Stochastic Modeling Approach for Performance and Dependability Analysis of the Cellular Networks

By

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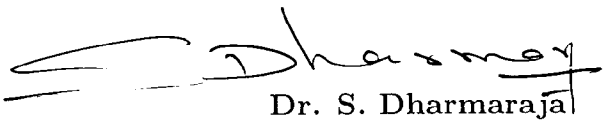
Dedicated to My Family

Certificate

This is to certify that the thesis entitled *Stochastic Modeling Approach for Performance and Dependability Analysis of the Cellular Networks* submitted by *Ms. Vaneeta Jindal* to the Indian Institute of Technology Delhi, for the award of the Degree of Doctor of Philosophy, is a record of the original bona fide research work carried out by her under my supervision and guidance. The thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted in part or full to any other university or institute for the award of any degree or diploma.



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Abstract

The third generation and beyond cellular networks will support multi-media applications, file transfer, live programs and web access in addition to traditional voice and video telephony, with guaranteed Quality of Service (QoS) requirements. Scarce radio resources at cellular networks limit the service offerings as well as their QoS. The occurrence of hardware and software failures in the network elements, power outages, malicious attacks and natural disasters (for example, earth quakes, storms, floods and ground shaking) further degrade the QoS. Call admission control (CAC) schemes improve QoS of the cellular networks by efficiently utilizing the limited radio resources. On the other hand, the impact of failures at network elements is mitigated by incorporating the fault tolerance strategies such as redundancy, automatic software recovery mechanisms, back up batteries and highly reliable wired/wireless links.

The efficiency of cellular networks depend critically on its performance and dependability attributes (e.g. reliability, availability and survivability). Performance analysis of cellular networks involves the characterization of network traffic and derive the QoS measures such as call blocking probabilities, call dropping probabilities, total carried traffic and average waiting times. Dependability analysis of cellular network involves the study of at least two of its attributes. The research work in this thesis focusses on applying the stochastic modeling approaches such

as Reliability Block Diagrams (RBD), continuous time Markov chains (CTMC), birth-death process, quasi birth death process and Markov regenerative process, for computing performance metrics such as call blocking and dropping probabilities, and dependability attributes in terms of reliability and survivability.

First, we consider performance issues of cellular networks supporting voice, video and data calls. We propose two CAC schemes, viz. fixed guard channel scheme and fuzzy logic based CAC scheme. In fixed guard channel CAC scheme, after characterizing call arrivals, cell residence times, call holding times and cell retrial times appropriately, the underlying stochastic process for a cell is a quasi birth death process. After obtaining the infinitesimal generator matrix, expressions for the performance metrics are derived. In the proposed fuzzy logic based CAC scheme, incoming calls are accepted based on the fuzzy decision. The decision depends on certain input parameters, for example, number of idle channels available with a cell and the type (voice, video or data) of call. We, then apply Markov regenerative process theory to compute performance metrics for this scheme.

With an increase in the services offered by the cellular networks, the societal dependence on the networks has increased significantly, which magnifies consequences of the failures and amplifies the importance of ensuring reliability and survivability of cellular networks. We, therefore, consider the reliability and survivability attributes of the cellular networks in this research work. CTMCs and RBDs are used for constructing the analytical models for reliability and survivability analysis.

Further, in this thesis, we develop a queueing model for analyzing the delay in processing of a call request message, generated by a mobile device which wants to initiate a call. Finally, the thesis concludes the research work.

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