Comparison of Channel Models for Evaluating the Performance of Mobile Broadcasting Systems

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Channel modeling

- Mobile radio channel models illustrate the physical medium
- Development of channel models is difficult
- Different parameters and environments have to be considered

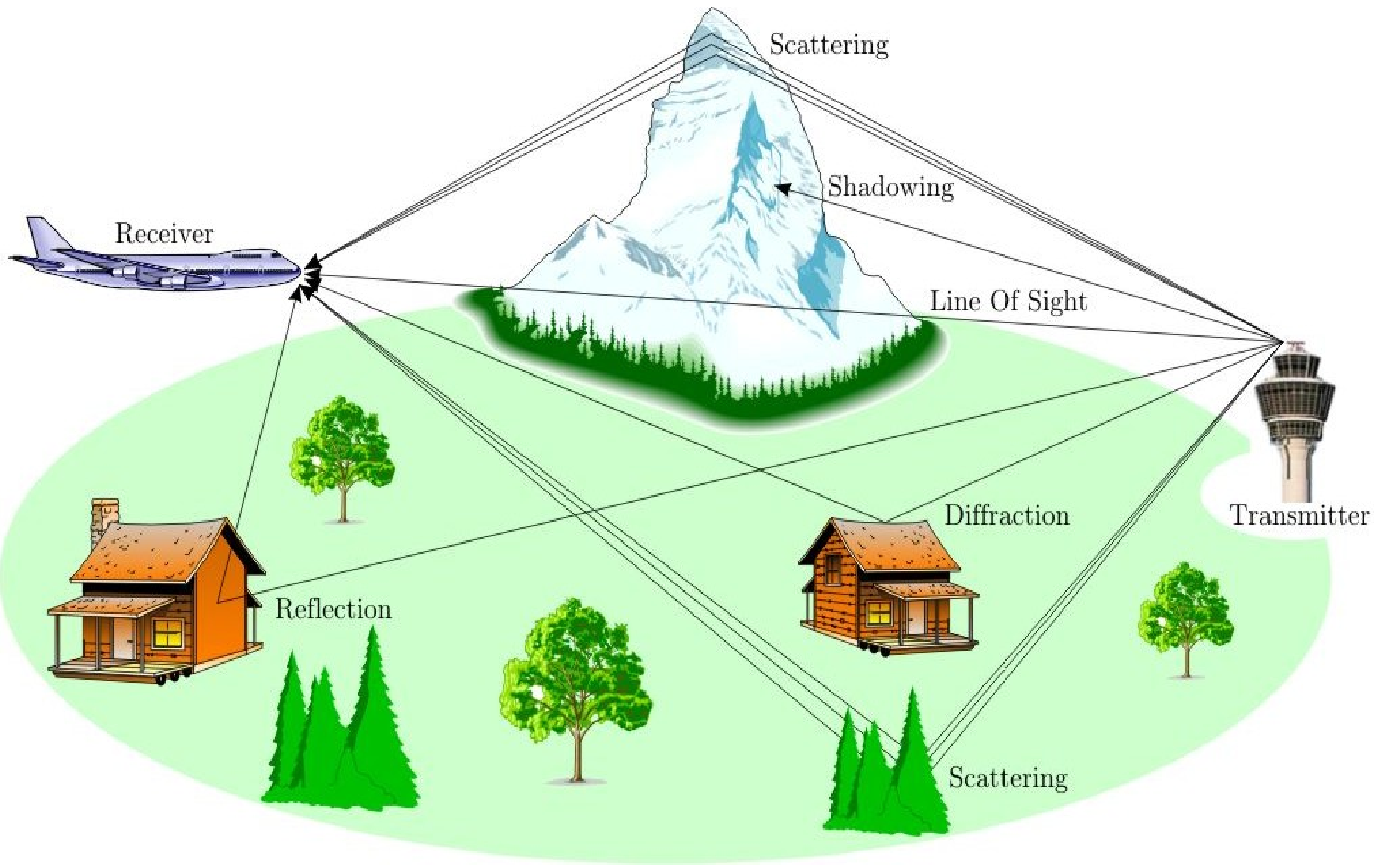
- Multipath radio signal
  - large-scale path loss component
  - medium-scale slow varying component (shadowing)
  - small-scale fast varying component (fading)

Path loss and shadowing

- Received power decreases with distance → free-space path loss (LOS)
- Path loss characterizes the received power averaged over long distances
- Path loss can be modeled e.g. with Hata and Walfisch-Ikegami models

- Medium-scale propagation models define slow changes in the received signal power
- Obstructions create shadowing
- Medium-scale variation of the received power can be modeled with log-normal distribution

Multipath propagation



Small-scale fading

- Small-scale propagation models define fast changes in the received signal power
- Small-scale fading occurs due to multipath reflections of the transmitted signal by different scatterers
- Multipath signals arriving to the receiver sum up either constructively or destructively depending on the signal phase
- Doppler effect
- Small-scale fading can be modeled with Ricean or Rayleigh distributions

Small-scale fading types

- Fading dependent on multipath time delay spread
  - **flat fading**
    - symbol period > time delay spread
    - signal bandwidth < coherence bandwidth
  - **frequency selective fading**
    - symbol period < time delay spread
    - signal bandwidth > coherence bandwidth
- Fading dependent on Doppler spread
  - **fast fading**
    - symbol period > coherence time
    - signal bandwidth < Doppler spread
  - **slow fading**
    - symbol period < coherence time
    - signal bandwidth > Doppler spread

Cellular radio environments

- Radio environments vary so much that it is not possible to model all environments

- Different environments can be modeled e.g. with generic environments
  - vehicular radio environment (rural, suburban or urban areas)
  - pedestrian radio environment (suburban or urban areas)
  - indoor office radio environment (suburban or urban areas)

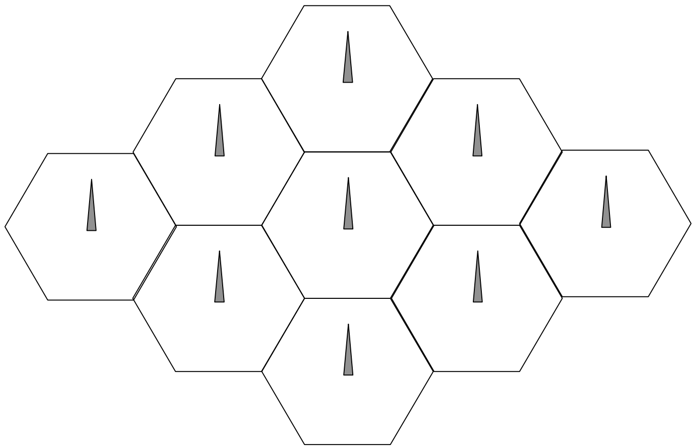
Cell types

- Macrocell
  - cell with radius of kilometers
  - base station antennas above rooftop levels
  - environment from rural to urban
- Microcell
  - cell with typical radius of 20-300 m
  - base station antennas below rooftop levels
  - environment typically urban
  - LOS and NLOS connections
- Picocell
  - cell with typical radius of 5-30 m
  - environment typically indoor
  - LOS and NLOS connections

Mobile broadcasting environment (I)

- Multi-frequency network
  - e.g. DVB-T network
  - *n* transmitters - *n* frequencies
  - several frequencies are needed for good coverage
  - no synchronization needed

- Single-frequency network
  - e.g. DVB-H network
  - *n* transmitters - one frequency
  - additional frequencies are not needed to fill the gaps in the coverage area, new transmitters can be added
  - synchronization is needed



Mobile broadcasting environment (II)

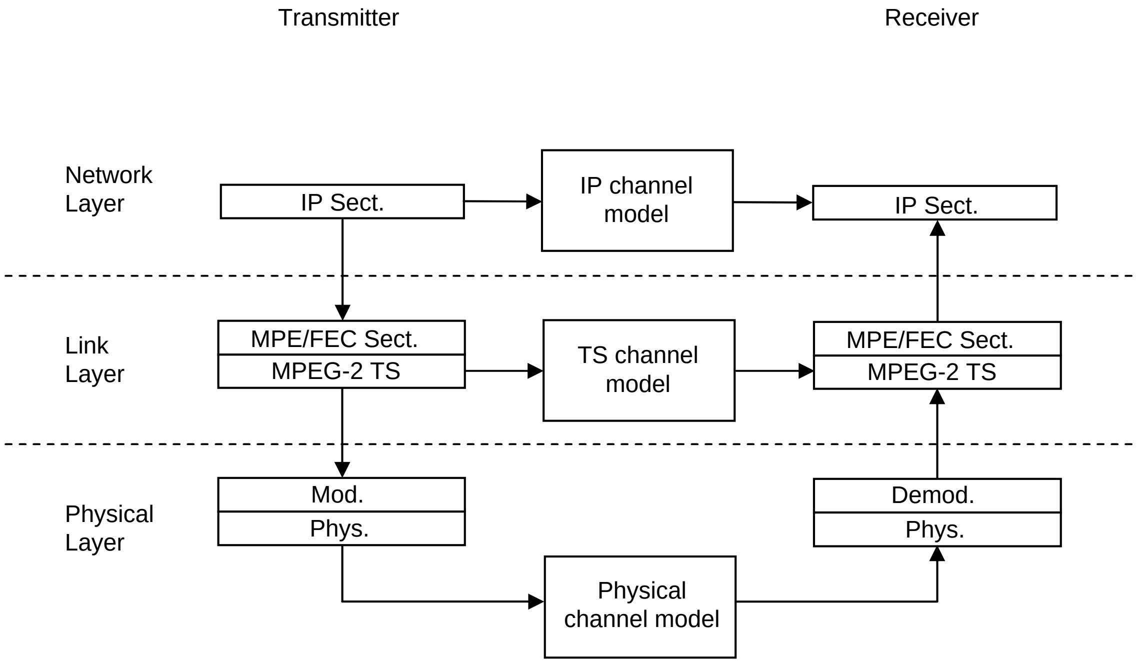
- Terrestrial digital television broadcasting were traditionally allocated for rooftop antenna reception, portable indoor reception and vehicular reception
  → handheld reception needed

- Dedicated broadcasting channel models for DVB-H (Digital Video Broadcasting - Handheld)
  - **Pedestrian Indoor**, with traveling speed 3 km/h (PI3)
  - **Pedestrian Outdoor**, with traveling speed 3 km/h (PO3)
  - **Vehicular Urban**, with traveling speed 30 km/h (VU30)
  - **Motorway Rural**, with traveling speed 100 km/h (MR100)

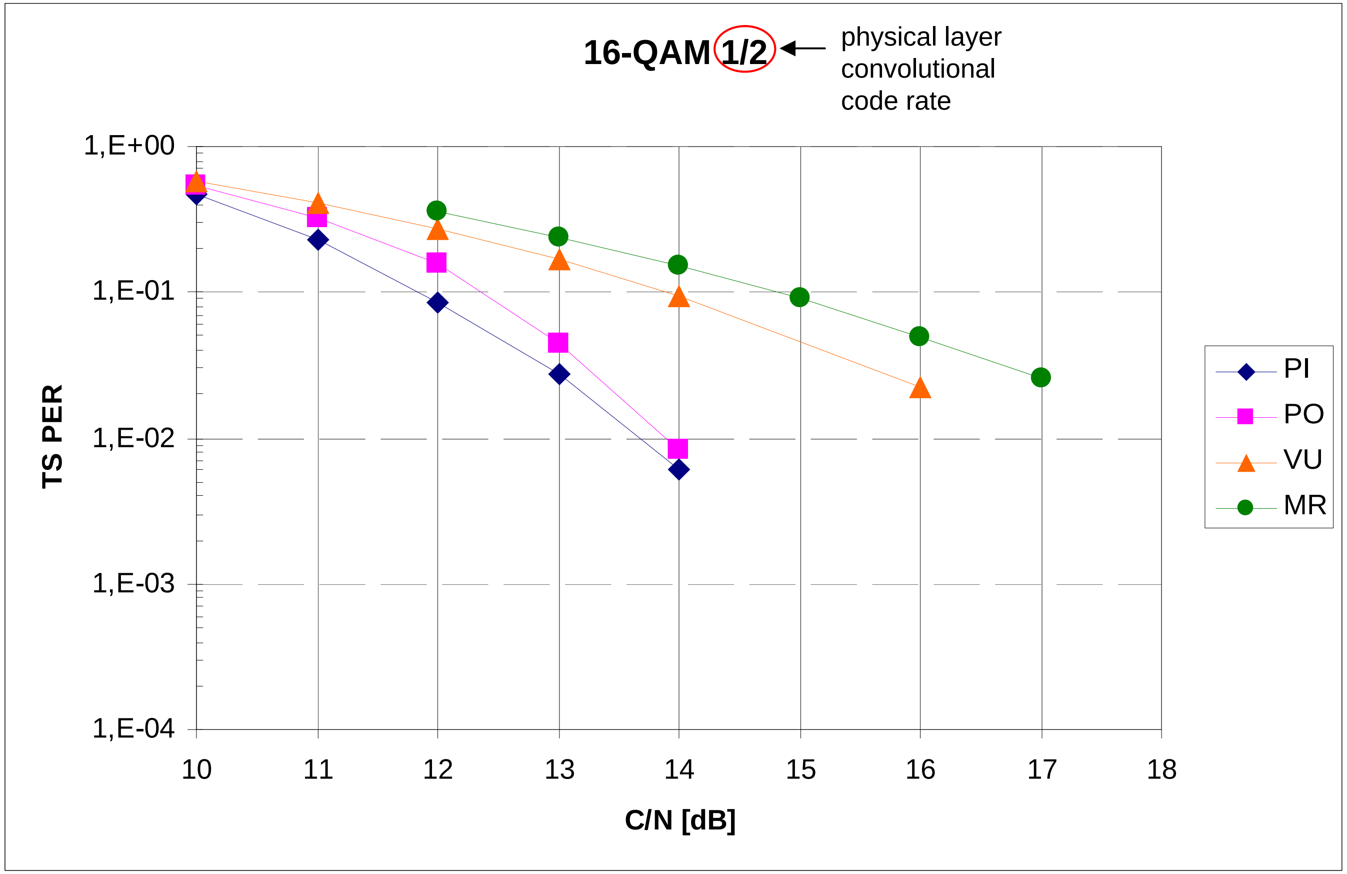
Simulation model

- DVB-H system was simulated
- DVB-H system was developed for efficient delivery of IP services to battery-powered handheld receivers over terrestrial networks

- Simulations were performed in order to
  - illustrate how the system performance changes depending on the channel model
  - show how the effects of small-scale fading can be mitigated



Simulation results after the physical layer



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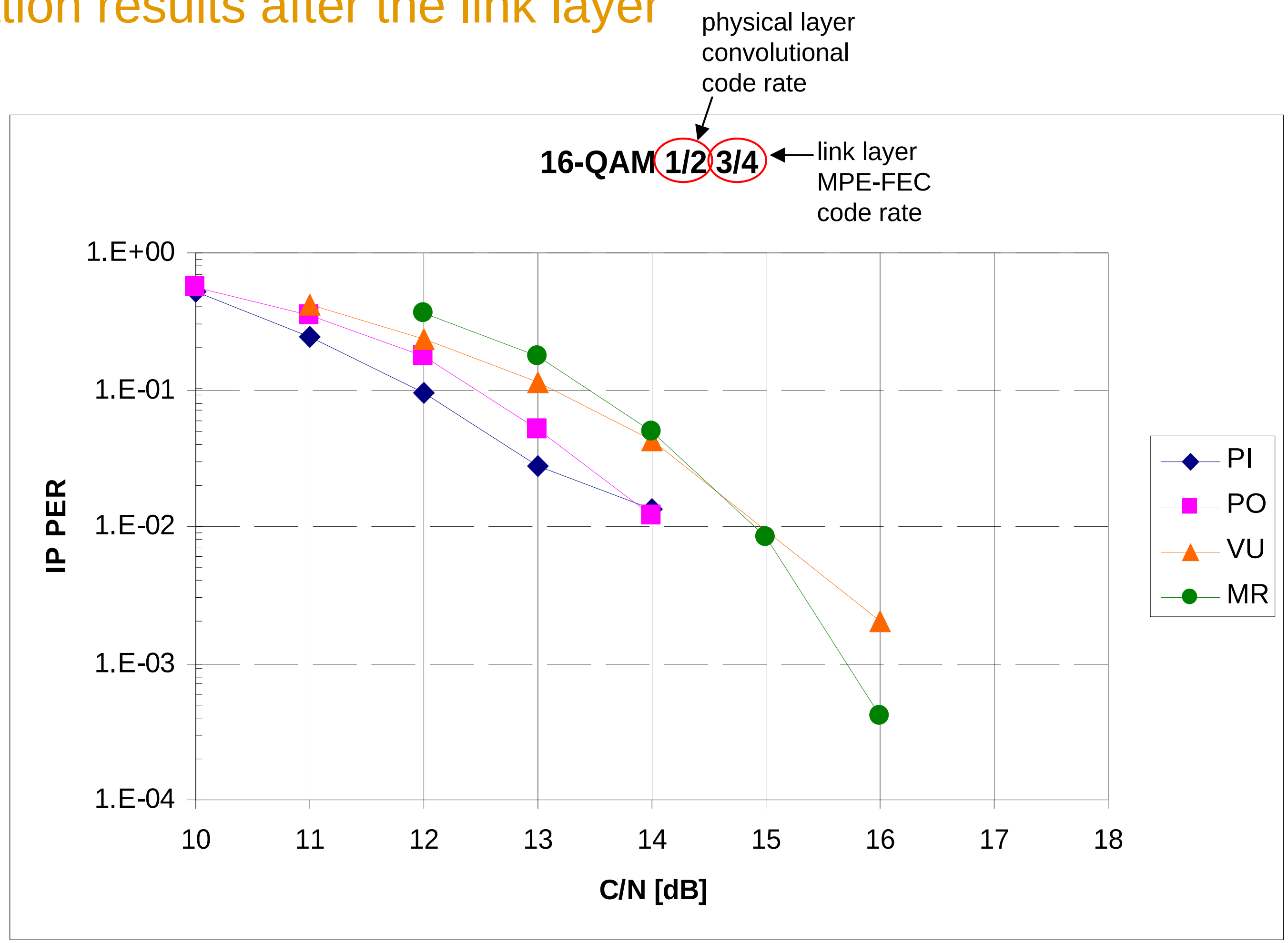
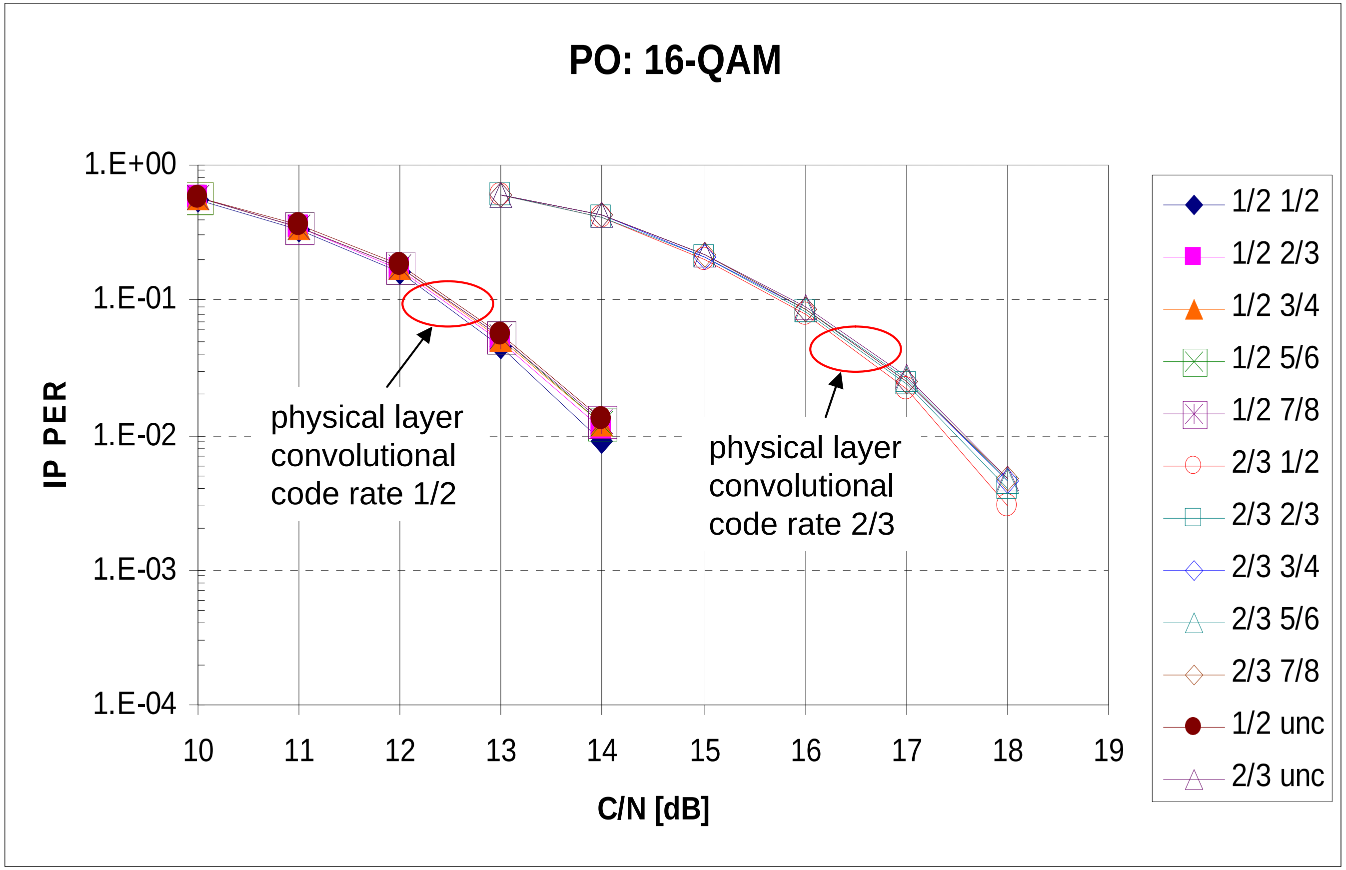
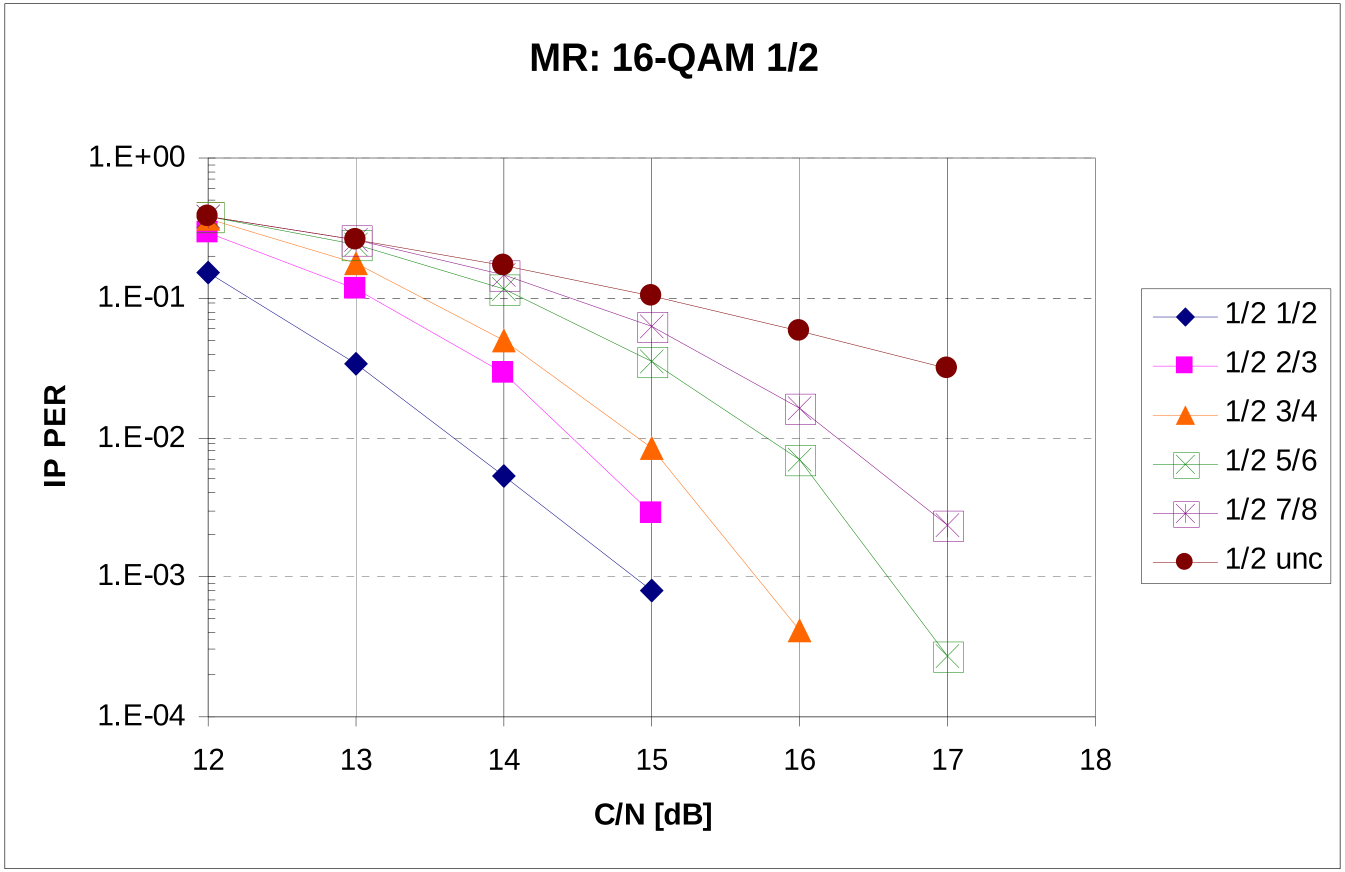
Simulation results after the link layer



MPE-FEC coding gain in the pedestrian outdoor channel



MPE-FEC coding gain in the motorway rural channel



Conclusions

- Development of radio channels is a difficult task
- Mobility results in degraded performance in channel models (higher receiver velocity → poorer performance)
- The vehicular channel models require higher C/N than the pedestrian channel models to achieve the same error ratio
- MPE-FEC (multiprotocol encapsulation – forward error correction) at the link layer in DVB-H is optional
  - MPE-FEC is not needed in the pedestrian channel models (no coding gain)
  - MPE-FEC improves the performance of the vehicular channel models