MODEM RECOGNITION ALGORITHM FOR SOFTWARE DEFINED RADIO BASE STATION

By

SIVARAMAN RUKUMANGATHA RAJAH

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This project is specially dedicated to my father Mr. Rukumangatha Rajah, and mother Mrs. Vethavalli, and my wife Mrs. Muthuletchumy.

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

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Chairman: **Professor Borhanuddin Mohd. Ali, Ph.D.**

Faculty: **Engineering**

Mobile communications industry continuously evolves the wireless standards from 2G to 2.5G, 3G and then further onto 4G. Each generation differs significantly in link layer and physical layer protocol standards causing problems to subscribers, network operators and equipment vendors. The root cause of the problem is that the current hardware is not flexible enough to support future communication systems. To address this issue, Software Defined Radio (SDR) plays an important role to bridge the hardware limitation.

SDR is the integration of software and hardware technology that promises cost effective seamless networkability and value added services between end users and network operators. Modem is the heart of a SDR system; it functions as an incoming modulation recogniser, multi-format demodulator, outgoing modulation recogniser, and multi-format modulator. These functions generally require high overhead like extensive memory, high-

level database, and efficient and uninterrupted power management system. Because of this, the Base Station (BS) is preferred to handle the modem function since it has the capacity to allocate the required overhead and maintenance. The implementation of SDR modem function in the BS provides the flexibility for the subscriber or Mobile Station (MS) to communicate with any mobile communication systems available in the market. However to support all available communication systems, it is necessary to make some modifications to the MS, which is configured through software download from wireless terminals. In addition, the proposed modem algorithm will also assist in accelerating the SDR deployment since the main attention of the SDR deployment focuses on the BS.

The proposed algorithm was developed based on 8th order statistical moment and the technique was chosen based on the research work done by Keith et al [15]. However, in this thesis the former technique is modified to accommodate non-equally likely received signal recognitions, wider range of modulation scheme, and modulation recognition efficiency for lower channel SNR. The performance of the algorithm was verified in the presence of white Gaussian noise and Rayleigh Fading. The statistical order was classified based on the latency and the effectiveness of recognition among the identified modulation schemes. The average latency for each QPSK, MSK, QASK, and BPSK modulation scheme is approximately 20ms. As a whole, the proposed modem recognition algorithm demonstrated successful recognition of QPSK, MSK, QASK, and BPSK for a lower-bound channel SNR greater than 5dB with average processing time of approximately 75ms.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian daripada keperluan ijazah Master Sains

AlGORITMA MODEM UNTUK RADIO TAKRIFAN PERISIAN STESEN PANGKALAN

Oleh

SIVARAMAN RUKUMANGATHA RAJAH

Disember 2004

Pengerusi :   Profesor Borhanuddin Mohd. Ali, Ph.D.

Fakulti :   Kejuruteraan

Industri komunikasi selular berubah generasinya ke alaf baru dari masa ke masa, ini merangkumi perubahan generasi dari generasi pertama ke generasi tiga dan tak lama lagi akan berubah ke generasi empat. Setiap generasi momunikasi in berbeza dari segi lapisan fizikal dan lapisan "link" dan menyebabkan kesusahan kepada pengguna, operasi rangkaian, dan pembekal system komunikasi. Pekakasan system komunikasi merupakan salah satu limitasi yang tidah boled diubah suai mengikut kehendak teknologi yang sedia ada. Untuk mengatasi limitasi ini Radio Takrifan Perisian di perkenalkan

Radio Takrifan Perisian (RTP) merupakan integrasi di antara teknologi perisian dan teknologi pekakasan untuk menjamin rangkaian komunikasi tanpa wayar dan servis nilai ditambah di antara pengguna dan operator rangkaian. Salah satu limitasi adalah pada halangan yang dialami pada Modem merupakan komponen yang paling utama di dalam sistem RTP, dimana ia berfungsi sebagai pengenalpasti modulasi isyarat pembawa, demodulasi format pelbagai, pengenalpasti modulasi isyarat pegeluar, dan modulasi

pelbagai format. Fungsi tersebut biasanya memerlukan perbelanjaan yang lebh tinggi untuk pengendalian memori ingatan, pangkalan data, dan pegurusan bekalan kuasa tidak terganggu. Stesen pangkalan dipilih untuk mengendalikan fungsi algoritma modem tersebut kerana ia mempunyai kapasiti yang diperlukan oleh algorithma modem. Selain itu, pengimplimentasi sistem RTP di dalam stesen pangkalan memberikan fleksibiliti kepada palanggan telefon bimbit untuk berkomunikasi dengan mana – mana sistem komunikasi yang terdapat di pasaran. Walaubagaimanapun, untuk menikmati semua kemudahan yang ditawarkan oleh RTP, stesen bergerak memerlukan sedikit modifikasi yang boleh dicapai dengan konfigurasi perisian muat turun daripada terminal tanpa wayar.

Algoritma modem yang dicadangkan juga memberikan kelebihan untuk mempercepatkan aktiviti implementasi RTP kerana tumpuan sepenuhnya di beri kepada stesen pangkalan. Algoritma modem yang dicadangkan telah direkabentuk dengan menggunakan teknik statistik peringkat ke lapan dan teknik ini adalag berdasar kepada cadangan yang telah dibuat oleh Keith et al [15]. Prestasinya telah diuji dan dibuktikan dengan ganguan "*white Gaussian*" dan "*Rayleigh Fading*". Statistik peringkat ke lapan telah di klasisfikasikan dengan mengambil kira masa purata untuk operasi perlaksanaan algoritma dan kecekapannya dalam mengenalpasti sesuatu modulasi isyarat pembawa. Masa purata perlaksanaan algoritma yang dicapai oleh modulasi QPSK, MSK,QASK, dan BPSK adalah 20ms. Secara keseluruhan Algoritma modem yang dicadangkan telah mendemonstrasi pencapaian yang memuaskan pada kadar isyarat dan bunyi lebih besar daripada 5dB untuk modulasi "*OPSK*", "*MSK*", "*QASK*", dan "*BPSK*" dengan masa purata 75ms.

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I certify that an Examination Committee met on 8 December 2004 to conduct the final examination of Sivaraman Rukumangatha Rajah on his Master of Science thesis entitled " Modem Algorithm for Software Define Radio Base Station" 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:

ABDUL RAHMAN RAMLI, Ph.D.
Department of Communication and Networking Systems
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

MOHAMAD KHAZANI ABDULLAH, Ph.D.
Head,
Department of Communication and Networking Systems
Faculty of Engineering
Universiti Putra Malaysia
(Member)

ELSADIG AHMED MOHAMED BABIKER, Ph.D.
Lecturer,
Department of Communication and Networking Systems
Faculty of Engineering
Universiti Putra Malaysia
(Member)

_____
GULAM RUSUL RAHMAT ALI, Ph.D.
Professor/Deputy Dean
School of Graduate Studies,
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as partial fulfilment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

BORHANUDDIN MOHD ALI, Ph.D.
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

SABIRA KHATUN, Ph.D.
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

_____
AINI IDERIS, Ph.D.
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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 currently submitted for any other degree at UPM or other institutions.

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SIVARAMA RUKUMANGATHA RAJAH

Date: 3 February 2005

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