Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Adaptive Multi-hop Relay Frame Structure in IEEE 802.16m**
Date Submitted	**2008-03-10**
Source(s)	Gang Shen, Kaibin Zhang, Jimin Liu, Dongyao Wang, Jianming Wu, Shan Jin Alcatel Shanghai Bell Voice: + 86-21-50554550-7167 Fax: + 86-21-50554554 Email: gang.a.shen@alcatel-sbell.com.cn
Re:	Call for Contributions on Project 802.16m System Description Document (SDD) Contribution pertains to: Multi-hop Relay Support in IEEE 802.16m Frame Structure Design
Abstract	Propose adaptive multi-hop relay frame structure and procedures
Purpose	For IEEE 802.16m discussion and eventual adoption
Notice	*This document does not represent the agreed views of the IEEE 802.16 Working Group or any of its subgroups.* It represents only the views of the participants listed in the "Source(s)" field above. It is offered as a basis for discussion. It is not binding on the contributor(s), who reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy	The contributor is familiar with the IEEE-SA Patent Policy and Procedures: <http://standards.ieee.org/guides/bylaws/sect6-7.html#6> and <http://standards.ieee.org/guides/opman/sect6.html#6.3>. Further information is located at <http://standards.ieee.org/board/pat/pat-material.html> and <http://standards.ieee.org/board/pat>.

Adaptive Multi-hop Relay in IEEE 802.16m

Alcatel Shanghai Bell

1. Introduction

Two kinds of relay operation modes and corresponding relay frame structures are defined in the IEEE 802.16j: transparent relay and non-transparent relay. RS shall work in one mode at one time. Each mode has its own advantages and corresponding usage cases. For MS within BS coverage, it is better to use transparent relay. For the purpose of coverage extension, non-transparent relay works well. The Tab. 1 lists the advantages of transparent relay and non-transparent relay.

Tab. 1 Transparent RS vs. Non-transparent RS

	Advantages
Transparent RS	• Simple RS design with BS central control • Less control signal latency • No intra-BS handover • Low overhead • Flexible and efficient resource allocation between relay link and access link without segment assignment limitation
Non-transparent RS	• Support coverage extension

The multi-hop relay in 16m shall support both legacy 16e MS and new 16m MS. For more than two years of standardization efforts, 16j is the best solution available for multi-hop relay with backward compatibility, so 16m should support 16j RS for the purpose of providing multi-hop relay for 16e MS. It is suggested to support 16j RS in the legacy zone of the 16m frame structure

For 16m MS, an advanced multi-hop relay without the limitation of the backward compatibility is required with performance enhancement compared to 16j. It is suggested to define one RS type to support different deployment models and flexible operation modes, and to have one unified multi-hop relay frame structure.

For 16m MS multi-hop relay support, there are some considerations.

- **MS can see the existence of relay**
  - 16m MS should see the existence of relay. The awareness of RS benefits many relay involved procedures, e.g. MS handover. If this awareness is not allowed in 16m, it is difficult that the relay performance in 16m overwhelms what we have had in 16j.
- **One unified multi-hop relay frame structure**
  - It is suggested to have one unified multi-hop relay frame structure, thus decreasing RS complexity. This unified relay frame structure should flexibly support different multi-hop relay operation modes.
- **16m should consider both TDD and FDD relay**
  - To be consistent with 16m requirement

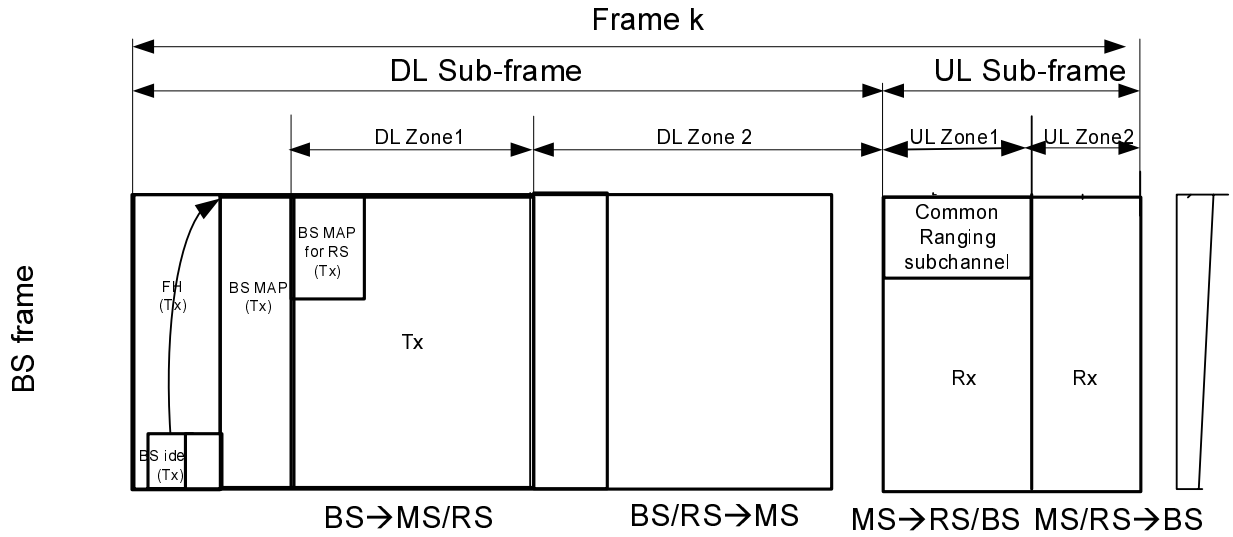
- **DL and UL multi-hop traffic may follow different paths**
  - DL and UL channels are irreciprocal, especially for FDD system
  - E.g uplink-only relay
- **Control signal and data traffic may follow different paths**
  - Different requirements for control and data: for control signal, there is stricter requirement on latency, and less consideration on bandwidth efficiency. For data traffic, attention is focused on the bandwidth efficiency (throughput) under the allowed latency. To meet both requirements, control signal and data traffic are possibly separated in paths.
- **Avoid frequent intra-BS handover**
- **Flexible and adaptive resource allocation** between relay link and access link.

This contribution proposes a unified multi-hop relay frame structure in IEEE 802.16m, and corresponding schemes for multi-hop relay operation modes. In this proposed relay frame structure, BS and RS transmit different identifiers to let MS know by which access station (BS or RS) it is covered in DL. MS measures the signal qualities from BS and/or RS, and these measurement results may be used for DL path decision reference. In the uplink, a common ranging channel shared by BS and RS is defined for MS initial ranging and periodic ranging. BS and RS measure MS UL signal qualities in this common ranging channel or via UL data. The measurement results will be used for UL path decision reference. Based on the DL/UL measurement reports, the most suitable multi-hop rely mode is adaptively selected for MS. Different kinds of multi-hop relay operation modes are given, while all these relay modes are performed under one unified multi-hop relay frame structure.

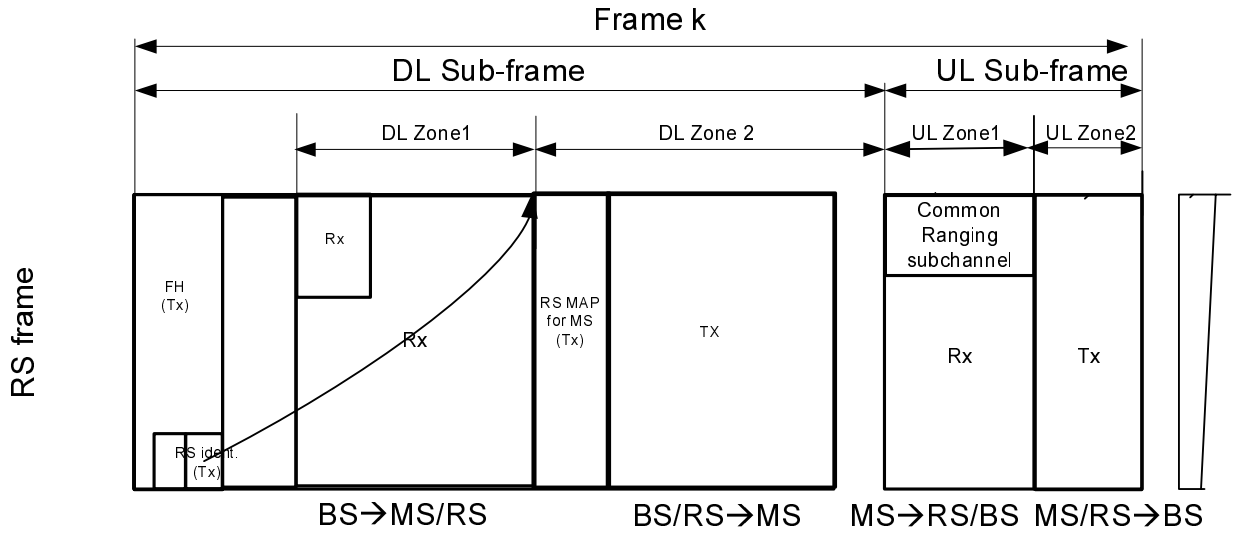
2. Description

1, Unified frame structure for adaptive multi-hop relay

An example of the proposed adaptive multi-hop relay frame structure is illustrated in Figure 1. The frame structure is suitable for both TDD and FDD.



(a), BS frame structure



(b), RS frame structure

Fig. 1 Example of adaptive multi-hop relay frame structure

(1), Common frame header

BS and RS simultaneously transmit the same frame header for DL broadcast control information, possibly including preamble, FCH, etc. The content in this common frame header should be relatively invariable. As the effect of signal combination, the common frame header can reach large coverage. No matter MS is located within BS coverage or RS coverage, it can receive this common frame header with broadcast control information.

(2), BS identifier and RS identifier

A BS identifier is transmitted by BS only, while RS keeps silent in this transmission period. A RS identifier is transmitted by RS only, while BS keeps silent in this transmission. These two identifiers are different and may occupy different time-frequency resources. Optionally they may be transmitted with different CDMA codes. MS can estimate its own position in DL (located within BS coverage or RS coverage) according to the received

identifier. e.g., if MS receives BS identifier, MS is within BS DL coverage; if MS receives RS identifier, MS is within RS DL coverage. Thus MS knows by which access station (BS or RS) it is covered in DL. MS measures the link qualities from available BS and/or RS, and then reports the results. BS / RS may use these measurement results for DL path decision reference. Different RSs within one BS cell may share one identifier or have different identifiers.

BS MAP is used for the resource allocation for BS→MS and BS→RS. Similarly, RS MAP assigns resource for RS→MS. The address information to point to the start of RS MAP may be announced in FH or given in the identifier. In the operation without RS, the slot reserved for BS identifier and RS identifier can be used for data traffic transmission.

(3), Multi-hop relay zone

The downlink/uplink sub-frame is divided into several zones in TDM to support multi-hop relay. As illustrated in Figure1, the sequences of zones and transmission in each zone are flexibly changeable, and the size of the zones is flexibly adjustable.

(4), Common ranging subchannel

In UL sub-frame, a common ranging channel is defined for initial ranging and periodic ranging, where BS and RS share this common ranging channel for MS UL ranging signal measurement. BS and RS also measures MS UL data transmission. The measurement results will be reported for the reference of multi-hop relay mode decision and UL path selection.

2, Different operation modes under the unified frame structure

According to the link quality information reported by MR/RS or measured by itself, BS/RS may select a suitable operation mode for each MS. The DL and UL traffic may follow different paths, and the control signal and data traffic may follow different paths. Figure 2 illustrates some examples of operation modes under this unified multi-hop relay frame structure.

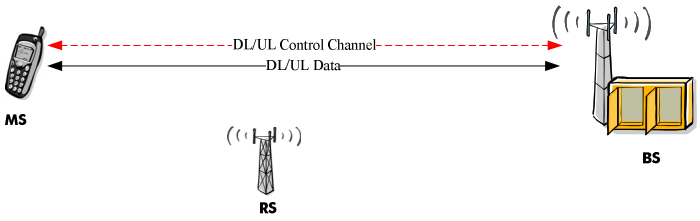
(1), No RS forwarding. This operation mode is performed without RS involvement, MS and BS directly communicate with each other to exchange both control signal and data (as illustrated in Figure 2(a)).

(2), Transparent RS. BS Control signal directly reaches MS, and UL control signal and data is relayed. It is similar to the transparent relay operation mode in IEEE 802.16j (as illustrated in Figure 2(b)).

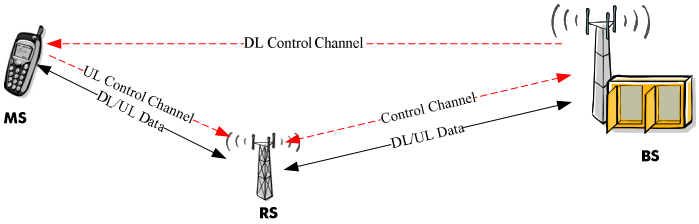
(3), Separation of control and data. BS and MS exchange DL/UL control information directly, and data is relayed. Control and data is separated (as illustrated in Figure 2(c)).

(4), Non-transparent RS. All control signal and data are relayed. It is similar to the non-transparent relay mode in IEEE 802.16j (as illustrated in Figure 2(d)).

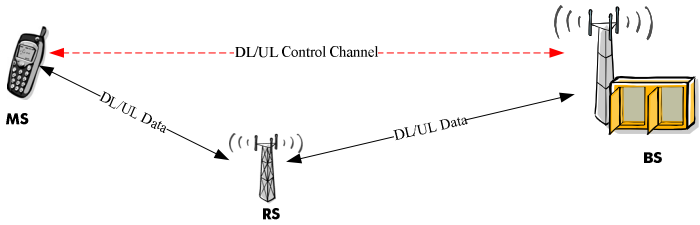
(5), Uplink RS only. Relay only works in UL forwarding (as illustrated in Figure 2(e)).



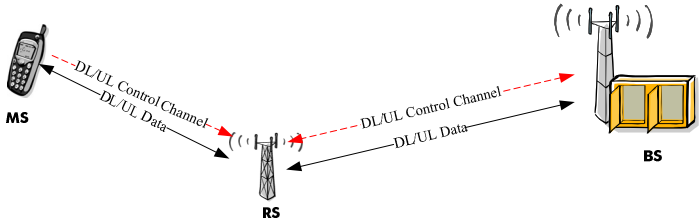
(a), Operation without RS involvement



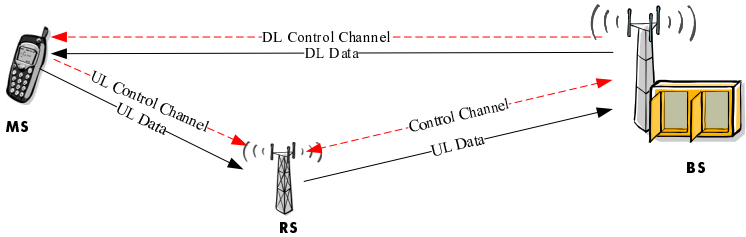
(b), BS Control signal directly reaches MS, and UL control signal and data is relayed (transparent relay operation mode)



(c), BS and MS exchange DL/UL control information directly, and data is relayed



(d), All control signal and data are relayed (Non-transparent relay mode)



(e), Uplink only relay

Fig. 2 Adaptive multi-hop relay operation modes under one unified relay frame structure

3, Procedures

MS first gets time/frequency synchronization, and gets broadcast information from the common frame header. Then, MS searches the BS identifier in the assigned position. If it receives the BS identifier, it measures the link quality and records it as well as BS ID if available. Next, MS searches the RS identifier in the assigned place. If it receives the RS identifier, it measures the link quality and records it as well as RS ID if available. The measurement results will be reported to BS directly or via RS. MS reports the link measurement results only when the link quality is strong enough.

In UL, BS and RS keep monitoring ranging signal generated by MSs in the common ranging subchannel. RS measures the signal level of these ranging signals and estimates the distance between MSs and itself. Only when the signal quality is strong enough should RS forward the ranging signals and reports the measurement results to it upper level station if required. Other weaker ranging signals are omitted by RS. BS/RS performs the same measurement on MS UL data transmission.

Based on the DL/UL measurement results, BS/RS adaptively selects the most suitable multi-hop rely mode for MS. The selection algorithms are out of the scope of this contribution.

3, Summary

The proposed frame structure has both merits of transparent relay and non-transparent relay, while eliminating their drawbacks. In DL, according to the specific BS identifier and RS identifier, MS knows by which access station (BS or RS) it is covered, and also gets the link qualities. This information helps to decide the DL paths for both control and data. In UL, BS and RS measures MS UL data or ranging signals for UL path selection. Different multi-hop relay operation modes are given to select a suitable one for MS to achieve the better performance, e.g. less control signal latency, less overhead, high bandwidth efficiency, etc. All these relay operation modes are performed under one unified relay frame structure, which greatly decreases the RS complexity and simplifies protocols. This multi-hop relay frame structure works for both TDD and FDD system. It also works for the super-frame structure.

Proposed Text for SDD

Insert the following text

---------- Text Start ----------

11.x.x Support of Relay Operation in Frame Structure

An example relay-enabled TDD frame structure is illustrated. Each frame in the downlink transmission begins with a frame header. BS and RS simultaneously transmit the same frame header for DL broadcast control information. The downlink/uplink sub-frame is divided into several zones in TDM to support multi-hop relay. The sequences of zones and transmission in each zone are flexibly changeable, and the size of the zones is adjustable. BS and RS transmit different identifiers to let MS know which access station (BS or RS) it is covered by in DL. In UL sub-frame, a common ranging channel is defined for initial ranging and periodic ranging, where BS and RS share this common ranging channel for MS UL ranging signal measurement. BS and RS also measures MS data transmission for UL path selection. Different multi-hop relay operation modes are supported under one unified relay frame structure. This multi-hop relay frame structure works for both TDD and FDD system. ---------- Text End ----------