G2G Waveform Design Challenges

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Outline

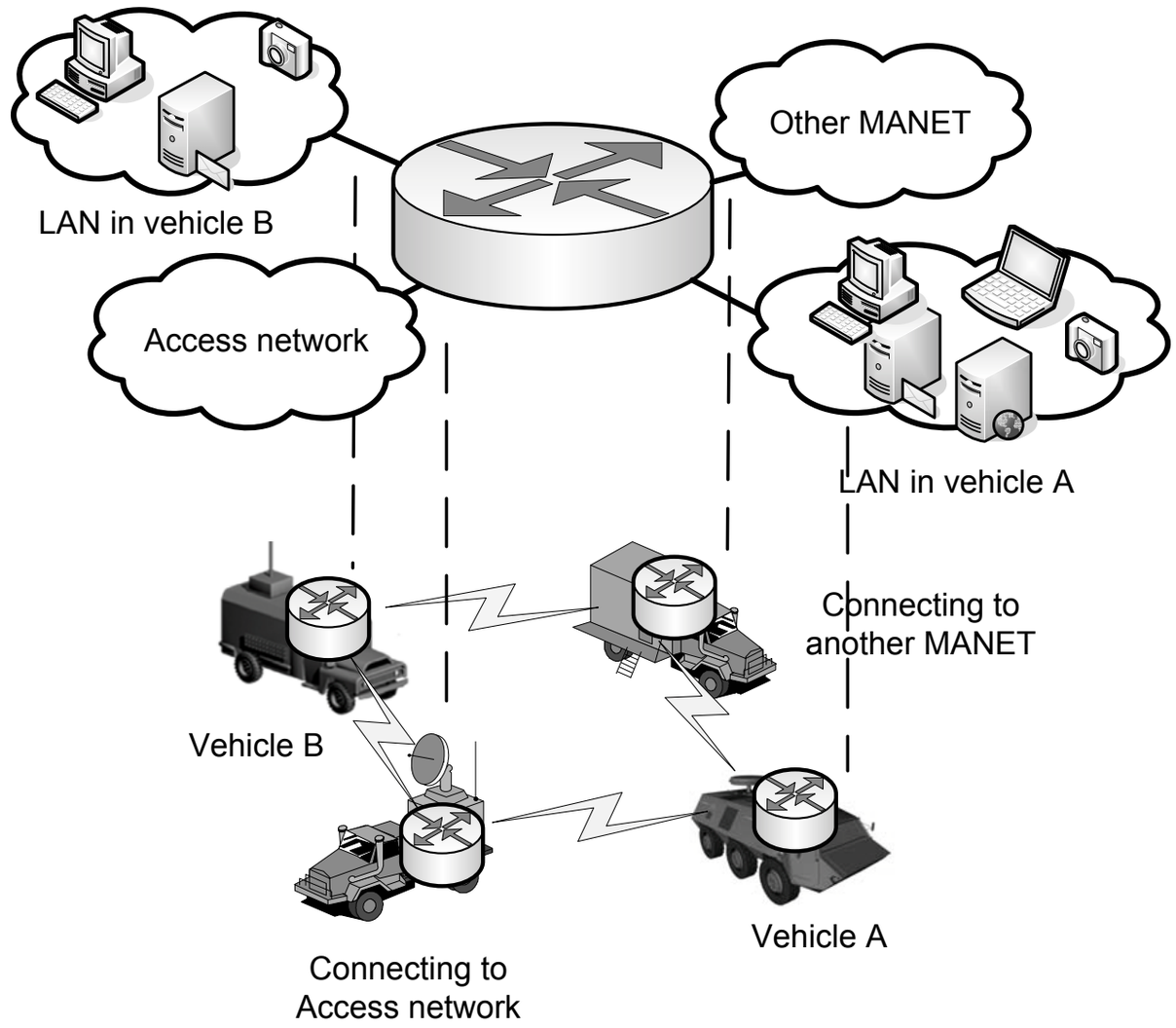
- Motivation and a ‘typical’ scenario.
- Design challenges:
  - MANET peculiarities.
  - Source coding.
  - Channel coding.
  - Medium access.
- Conclusion & outlook.

What this talk is about

Design challenges for robust ground-to-ground waveforms in software-defined radio ad-hoc networks

A ‘typical’ scenario

- Kilometer-scale node-to-node distances.
- Relative velocities typically 80 km/h, up to 300 km/h.
- Voice, real-time and non-real-time data, position and location tracking.



Challenge: MANET peculiarities

- No *single hop* behaviour – *multi hop* is the norm.
- Additional overhead due to decentralised and possibly hierarchical infrastructure.
- Node mobility makes link outages frequent.
- Unicast bit rate-distance ratio is limited by

$$\Theta\left(\frac{W}{\sqrt{An}}\right)$$

Challenge: Source coding

- 2.5 kBit/s is sufficient for speech encoders (*Codec 2*).
- Beware: Voice codec efficiency is not everything.
- Usual protocol stack (Codec, RTP, UDP, IP) incurs tremendous overhead—use header compression schemes (*ROHC*) or layer-3 alternatives (e.g. STANAG 5066).

Challenge: Channel coding

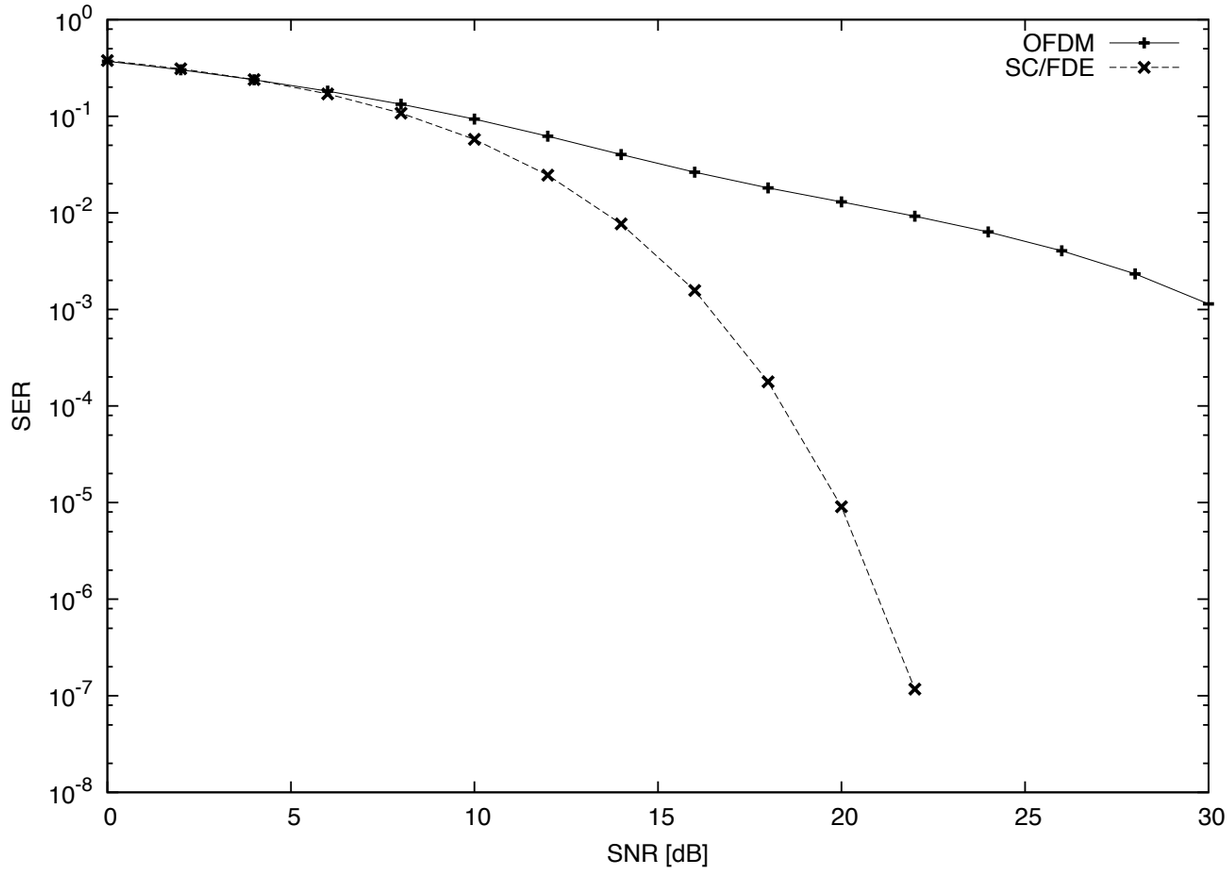
- Channel models for vehicular networks often are modified models (e.g. mod. Okumura-Hata, Nakagami).
- Model verification and validation is laborious (Berger 1998, Fraunhofer IIS 2010).
- **Pragmatic approach**: (re-)use commercial models and solutions (GSM/3GPP, DVB-T, etc.).
- OFDM and SC/FDE, turbo and LDPC codes, separation via CDMA.

Challenge: Medium access

- Probabilistic schemes does not provide hard *QoS* guarantees.
- Deterministic schemes are often inflexible and lack self-organising capabilities.
- **Research is needed and under way**: USAP, STDMA (ICAO/IMO), cross-layer approaches.
- Again: re-use commercial approaches (e.g. LTE radio ressource control).

Single Carrier FDMA vs. OFDMA

- Specified in 3GPP LTE.
- SC/FDMA has better symbol error rate.
- SC/FDMA has better PAPR – simpler transmitter design.
- Interleaved SC/FDMA mitigates subcarrier fading better than OFDMA.



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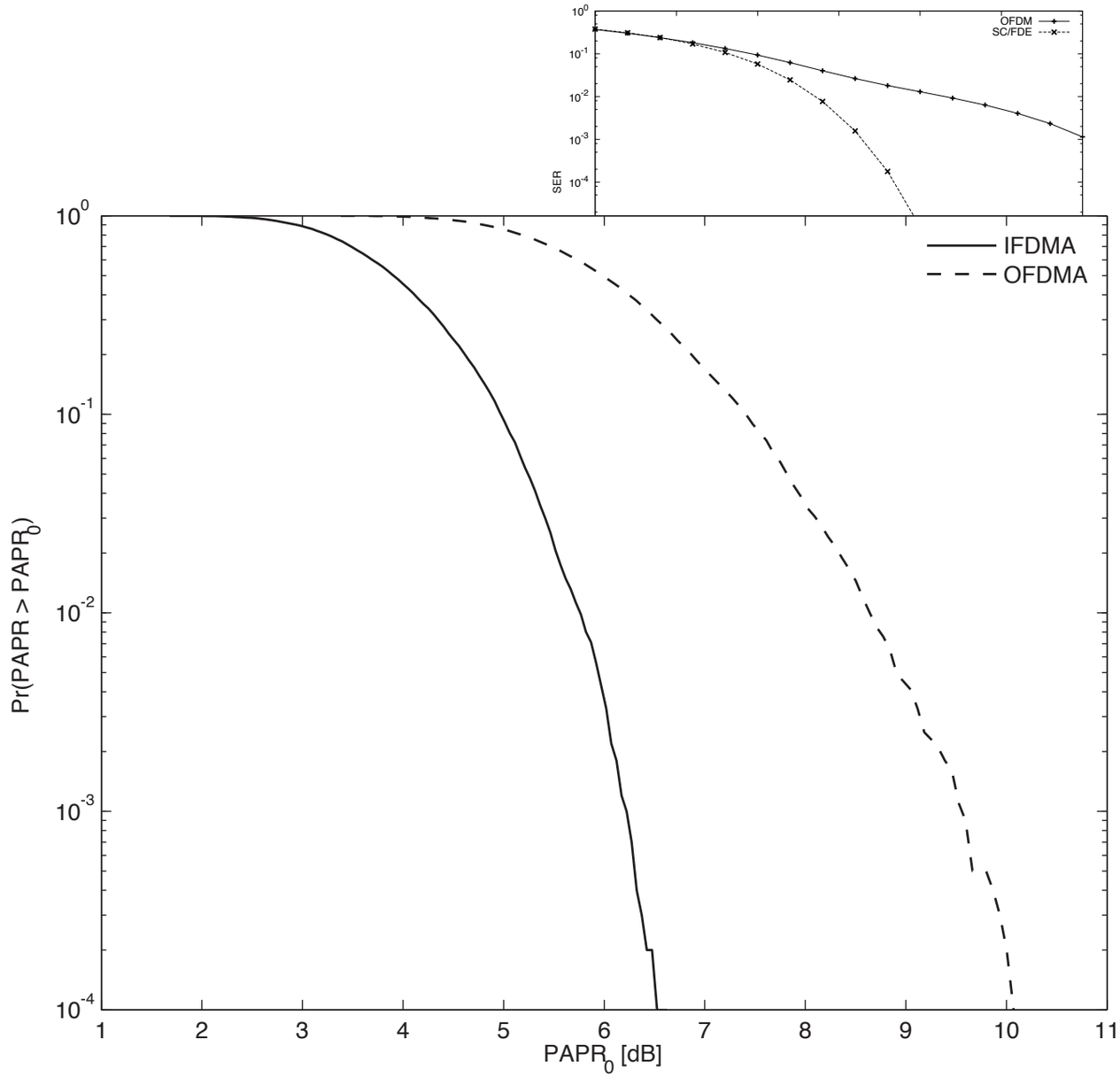

Conclusion & Outlook

- Vehicular QoS-supporting ad-hoc networks will be an integral part of future communications—military and civil.
- *Knowledge islands* exist, often the work is more in the integration.
- Look ahead: management of mobile SDR nets is challenging.

What you should take away

- SDR enables flexibility—ASICs excel in performance.
- Good channel models for wide-band waveforms are scarce—measure, validate, and verify.
- Medium access is the linchpin—strike a compromise between self-organisation, overhead, and pre-planning.
- **Do not re-invent the wheel**—avoid NIH syndrome!

Thank you for your attention!

Questions?