Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

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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• Overview of MHN System

• Field trial of MHN system

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• Overview 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 spectral efficiency
      – Improve handover performance

* 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>
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<th>Design Parameters</th>
<th>Comparison</th>
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<td><strong>MHN-E</strong></td>
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<tr>
<td>Frequency</td>
<td>25.5 GHz*</td>
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<tr>
<td>Bandwidth</td>
<td>1 GHz</td>
</tr>
<tr>
<td>EIRP</td>
<td>36 dBm**</td>
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<tr>
<td>Mobility support</td>
<td>Up to 500 km/h</td>
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<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

Radio frame, $T_{frame} = 10$ ms

Subframe, $T_{subframe} = 2$ ms

One symbol, $T_{symbol} = 6.25$ μs

Subframe

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</table>

Downlink slot

Special slot

Uplink slot

One Slot, $T_{slot} = 250$ μs

$mRU \#i$, $mRU \#j$

$mRU \#i+1$, $mRU \#j+1$

Subframe structure of MHN-E system

MHN-Enhancement Maximum Bandwidth 125MHz $\times 8 = 1$ GHz

Carrier aggregation of MHN-E system (8 $\times$ 125MHz)

<Carrier aggregation of MHN-E system(8 $\times$ 125MHz)>
Overview of MHN System

- Frame structure and numerology of MHN-E system
  - Resource grid
    - 1 RB = 12×40 resource elements, $\Delta f = 180kHz, N_{symb}^{DL} = 40, N_{sc}^{RB} = 12, N_{RB}^{DL} = 50$
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
- Different resource allocation
  - Primary cell (PCell)
  - Secondary Cell (SCell)
  - Tertiary cell (TCell)

<Received SNR at mVE#1>

MHN-Enhancement Maximum Bandwidth
125MHz × 8 = 1GHz

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

- Resource nulling: SCell vacates the resources in order to detect target cell signal without interference from serving cell

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• Overview of MHN System

• Field trial of MHN system

• References
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 at Gangneung IoT 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\textsuperscript{2}\textsuperscript{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
Field trial/demo of MHN-E system

- Phase 3: field trial at Gangneung IoT 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)

Multiple UHD video streaming

Immersive experience (VR/AR)

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

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References


Thank you