SIMULATION OF OPTICAL SPECTRUM CODE DIVISION MULTIPLE ACCESS IN FIBRE TO THE HOME ACCESS NETWORK

By

MAISARA BINTI OTHMAN

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

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In the name of God, Most Gracious, Most Merciful

To my beloved husband, for your devoted love and support
To my parents, for your endless care and comfort

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

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Faculty: **Engineering**

Nowadays, the increasing number of end users accessing the Internet and taking advantage of today's data transport capabilities has ignited an explosive demand for bandwidth. One of the next generation access systems that helps to improve this situation by pushing optical fibre closer to the home is called fibre-to-the-home (FTTH). FTTH offers virtually unlimited bandwidth to the subscriber with high splitting ratio, longer fibre span and provide the residential customers with bundled of high speed voice, data and video services.

Generally, the study of FTTH access network by implementing Optical Spectrum Code Division Multiple Access (OSCDMA) technique was presented. This technique is one of the multiplexing schemes that recently have become popular among researchers because of its flexibility in allocating channels, ability to operate asynchronously, enhanced privacy and increased capacity in bursty nature networks. One of the considerations in designing OSCDMA systems is

coding. So in this study, we proposed a new code namely Double Weight Code (DWC) with basic fixed weight of 2 that exists for every natural number. The DW codes possess ideal cross correlation properties, that are important characteristics in spectral encoding OCDMA system since these can eliminate multiple user interference and reduce noise. The performance of DW code against Hadamard code is compared through simulation by using OptiSystem version 2.2.

There are two types of FTTH networks; point-to-point (P2P) and point-to-multipoint (P2MP) that have been designed for downstream application and both codes are being implemented inside the networks and the performance are characterized through Bit Error Rate (BER), eye opening and Q factor. It is found that DW code is better than Hadamard code for all simulation results at bit rates of 622 Mbps, 1.25 Gbps and 2.5 Gbps. The optimization configuration for P2P network with 16 users, with BER as good as 10^{-9} value is achieved at 38 km distance for 2.5 Gbps with transmission power set at 0 dBm. While for P2MP network, the other configurations value is still the same like P2P network but the changes only happen at the transmission side. A single light emitting diode (LED) has been used with total transmission power set to 16.4 dBm. The bit rate can only reach up to 1.25 Gbps with distance up to 20 km to get the minimal value of BER. However the results on P2MP network shows enhancements offered by erbium doped fibre amplifier (EDFA) provides longer fibre span, larger distribution to the end user and it is suitable to support high speed gigabit network.

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

SIMULASI TEKNIK SPEKTRUM OPTIK PEMBAHAGI KOD PELBAGAI CAPAIAN PADA RANGKAIAN CAPAIAN GENTIAN OPTIK KE RUMAH

Oleh

MAISARA BINTI OTHMAN

Januari 2005

Pengerusi: **Profesor Madya Mohd Khazani Abdullah, PhD**

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Pada masa kini, pertambahan pengguna yang menggunakan Internet semakin meningkat dan mereka mengambil faedah daripada kecekapan penghantaran data untuk memenuhi keperluan jalur lebar. Pada masa akan datang, salah satu sistem capaian yang boleh digunakan untuk mengatasi masalah tersebut, dengan cara meletakkan gentian fiber berdekatan kawasan perumahan dipanggil gentian optik ke rumah (*fibre-to-the-home* (*FTTH))*. *FTTH* berupaya menawarkan rangkaian capaian jalur lebar tidak terhingga secara terus ke kediaman pelanggan dengan kadar pecahan yang tinggi, rangkuman fiber yang luas serta penghantaran pakej yang mengandungi suara, data dan video pada kelajuan yang tinggi.

Secara amnya, tesis ini menunjukkan kajian tentang rangkaian capaian *FTTH* dengan menggunakan teknik Spektrum Optik Pembahagi Kod Pelbagai Capaian

(*OSCDMA)*. Teknik ini merupakan salah satu skim multipleksan yang semakin popular dikalangan pengkaji kebelakangan ini, kerana skim ini mengandungi beberapa kebaikan seperti dapat disesuaikan dalam memperuntukkan saluran – saluran, berkebolehan menjalankan operasi tak segerak, mempertingkatkan keselamatan daripada gangguan pengguna lain dan meninggikan kapasiti dalam rangkaian yang sibuk. Salah satu faktor yang harus dititik beratkan dalam mereka sistem *OSCDMA* ialah pengekodan. Jadi dalam tesis ini, kami mencadangkan kod baru yang dinamakan Kod Berat Berganda (*Double Weight Code* (*DWC*)) dengan asas pemberat yang bernilai 2 untuk setiap pengguna dan wujud pada setiap nombor semulajadi. Kod DW mempunyai keupayaan memiliki korelasi silang yang sesuai serta ciri – cirinya yang amat penting dalam pengkodan sistem spektrum *OCDMA*. Sistem ini juga boleh menghapuskan gangguan daripada pengguna yang ramai pada satu masa dan mengurangkan hingar. Prestasi diantara kod *DW* dan kod *Hadamard* dibandingkan dengan menggunakan simulasi OptiSystem versi 2.2.

Terdapat dua jenis rangkaian FTTH iaitu; titik-ke-titik (*point-to-point*) dan titik-ke-pelbagai titik (*point-to-multipoint*) telah direka untuk aplikasi hiliran dengan memasukkan kedua – dua kod ke dalam rangkain tersebut dan prestasinya dilihat melalui ciri – ciri kadar ralat bit, bukaan mata dan faktor Q. Keputusan yang diperolehi menunjukkan bahawa prestasi kod *DW* lebih baik daripada kod *Hadamard* untuk semua keputusan simulasi yang dibuat pada kadar bit 622 Mbps, 1.25 Gbps dan 2.5 Gbps. Adalah didapati konfigurasi optimum untuk rangkaian titik-ke-titik ialah dengan 16 pengguna, untuk mengekalkan kadar

ralat bit pada tahap yang baik iaitu 10^{-10}, dicapai pada 38 km jarak fiber pada kadar bit 2.5 Gbps dengan kuasa penghantaran ditetapkan 0 dBm. Sebaliknya untuk titik-ke-pelbagai titik, nilai konfigurasi yang lain ditetapkan sama seperti rangkaian titik-ke-titik, tetapi perubahan dibuat hanya pada kawasan penghantaran. Satu diod pemancar cahaya digunakan dengan jumlah kuasa penghantaran sebanyak 16.4 dBm. Kadar bit hanya boleh dicapai sehingga 1.25 Gbps dengan jarak fiber 20 km untuk mengekalkan kadar ralat bit yang minimum. Walaubagaimanapun, keputusan rangkaian titik-ke-pelbagai titik menunjukkan peningkatan yang ditawarkan oleh *EDFA* dengan menyediakan jarak gentian fiber yang panjang, meluaskan cabang penghantaran kepada pengguna dan juga sesuai untuk menyokong rangkaian gigabit yang berkelajuan tinggi.

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I certify that an Examination Committee met on 27th January 2005 to conduct the final examination of Maisara Othman on her Master of Science thesis entitled "Simulation of Optical Spectrum Code Division Multiple Access in Fibre to the Home Access Network" 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 Master of Science. 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 the 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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MAISARA OTHMAN

Date:

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