WiFIX+: A Multicast Solution for 802.11-based Wireless Mesh Networks

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February 2011
Outline

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2. Problem Statement
3. State of the Art
4. WiFIX+
5. Experimental Evaluation
6. Conclusion
Scope

• Internet as THE global communication infrastructure
  – supports myriad of applications/services ...
    • including multicast-oriented

• Increasing demand for wireless Internet access

• 802.11 assuming prominent role
  – But ... it has limited radio range
Scope

- 802.11-based WMNs as solution
  - static MAPs
  - mobile terminals
Problem Statement

Current Infrastructure

Multicast Services

Internet

Multicast Services

AP
Problem Statement

Current Infrastructure

Multicast Services

Internet

Multicast Services

AP

Infrastructure Extension

MAP2

MAP1

MAP3

MAP4

Mobile terminal

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13th Seminar of the RTCM, Lisbon, February 2011
State of the Art

- **Multicast ad-hoc routing protocols**
  - too complex for our target scenario
  - e.g., MAODV, MOLSR, etc.

- **Pure flooding**
  - e.g., 802.11s

- **Controlled flooding**
  - e.g., WiFIX
WiFIX Overview

- ATCM mechanism
  - tree active topology creation/maintenance

- Frame forwarding ...
  - unicast
    - based on tree active topology and learning bridges
  - multicast/broadcast
    - using controlled flooding

- Eo11 encapsulation for multi-hop frame transportation
WiFiX – Eo11 encapsulation

IEEE 802.11 MAC header

<table>
<thead>
<tr>
<th>Frame Control</th>
<th>Duration/ID</th>
<th>Address 1 = Next Hop</th>
<th>Address 2 = Current Node</th>
<th>Address 3 = IBSS</th>
<th>Sequence Control</th>
<th>Address 4</th>
<th>QoS Control</th>
<th>Frame Body</th>
<th>FCS</th>
</tr>
</thead>
</table>

LLC + SNAP header → Eo11 header
WiFIX+ – Rationale

- Treating multicast as broadcast is inefficient

- In 802.11 ...
  - multicast/broadcast frames
    - unreliable transmission at lowest data rate
  - unicast frames
    - reliable transmission at highest data rate possible

What if we used WiFIX active topology for multicast too?
WiFIX+ – Overview

• **Builds upon WiFIX**
  - unicast tree active topology and learning bridges

• **Considers three approaches ...**
  - Multicast as Broadcast (MaB)
  - Selective Multicast (SM)
  - Selective Multicast with Mobility Support (SMob)
WiFIX+ – Multicast as Broadcast

• Multicast frames sent over active tree
  – encapsulated in 802.11 unicast frames

• All MAPs receive them

• Terminal mobility inherently supported

Advantages:

  – multicast data rate = highest 802.11 data rate possible

  – 802.11 unicast rate adaptive mechanism implicitly used

  – reliable multicast is implicitly enabled
WiFIX+ – Selective Multicast

- Multicast traffic sent only to requesting nodes
  - reuse of IGMP snooping
WiFIX+ – Selective Multicast

• Multicast traffic sent only to requesting nodes
  – reuse of IGMP snooping
  – per-group multicast trees

Advantage:
  – spare bandwidth available for other flows
WiFIX+ – Selective Multicast with Mobility Support

• Selective multicast and terminal mobility
  – without changes in mobile terminals
  – use of DHCP snooping
Selective multicast and terminal mobility

- without changes in mobile terminals
- use of DHCP snooping
WiFIX+ – Selective Multicast with Mobility Support

- Selective multicast and terminal mobility
  - without changes in mobile terminals
  - use of DHCP snooping
Selective multicast and terminal mobility

- without changes in mobile terminals
- use of DHCP snooping

Advantage:

- mobility support without affecting support for selective multicast
Experimental Evaluation

• Test-bed with 4 machines
  – running Linux OS and 802.11b

• Performance metrics
  – throughput, delay, packet loss
  – flow reacquisition time
Experimental Evaluation – MaB vs 802.11s

Throughput

MaB

Saturation ⇒ 2.2 Mbit/s

802.11s

Saturation ⇒ < 200 kbit/s
Experimental Evaluation – MaB vs 802.11s

Delay

MaB

802.11s
Experimental Evaluation – MaB vs SM
Experimental Evaluation – MaB vs SM

MaB

SM

Decrease of 1.3 Mbit/s $\Rightarrow$ 46%

Decrease of 400 kbit/s $\Rightarrow$ 14%
## Experimental Evaluation – MaB vs SMob

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Reacquisition time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MaB</td>
<td>207</td>
</tr>
<tr>
<td>SMob</td>
<td>384*</td>
</tr>
</tbody>
</table>

* worst-case scenario
Conclusion

- WMNs as solution to extend 802.11 coverage
- Multicast-oriented applications to be supported
- Existing solutions are too complex and/or inefficient
- WiFiX+ is simple and outperforms SoA approach
  - higher throughput; lower delay and packet loss
  - more efficient use of network resources
Future Work

- **Specification/Implementation**
  - IPv6 support → MLD and DHCPv6 snooping
  - mobility solution with terminal support

- **Further experimental evaluation**
  - scalability
  - consider other unicast data rates and different 802.11 variants
Thank you!

Questions?