ENHANCEMENT OF SPACE-TIME RECEIVER STRUCTURE WITH MULTIUSER DETECTION FOR WIDEBAND CDMA COMMUNICATION SYSTEMS

By

JEEVAN RAO SUBRAMANIAM

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Partial Fulfilment of the Requirements for the Degree of Masters of Science

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DEDICATION

To my loving parents for their endless care and support,

and who are always there for me.

Thank you.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in partial fulfilment of the requirement for the degree of Master of Science

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Wideband CDMA (WCDMA) which has been accepted as one of the radio access technology for third generation (3G) systems has many advantages such as efficient spectrum utilization and variable user data rates. However, multiple access interference (MAI) is a major constraint limiting the capacity of the system. Multiuser detection and smart antenna technologies are capable of increasing the system capacity through mitigation of such impairment.

In this thesis, a combination of spatial signal processing with temporal signal processing is proposed. Additionally, the space-time receiver structure is combined with multiuser detection to further enhance the system. We propose and analyze different combined space-time linear multiuser detection configurations in an uplink mobile radio communications channel that incorporates the spatial temporal parameters. The performance of these receivers is evaluated as a function of the number of antenna elements, Rake fingers and number of users. We consider two different pilot symbol assisted adaptive beamforming algorithms, Least Mean Square (LMS) and Recursive Least Square (RLS). The algorithms are used to adjust the weights of the antenna array to form the appropriate beam patterns to track the desired user and null interfering users. The adaptive algorithms are evaluated as a function of the number of iterations it takes to converge and its transmission performance are compared. Additionally, two different linear multiuser detection techniques, Decorrelator and linear Minimum Mean Square Error (MMSE) strategies are used in conjunction with the combined receiver structure.

The proposed combined Space Time Multiuser Detector which is suitable for WCDMA systems is shown to provide significant gain in transmission performance and system capacity. It is shown via simulation that the combined RLS adaptive algorithm with the linear MMSE multiuser detector provides the best overall performance. The simulation result also shows that the combined receiver structure is robust in the presence of strong interference due to high data rate users.

Abstrak tesis yang dikemukakan kepada Senat Univeristi Putra Malaysia sebagai memenuhi sebahagian keperluan untuk ijazah Master Sains

PENINGKATAN KEUPAYAAN STRUKTUR GABUNGAN PENERIMA ANGKASA-MASA DAN PENGESAN PELBAGAI PENGGUNA DI DALAM SISTEM KOMUNIKASI JALUR LEBAR CDMA

Oleh

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Jalur lebar CDMA (WCDMA) telah dipilih sebagai salah satu daripada teknologi pencapaian radio bagi sistem generasi ketiga (3G) kerana ia mempunyai banyak kelebihan seperti penggunaan jalur spektrum yang rapi and kadar data yang boleh diubah. Walaubagaimana pun, gangguan pelbagai pengguna (MAI) menjadi halangan utama mengurangkan keupayaan sistem tersebut. Teknoloji pengesan pelbagai pengguna dan antenna pintar berupaya menambah muatan sesebuah sistem dengan mengurangkan kelemahan tersebut.

Di dalam tesis ini, satu kombinasi pemprosesan signal angkasa and pemprosesan signal masa telah dicadangkan. Sebagai tambahan, struktur pengesan angkasa-masa ini digabungkan dengan pengesan pelbagai pengguna untuk meningkatkan keupayaan sistem tersebut. Kami mancadangkan dan menganalisa pelbagai kombinasi sistem gabungan angkasa-masa ini bagi saluran pemancar sistem radio

komunikasi dengan model yang merangkumi parameter angkasa dan masa. Keupayaan pengesan tersebut dikaji dari segi bilangan elemen antenna yang digunakan, bilangan jari Rake and bilangan pengguna di dalam sistem tersebut.

Dua algoritma penyesuaian yang dibantu oleh simbol pilot bagi penghasilan sinaran (beamformer) iaitu Purata Kuasa Dua Terendah (LMS) dan Pendaraban Kuasa Dua Terendah (RLS) turut dikaji. Algoritma ini digunakan untuk mengawal pemberat bagi antenna untuk membentuk sinaran yang menjejaki pengguna yang dihendaki dan menghalang pengguna yang tidak dihendaki. Prestasi algoritma penyesuaian tersebut dikaji sebagai fungsi bilangan gelungan yang diambil untuk menumpu ke keadaan yang stabil and prestasinya turut dibandingkan. Sebagai tambahan, dua jenis pengesan pelbagai pengguna iaitu Decorrelator dan MMSE turut digunakan di dalam struktur pengesan kombinasi tersebut.

Kombinasi pengesan angkasa-masa and pengesan pelbagai pengguna yang dicadangkan ini sesuai digunakan di dalam sistem WCDMA dan ia telah ditunjukkan boleh memberi banyak manafaat di dalam prestasi and kapasiti sistem tersebut. Melalui simulasi, ia telah ditunjukkan bahawa kombinasi algoritma Pendaraban Kuasa Dua Terendah (RLS) dengan pengesan pelbagai pengguna MMSE menunjukkan prestasi terbaik berbanding pengesan yang lain. Keputusan simulasi ini turut menunjukkan bahawa pengesan yang dicadangkan itu tahan lasak sungguhpun terdapat banyak gangguan dari pengguna yang mempunyai kadar data yang tinggi.

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I certify that an Examination Committee has met on 13th March 2006 to conduct the final examination of Jeevan Rao Subramaniam on his Master of Science thesis entitled "Enhancement of Space-Time Receiver Structure with Multiuser Detection for Wideband CDMA Communication Systems" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

_____

JEEVAN RAO SUBRAMANIAM

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