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Optimisation of Base Station Placement for Indoor Wireless Communications

Liza Pujji

Abstract

The development of wireless communication systems has enabled ‘anywhere, anytime’ communication and significantly influenced the working habits of the people in modern society. Engineers responsible for deploying base stations in wireless systems face opposing constraints of maximising the quality and capacity of the system while minimising the interference and cost. In addition, indoor wireless systems must cope with three-dimensional variations in signal strength and limitations in site selection. Consequently, the indoor Base Station Placement (BSP) problem becomes a multi-objective, multi-dimensional optimisation problem. This thesis investigates the BSP problem for indoor wireless communication systems by using mathematical models and optimisation algorithms and considering the effect of several factors on BSP.

Researchers have proposed a number of algorithms to find the optimal solution for the BSP problem. In this thesis, some proposed algorithms are compared to identify the most appropriate algorithm to solve the indoor BSP problem. Based on the advantages and disadvantages of the existing algorithms, a novel hybrid algorithm is developed and its performance is compared to the existing algorithms. It is seen that the proposed hybrid algorithm provides optimal deployments, without significantly compromising accuracy and efficiency.

Although there are several factors that can affect BSP in indoor wireless systems, the effects of three factors, namely call traffic variability, user mobility and call switching technologies on BSP are investigated. Two options are considered for each factor — call traffic can be static or dynamic, users can be fixed or moving and call switching technology can be circuit or packet switched. It is seen that dynamic call traffic, user mobility and circuit switched traffic must be considered in order to identify the optimal BSP. In addition, the BSP problem is extended to multi-floored buildings by considering internal and external potential base station sites. It is seen that the vertically aligned internal base station sites achieve the least call failure rate.

The results obtained from this thesis are intended to provide a practical and useful framework for solving the BSP problem of indoor wireless communication systems.
Dedication

To my grandparents, parents and brother,
who have always encouraged me and given me unfailing love, support and guidance.
Acknowledgments

I would like to express my sincere gratitude to my supervisors, Assoc. Prof. Kevin Sowerby and Dr. Michael Neve. Their invaluable guidance, unfailing patience and inspiring support over the past four years have been instrumental in shaping the quality of this research.

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I would also like to thank my mom, dad and brother for their unconditional love and unfailing support. They have always believed in me and encouraged me to overcome all the problems in life. Finally and most importantly, I would like to thank God for everything.
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# Glossary

## Abbreviations and Acronyms

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<td>BFS</td>
<td>Brute Force Search</td>
</tr>
<tr>
<td>CAC</td>
<td>Call Admission Control</td>
</tr>
<tr>
<td>CBR</td>
<td>Constant-Bit-Rate</td>
</tr>
<tr>
<td>CDMA</td>
<td>Code Division Multiple Access</td>
</tr>
<tr>
<td>CIR</td>
<td>Carrier-to-Interference Ratio</td>
</tr>
<tr>
<td>D/F/C</td>
<td>Dynamic traffic/ Fixed users/ Circuit switched calls</td>
</tr>
<tr>
<td>D/M/C</td>
<td>Dynamic traffic/ Moving users/ Circuit switched calls</td>
</tr>
<tr>
<td>D/M/P</td>
<td>Dynamic traffic/ Moving users/ Packet switched calls</td>
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<tr>
<td>FDMA</td>
<td>Frequency Division Multiple Access</td>
</tr>
<tr>
<td>GEN</td>
<td>Genetic Algorithm</td>
</tr>
<tr>
<td>GoS</td>
<td>Grade of Service</td>
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<tr>
<td>GRE</td>
<td>Greedy Algorithm</td>
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<tr>
<td>LTE</td>
<td>Long Term Evolution</td>
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<tr>
<td>NGA</td>
<td>Ngadiman’s Algorithm</td>
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<tr>
<td>OFDMA</td>
<td>Orthogonal Frequency Division Multiple Access</td>
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<tr>
<td>RCR</td>
<td>Reduction Estimation - Combinatorial Optimisation - Reduction Approximation</td>
</tr>
<tr>
<td>S/F/C</td>
<td>Static traffic/ Fixed users/ Circuit switched calls</td>
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<tr>
<td>SIR</td>
<td>Signal-to-Interference Ratio</td>
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TDMA  Time Division Multiple Access
VBR  Variable-Bit-Rate
WiMAX  Worldwide Interoperability for Microwave Access

Symbols

\( G_p \)  Processing gain
\( N_{bs} \)  Number of potential base station sites
\( N_u \)  Number of potential user locations
\( N_{u,o} \)  Number of office bearers
\( N_{u,v} \)  Number of visitors
\( P_{max} \)  Maximum signal power transmitted by a user
\( P_{min} \)  Minimum required signal power received by a user
\( P_{ru} \)  Received signal power of user \( u \)
\( P_{tu} \)  Transmitted signal power of user \( u \)
\( Q_f \)  Forward link SIR threshold
\( Q_r \)  Reverse link SIR threshold