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Performance Evaluation of AeroMACS using existing WiMAX System in Japanese High-Speed Trains

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Abstract AeroMACS (Aeronautical Mobile Airport Communication System) is being developed in order to provide new broadband wireless communications on the airport surface. In this paper, results of experiments using existing WiMAX (Worldwide Interoperability for Microwave Access) systems and Japanese high-speed trains (Shinkansen) are reported. We consider the capability of the AeroMACS system in high-speed scenarios, e.g. take-offs and landings. The relationship among frequency offset, moving speed and throughput are analyzed. We found that transmission of movies during take-off and landing is possible if CINR on the runway is higher than about 24dB and the base station is set at an appropriate position to reduce the influence of the Doppler shift.

Keyword AeroMACS, WiMAX, CINR, Frequency Offset, High-Speed Trains

1. Introduction

Recently, air traffic is increasing more and more. So, safer and more efficient air traffic management systems are required. In order to realize such air traffic management systems, it is important to cooperate with people who are working at airports and facilities by using communication systems. However, current aeronautical data communication systems have very low capacity. So, higher capacity and safer data communication systems are required.

AeroMACS (Aeronautical Mobile Airport Communication System) is being developed in order to provide new broadband wireless communications on the airport surface. AeroMACS is based on WiMAX (Worldwide Interoperability for Microwave Access), and 5091MHz - 5150MHz frequency band are allocated for AeroMACS.

Some results are reported in order to realize AeroMACS systems[1][2][3]. In this paper, results of experiments using existing WiMAX systems and Japanese high-speed trains (Shinkansen) are reported. We consider the capability of AeroMACS system in high-speed scenarios, e.g. take-offs and landings. Table 1 shows the summary of the WiMAX system.

Table 1 WiMAX System

Center Frequency	2.4GHz
Bandwidth	10MHz
Flame Length	5ms
Subcarrier Spacing	10.94kHz
Number of Subcarriers	1024
CP Ratio	1/8
Duplex Mode	TDD

2. Evaluation System

We moved from Tokyo to Shin-Osaka on a Japanese high-speed train at a maximum speed of about 280km/h.

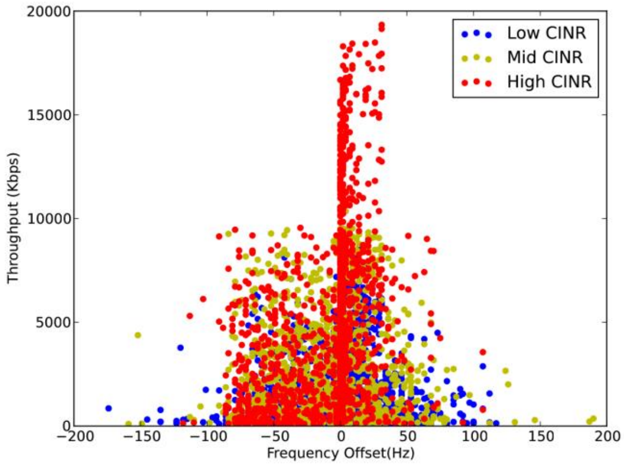

Fig.2. Frequency Offset and Throughput.

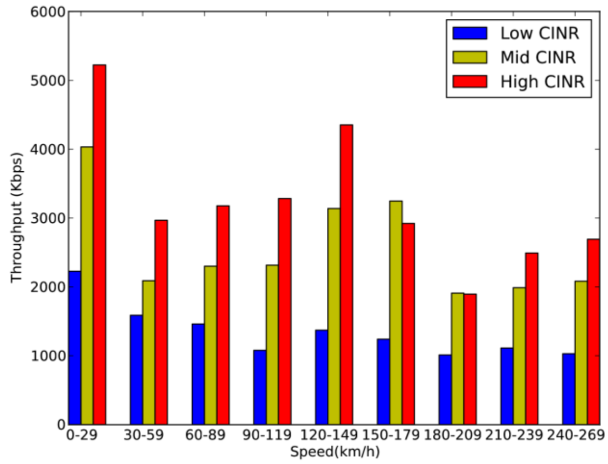

Fig.3. Moving Speed and Throughput.

A laptop PC with a WiMAX USB dongle was set by the window in the train. Also GPS position was recorded at the same time. We measured throughput between the mobile PC and iperf server which was set at the Electronic Navigation Research Institute (ENRI) in Chofu city. We measured downlink throughput with the iperf tool. Also, CINR (Carrier to Interference and Noise Ratio) and frequency offset were recorded with the signal analyzing tool. CINR is the ratio of carrier power to the sum of interference and noise power. The communication environment improves when CINR is higher. Frequency offset is the difference between frequency which is detected by a receiver and the desired frequency. It is caused by the difference in frequency of the receiver and transmitter local oscillator. Also, it is caused by Doppler shift when the mobile terminal is moving.

We analyzed CINR and Modulation format. Then we found that QPSK was used frequently when CINR is lower than 14.56dB and 16QAM was used when CINR is 14.57 - 23.24dB. Also, 64QAM was used very often when CINR is higher than 23.25dB. So, we categorized CINR into “Low CINR” in which CINR is lower than 14.56dB, “Middle CINR” in which CINR is 14.57-23.24dB and “High CINR” in which CINR is higher than 23.25dB.

3. Results

Figure.2 shows a scatter diagram of throughput. Horizontal axis is frequency offset and vertical axis is throughput. Figure.2 shows that throughput becomes lower when frequency offset becomes higher. Especially, frequency offset is within about 10Hz when throughput is higher than 10Mbps. Also, throughput becomes extremely low when frequency offset is over pulse/minus 100Hz.

One of the causes of frequency offset is Doppler shift due to movement of the mobile terminal.

As for the airport surface environment, high speed only occurs along the runway. So, if a base station is set up at right angles to the runway, effects of Doppler shift can be reduced.

Figure.3 shows results of average throughput. Horizontal axis is moving speed and vertical axis is average throughput.

Figure.3 shows that average throughput is about 5Mbps when moving speed is slow. Also, average throughput is about 3Mbps when moving speed is fast if CINR is high. This means that if CINR on the runway is higher than 23.25dB, it is possible to use it for movies.

4. Conclusion

Results show that throughput becomes lower when frequency offset becomes higher. Especially, throughput becomes extremely low when frequency offset is over pulse/minus 100Hz. As for the airport surface environment, high speed only occurs along the runway. So, if a base station is set up at right angles to the runway, effects of Doppler shift can be reduced. Also, if CINR on the runway is higher than 23.25dB, it is possible to use it for movies.

References

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