TECHNISCHE WETENSCHAPPEN

Project title: *Network Dynamics and QoS*

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1. Summary

1.1 Research

During the last years, several new IETF working groups and framework documents have emerged such as Intserv, Diffserv, MPLS and traffic engineering. From an architectural point of view, a wealth of new – although some inspired by ATM - networking concepts has been introduced. While serious progress has been made on the architectural level, the evaluation of the impact (performance, behavior and limitations) of these new concepts appeared to be complex. This complexity has attracted increased interest in networking even from other disciplines than electrical engineering and computer science. For example, the field of "the physics of networking[1]" was born in a desire to understand how large networks such as the Internet behave. But also within electrical engineering and computer science, it is realized that we do not understand enough about the dynamics of communication (future) networks. In former networks such as the telephony network, the network was fixed, manually operated and designed for transport of a mono-service with well-defined traffic profiles and QoS requirements. The future networks are much more dynamic with automated network management, but above all, the intended services are widely varying in both capacity demand and QoS requirements.

The main purpose of this proposal is to *understand the network dynamics to propose efficient, QoS-aware and scientifically proven methods/algorithms/protocols to control/manage network behavior.* We first propose to study network dynamics (specified in depth in sec. 3) in fixed (as Internet, telephony, LANs) as well as in ad-hoc and peer-to-peer networks.
Specifically, the goal is to

a. understand the relevant physics of the dynamics of networks (interplay of time-scales, the influence of the scaling laws (hopcount, degree, disconnectivity, etc.) in the graph, translation of actual traffic to link weights, etc.)

[1] Relevant references on "the Physics of Networks" are

- D. J. Watts, *Small Worlds, The Dynamics of Networks between Order and Randomness*, Princeton University Press, 1999
- Albert-Laszlo Barabasi, *Linked, The New Science of Networks*, Perseus Publishing, Cambridge, Massachusetts, 2002
- S. N. Dorogovtsev and J. F. F. Mendes, *Evolution of Networks. From Biological Nets to the Internet and WWW*, Oxford University Press, 2003

b. propose a concrete 'network update strategy' (i.e. an algorithm that controls optimally the flooding in high bandwidth multimedia networks) for QoS routing in both fixed, ad-hoc and possibly peer-to-peer networks

The immediate outcome of the proposed research will translate to knowledge in computing/controlling network aspects such as e.g. loading, blocking, congestions, e2e-delay. Moreover, it is expected that scaling laws are obtained for network behavior (computational complexity, connectivity, etc.) if network/traffic/heterogeneity grows. The latter is useful for establishing dimensioning rules and for network management. At last, feedback to architectures and to specific service applications (such as massive deployment of VoIP, level of QoS achievable in ad-hoc networks, quality level of inter-ISP communication, etc.) is targeted.

1.2 Utilisation

This research in multimedia networking is important for at least two reasons: (a) a technical reason and (b) an economic reason.

(a) Real-time or interactive services (like telephony, real-time video, electronic games) need a minimum bandwidth and a guaranteed end-to-end transfer time. Although a first approach to meet these requirements consists of increasing the capacity in the network, future-save and well-controlled networking requires to implement some of the (difficult) QoS control mechanisms (signaling, admission control, resource reservation and routing).

(b) Control of QoS (technical lever) linked with a pricing strategy (economic lever) is a competitive weapon for a service/network provider to differentiate from his competitors. Moreover, QoS offers certain levels of guarantees for certain QoS classes. Clear service levels can be associated with a price such that a business model (which is currently lacking in Internet) can be made.

With respect to the telecom sector, the current IETF[2] strategy is to make the Internet QoS-aware. One of the crucial missing functionalities is QoS routing. The other IETF working groups (Intserv, Diffserv, (G)MPLS, Traffic engineering) are progressing and but are still far from maturity because of the inherent complexity of QoS mechanisms.

Some of the immediate applications of the project are:

- design/control of QoS-overlay networks on top of Internet
- design/control of MPLS (for Virtual Private networks, secured big pipes over Internet, etc.)
- data/results that the user group can use as input to standardization bodies (mainly IETF).
- insight in dynamics of wireless Ad-hoc networks
- applications of these network insights to content distribution and/or peer-to-peer networks

[2] The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet.