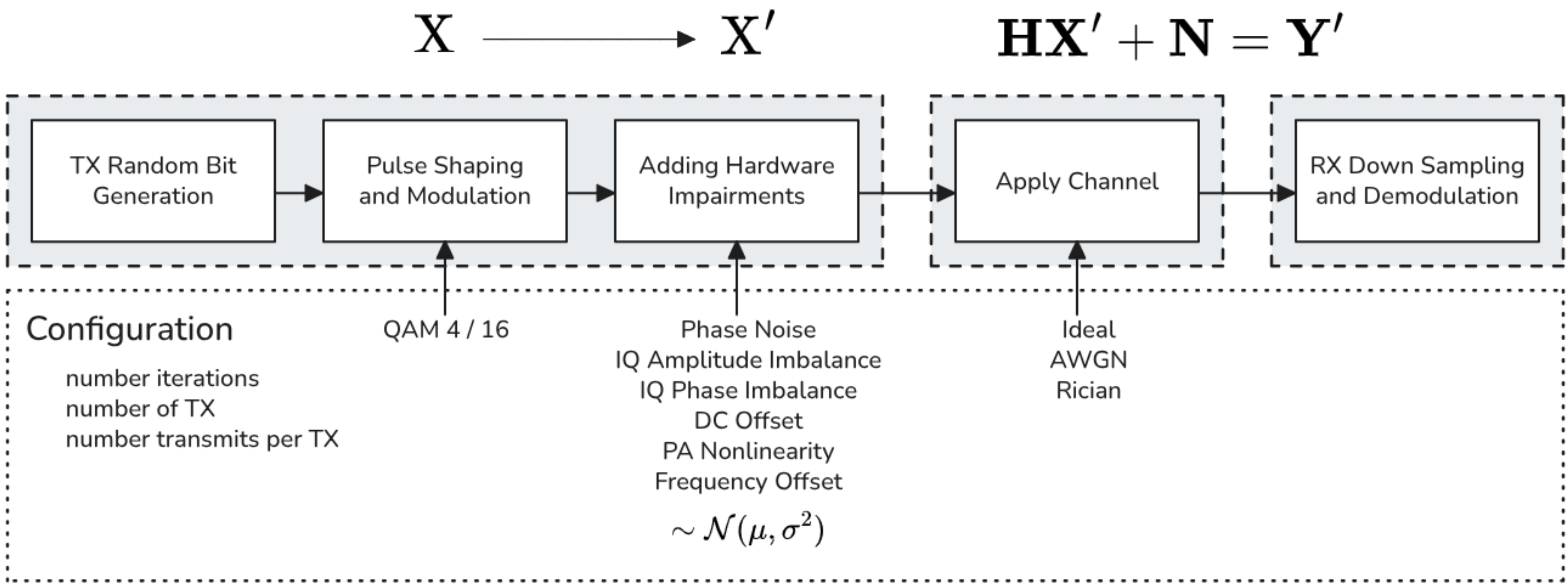

Monte Carlo simulation

- Simulation of multiple transmitters (1000)
- Impairments follow a Normal distribution and are sampled per transmitter
- QAM4 modulated signal
- Different channels: ideal, AWGN, Rician (line-of-sight fading)
- Varying standard deviation of impairments

Feature extraction from IQ signal (machine learning)

- Time Domain
- Statistical
- Frequency Domain
- IQ-Features
- Transient
- Phase Noise
- Non-Linearities
- → multi dimensional feature set passed to multi-layer perceptron (neural network)
- → generate baseline classification

$$X \longrightarrow X' \qquad HX' + N = Y'$$

Configuration   QAM 4 / 16   Phase Noise   Ideal

number iterations   IQ Amplitude Imbalance   AWGN
number of TX   IQ Phase Imbalance   Rician
number transmits per TX   DC Offset
PA Nonlinearity
Frequency Offset

$$\sim \mathcal{N}(\mu, \sigma^2)$$

Multi Layer Perceptron

features in $u_0 \dots u_n$ → Input → 256 ReLU → 128 ReLU → 64 ReLU → Output → classes out $y_0 \dots y_n$

Transmitter classification with multi layer perceptron (MLP)

Decreasing standard deviation:
- AWGN and Ideal channel almost maintain performance
- Rician channel has big impact on classification performance

Future approach for RF Fingerprinting

- Problem of evaluation: not feasible to measure many thousand devices
  → Data augmentation
- Artificially "enhancing" impairments
- Integration of cryptographic schemes into PHY-layer authentication

• K. Sankhe u. a., „No Radio Left Behind: Radio Fingerprinting Through Deep Learning of Physical-Layer Hardware Impairments", IEEE Trans. Cogn. Commun. Netw., Bd. 6, Nr. 1, S. 165–178, März 2020, doi: 10.1109/TCCN.2019.2949308.

• C. Spinnler, T. Labs, und N. Franchi, „SoK: A Taxonomy for Hardware-Based Fingerprinting in the Internet of Things", in Proceedings of the 19th International Conference on Availability, Reliability and Security, in ARES '24. New York, NY, USA: Association for Computing Machinery, Juli 2024, S. 1–12. doi: 10.1145/3664476.3670872.

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