Optimization of Coverage Extension in IEEE 802.16j MMR System

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ABSTRACT

In this paper, we propose two optimization schemes to solve related to the coverage extension using non-transparent RSs. Firstly, we propose a frequency assignment scheme for maximum system throughput. And then, we analyze the maximum number of RS hops under the given BS capacity. Our analytical results show that MMR system is more efficient for both coverage extension.

1. Introduction

There have been numerous standard activities to make the IEEE802.16e systems which can support highly effective mobile environment based on OFDM(A) with TDD mode [1]. Those standard activities (IEEE802.16e), currently, were completed and the standard document was published 2005, and now the enhancements of IEEE802.16e standard are under discussion and carefully considered by the standard committee and several companies which have been developing IEEE802.16e/WiMAX products [2]. And also, the IEEE802.16 TGj has been focusing on Mobile Multihop Relay systems based on the IEEE802.16e standard document. In the last IEEE802 plenary meeting held in March, TGj has been officially created and qualified in order to make standard documents as one of IEEE802.16 task groups [3]. Of course, before becoming a TG, great number of experts and companies have been working and researching on the mobile multihop relay issues [4].

In this paper, we propose two optimization schemes to solve some problems. Firstly, we propose a frequency assignment scheme for maximum system throughput. And then, we analyze the maximum number of RS hops under the given BS capacity.

The remainder of the paper is organized as follows. Section 2 proposes a frequency assignment scheme and section 3 analyze the maximum number of RS hops. Finally, section 4 concludes with a discussion of future studies.

2. Frequency Assignment Scheme for Maximum throughput

![Figure 1. An example of frequency assignment method](image)

We propose a new frequency assignment scheme to maximize system throughput using multi-hop RS in an OFDMA-TDD system. We assume that the system use different frequencies (f0, f1, f2, ..., fn1) such as figure 1. We only consider the MMR system with 1-tier RSs and N1 is the number of 1-tier RS. BS transmits data to RSs by using f0. And then, RS1 and RS2 use f1 and f2 respectively. So BS and each RS have no effect from interference.

Figure 2 shows a frequency assignment scheme in a frame. BS transmits data to MSs during the time t0 using the frequency f0. RS1 and RS2 transmit data to MSs during the time t0 using f1 and f2. BS transmits to each RS during time t1 and t2. For this case, the sizes of two frequency blocks are the same between t1 * f0 and (t0 * f1) + (t2 * f1). The sizes are also the same between t2 * f0 and (t0 + t1) * f2. The blocks (holes) of t1 * f1 and t2 * f2 are...
wasted in this assignment scheme because RSs receive data from BS during the time. In this frequency assignment scheme, the time ratio t₀ is formulated by (1) and (2) when t₁ and t₂ are the same.

\[
BS \text{ coverage to RS coverage ratio } u = \frac{A_B}{A_R} \quad (1)
\]

where AB and AR are the coverage of BS and RS receptively.

\[
\text{BS time to total time ratio } \frac{t_0}{t_{total}} = \frac{u}{N_1 \times u} \quad (2)
\]

where total is the time of a frame length and N₁ is the number of RS.

Figure 3 shows another frequency assignment scheme. In this case, the wasted blocks in Figure 2 are used for transmitting from BS to RSs. So this scheme can increase throughput. The time ratio t₀ is formulated by (3) and (4).

\[
\xi = -\frac{1}{2} (N_1 - u - 2) + \frac{1}{\sqrt{4}} (N_1 - u - 2)^2 + (N_1 - 1) \cdot u \quad (3)
\]

where N₁ is the number of RS in 1-tier and u is from (1).

\[
\frac{t_0}{t_{total}} = \frac{\xi}{N_1 \times \xi} \quad (4)
\]

Figure 4 shows the BS time to total time ratio according to the number of N₁. The (a) is with holes and the (b) is without holes. The results show that BS time to total time ratio increases according to increase u. Also BS time to total time ratio is higher in the assignment scheme without holes.

3. Analysis of Maximum Number of RS hops

In this section, the maximum coverage of system is analyzed using the assignment scheme without holes. We assume no frequency reuse, no AMC, no boundary effect, and perfect cell shape. The traffic is uniformly distributed and BS radius (rₐ) is longer than RS radius (rᵣ). By using approximation, the coverage of each RS is obtained such as rᵣᵃ. The number of RSs in the kᵗʰ tier is obtained from (5).

\[
\text{Max number of RS's (kᵗʰ tier) : } n_{R,k^{th}} = \pi \left( \frac{2 \cdot f_{th}}{r_k} \right) \left( \frac{k}{2} \right) \left( \frac{1}{\sqrt{2}} \right) \quad (5)
\]

In (6), we can obtain the maximum coverage by given BS capacity(C).

\[
C = \rho \cdot A_B + n_{R,1^{st}} \cdot 2 \rho \cdot A_R + n_{R,2^{nd}} \cdot 3 \rho \cdot A_R + n_{R,3^{rd}} \cdot 4 \rho \cdot A_R \cdots
\]

\[
= \rho \left( A_B + A_R \sum_{k=1}^{\max hop} (k+1) \cdot n_{R,k^{th}} \right) \quad (6)
\]

where ρ is traffic density.
Figure 5 shows the result of maximum coverage according to the traffic density under the given BS capacity, 50 Mbps. The dotted line means that all RS use frequency reuse by the same channel. So the line means the maximum coverage without considering interference. However, the solid line means that all RS do not use frequency reuse. So the frequency in each frame is used only one time by BS and RSs. The threshold of tier means the number of RS tier. For example, the “a” is the maximum coverage of BS (when the traffic density is 1.6). And then, 1-tier RS can be used for extending coverage by using the remained BS capacity. The “b” means maximum coverage of 1-tier RS. If there is remained BS capacity, 2-tier RS can be used. We also know the number of 1-tier RS by (b-a)/coverage of one RS. In “c”, 3-tier RS can be used.

4. Conclusion

In this paper, we proposed two different schemes in aspects of maximizing coverage in IEEE 802.16j MMR system. The results of our analysis show that MMR system (BS and RSs are mixed) is more efficient for both coverage extension if traffic density is low. Moreover, we know that the difference of extended coverage between the two systems, one is no frequency reuse and the other is ideal frequency reuse. For the future research, we need to consider frame structure similar to the standard of IEEE 802.16j and various factors for cost model such as detailed cost, traffic delay and overhead of control channel.

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6. Reference