A Multi-hop, Mesh Broadband Fixed Wireless Access Network *

By

Aditi Ramdorai, Shinichi Nomato, Yoji Kishi, Satoshi Konishi, Shinobu Nanba, Takeshi Kitahara, Yujin Noishiki and Akira Idoue

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Agenda

- Introduction to BFWA
- System Characteristics
- Performance Evaluation
- Conclusion
Introduction

• **Broadband Fixed Wireless Access**
  
  • Provide wireless communications using fixed terminals as a "last mile" solution
  
  • Operating at millimeter wavelength (>17GHz)
  
  • Conventional Systems are P-P or P-MP
Advantages of BFWA

- High speed
- High capacity
- Large Coverage area
- Easy deployment
- Cost effective
- An alternative to Cable Modem, DSL, Fibre and Broadband Satellite
Mesh networks

- Mesh topology vs. P-MP
  - Spectral Efficiency
  - Higher capacity
  - Route Diversity
  - Highly Scaleable
  - Coexistence
  - Possible cost reduction

Backbone
Ingress node
Egress node
• Introduction to BFWA

• **System Characteristics**

• Performance Evaluation

• Conclusion
- Multi-hop.
- Mesh topology.
- Operating at 26 GHz
- Achieves up to 420Mbps
- MP-MP using a combination of P-P LOS links using directional pencil beam antenna.
Adaptive System Characteristics

Low Spectral Efficiency:
- Solved by Mesh topology and the use of 1024 QAM modems that achieve 7bits/s/Hz

Vulnerability to link quality attenuation due to rainfall:
- Adaptive modulation (QPSK-1024QAM) + route diversity over mesh network

Inflexible towards expansion of network:
- Decentralized algorithms and dynamic control of frequency slots, routes etc

Low Adaptability for dynamic variation of traffic:
- Adaptive Traffic Load Balancing + Dynamic TDD boundary control + Dynamic wireless channel allocation

### System Characteristics

**Major Function**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Major Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network Control Unit (NCU)</strong></td>
<td>MPLS routing, channel allocation to links, optimum route selection, load balancing</td>
</tr>
<tr>
<td><strong>Outdoor Unit (ODU)</strong></td>
<td>Tx and Rx using directional antennas</td>
</tr>
<tr>
<td><strong>Indoor Unit (IDU)</strong></td>
<td>Adaptive modulation and demodulation, dynamic frequency and TDD boundary selection</td>
</tr>
</tbody>
</table>

Adaptive load balancing

- Causes of link quality degradation could be:
  - Decrease in link quality due to atmospheric conditions
  - Increase of interference/Shadowing
  - Increase of instantaneous traffic along a single route

Advantages over IP routing

- Route diversity
- Higher throughput
- Lower probability of congestion
- Effective utilization of network resources

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Field Experiment Configuration

A birds eye view

Wireless Link

Distance [m]

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Wireless Node
Performance evaluation

Field Experiment to evaluate Route Diversity:

Link #1 – Direct Route
Link #2 #3 – Diversity Route

Metrics:
- Node availability improvement
- Diversity Gain

Major specifications of prototype radio units

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio frequency (RF)</td>
<td>26.80 – 26.86 GHz</td>
</tr>
<tr>
<td>Number of frequency slots</td>
<td>7 over 60 MHz band</td>
</tr>
<tr>
<td>Frequency slot separation</td>
<td>8.5 MHz</td>
</tr>
<tr>
<td>Duplex mode</td>
<td>TDD</td>
</tr>
<tr>
<td>Maximum transmission power per carrier</td>
<td>50 mW</td>
</tr>
<tr>
<td>Antenna gain</td>
<td>35 dBi</td>
</tr>
</tbody>
</table>

Source: Recommendation ITU-R F.1704 - Characteristics of multipoint-to-multipoint fixed wireless systems with mesh network topology operating in frequency bands above about 17 GHz
Performance Results (on one stormy day...)

Source: Recommendation ITU-R F.1704 - Characteristics of multipoint-to-multipoint fixed wireless systems with mesh network topology operating in frequency bands above about 17 GHz
Performance results

Source: Recommendation ITU-R F.1704 - Characteristics of multipoint-to-multipoint fixed wireless systems with mesh network topology operating in frequency bands above about 17 GHz
Performance results

• Results:
  • Max. achieved diversity gain more than 8dB
  • At least 1dB gain achieved for 20% of the measurement period
  • At least 3dB gain obtained for 2.4% of measurement period

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Conclusion

• Mesh networks:
  • Route diversity
  • Adaptive techniques
  • Good choice for BFWA!!

• Field experiments show thumbs up.
Thank You
for your attention!!

Contact Information:
Email: aditi@imst.de
Phone: +49-2842-981-464