Co-channel interference Assessment for LMDS Macroscopic Diversity Cellular Architecture

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Abstract

Local multipoint distribution system (LMDS) uses cellular fashion to cover service area. In this broadband wireless cellular network, co-channel interference is a severe problem for system performance degradation because the frequency must be reused aggressively. Performance of macroscopic diversity cellular is compared to the typical cellular system. To address the demand of capacity increment, area coverage performances with directional terminal antenna are investigated. The results show that the proposed deployment scheme outperforms than typical cellular architecture.

Keywords: LMDS, Macroscopic diversity, co-channel interference

1. INTRODUCTION

The rapid growth of Internet has increased the demand for broadband services. Users of small office home office (SOHO) are expecting high quality, reliability and high-speed communication to easily access broadband services. On march 19, 2000, R.O.C. government issued three licenses for fixed network, hence our telecommunication business will move into a new generation.

A wireless approach to the last mile access is attractive to network operators and service providers for its quick installation. It is particularly appropriate in area with poor telecommunication infrastructure. LMDS is designed as a low cost, two way 28 GHz digital cellular technology that offer a wireless method of access to broadband interactive services. The system capacity comes mainly from the huge radio frequency bandwidth available. Supported users in these systems employ highly directional antennas and signal polarization to communicate with his home hub. Therefore, the consideration of LMDS cellular architecture is extremely different from mobile cellular. The challenging research subjects are located on broadband service requirement, high channel impairment and cellular co-channel interference.

Following the progress in mobile cellular, sectored hub antenna is applied to reduce the co-channel interference. Many cellular layouts have been proposed to provide services on LMDS[1]-[4]. Typical LMDS cell layout depicted in Fig. 1 reuse complete frequency in each cell by attempted with alternating polarization in either adjacent hub antenna sectors[2]. By using interleaved channel assignment, each terminal station belong to his own home hub and the interference between adjacent cells can be entirely eliminated. However, the interference from the second tier cell always exists and the system performance of users located at strong interference region is limited for co-channel interference.

Since the fact that the demand on the bandwidth for the broadband service is so high, all the available bandwidth must be used at least once. In this paper, we investigate the coverage performance on the macroscopic diversity with different directional terminal antenna beam-width, and compare to typical LMDS cellular. Since LMDS generally have more downstream traffic than upstream and the main problem related to frequency reuse is the interference between different sectors, the downstream interference is our concern in system evaluation.

In the rest of this paper, a detail introduction of the cellular architecture is described in Section 2. We compare the area coverage performance to typical cellular for different directional terminal antenna beam-width in Section 3. Finally, some conclusions are given in section 4.

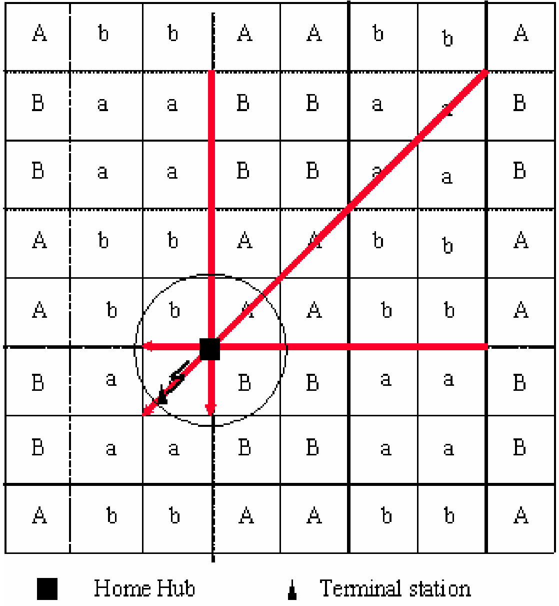

Fig. 1 typical cellular and co-channel interference scenario.

2.MACROSCOPIC DIVERSITY CELLULAR ARCHITECTURE

Macroscopic diversity, a form of spatial diversity using widely separated transmitters, dates back to the 1920's, more recently, land-mobile cellular radio systems use it in the form of handoff from one base station to another [5],[6].

A different implementation is considered here for LMDS cellular architecture [7], [8]. Fig. 2 illustrates LMDS macroscopic diversity cellular. Considering the macroscopic diversity, a terminal will measure the power from each base station and selects the one with the highest power available as its home hub under considering co-channel interference. It is obvious implementing the macroscopic diversity by corner excited cell is simple and carry no extra equipment costs.

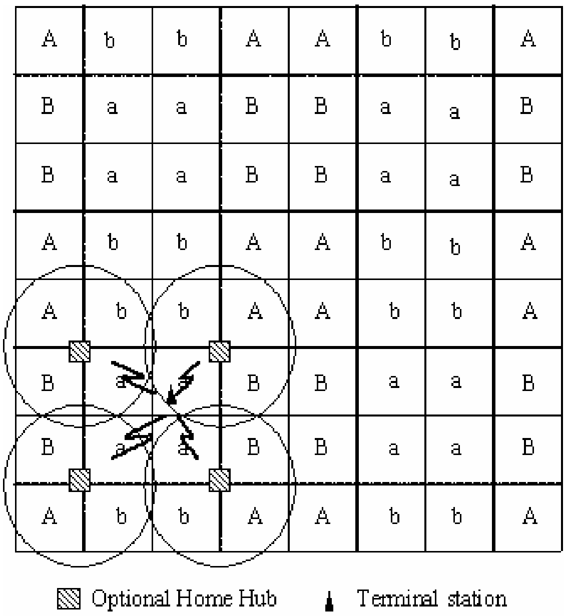

Fig. 2 macroscopic diversity cellular and optional hub selection.

3.PERFORMANCE ANALYSIS

In LMDS the upstream is usually lower capacity and employs lower-order modulation. Therefore downstream interference is the most problematic. In this section, we firstly describe the radio link formulas and general procedure for the down link calculation, then analysis and compare the performance of the typical intra-cell polarization interleaving cell and macroscopic diversity based on terminal directional antenna with different directional terminal antenna beam-width. Taking into account noise and co-channel interference, the C/I is evaluated by analytical formulas. This work is based on system configuration according Figs. 1-2 and practical system parameters considered in [4]. To proceed further, we assume that all hubs transmit the same signal power .

The radio link budget and the signal-to-interference ratio for the considered user have the following forms [4].

$$\mathrm{CNR(dB)} = 60.24 - 20\log r \tag{1}$$

$$\mathrm{CIR(dB)} = 20\log[(4r + R)/R] \tag{2}$$

R (km) : distance between home hub station and terminal station

r (km) : distance between home hub station and interference station

The general procedure for the down link calculation in our study are as follows.

1) We firstly choose the channel assignments so-that the set of channel used in a specified cluster is determined.

2) A reference cell is chosen and the terminal location is decided.

3) Identify the terminal location then calculate the CIR or CNR for each hub station.

4) Select the one with the highest CIR/CNR as its home hub.

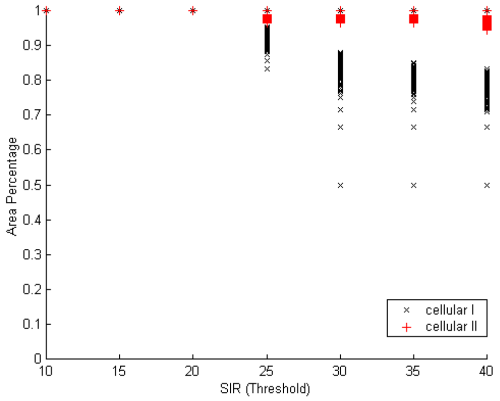

Fig. 3 Coverage performance vs. SIR for cellular I and cellular II with terminal antenna beam-width of 3°.

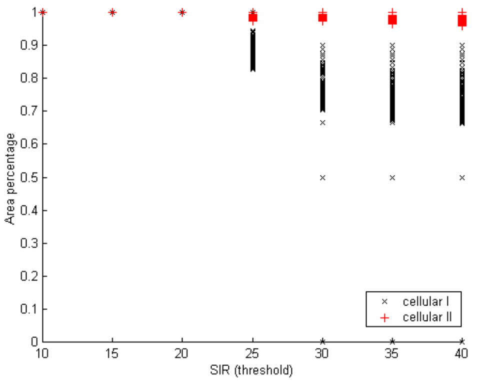

Fig. 4 Coverage performance vs. SIR for cellular I and cellular II with terminal antenna beam-width of 5°.

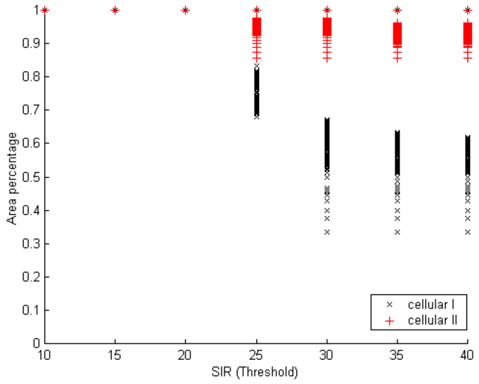

Fig. 5 Coverage performance vs. SIR for cellular I and cellular II with terminal antenna beam-width of 7°.

TABLE I
COMPARISONS BETWEEN SINGLE POLARIZATION CELLULAR AND PROPOSED CELLULAR FOR 16 QAM

Terminal antenna beam-width	Cellular I		Cellular II	
	Mean	*Standard deviation*	*Mean*	*Standard deviation*
3°	0.8858	0.0143	0.9846	0.0056
5°	0.7898	0.0398	0.9745	0.0104
7°	0.6973	0.0475	0.9462	0.0405

TABLE II
COMPARISONS BETWEEN SINGLE POLARIZATION CELLULAR AND PROPOSED CELLULAR FOR 64 QAM

Terminal antenna beam-width	Cellular I		Cellular II	
	Mean	*Standard deviation*	*Mean*	*Standard deviation*
3°	0.8231	0.0182	0.9846	0.0056
5°	0.7141	0.0427	0.9745	0.0104
7°	0.5863	0.0486	0.9343	0.0396

Figs. 3-5 illustrate the coverage performance versus SIR based on cellular system I and II with 3°, 5° and 7° terminal antenna beam widths. The user locations are randomly generated from a uniform distribution over the reference cell. We considered the first and second tier inter-cell interfering hub stations over 1000 trials. The area coverage ratio is presented as the percentage of the sector area where the received SIR exceeds the specific protection ratio.

$$Area \quad percentage = \frac{Area \ of \ \frac{S}{I} \geq (\frac{S}{I})_{threshold}}{Sector \quad area} \qquad (3)$$

It is observed that the area percentage of cellular II is better then cellular I. The reason is the terminals with a transmitting antenna that covers the other hubs antenna operating at the same channel encounter co-channel interference. The severe degradation area is very specific when using the terminal directional antenna. Various terminal antenna beam-width cases are summarized in Table1, 2 under protection ratio 20.68 corresponding 16 QAM and protection ratio 26.82 corresponding 64 QAM. A narrower terminal beam-width produces better performance for high SIR threshold demand. It performs no difference between the cellular system I and cellular II. For 16QAM transmission with terminal antenna beam-width 7°, the mean of cellular II is larger than cellular I by about 25%. The standard deviation of the cellular II is smaller than cellular I by about 0.7%. For 64QAM transmission with terminal antenna beam-width 7°, the mean of cellular II is larger than cellular I by about 35%. The standard deviation of the cellular II is smaller than cellular I by about 0.9%. This implies that cellular II is good for a higher order modulation scheme. It is obvious that the macroscopic diversity can provides superior performance for a higher order modulation scheme. This improvement comes from the SIR of the users located in regions with strong interference increases by more narrow directional terminal antenna and suitable home hub station selection in macroscopic diversity cellular architecture.

4.CONCLUSION

In typical LMDS system, co-channel interference can result severe system degradation in spite of it only occur in some region. In order to adopt high order modulation scheme, co-channel interference is the critical factor and should be concerned. Macroscopic diversity can increase the service area and provide system high quality service. In this paper, we examine the effect of co-channel interference with different directional terminal antenna beam-width for capacity considering. According to the results, it shows that the macroscopic diversity can provides superior performance for a higher order modulation scheme and carry no extra equipment costs.

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