

**Capacity Improvement Using Adaptive
Sectorisation in WCDMA Cellular Systems with
Non-Uniform and Packet Mode Traffic**

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Declaration

I declare that, to the best of my knowledge, the research described herein is the result of my own work, except where otherwise stated. I also declare that this work has not been submitted for this degree before and is not being submitted concurrently for any other degree.

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Signature of Author

Date: **March 2005**

*To my dear wife **Thuy Thanh Phuong** and
my lovely daughter **Evonne Nguyen***

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Abstract

CDMA cellular mobile systems find widespread acceptance particularly in regional centres where there are large geographical areas to cover. However, temporal changes of user density due to formation of congregated population centres (called hot spots) can seriously undermine the system design goals in terms of quality of service (QoS) and system capacity. This investigation deals with the problem of hot spots in a bid to improve system capacity at acceptable quality of service levels. Among the techniques considered is the adaptive sectorisation and its implementation with finite antenna beam switching.

The future wireless communications systems are expected to offer a wide variety of services, which have vastly differing QoS requirements. To handle this, the third generation cellular mobile communication systems are designed to carry packet mode traffic. This investigation also deals with the impact of third generation cellular system traffic on system capacity. It examines the system activity in the presence of mixed mode traffic and the capacity and QoS trade-offs possible in Wideband CDMA (WCDMA) cellular systems. Application of adaptive sectorisation to improve capacity in such systems when confronted with hot spots is also investigated.

It is found that in all situations the adaptive sectorisation brings an overall improvement to system capacity and this is particularly significant when the user concentration in hot spots is substantially bigger than that of the rest of the cell.

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Abbreviations

| | |
|----------|--|
| 3G | 3 rd Generation |
| 3GPP | 3 rd Generation Project Partnership |
| AMPS | Advanced Mobile Phone System |
| ARIB | Association of Radio Industries and Bussiness |
| AWGN | Additive White Gaussian Noise |
| BCH | Broadcast Channel |
| BER | Bit-Error-Rate |
| BS | Base Station |
| CDMA | Code Division Multiple Access |
| cdma2000 | Code Division Multiple Access 2000 |
| CIR | Carrier-to-Interference Ratio |
| DL | Down Link |
| DPCCH | Dedicated Physical Control Channel |
| DPDCH | Dedicated Physical Data Channel |
| DQPSK | Differentially Encoded Quadrature Phase Shift Keying |
| DS | Direct Sequence |
| ETSI | Europe Telecommunications Standards Institute |
| FBI | Feedback Information |
| FDD | Frequency Division Duplexing |
| FDMA | Frequency Division Multiple Access |
| FIFO | First-In-First-Out |
| GPRS | General Packet Radio Service |
| GSM | Global System For Mobile Commnications |

| | |
|----------|--|
| HR | High Rate |
| HS | Hot Spot |
| HSA | Hot Spot Area |
| HSCSD | High Speed Circuit Switched Data |
| HSS | Hot Spot Sector |
| IMT-2000 | International Mobile Telecommunications - 2000 |
| ISI | Inter-Symbol Interference |
| ISR | Interference-to-Signal Ratio |
| LR | Low Rate |
| MAI | Multiple Access Anterferenc |
| MC | Multicode |
| MR | Mixed Rate |
| MS | Mobile Station |
| MSC | Mobile Switching Center |
| OVSF | Orthogonal Variable Spreading Factor |
| PCS | Personal Communication Systems |
| PDC | Personal Digital Cellular |
| PG | Processing Gain |
| P_r | Blocking Probability |
| PRACH | Physical Random Access Channel |
| PSTN | Public Switching Telephone Network |
| QoS | Quality of Service |
| RV | Random Variable |
| SIR | Signal-to-Interference Ratio |
| SINR | Signal-to-Interference-Plus-Noise Ratio |
| SNR | Signal-to-Noise Ratio |
| TCC | Telecommunication Technology Committee |
| TDD | Time Division Duplexing |
| TDMA | Time Division Multiple Access |
| TFCI | Transport Format Combination Indicator |
| TIA | Telecommunications Industry Association |

| | |
|-------|---|
| TPC | Transmit Power Control |
| VCR | Variable Chip Rate |
| VSF | Variable Spreading Factor |
| UE | User Equipment |
| UL | Up Link |
| UMTS | Universal Mobile Telecommunications Service |
| UTRA | UMTS Terrestrial Radio Access |
| WCDMA | Wideband Code Division Multiple Access |
| WLAN | Wireless Local Area Network |

Notations

Variables

| | |
|-------------|--|
| t_{ai} | Time of arrival of the i^{th} user |
| A_i | Inter-arrival time between $(i - 1)^{th}$ and i^{th} arrivals, $(t_{ai} - t_{a(i-1)})$ |
| S_i | Service time of i^{th} user (exclusive of customer's delay in queue) |
| D_i | Delay time of the i^{th} user in the queue |
| t_{di} | Time of departure of i^{th} user after receiving service, $(T_{ai} + D_i + S_i)$ |
| N | Average number of users in the system |
| $N(t)$ | Number of users in the system at any given time |
| $\gamma(t)$ | Number of arrivals (total) |
| $\beta(t)$ | Number of departures (total) |