3GPP Mobile Systems Evolutions

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3GPP Specifications & Impact

- 3GPP produces evolving technologies and specifications for commercial /cellular mobile systems since 1998

- 3GPP impact is increasing: it becomes the focal point for mobile systems beyond 3G (B3G)
  - Inside AND outside the community of public mobile cellular systems

- Long-Term Evolution (LTE) is now considered as a candidate radio access technology for next generation train radio
  - Under discussion in UIC/ERIG, also addressed by the Urban rail community

Future Releases
How Close is LTE to Railway Requirements?

• User Requirement Specifications (URS)
  – V1.0 produced by ERIG on Dec. 1st, 2010
• Few information in URS to assess candidate radio access technologies
  – Focus on the needed applications & services
  – Page 36
    • “Provision of real time CCTV picture transmission via radio between train and ground based systems”
  – Page 74
    • “The technology used shall be capable of operating at speeds up to 360 km/h.”
LTE Evaluation at Railway Speeds

- Mobility support in LTE [3GPP TR 25.913 Section 7.3]
  - “Optimized for low mobile speed (0-15km/h)”
  - “High performance for intermediate speeds (15-120km/h)”
  - “Support of high speeds (120-350km/h)”

- From the radio frame design, the limiting radio link to high speeds is the reverse link (i.e., from the train to the ground)

Let’s evaluate the reverse link by computer simulations!

Simulation scenario
- 800 MHz Carrier frequency, 4 MHz bandwidth
- Up to 4 trains connected in the same time at the same base station
- LTE reference receiver design

Figure of merit
- **Achievable throughput** for a 20 dB operating Signal-to-Noise Ratio (SNR)
  - \( \text{Maximum throughput} \times (1 - \text{PER}) \)
**LTE Results at Railway Speeds**

- **Maximum throughput for various modulation formats**
- **Achievable throughput**

<table>
<thead>
<tr>
<th>Modulation format</th>
<th>Max. throughput (1 train/BS)</th>
<th>Max. throughput (4 trains/BS)</th>
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<tbody>
<tr>
<td>64QAM 5/6</td>
<td>14.4 Mbit/s</td>
<td>3.6 Mbit/s</td>
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<tr>
<td>16QAM 3/4</td>
<td>8.64 Mbit/s</td>
<td>2.16 Mbit/s</td>
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<tr>
<td>QPSK 1/2</td>
<td>2.88 Mbit/s</td>
<td>720 kbit/s</td>
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- **Velocity (km/h)**
  - **Achievable Throughput (Mbit/s)**
    - **Urban environment**
      - 3: 1.44
      - 120: 1.4
      - 300: 1.18
      - 360: 1.05
      - 400: 1.02
      - 500: 0.95
    - **Rural environment**
      - 3: 2.94
      - 120: 2.75
      - 300: 1.92
      - 360: 1.86
      - 400: 1.79
      - 500: 1.66

- Strong throughput decrease according to the speed

=> Throughput limitation even in optimistic scenarios (only mobility impacts)

- **CCTV traffic for 1 camera**
  - **Low quality**: 350 kbit/s
  - **Typical**: 3 Mbit/s for 640x480 pixels @ 10 frames/s, MJPEG

OK

NOT OK with mobility
Towards an expansion of the 3GPP initial scope

3GPP path toward Standards(*):
- Work items (specifications)
- Study items (performance reports)
- Preliminary discussions

Professional businesses

Carrier business

Large cells (macro) / Medium cells (pico)
- Small cells (outdoor)
- Home cells (Femto)
- Heterogeneous Networks
- Fixed Relays
- Machine-to-Machine
- Trains: Mobile Relays
- Resilience
- Public Safety
- Group Com.
- Device-to-Device

(*): The progress of each item is prioritised according to 3GPP members’ interests
Railway-related Work @ 3GPP: Mobile Relays

- Discussions initiated in 2009
  - Target: public on-board access only

- Study Item launched in Sept. 2011
  - Study objectives
    - Identify the scenarios and their requirements
    - Assess the benefits of mobile relays over existing solutions
      - From Radio point of view (high speeds)
      - From Architecture point of view
  - Study status unclear due to the low number of contributors
Public Safety-Related Work @ 3GPP

• First Study Item started in Sept. 11

  First Target: Proximity-based Services
  – Use cases and requirements for Device-to-Device (D2D) Com.
  √ Requirements captured in TR 22.803 (Mar. 2013)

  Second target: Group Communication Enablers for LTE
  – Service requirements to support Group Com. for critical communications such as Public Safety
  √ Requirements captured in TS 22.468 (June 2013)

• Now Running

  2 Work Items on architectures for D2D and Group Com.
  1 Study Item on radio aspects for D2D

• Status: Many contributions but work is late
  – Some tensions to define priorities in order to have at least basic D2D features available in Dec 2014

Potential impact on railways

- Group call setup <= 300 ms
- No audio delay difference from 2 nearby terminals
- 4 priority levels at least
- Unlimited group members
What’s coming after

- Every 10 years, a new G on the market
- 3GPP strongly influenced by EU R&D projects

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Telecom Era

- 2G
- 3G
- 4G
- 5G

Wordle of new EU R&D projects (e.g. METIS)
Conclusions

• **3GPP LTE for next generation train radio?**
  – Interest has recently been shown from the rail and the light rail communities
  – Future decisions on spectrum at WRC will have an influence
  – An optimization is needed to meet very strict railway requirements

• A 3GPP window is now open for professional businesses
  – Still, the carrier business remains the priority
  – But enough players involved in Public Safety could start impacting the work
  – Possible key features as part of 5G
Thank you for your attention