MULTIPLE-INPUT MULTIPLE-OUTPUT (MIMO) RADIO CHANNEL MEASUREMENTS

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1. EXTENDED ABSTRACT

Multiple antennas at both the transmitter and receiver have the potential to significantly increase the capacity of a wireless communications channel [1, 2, 3]. That is, using multiple-input multiple-output (MIMO) techniques with these antennas, multiple independent channels can be supported in the same bandwidth, but only if the scattering environment is rich enough. Recent research has shown that high theoretical capacity is possible – data rates as high as 40 bits/s/Hz have been demonstrated (in an indoor slow-fading environment) [4]. However, in cellular mobile radio, the channel differs in several important ways from the indoor channel. Therefore, to determine the potential of MIMO techniques for 3G and 4G wireless systems, we conducted the first field tests to characterize the mobile MIMO radio channel in a typical cellular environment.

In this paper we present field test results showing the potential increase in capacity using 4 transmit and 4 receive antennas at both the base station and terminal in a mobile environment. We describe the test system that consisted of a 4-branch base station receiver with rooftop antennas and 4 transmitters at the mobile with antennas mounted on a laptop computer. The 4-antenna base station receiver was similar to that used in previous IS-136 field trials [5, 6]. We considered several different antenna configurations for the base station and terminal. We show results for a base station rooftop antenna array consisting of dual-polarized spatially separated antennas and a terminal antenna array mounted on a laptop with elements spaced a half wavelength apart. We conducted our tests using a 30 kHz bandwidth, with bit and frame synchronous orthogonal sequences transmitted from each of the 4 transmitters at the mobile. Real-time baseband signal processing at the base station performed timing recovery and symbol synchronization, and calculated and recorded the 4×4 complex channel matrix every 300 μs.

Extensive drive tests plus pedestrian and indoor tests were conducted at 1900 MHz from a typical cellular base station site located in a suburban environment. Data was collected along drive routes in a residential area with vehicle speeds on the order of 30 mph and on a highway with speeds more than 60 mph. To assess performance we calculated the capacity from the complex channel measurements and compared its distribution to our computer simulation results.

The field test results show that, with 4 transmit and 4 receive antennas, close to the theoretical 4 times the capacity of a single antenna system can be supported in a 30 kHz channel with dual-polarized, spatially-separated base station and terminal antennas. Results show that for a MIMO system the capacity averaged over the spatial channels does not vary significantly with time in contrast to the capacity of a single transmit/receive antenna system where the capacity varies substantially with the Rayleigh fading. Thus, the capacity for pedestrian users does not vary significantly with small changes in position or with time and is similar to that of mobile users. With our field test data we obtained close to the ideal capacity distribution for a 4 transmit/receive MIMO system. Therefore, it may be possible to provide in excess of 1 Mbits/s in a 200 kHz mobile radio channel (for the 3G wireless TDMA system EDGE) [7]. These field test data and results are valuable inputs to the development of MIMO adaptive antenna algorithms and show that MIMO techniques could substantially increase the data rate and capacity of future cellular systems.

2. REFERENCES

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