Recommendation on PMP Mode Compatible TDD Frame Structure

IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number:
IEEE C802.16mmr-05/027

Date Submitted: 2005-09-09
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Venue:
IEEE 802.16 Session #39, Taipei, Taiwan

Base Document:
None.

Purpose:
This is a response to IEEE 802.16mmr-05/001(call for contributions: IEEE 802.16’s Study Group on Mobile Multi-hop Relay) to present a compatible frame structure.

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Recommendation on PMP Mode Compatible TDD Frame Structure

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Basic Requirements

- **Support Scenarios**
  - Throughput Enhancement ➔ Target in this contribution
  - Coverage Extension ➔ For future study

- **The proposed frame structure shall be compatible to the TDD mode with no relaying**
  - BS/RS and RS/MS use the same frequency, i.e., homogeneous relaying.
  - From the BS viewpoint, an RS behaves the same as an SS. The transmission/reception burst is controlled by the BS.
  - From the MS viewpoint, an RS just performs coverage extension and is transparent to MSs.
Scenario and Assumptions

Coverage Extension (2) 

Throughput Enhancement (1)

<table>
<thead>
<tr>
<th>Coverage Extension</th>
<th>Throughput Enhancement</th>
</tr>
</thead>
</table>
| Broadcast information | BS → MS  
BS → RS → MS | BS → MS |
| Preamble for DL Sync | Provided by BS and RS | Provided by BS |
| Initial Ranging | MS → BS  
MS → RS → BS | MS → BS |

Target Case
Supporting Functions for MMR

- **Frame structure**
  - Modified frame structure to support the operations of RSs

- **Network entry**
  - Support transparent RS while a MS process network entry procedure in MMR application.

- **Normal operation**
  - RS can relay the transmission over the air and increase link throughput.
  - MMR operation between BS/RS/MS should be produced and full utilized

- **Synchronization**
  - The MSs and RSs can synchronize with BS in the proposed relay frame structure.

- **RS switch**
  - Support ambiguous RS switch (not handoff)
  - Diversity RS set add/del ➔ FFS
Frame Structure for Two-hop

TDD OFDM Frame Structure

DL sub-frame | UL sub-frame

| P | FCH | DL burst #1 | BR | BM | RM | C | MR | MB | RB |

(DL-MAP, UL-MAP, …)

Pilot | Data burst(s) | Data burst(s)

- **C** contention area
- **FCH** frame control header
- **P** preamble
- **BM** base station to mobile station
- **BR** base station to relay station
- **MB** mobile station to base station
- **MR** mobile station to relay station
- **RB** relay station to base station
- **RM** relay station to mobile station

- **All MSs are located in the coverage of the BS so BS can directly assign resource allocation in MAP_IE and transmit control messages in by broadcast information.**

- **RS shall perform decode and forward the relay data within current or upcoming frame according to scheduling of BS.**
Example of Two Hop Relaying
(Synchronization & Network Entry)

- DL sub-frame
- UL sub-frame

- Relay DL
- Relay UL

Send “Initial Ranging Request”

DL Sync by receiving “Preamble” from BS

Perform DL Sync by receiving “Preamble” from BS
Example of Two Hop Relaying (DL Relay)

MS1

MS2

RS

BS

DL sub-frame

UL sub-frame

Relay DL

Relay UL

P F C H MAP BR BM RM C MR MB RB

RSE_DL

MS1 PDU

MS2 PDU

Pilot

RS→MS1

RS→MS2

RS DL PDU

MS1 DL PDU

MS2 DL PDU

RSE_DL relay service element in downlink
Example of Two Hop Relaying (UL Relay)

- BS (Base Station)
- RS (Relay Station)
- MS1
- MS2

DL sub-frame
UL sub-frame

Relay DL
Relay UL

- P
- FCH
- MAP
- BR
- BM
- RM
- C
- MR
- MB
- RB

- MS1→RS
- MS2→RS
- MS1 UL PDU
- MS2 UL PDU
- RS UL PDU

RSE_UL: relay service element in uplink
Relay Service Element (RSE)

- **RSE_DL** (relay service element in downlink)
  - Relay service CID for an RS
  - The relayed MS info including
    - The downlink relaying service CIDs and their DL burst profiles of the MSs served by the RS.
    - The uplink relaying service CIDs and their UL burst profiles of the MSs served by the RS.

- **RSE_UL** (relay service element in uplink)
  - Relay service CID for an RS
  - Uplink measurements for existing/candidate relayed MSs.
Access Relay Services (by BW_REQ)

- Measurement
  - BS
  - RS
  - MS

- BW_REQ
- RS_MEAS_REP
- Switch to RS

- UL_MAP
  - RNG_REQ (periodic)
  - RNG_RSP (Continue)
  - ::
  - RNG_RSP (Success)

- UL_MAP/DL_MAP (BW for connection with RS)

- MS perform periodic ranging with respect to RS
OFDMA Frame Structure for Two-hop (FDM)

TDD OFDMA Frame Structure

Sub-channel logic number

Preamble

UL MAP

DL MAP

BS $\rightarrow$ MS

BS $\rightarrow$ RS1

BS $\rightarrow$ RS2

BS $\rightarrow$ RS3

P1

P2

P3

RS1 $\rightarrow$ MS

RS2 $\rightarrow$ MS

RS3 $\rightarrow$ MS

UL sub-frame

DL sub-frame

TTG

RNG/BW-REQ Sub-channel

MS $\rightarrow$ RS1

MS $\rightarrow$ RS2

MS $\rightarrow$ RS3

RS1 $\rightarrow$ BS

RS2 $\rightarrow$ BS

RS3 $\rightarrow$ BS

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OFDMA Frame Structure for Two-hop (TDM)

TDD OFDMA Frame Structure

Sub-channel logic number

Preamble  DL MAP  UL MAP

BS → RS1  BS → RS1  BS → RS1  RS1 → MS  RS2 → MS  RS3 → MS

BS → MS

MS → RS1  MS → RS2  MS → RS3  RS1 → BS  RS2 → BS  RS3 → BS

RNG/BW-REQ Sub-channel

DL sub-frame  TTG  UL sub-frame
Summaries

- Based on assumption of “all MSs located in BS coverage”, a PMP mode compatible TDD frame structure for two hop relay is proposed.
- RS is fully transparent from view of MS.
  - DL synchronization and network entry process are the same as the relayless case.
  - RS support UL measurement for BS to determine RS selection.
    - No effort on MS.
References

- IEEE C80216mmr-05/005r2, Fang-Ching Ren, Chang-Lung Hsiao, Yu-Ching Hsu, and Wern-Ho Sheen, A Recommendation on PMP Mode Compatible Frame Structure
- IEEE: S802_16mmr-05/019, Naftali Chayat and Ran Yaniv, PHY aspects in MMR-enabled networks