DESIGN AND ANALYSIS OF A DYNAMIC SPACE-CODE MULTIPLE ACCESS WITH LARGE AREA SYNCHRONOUS SCHEME USING THE SMART ANTENNA SYSTEM

By

NG CHEE KYUN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

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DEDICATIONS

"To my family members especially my beloved parent for their endurance support and love."

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman: Associate Professor Sabira Khatun, PhD
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The most important property in wireless systems, when it comes to increase the system capacity and spectrum efficiency, is eliminating interference. Code Division Multiple Access (CDMA) is considered interference-limited system. Spatial filtering using smart antenna has emerged as a promising technique to improve the performance of cellular communication systems; hence, Space Division Multiple Access (SDMA) has recently received increasing interest in improving the performance of wireless systems. These interference-limited systems are susceptible to time of arrival (TOA) and angle of arrival (AOA) of individual user signals, thus, a non-uniform traffic can severely degrade the performance of CDMA and SDMA systems. In this thesis, new approach of the joint multiple access system arising from the combination of CDMA and SDMA systems is designed, and its system performances are then investigated.

An innovative approach to eliminate the existing interferences in this joint multiple access system is proposed. The spreading sequences of Large Area Synchronous Even

Ternary (LAS-ET) which exhibited an interference free window (IFW) in their correlation are exploited here. The spatial signature from smart antenna narrower beam is exploited to drive all the multipath propagation signals to arrive within the IFW in reverse link transmission. The size of IFW is adaptable with the size of smart antenna beamwidth through dynamic space code (DSC) algorithm. Hence, this double signatures scheme forms a novel multiple access scheme called Dynamic Space Code Multiple Access (DSCMA) system. From the nature of spatial filtering of smart antenna systems, a dynamic sequence reuse assignment is possible in DSCMA to increase its spectrum efficiency. The non-zero pulse intervals and sequence length of LAS-ET are arranged in even numbers which has demonstrated some performance improvements in ternary phase shift keying (TPSK) signalling. On the other hand, the combined spreading sequence and spatial signature scheme also prompts a possibility of developing a novel Space Division Duplexing (SDD) scheme. The reverse and forward links are transmitted within a narrower beam of smart antenna, and both links are distinguished by different LAS-ET sequences.

The simulation results indicate that the reverse link system capacity in DSCMA using LAS-ET spreading sequences together with smart antenna system is increased dramatically compared to traditional binary spreading sequences. The results also showed that the spectrum efficiency of DSCMA is increased when the number of elements in smart antenna system is increased. Finally, it can be concluded that the system capacity and spectrum efficiency are increased significantly from DSCMA using smart antenna systems due to its perfect interference cancellation scheme.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

REKA BENTUK DAN ANALISIS SATU CAPAIAN BERBILANG RUANG KOD DINAMIK DENGAN SKIM LUAS RUANG SEGERAK MENGGUNAKAN SISTEM ANTENA PINTAR

Oleh

NG CHEE KYUN

Januari 2007

Pengerusi: **Profesor Madya Sabira Khatun, PhD**
Fakulti: **Kejuruteraan**

Sifat yang sangat penting dalam sistem wayarles apabila menyentuhi tentang pertambahan muatan sistem dan kecekapan spectrum adalah penghapusan gangguan. Capaian Berbilang Pembahagian Kod (CBPK) boleh dianggap sebagai sistem gangguan terhad. Penurasan ruang dengan menggunakan antena pintar telah muncul sebagai satu teknik harapan untuk meningkatkan prestasi sistem komunikasi bersel; iaitu baru-baru ini Capaian Berbilang Pembahagian Ruang (CBPR) telah menerima sambutan yang tinggi dalam peningkatan prestasi sistem wayarles. Sistem-sistem gangguan terhad ini mudah terpengaruh kepada masa ketibaan dan sudut ketibaan isyarat seseorang pengguna; iaitu ketidakragaman sesebuah lalu-lintas boleh menyusutkan prestasi sistem-sistem CBPK dan CBPR dengan lebih teruk. Dalam tesis ini, pendekatan baru capaian berbilang bersepadu hasil daripada penggabungan sistem-sistem CBPK dan CBPR direkabentukkan, dan seterusnya prestasi sistem itu diselidiki.

Satu pendekatan yang inovatif untuk menghapuskan sebarang gangguan yang wujud dalam sistem capaian berbilang bersepadu ini dicadangkan. Pelebaran jujukan oleh Luas Ruang Segerak Tigaan Genap (LRS-TG) yang mempamerkan satu tingkap bebas gangguan (TBG) dalam kolerasinya digunakan di sini. Pengenalan ruang daripada alur antena pintar yang sempit itu digunakan untuk memandukan semua perambatan isyarat berbilang laluan supaya tiba di dalam TBG dalam pemancaran rangkai bertentangan. Saiz TBG itu adalah diselaraskan dengan saiz lebar alur antena pintar melalui algoritma ruang kod dinamik (RKD). Justeru itu, skim pengenalan gandaan ini membentukkan satu skim capaian berbilang yang baru dikenali sebagai sistem Capaian Berbilang Ruang Kod Dinamik (CBRKD). Dari kesemulajadian pengenalan ruang oleh sistem-sistem antena pintar itu, satu tugasan penggunaan semula jujukan secara dinamik adalah munasabah dalam CBRKD untuk meningkatkan kecekapan spectrumnya. Selang antara denyutan-denyutan bukan sifar serta lebar jujukan LRS-TG itu disusun berbentuk nombor-nombor genap telah menunjukkan beberapa peningkatan prestasi dalam pengisyaratan penguncian anjakan fasa tigaan (PAFT). Di samping itu, skim gabungan pelebaran jujukan dan pengenalan ruang juga menyebabkan satu kemungkinan untuk membangunkan satu skim Dupleks Pembahagian Ruang (DPR) yang baru. Rangkai-rangkai bertentangan dan berhadapan dipancar melalui satu alur antena pintar yang sempit, dan kedua-dua rangkai itu dibezakan dengan jujukan LRS-TG yang beza.

Keputusan-keputusan simulasi menunjukkan bahawa muatan sistem dalam CBRKD dengan menggunakan jujukan pelebaran LRS-TG bersama-sama dengan sistem antena pintar dalam rangkai bertentangan ditingkatkan secara dramatik berbanding dengan jujukan duaan pelebaran tradisi. Keputusan-keputusan itu juga menunjukkan bahawa

kecekapan spectrum dalam CBRKD ditingkatkan apabila bilangan unsur dalam sistem antena pintar itu ditambah. Akhirnya, ini boleh disimpulkan bahawa muatan sistem dan kecekapan spectrum ditingkatkan dengan ketara daripada CBRKD dengan menggunakan sistem antena pintar disebabkan oleh skim pemansuhan gangguan yang sempurna.

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I certify that an Examination Committee has met on 30 January 2007 to conduct the final examination of Ng Chee Kyun on his Doctor of Philosophy thesis entitled "Design and Analysis of a Dynamic Space-Code Multiple Access with Large Area Synchronous Scheme Using the Smart Antenna System" 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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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory 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.

NG CHEE KYUN

Date: 3 March 2007

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