Integration of QoS provisioning in home and access networks

M. Popov(1), A. Gavler(1), P. Sköldström(1), and L. Brewka (2)
(1) Acreo AB, Electrum 236, 164 40 Kista, Sweden
(2) DTU Photonics, 2800 Kgs. Lyngby, Denmark
mikhail.popov@acreo.se

Abstract: Approaches for QoS provisioning using UPnP for home networks and GMPLS for access networks are described. A solution for interworking the UPnP and the GMPLS at the residential gateway is proposed.

OCIS codes: (060.0060) Fiber optics and optical communications, (060.4250) Networks

1. Access and home networks & residential gateway.

The access network is in general based on various wired (xDSL, cable, or optical fiber) and/or wireless (WiMAX, UMTS, LTE) technologies. The optical fiber access network comes in two major flavors: point-to-multipoint passive optical network (PON) with a passive optical splitter as a “distribution element”, and point-to-point active optical networks (AON) with an active switch in the field (also known as the Active Ethernet). In some cases, the fiber is deployed to the premises directly from the central office (with no active equipment in the field) which is referred to as the “home run” architecture [1].

The home network is a small network in an apartment or private house. The purpose of the home network is to deliver data services originating from the outside (the access network) or from the inside (e.g. from a media server). Computers and other devices in the home are connected to this network. An important property of the home network is that the data traffic rate inside the home can substantially exceed (up to two orders of magnitude) that of coming to or from the access network. The physical layer (PHY) solutions for the home network include wireless radio (mostly WiFi), wireless optics, Cat-5/6 cables, coaxial cables, power line communication (PLC) and optical fibers. The Cat5, coax and PLC solutions together with WiFi are the most typical home networking solutions today, whereas plastic optical fiber (POF) is an emerging solution [2, 3].

Typically, the home network consists of a modem (cable or DSL/fiber ONU and a residential gateway (RG) which incorporates a number of Ethernet ports (and can thus perform Layer 2 switching) as well as a wireless access point. Also, the RG typically performs IP routing and may include other network functionalities, for example, a built-in firewall and network address translation. In many practical cases of today, the majority of home network traffic goes via the gateway, in other words the connected devices communicate via the RG, but not directly to each other. Fig. 1 below illustrates the communication of devices inside the home with the services located in the local access network (video streaming) or outside it (Internet connection).

![Fig.1. Devices from the home network connect to the outside world via the gateway and access network.](image)

2 QoS provisioning in FTTx access and home networks

PON uses time-division multiplexing and one can configure the necessary QoS at the PON OLT for each end-user or a group of end-users. If the last mile of the access network is an Ethernet-based AON or one considers the QoS provisioning over the entire Ethernet-based access-distribution network, then one can either rely on statistical multiplexing or apply certain means of Traffic Engineering (TE) for data aggregation and delivery. The same applies to the home networks, which up to the date almost exclusively use Ethernet as the data link protocol.
The simplest “traffic engineering” measure one can think about is to overprovision the network, i.e. build it with the capacity a few times more than the expected aggregated traffic. As soon as the load of the network does not exceed a certain threshold, the packet loss and delay of data will be negligible and no other special measures for QoS provisioning will be required. If overprovisioning is not possible (e.g., too expensive to implement), one has to implement true traffic engineering in the network in order to minimize the delay and packet loss. A simple way to introduce the TE is to prioritize the data packets using tags in the Ethernet frames or “Type-of-Service” bits in the Internet Protocol packets.

Another way of implementing traffic engineering to is to direct packets in a pre-computed path. This approach requires an implementation of a control & management (C&M) plane for performing the operations related to the path computation, investigation of the available capacity of the links, resources reservation and other functions. The Universal Plug & Play (UPnP) QoS protocol can be conveniently used to communicate the C&M QoS information between the network elements configuring them in the proper way for transporting the data packets. This approach has been implemented for the home network within the European ALPHA project [4].

The major results up to date include the development of the UPnP QoS architecture framework and the initial tests allowing the verification of the UPnP C&M usability. In particular, the modeling and simulations have been performed for assessing the QoS for different traffic scenarios both for the signaling and data planes. The developed tools can be used, in particular, for fast prototyping of new features like automating the traffic classification.

For the access and distribution networks, consisting in general of the optical, Ethernet, and IP layers, the traffic engineering can be conveniently implemented using the Generalized Multi-Protocol Label Switching (GMPLS) suite protocols, in particular, the GMPLS control of multi-layer IEEE Ethernet 802.1Q (with amendments) [5]. The extension of GMPLS to cover the access and distribution network allows to ease its integration with other parts of the network (e.g., core) and to substantially simplify the management and operation of the entire operator network.

The key multi-layer Ethernet functions required for the GMPLS control plane have reported in [6]. Other major ALPHA results in the area include a multi-layer GMPLS Ethernet information model (i.e. which and where to describe Ethernet functions in the GMPLS control plane) and a number of GMPLS protocol extensions to support this model. Specifically, the achievements include: (1) layer/domain definitions, (2) link/node capability announcement, (3) constrained path request and calculation using PCE, (4) new multi-layer Ethernet label types, (5) advanced label management, and (6) inter-domain service provisioning.

3 Integration of QoS provisioning across access and home networks

In order to provide the end-to-end QoS across the access and home network domains the QoS provisioning mechanism must be mapped at the RG. This can be done, e.g., by incorporating a translation engine into the gateway which is responsible for translating the QoS requirements of the home networks (defined in the Traffic Specification parameter of UPnP QoS) to those of the access network and vice versa. For the case of the GMPLS access network, the information contained in the UPnP traffic specification can be mapped to the reservation protocol (RSVP) and together with the information gathered during the reservation procedure can be used for determining whether the required end-to-end QoS can be guaranteed. This and other approaches for GMPLS-UPnP interworking are currently under study within the ALPHA project.

5. Conclusions and acknowledgements

Approaches for QoS provisioning using GMPLS for access and UPnP for home networks have been successfully implemented and are currently under testing within the ALPHA project. A solution for interworking GMPLS and UPnP at the residential gateway is also under development. The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7) under project 212 352 ALPHA “Architectures for fLexible Photonic Home and Access networks”.