Abstract

The fundamental problem of accessing a common resource by multiple actors is faced by many distributed systems, including processor transactional memory, wire and radio networks communication medium, and access to a shared resource on machines or data-centers. In many systems when more than one device attempts to access the common resource simultaneously, a *collision* occurs and in effect no device can use it.

Multiple-access channel (MAC) is a well-established model reflecting the key algorithmic challenges of such systems. In this model, stations attempt to transmit packets via the shared communication channel in discrete intervals of time called *rounds*. Due to the constraints of the channel, at most one successful transmission can happen at any round. Usually we consider the problem of keeping the system *stable*, while the packets to be transmitted can be injected into devices' buffers in an arbitrary way. That is, the total number of packets kept in the buffers needs to be limited even in an infinite execution.

In this dissertation we expand the classical MAC model by introducing channel *restraint*, understood as a bound on the number of stations that can be switched on simultaneously. Apart from proving bounds this restraint puts on several classical protocol classes, we design and analyse optimal and near-optimal algorithms functioning within this restraint as well as implement simulations for those algorithms.

In this dissertation we further expand the model by introducing routing ability for algorithms on MAC. Combined with the channel restraint, this model substantially changes the way algorithms on MAC can operate. We provide algorithms as well as bounds on abilities of protocol classes to achieve certain levels of stability or packet latency.

The third original contribution presented here is a novel adversarial average-case analysis method to study and compare algorithms performance. We demonstrate how such approach can be used for analysis of behaviour of some well-known algorithms. We also prove some dependencies between average-case and the popular worst-case analysis, including a counterpart

of Little's Law, in the context of adversarial packet arrival.

Finally we introduce a new taxonomy for the consider classes of models and algorithms that covers and unifies a very wide spectrum of similar settings considered in a vast related literature.

Keywords: multiple-access channel, adversarial packet injection, parallel queuing, routing, channel restraint, latency, throughput, stability