Chapter 11
Traffic and Network Performance Monitoring for Effective Quality of Service and Network Management

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ABSTRACT
The authors consider distributed mobile networks carrying time-varying heterogeneous traffics. To deal effectively with the mobile and time-varying distributed environment, the deployment of traffic and network performance monitoring techniques is necessary for the identification of traffic changes, network failures, and also for the facilitation of protocol adaptations and topological modifications. Concurrently, the heterogeneous traffic environment necessitates the deployment of hybrid information transport techniques. This chapter discusses the design, analysis, and evaluation of distributed and dynamic techniques which manage the traffic and monitor the network performance effectively, while capturing the dynamics inherent in the mobile heterogeneous environments. Specifically, the design of a monitoring sub-network is sought, where the arising research tasks include: the adoption of a core sequential algorithm which monitors both the variations in the rates of the information data flows and the dynamics of the network performance. The identification of the specific operational and performance characteristics of the monitoring systems, when the core algorithm is implemented in a distributed environment; for a given network topology, it is important to identify the minimum size monitoring sub-network for complete “visibility” of data flows and network functions. Dynamically changing monitoring sub-network architectures, as functions of time-varying network topologies. The deployment of Artificial Intelligence learning techniques, in the presence of dynamically changing network and information flow environments, to appropriately adapt crucial operational parameters of the data monitoring algorithms.

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INTRODUCTION

Distributed mobile networks are of high interest in this information technology era, where efficient bandwidth utilization is a key issue due to its limited availability. These networks aim at the satisfaction of the Quality of Service (QOS) of heterogeneous information data traffics (e.g., image, audio, data, graphics, text), with simultaneous high utilization of network resources and bandwidths. The performance demands imposed on mobile networks carrying heterogeneous connections are challenging and can be satisfied via the deployment of highly dynamic statistical multiplexing protocols which honor the traffic QOS, while utilizing the network resources efficiently. While the successful design of high-performance traffic multiplexing protocols requires accurate modeling of traffic statistical characteristics and QOS, variations in the latter characteristics, topological network changes (some due to mobility) and/or failures in the response of network components, affect directly, and frequently dramatically, their performance characteristics. It is thus crucial that traffic and network performance monitoring techniques be deployed, first for the identification of traffic changes and network failures, and then for the subsequent adaptation of the protocol operations, the pertinent recovery of failures, and the appropriate reconfiguration of network topologies; such are the fundamental components towards the successful information management.

The main theme of this chapter is the effective traffic and performance monitoring of mobile heterogeneous networks, via the deployment of distributed and dynamic information management and network performance monitoring techniques. These techniques are implemented by statistically sound algorithms and are placed at key network locations, to accurately and efficiently track the dynamics of the system. The locations change as the network topology does; thus the traffic management and network performance monitoring system is mobile, where mobility induces time-varying network topologies.

This chapter suggests a systematic and comprehensive approach for the design of the distributed and mobile sub-network that monitors network and traffic dynamics, to subsequently dictate appropriate changes in accessing protocols (including bandwidth allocation), routing, and network topologies, and to also identify network failures.

We seek to develop and evaluate a mobile and distributed sub-network whose objective is to manage information traffic and to monitor network performance, in mobile heterogeneous networks. The fundamental issues addressed are:

- Characterization and modeling of the fundamental environment in which traffic and network performance monitoring operate, towards the development of a core monitoring algorithm.
- Identification of performance metrics and exploitation of algorithmic characteristics of the traffic and network performance monitoring techniques, as implemented by a mobile and distributed system.
- For given network topologies, identification of the minimum-size monitoring sub-network and its optimal topology, for complete traffic and network “visibility”. Exploitation of tradeoffs between computational load and bandwidth for information exchange within the monitoring sub-network.
- Investigation of mobility and the time-varying topology for the monitoring sub-network, as functions of dynamically changing network topologies.
- Consideration of Artificial Intelligence (AI) learning techniques for the adaptation of key monitoring operational parameters in the presence of dynamically changing traffic and network environments.