ASYMPTOTIC AVAILABILITY OF AN ELECTRICAL SUBSTATION VIA A SEMI-MARKOV PROCESS COMPUTED BY GENERALIZED APPROXIMATE INVERSE PRECONDITIONING

J.B. VIOLENTIS[1], V.P. KOUTRAS[1], A.N. PLATIS[1] and G.A. GRAVVANIS[2]

**[1]Department of Financial and Management Engineering, Business School,
University of the Aegean, 31, Fostini street, GR 82100 Chios, Greece; Email:
fmem05027@fme.aegean.gr; v.koutras@fme.aegean.gr; platis@aegean.gr**

**[2] Department of Electrical and Computer Engineering, School of Engineering,
Democritus University of Thrace, 12, Vas. Sofias street, GR 67100 Xanthi,
Greece; Email: ggravvan@ee.duth.gr**

ABSTRACT

The rapid increase of power consumption has become more intense nowadays due to the continuous economical and population growth. Consequently the demand for uninterrupted power supply or the minimization of the down time of such systems inevitably results into developing highly reliable and available energy plants.

The reduction of the down time of the power plants can be achieved by scheduled maintenance activities and including stand-by components which will be activated to replace the corresponding component in a case of failure during its repair. In power plants the maintenance is performed to the stand-by components, hence in a case of malfunction of the main components, an extensive down time period is observed due to the unavailability of the reserved units. The power supply will be restored only after the repair of the damaged component or the completion of the maintenance procedure. Consequently, the starting time of the preventive maintenance and its duration might have a great affect on the uninterrupted energy supply.

In this paper the behavior of an electric substation which is equipped with two power cables, one of which is under stand-by condition, and two high to medium voltage transformers is studied. Furthermore, scheduled maintenances of the lines and the transformers are modeled along with malfunctions of specific components. The system is modeled by a Semi-Markov process in order to capture events with non-exponential distributions, but the computation of the steady state probabilities for the asymptotic analysis is quite complex, especially on large scale systems.

In some cases, although the system has been modeled with a Semi-Markov process, it is possible to replace a non-exponential with an exponential distribution by setting its parameter equal to the inverse mean value of the non-exponential distribution, under specific conditions. Hence, under such assumptions, the computation of the steady

state probabilities with the Semi-Markov process is reduced to the computation of the steady state probabilities in the Continuous Time Markov Chain framework.

The steady state probabilities have been computed by solving a sparse linear system, which is derived by the corresponding Homogeneous Markov Chain. Explicit approximate inverse preconditioning has been extensively used for solving efficiently sparse linear systems on multiprocessor and multicomputer systems. The approximate inverse is a close approximant to the coefficient matrix of the sparse linear system and is fast to compute in parallel. Finally the performance and the applicability of the explicit preconditioned conjugate gradient type schemes are discussed and the numerical results of the electrical substation availability are given.

REFERENCES

[1]. **A.F. Brandao**. "A model for substation reliability analysis including overload effects", *International Journal of Electrical Power & Energy Systems* **9(4)**, 1987, 194-205.

[2]. **C.K. Jeffery, M. Arvindh and K. Vijayalakshmi**. "Generic Markov models for availability estimation and failure characterization in petroleum refineries", *Computers & Operations Research* **28(1)**, 2001, 1-12.

[3]. **K.M. Giannoutakis, G.A. Gravvanis, B. Clayton, A. Patil, T. Enright and J.P. Morrison**. "Matching high performance approximate inverse preconditioning to architectural platforms", *The Journal of Supercomputing*, to appear

[4]. **G.A. Gravvanis**. "Explicit Approximate Inverse Preconditioning Techniques", *Archives of Computational Methods in Engineering* **9(4)**, 2002, 371-402.

[5]. **G.A. Gravvanis**. "A note on the rate of convergence and complexity of domain decomposition approximate inverse preconditioning", Computational Fluid and Solid Mechanics, *Proceedings of the First MIT Conference on Computational Fluid and Solid Mechanics*, eds. K.J. Bathe, vol. **2**, 1586-1589, Elsevier, 2001

[6]. **G.A. Gravvanis**. "Explicit preconditioned generalized domain decomposition methods", *I. J. of Applied Mathematics* **4(1)**, 2000, 57-71.

[7]. **G.A. Gravvanis, V.N. Epitropou and K.M. Giannoutakis**. "On the performance of parallel approximate inverse preconditioning using Java multithreading techniques", *Applied Mathematics and Computation*, to appear

[8]. **A.N. Platis, N.E. Limnios and Marc Le Du**. "Dependability Analysis of systems modeled by non-Homogeneous Markov Chains", *Reliability Engineering and System Safety* **61**, 1998, 235-249.

[9]. **M. Tanrioven and M.S. Alam**. "Reliability modelling and analysis of stand-alone PEM fuel cell power plants", *Renewable Energy* **31(7)**, 2006, 915-933.

[10]. **K. S. Trivedi**. "Probability and Statistics with Reliability, Queuing and Computer Science Applications", John Wiley and Sons, 2002