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Abstract

The unprecedented growth of the Information Technologies sector observed within the past years creates an excellent opportunity to conduct new, exciting and interdisciplinary research. Increasing complexity of the communication networks calls for incorporating rigorously developed and reliable methods for traffic control and management. Mathematics may offer extremely valuable tools to achieve these goals but transforming an engineering problem into the mathematical one requires a good understanding of the questions which arise in both domains. Furthermore, once the mathematical problem has been successfully dealt with, challenges in the application of the solution often arise back in the technical domain. One of the most important problems faced by networks users and operators are different anomalies by which we define any atypical situations in the network, regardless of their origin. Abnormal network behaviour from the user point of view may manifest itself in a very long waiting time for a service or a voice call having a bad quality. This may be a result of a hardware failure, a deliberate attack or simply a sudden big demand for a given service, just to name a few reasons. Such a situation in the language of mathematics may be re-expressed as a changepoint detection problem, i.e., a statistical test is developed to assess whether certain observed values originating from network measurements allow us to claim that some kind of statistically significant change took place in the network. Chapters 2,3 and 5 are devoted to the changepoint detection problem. Load estimation is another important question when considering network capacity planning. The method of calculating an average utilization is a nontrivial task in itself but in addition there are questions related to the probability of its value deviating substantially from the mean. Such situations may severely degrade network performance and thus should not be disregarded despite their possibly relatively low chance of happening. In Chapter 4 we consider this issue for one of the most fundamental models in networking. Another common question regarding communication networks is a resource allocation problem. Given parameters like link capacity, number of customers and their statistical characteristics, how many clients can be admitted while still meeting quality of service requirements? What if some customers should be treated with a higher priority than the others? These types of questions and the guidelines on how to deal with them can be found in Chapter 6.