Project	**IEEE 802.16 Multihop Relay Project < http://ieee802.org/16/relay/index.html >**
Title	**Fractional Frequency Reuse for IEEE802.16j Relaying Mode**
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Re:	Response to a call for Technical Proposals regarding IEEE Project 802.16j, see C802.16j-06/027.pdf
Abstract	This document outlines the concept of fractional frequency re-use in a relay based system.
Purpose	A partial technical proposal submitted IEEE 802.16j TG for considerations and further discussions.
Notice	
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Patent Policy and Procedures	

Fractional Frequency Reuse for IEEE802.16j Relaying Mode

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Introduction

In order to realize high efficient relaying transmission, radio resource sharing should be considered. In this contribution we propose a fractional frequency reused relaying mode based on the existing fractional frequency reuse scheme in WiMAX. The proposed relaying mode is intended to take advantage of the nature spatial separation of the relaying topologies and the available fractional frequencies of an OFDMA transmission. However, interference is also an issue which has to be taken into account. To prevent or minimise interference between adjacent and/or near adjacent cells or sectors, certain strategies are required. Attenuation of signals over distance allows for spatial re-use with minimal interference.

In this document, the fraction frequency re-use in WiMAX will be briefly overviewed and the fractional frequency reused relaying mode is proposed to meet the requirement of flexible radio resource assignment [1] to support sharing channels between access links and relay links, sharing channels between multiple relay links using different channels for different links and frequency reuse between access links and relay links.

Noted that this document is described mainly based on a fixed relaying topology as an example for clear description, however, it can be extended to a nomadic and/or a mobile relay with the same concept.

Fractional Frequency Re-use in WiMAX

Frequency division of cells results in a reduction of spectral efficiency according to the Frequency Re-use Factor (FRF). Single Frequency Networks (SFNs) maximise spectral efficiency by having a FRF=1 but require an alternative method of separating signals. This may be achieved by means of Pseudo Random Mapping (PRM) of sub-carriers in the case of OFDMA, which reduces the interference but cannot entirely eliminate it.

Mobile WiMAX, 1xEVDO and HSPA all support frequency reuse one, i.e. all cells/sectors operate on one frequency channel to maximize spectrum utilization. However, due to heavy interference in frequency reuse deployment, users at the cell edge may suffer low connection quality.

In WiMAX, users operate on sub-channels, which only occupy a small fraction of the channel bandwidth, where the cell edge interference problem can be easily addressed by reconfiguration of the sub-channel usage without resorting to traditional frequency planning [2]. In Mobile WiMAX, the flexible sub-channel reuse pattern can be configured so that users close to the base station operate on the zone with all sub-channels available. While for the edge users, each cell/sector operates on the zone with a fraction of all sub-channels available.

In Figure 1, F1, F2 and F3 are different sets of sub-channels in the same frequency channel. In this configuration, the full load frequency reuse of one is maintained for center users to maximize spectral efficiency while fractional frequency reuse is achieved for edge users to improve edge user connection quality and throughput.

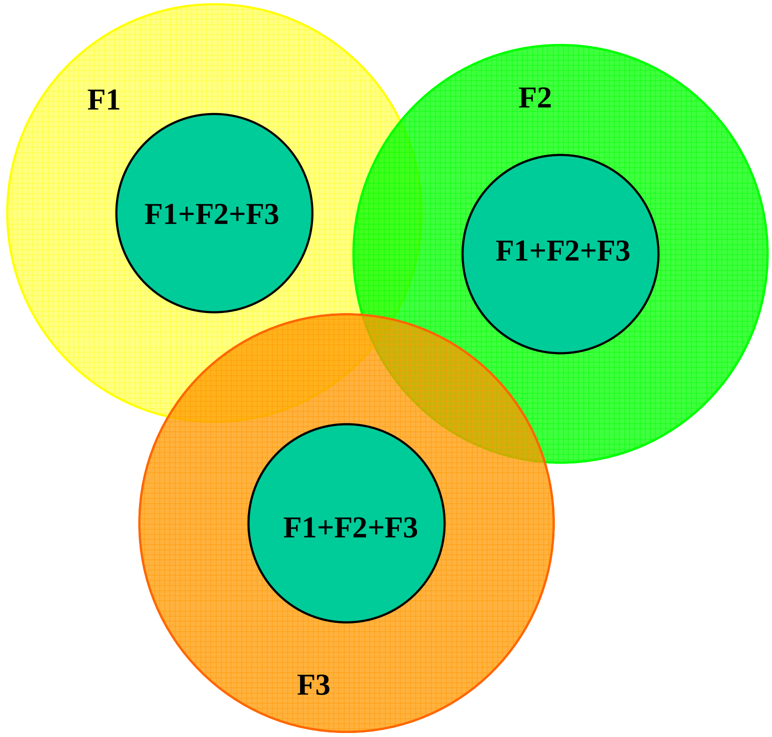

Figure 1 : Fractional frequency re-use with Mobile WiMAX [2]

Fractional Frequency Re-use recommendation for IEEE 802.16j

The aforementioned fractional frequency re-use concept can be extended to a relay based system as shown in Figure 2 and 3 (using the same 3 sets of sub-channels as for the earlier figure). Furthermore, use of hexagonal cellular layout pattern has been intentionally opted for, to distinctly highlight the potential advantages of applying the re-use concept to a multi-cellular relay-based system.

Upon receiving the signal from the BS, FRSs attempt to transmit an improved version of the same signal. This may be achieved by means exemplified but not limited to amplify and forward or decode and forward approaches. The latter typically results in more accurate regeneration of the signal at the expense of introducing more delay between the signal output by the BS and the RS.

Each FRS is required to *retransmit only a fraction of the total sub-carriers* received from the BS (determined by the number of sub-channels required to be supported by that FRS. This enables the FRS to concentrate its bandwidth into a fraction of the total system bandwidth on the downlink. Users outside the center zones receive their signals from both the FRS and BS with some delay between the two typically evident. The features of the multi-carrier modulation process are such that this delay can be accommodated at reasonable cost in terms of spectral efficiency via the mechanism of guard interval insertion and extraction. The additional signal facilitated by the FRS provides excellent protection against the effects of free space attenuation by reducing the distance between MS and FRS compared to MS and BS and also provides significant diversity to combat fading effects.

As illustrated in Figure 2, sub-channels are allocated in such a fashion so as to attempt to take account of their location. This has the benefit of ensuring that adjacent outer regions do not utilize the same sub-carrier-sub-channel combinations, thereby facilitating the re-use of sub-channels between spatially separate outer regions.

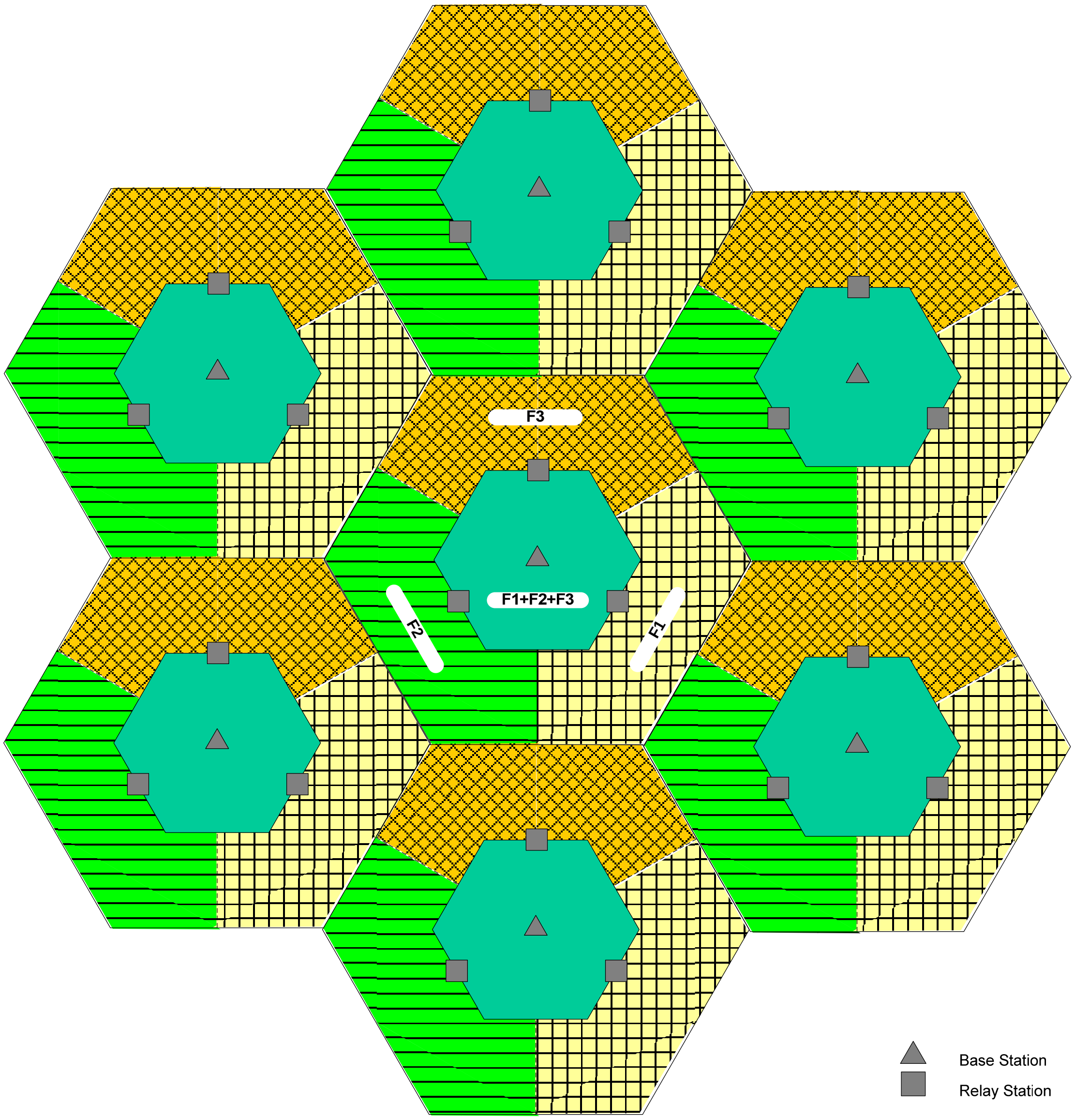

Figure 2 : Fractional frequency re-use in a relay-based system (number of FRSs = 3)

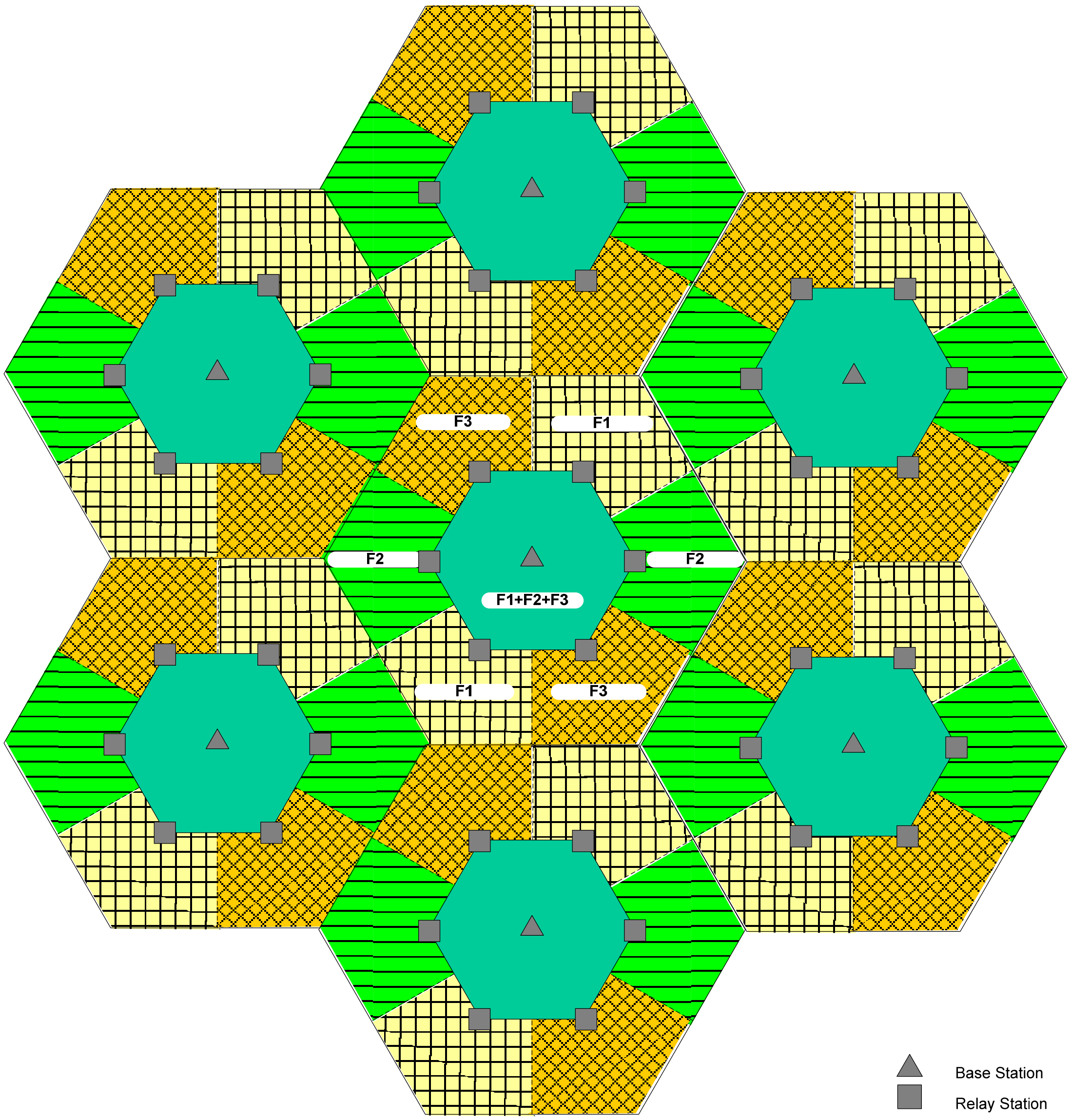

Figure 3 : Fractional frequency re-use in a relay-based system (number of FRSs = 6)

References :

[1] IEEE 802.16j-06/016r1, "Proposed Technical Requirement Guideline for IEEE 802.16 Relay TG", 11th October 2006.

[2] Mobile WiMAX – Part II : A Comparative Analysis, May 2006, *WiMAX Forum*