Middlesex University Modelling Group Uses the NAG Library for Analytical Modelling, Performance, Availability and Performability Evaluation of Communication Systems

Introduction

The analytical modelling and performance evaluation of communication systems is a popular research topic in The School of Engineering and Information Sciences, Middlesex University. In the Computer Communications Department, a significant number of academics and researchers work on optimisation studies of various communication systems. The research areas include the analytical modelling of homogeneous multi-server systems with reconfiguration and rebooting delays [1], studies of farm paradigm multi-server systems (e.g. Beowulf clusters) [2], fast performability evaluation models of open networks [3], and various new solution approaches for multi-dimensional models [4]. In addition to the theoretical work, systems such as Network Memory Servers which have been developed at Middlesex University [5, 6], and wireless communication systems, horizontal and vertical handoff schemes [7, 8] as well as wireless traffic modelling studies [9] have been considered for performance and availability evaluation and protocol optimisation.

Numerical Algorithms Group Library

The NAG Library is used effectively in analytical modelling studies of various multi-server, multi channel systems as mentioned above. It is employed for multi-dimensional modelling approaches and the methods used to solve the steady states of these models. The models derived are used in the performance, availability and performability evaluation of multi-server systems such as computing clusters, network memory servers, wireless communication systems and integration of heterogeneous systems [1-9] .

The NAG routine f02ab is used in order to find the real eigenvalues and eigenvectors of a real symmetric matrix. The matrix is first reduced to a real tridiagonal matrix using Householder's method, and its eigenvalues and eigenvectors are calculated using the QL algorithm.

Once the eigenvalues and eigenvectors have been calculated, it is possible to use other NAG routines to handle the resulting system of simultaneous equations. Thus, f07ad is used for LU factorization of the input matrix as $A = PLU$, where P is a permutation matrix, L is lower triangular with unit diagonal elements and U is upper triangular. Since the eigenvectors may occur as complex conjugates, f04ad is used to solve the set of complex linear equations $AX = B$ using a forward and backward substitution method.

Analytical Modelling for wireless communication systems

The main feature of the next generation wireless communication systems is the ability to establish ubiquitous and seamless access to various radio access technologies (RATs) and standards. For this reason, the integration of various wireless technologies and the performance evaluation of the interaction between these technologies is an important research area. A considerable amount of attention has been paid to the so-called handoff schemes (see Figure 1) between various technologies [7-9].

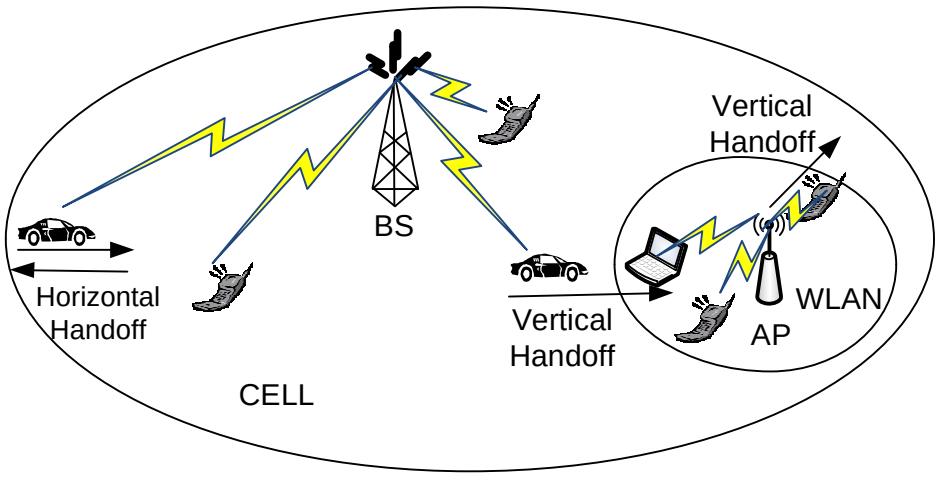

Figure 1. Cellular/WLAN Integration.

This figure illustrates the definition of Horizontal and Vertical Handoff

The modelling group in Middlesex University looks at performance, availability and performability evaluation of the handoff schemes. Since the problem itself is quite complicated with a number of

stochastic state variables, multi-dimensional models are employed and routines from the NAG Library are used for the determination of a steady state solution for the analytical systems.

The NAG Library Provides Accurate and Efficient Computations

The analytical approaches employed are validated using simulation programs developed at Middlesex University. The validation process clearly shows the efficiency and the accuracy of the calculations based on the analytical approaches. Some of the results obtained are illustrated in figure 2 [4]. The iterative calculations take up to 200 seconds, whereas the simulation takes more than six hours. When the accuracy of the new methods is considered, we find the discrepancy is within 5%, which is the confidence interval of the simulation [4]. These results show that NAG routines provided the desired level of accuracy as well as computational efficiency.

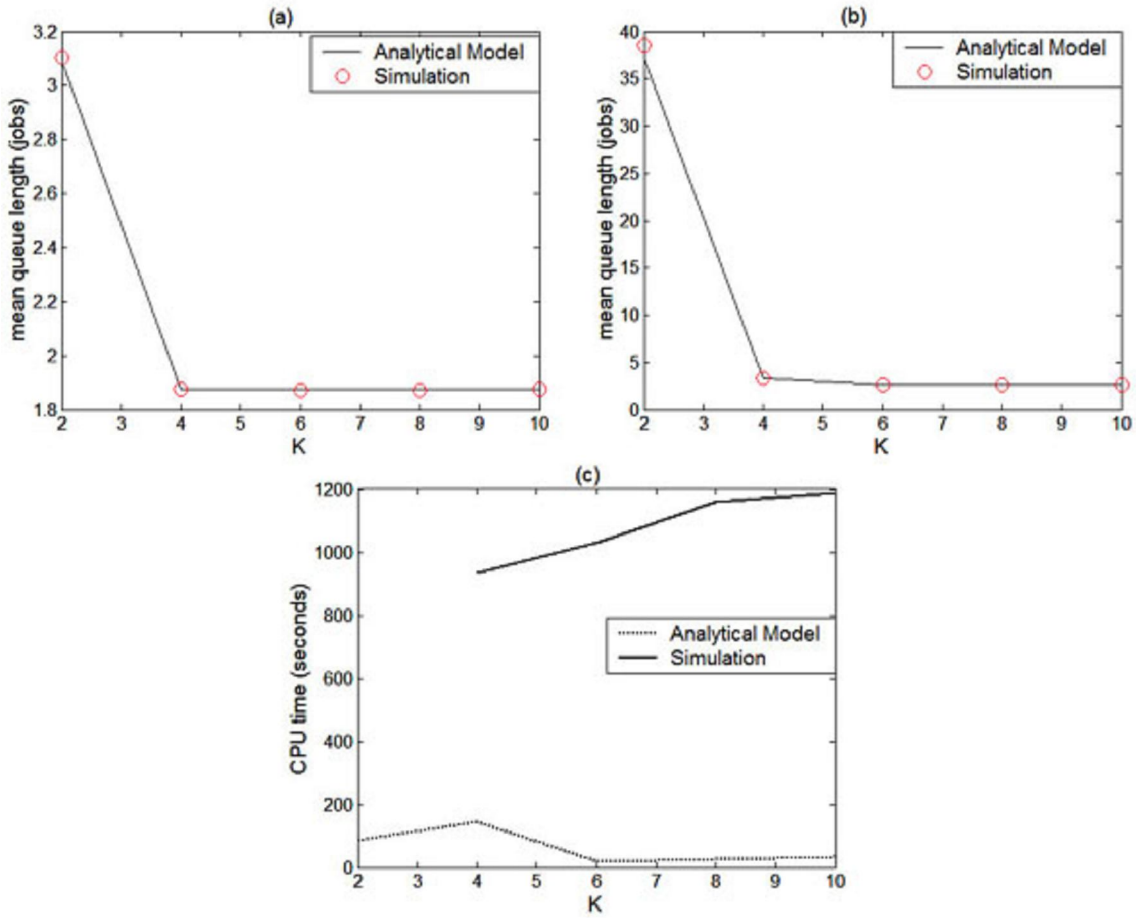

Figure 2. Accuracy and Efficiency of analytical approaches.

Conclusions

The Modelling group in the Computer Communications Department of Middlesex University uses the NAG Library for analytical modelling and validation of various optimisation studies. Dr. Enver Ever of the group comments "The NAG Library is reliable and well-documented. I have been using the NAG library for more than five years and the documentation provided is an excellent resource to help understand and use routines effectively. The routines are explained in detail and they are easy to invoke. We are happy with the quality of the Library and plan to make further use of NAG in the future".

References

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