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PhD position

Multipath routing and collaborative load balancing

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Routing is one of the keys for controlling network resources. In current IP networks, routing algorithms objective is to find either a single best path between each pair of routers, either several paths with equal and optimal costs (ECMP [1]). More generally, a multipath routing algorithm is an algorithm that allows finding multiple routes between two points on the network, regardless of the constraints on the costs of these paths. Such protocols have been proposed in the literature ([2, 3, 4]). At the router level, the goal is to provide, towards a given destination, not only one but several output interfaces. The hop-by-hop composition of these alternatives provides a wide variety of routes which are distinct or not.
There are many advantages with multipath routing. On the one hand, calculating multiple paths with anticipation allows to quickly adjusting routes and overcoming failures that may occur in the network. In a distributed environment, routers can make local routing decisions that are faster than a global routing calculation. On the other hand, different paths can be used simultaneously to take advantage of bandwidth available on each of them. The main key is then to decide the ideal distribution of traffic among these multiple routes. This way, two approaches can be considered. The first is the assumption that one central equipment has the complete knowledge of traffic demands: the load balancing then consists in optimizing an objective function (of overall resource usage, used bandwidth, etc.). This view has been the subject of many studies. The second approach is to assign routing decisions to different actors in the network: they are asked to work together to achieve a satisfactory solution. The study of solutions within this last approach motivates this thesis.

Once the routers have selected a set of interfaces to commute IP packets, load balancing is a decision process that may be based on indicators which are local or received from other routers.
The nature of these indicators should be adapted according to the context in which they are employed. In particular, with regard to wireless networks, sharing policy may focus on power management or end-to-end connectivity. Sensor networks can also benefit from these mechanisms. In the context of multi-homed mobile devices, performance and cost of the available connections could impose additional constraints. Moreover, in the core network, one may choose to prioritize resources or avoid congestions. Variables relating to the quality of service could also come into consideration, for example by assigning real-time flows to one or more paths respecting specific constraints.

The main objective of this thesis is to focus on the collaboration between routers, which relies on an exchange of messages. These messages can be upstream requests such as throughput reduction ("backpressure messages"), as introduced by Gojmerac [5]. One can also imagine whether messages allowing the admission of new flows (interesting ideas are developed in Ammar's thesis, [6]), or disseminating information relating to the current conditions of routers (e.g. radio links quality, position and speed of a mobile node, or its battery level).

The qualitative or quantitative nature of the data exchanged, the triggers of these messages, their rate, and the action to be taken upon receipt are all behaviors to define and study. The candidate will have to evaluate the solutions he proposes, using simulation tools. Besides the quality of the distribution, convergence is a crucial point. The performance analysis will determine whether the proposed solutions are constantly evolving in an unstable state or whether tend towards an acceptable steady solution. In this case, the convergence time is an important indicator.

Références

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