Submission Title: [Field trial of MHN system for high-speed train communications]
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Abstract: [This document presents field trials of MHN and MHN-E systems]
Purpose: [For discussion]
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Contents

• Overview of MHN System

• Field trial of MHN system

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Overview of MHN System

• Basic System Architecture of MHN
  – MHN system for high-speed train (HST) communications
  – Hierarchical two-hop network
    • Mobile wireless backhaul (MWB) link outside using *millimeter-wave*
    • Onboard access link
  – MHN*/MHN-E** system architecture[1]
    • Single Frequency Multi-Flow (SFMF)
      – Double
      – Improve

* MHN : mobile hotspot network  
**MHN-E : MHN Enhancement
Overview of MHN System

• Key Features of MHN-E System for HST Communications
  – High-mobility support up to 500km/h
  – A frame structure enabling effective neighbor cell search and high-performance handover
  – Carrier aggregation to attain a total transmission bandwidth of up to 1GHz
  – High-order modulation schemes (64-QAM and 256-QAM)
  – SFMF and MIMO using polarization antennas
  – Uplink-downlink duplexing : TDD
  – OFDM for both uplink and downlink transmissions

• MHN system VS MHN-E system

<table>
<thead>
<tr>
<th>Design Parameters</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>MHN-E</strong></td>
</tr>
<tr>
<td>Frequency</td>
<td>25.5 GHz*</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>1 GHz*</td>
</tr>
<tr>
<td>EIRP</td>
<td>36 dBm**</td>
</tr>
<tr>
<td>Mobility support</td>
<td>Up to 500 km/h</td>
</tr>
<tr>
<td>Modulation order</td>
<td>QPSK, 16QAM, 64QAM, 256QAM</td>
</tr>
<tr>
<td>Antenna configurations</td>
<td>2x2 SFMF, 2x2 MIMO</td>
</tr>
<tr>
<td>Maximum throughput</td>
<td>10Gbps</td>
</tr>
</tbody>
</table>
Overview of MHN System

- Frame structure and numerology of MHN-E system

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**<Numerology of MHN-E system>**

<table>
<thead>
<tr>
<th>Subcarrier spacing</th>
<th>180 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling clock rate (MHz)</td>
<td>184.32</td>
</tr>
<tr>
<td>OFDM symbol duration, no CP (us)</td>
<td>5.56</td>
</tr>
<tr>
<td>CP duration (us)</td>
<td>0.69</td>
</tr>
<tr>
<td>CP overhead (%)</td>
<td>12.4</td>
</tr>
<tr>
<td>Number of symbols per TTI</td>
<td>40</td>
</tr>
<tr>
<td>TTI duration (ms)</td>
<td>0.25</td>
</tr>
<tr>
<td>Frame duration (ms)</td>
<td>10</td>
</tr>
<tr>
<td>Number of RBs</td>
<td>50</td>
</tr>
<tr>
<td>in frequency domain</td>
<td></td>
</tr>
<tr>
<td>Number of subcarriers per RB</td>
<td>12</td>
</tr>
<tr>
<td>FFT size</td>
<td>1024</td>
</tr>
</tbody>
</table>

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**<Carrier aggregation of MHN-E system (8×125MHz)>**

- Radio frame, $T_{frame} = 10$ ms
- Subframe, $T_{subframe} = 2$ ms
- One Slot, $T_{slot} = 250$ μs

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**<TDD frame structure of MHN-E system>**

- Downlink slot
- Special slot
- Uplink slot

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**<Carrier aggregation of MHN-E system (8×125MHz)>**

- CC 0 (PCell)
- CC 1 (SCell)
- CC 2 (TCell)
- CC 3 (TCell)
- ...
Overview of MHN System

- Frame structure and numerology of MHN-E system
  - Resource grid
    - 1 RB = 12×40 resource elements, $\Delta f = 180kHz$, $N_{symb}^{DL} = 40$, $N_{RB}^{DL} = 12$, $N_{RB}^{SC} = 50$
Overview of MHN System

• Frame structure and numerology of MHN-E system
  – A frame structure enabling CA, efficient neighbor cell search and high-performance handover\[1\]
• Different resource allocation
  – Primary cell (PCell)
  – Secondary Cell (SCell)
  – Tertiary cell (TCell)

<Received SNR at mVE#1>

\[125\text{MHz} \times 8 = 1\text{GHz}\]
Overview of MHN System

- Frame structure and numerology of MHN-E system
  - A frame structure enabling CA, efficient neighbor cell search and high-performance handover\(^1\)
- Resource nulling: SCell vacates the resources in order to detect target cell signal without interference from serving cell

\(^{1}\text{[1]}\)
Contents

• Overview of MHN System

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Field trial of MHN system

• Field trial of MHN system (completed)
  – Phase 1: field trial on the highway
  – Phase 2: field trial at Seoul subway tunnel
  – Phase 3: field trial at Seoul subway tunnel (upgraded testbeds)

• Field trial/demonstration of MHN-E system
  – Phase 1: preliminary test in the lab (completed)
  – Phase 2: field trial using a vehicle with low mobility (being prepared)
  – Phase 3: field trial on the Gangneung street with a vehicle running at a speed of up to 60km/h (being prepared)
  – Phase 4: field trial with subway train (TBD)
Field trial of MHN system

• Phase 1: field trial on the highway
  – MHN testbeds installed in two moving vehicles
    • The speed of mTE vehicle was up to 80km/h
    • Demonstration of point-to-point communications showing a peak data rate of 500Mbps
Field trial of MHN system

• Phase 2: field trial at Seoul subway tunnel\cite{2}\cite{3}
  – MHN Test Bed Installation along Seoul Subway Line 8
    • Installation of mRU testbed and mTE testbed
  – Demonstration of the MHN system in the moving subway (Jan. 2016)

Data rate exceeding 400Mbps
Field trial of MHN system

- Phase 3: field trial at Seoul subway tunnel (upgraded testbeds)
  - Reinstallation of the upgraded MHN system prototype
  - A field trial along 2.4 km long railway line through three stations of Seoul Subway Line 8 (Feb. 2017)
Field trial of MHN system

- Phase 3: field trial at Seoul subway tunnel (upgraded testbeds)
  - Peak data rate of downlink was 1.2Gbps
    - Much higher than that of previous field trial\(^2\)\(^3\)
  - Peak data rate of uplink was 110 Mbps
    - Ratio of downlink to uplink time duration = 7:1
  - Handover test
    - 4 handover points: mRU 1 ~ 4
Field trial/demo of MHN-E system

• Phase 1: preliminary test in the lab (Feb. 2017)
  – Feasibility validation of SFMF transmission technique
  – Data rate of 2.5Gbps was achieved
Field trial/demo of MHN-E system

- Phase 2: field trial using a vehicle with low mobility (being prepared)
  - Demonstration of a peak data rate exceeding 2.5Gbps
  - VR/AR service demonstration
  - Handover demonstration

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Field trial/demo of MHN-E system

• Phase 3: field trial on the Gangneung street with a vehicle running at a speed of up to 60km/h, which is scheduled for Feb. 2018

• Phase 4: field trial of MHN-E system with subway train (TBD)

mmWave moving wireless backhaul
(data rate exceeding 2.5 Gbps)

Broadband Internet service via Giga Wi-Fi AP deployed in the vehicle

Immersive experience (VR/AR)

Multiple UHD video streaming
References


Thank you