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Quality of Service in Open Broadband Access Networks

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Swisscom invests in increased bandwidth in residential areas. Even for today's digital subscriber line (DSL)-based access, not all capacity is used all the time. The remaining capacity can be made available to the public over a wireless network. In this vision many wireless LAN (WLAN) access points in homes cooperate to form a public cellular network. Such cellular approaches based on WLAN are currently studied within the European project OBAN on Open Broadband Access Networks.

This innovative approach raises some challenges in terms of coverage, security, mobility, and Quality of Service (QoS). Here we focus mainly on the QoS aspect, which includes sharing capacity between home and visiting users, as well as service quality.

The OBAN Concept

A broadband Internet access subscriber is typically connected over a broadband access network based on DSL, cable, or fibre to an Internet service provider (ISP). An increasing number of these subscribers also take advantage of a WLAN Access Point (AP) in their homes to allow convenient wireless access from devices in the household such as computers, notebooks, PDAs, set-top-boxes, etc. If hundreds of broadband access lines with attached WLAN APs in a given area are coordinated in an intelligent way, the vision of a broadband wireless access network will become a reality. The portion of capacity of DSL lines that exceeds the subscriber's bandwidth, and the fraction of currently unused subscriber's bandwidth, will become available for public wireless access.

Fig. 1. OBAN Architecture Overview.

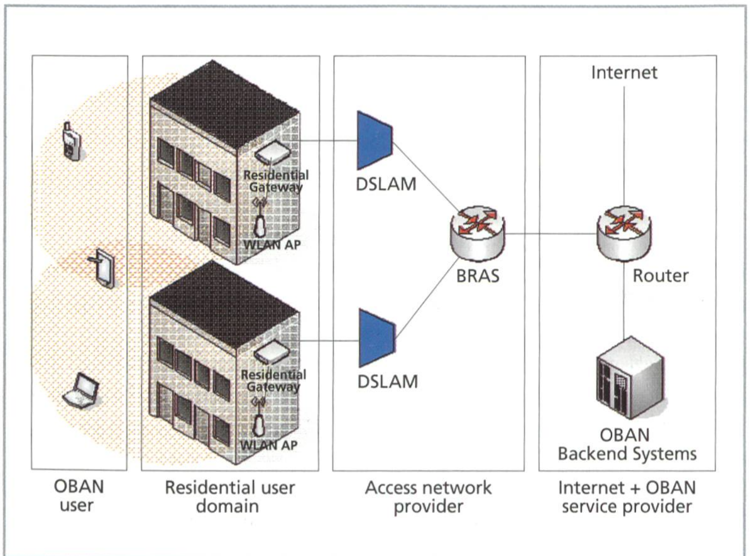

Figure 1 shows the basic architecture of the OBAN approach. This simplified concept involves four parties. The OBAN users are nomadic or mobile users with terminals able to access the OBAN network. Such terminals are, for example, connected to WLAN APs located in the residential user domain. Specific enhancements at the residential gateway enable a proper separation of the OBAN users from the residential network. The residential gateway is connected to the OBAN service provider over a broadband access network such as a digital subscriber line (DSL) connection and a digital subscriber line access multiplexer (DSLAM). A central element in the access network is the Broadband Remote Access Server (BRAS). The BRAS is responsible for subscriber management including authentication, access control, profile management and traffic control, and it serves as an edge router to the core network. The central management components and user databases of the OBAN system are located at the OBAN service provider. Authentication, authorisation and accounting (AAA) servers, the remote management of the OBAN components and mobility control components are located there.

To realise the OBAN concept, several extensions of existing technologies are needed in the area of network access, security, mobility, QoS and coverage. Here we give a short overview of important issues in these areas, and afterwards we concentrate on a solution to provide QoS.

A central concept for network access is the logical separation of the infrastructure in the residential user area into two parts. A first logical network serves the residential user while the second serves OBAN users. Such networks can each be assigned different network policies and security mechanisms.

The residential virtual network has the same characteristics as today's WLAN based home networks. Basically it consists of a WLAN AP and an access router with a DSL modem. The user sets the security association himself and the credentials are stored in the residential gateway. IP addresses are allocated by the residential gateway and network address translation (NAT) is also performed at this node. The second virtual network serves the OBAN users who are currently associated to a WLAN AP. This part looks more like a hot spot network, since it serves roaming users. In contrast to the residential network, communication with an AAA server in the OBAN backend system is required to control the access of OBAN users and to enable accounting. A central issue in the area of security is the mutual protection of the residential user and the OBAN users. Due to the fact that they need to share the home network resources special care needs to be taken to protect the devices of the different users. Further important security aspects concern the authentication of OBAN users. OBAN ISPs must not only control access of their own subscribers, but also potential subscribers from another ISP where a roaming agreement is in place.

In the field of mobility, the OBAN concept includes seamless solutions to enable visiting users to keep their sessions while moving from one AP to another. In particular, if a voice or video call is established, it should be continued without interruption when the user moves to another AP and a handover takes place. The seamless mobility solution is based on the Mobile IP (MIP) approach from the Internet Engineering Task Force (IETF).

A central issue for successful realisation of the OBAN concept is the coverage provided by the WLAN APs, as these are of low power (100mW). The high frequency band (2.4 GHz) where WLANs operate and the limited transmission power they are allowed to use, make it difficult to cover areas outside of buildings due to the dampening of walls etc. Upcoming concepts such as multiple antennas at the transmitter and at the receiver with advanced signal processing techniques (Multiple Input Multiple Output, MIMO) are a promising way to realise higher coverage without increasing the transmission power at the APs.

As it is rather unlikely that entire cities and urban areas can be entirely covered by WLAN APs located at the residential user's premises, it is necessary to include interworking with the 3G network. In areas without WLAN coverage the 3G network is able to fill the gaps and provide service continuity.

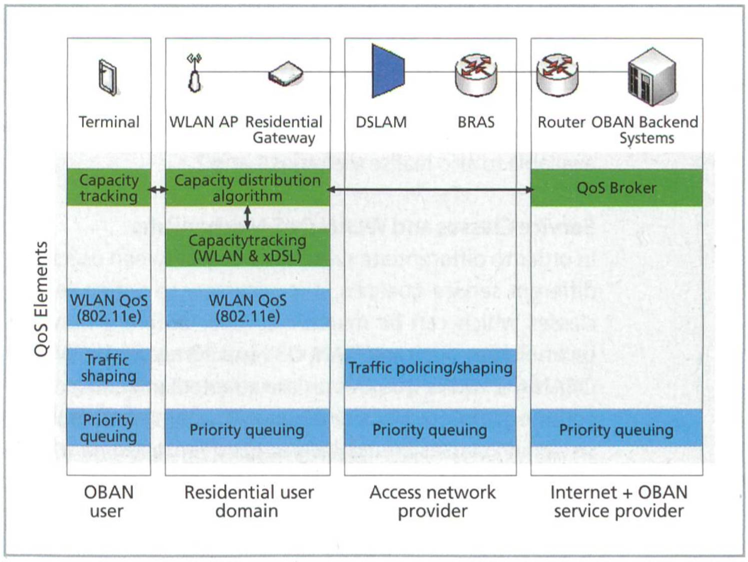

Fig. 2. QoS architecture.

Bandwidth Sharing among different Users

For traditional DSL access the residential user chooses a subscription with certain down- und upstream rates. With the OBAN approach the access line bandwidth needs to be shared with the visiting users. In order to achieve a high acceptance of the OBAN service and the residential user being ready to accept that visiting users share the access line, it is necessary to provide certain service guarantees. Depending on the business scenario a requirement for OBAN could be that residential users should be able to get their subscribed service without noticing that OBAN users are accessing their AP. Three relevant access line sharing scenarios are listed below:

Scenario 1: The residential user's subscribed network capacity is shared with the OBAN users. In this scenario, the access network provider just provides the capacity ordered by the residential user and visiting users take a part of this capacity. The residential subscribers traffic can be prioritised to prevent visiting users from taking all resources. From a business perspective, this scenario allows OBAN to be implemented without the cooperation of the access network provider. The scenario is currently applied by certain aggregators, such as Boingo and Linspot.

Scenario 2: Supplementary capacity is provided to the visiting users, without sharing the residential user's network capacity. In this scenario, the access network provider provides additional capacity for the visiting users. The residential user receives exactly the same service from the access network provider as before. The access network provider makes sure that the traffic of the residential and the visiting users do not interfere with each other. From a business perspective, this scenario involves the access network provider. One business variant is that the access network provider or the ISP of the residential user offers the same service to the visiting users. Another variant would be the cooperation of a fixed and mobile operator, or possibly a future converged fixed/mobile operator.

Scenario 3: Supplementary capacity for visiting users and sharing of residential user's capacity. In this scenario, the access network provider provides additional capacity for the visiting users (as scenario 2). However, these users can, in addition, use part of the residential user's capacity. From an access network operator's perspective, it is the best solution, as this provides the maximum capacity. From a business perspective, the access network provider is involved, as in scenario 2.

For QoS support, the architecture needs to handle different traffic classes according to the supported services. With Scenario 1, it is difficult to provide services with QoS support to visiting users because visiting traffic should not diminish the quality of the residential traffic. Therefore, only very little visiting traffic can potentially have priority over residential traffic. Thus, scenario 1 can mainly be used for best effort traffic offered to visiting users. Scenario 2 is a static sharing approach and needs two fixed dimensioned pipes for the residential and the visiting user, for example for ATM on layer 2, two ATM virtual circuits are needed. No additional QoS elements are needed in the fixed access network part to realise the sharing mechanism with two ATM virtual circuits. For the realisation of scenario 3, an additional QoS entity is necessary to restrict residential users to their subscribed capacity (with associated monthly fee). This can be done through the access network provider by applying shaping and policing mechanisms. With the implementation of scenario 3, sufficient flexibility and mechanisms are available to also realise scenarios 1 and 2.

Service Classes and WLAN QoS Mechanisms

In order to differentiate simultaneously between users and different service qualities, it is necessary to define service classes which can be maintained over different network technologies, such as WLAN, DSL and 3G networks. Within OBAN the UMTS QoS classes are adapted and chosen as a common basis for all technologies. The conversational and streaming classes are typically applied for real-time traffic, using UDP as transport protocol, while the interactive and background service classes are used for elastic traffic. In order to control the usage of these classes, it is necessary to have an admission control with entities controlling the available resources in the WLAN and the DSL part of the OBAN network. To keep complexity within reasonable limits, the admission control is performed on a terminal basis at the same time as the authentication process takes place. Therefore, a terminal is only admitted at an AP if a minimum amount of bandwidth is available to support the device. Otherwise, the terminal needs to scan for an alternative AP or access an umbrella cell (3G network).

The four service classes defined above need to be realised in all parts of the OBAN network in order to provide end-to-end QoS. In the fixed access network based on DSL, the service classes can be realised by multiple queues with priority queuing. In the case of an ATM-based DSL access, it is possible to serve different classes by the setup of multiple permanent virtual circuits (PVCs) with different QoS classes. In the WLAN part, QoS support is a slighly more challenging due to the distributed access to a common wireless medium. Here the upcoming IEEE (Institute for Electrical and Electronic Engineers) standard 802.11e introduces some relevant mechanisms to enable QoS. There are four different Access Categories (AC) defined which correspond to four different priorities. The 3GPP QoS classes introduced above are needed for seamless interworking with the 3G network; however they must be mapped to the ACs in the WLAN environment. Since it is necessary to differentiate between users and additionally between traffic classes, several user/traffic class combinations need to be assigned to each AC. There are different approaches for this mapping. In a first approach, the visiting user's real-time traffic takes priority over the residential user's low priority traffic, whereas in a second approach all residential user traffic has priority.

OBAN QoS Architecture

In the previous section, the mechanisms needed to provide QoS in each part of the network were discussed. As a next step we need to define where the different QoS elements are placed and how they interact in order to provide an end-to-end solution for QoS support.

Figure 2 shows an overview of the QoS architecture. The green boxes are QoS elements that are dedicated to resource management. The decision as to whether or not a mobile terminal that requests admission to OBAN can be accepted is made by the *QoS broker*. In a first step *the QoS broker* gets the profile of the user from the backend AAA server. The profile includes basic service classes and rates which correspond to the subscription of the user. Given the user profile, the broker asks the *capacity distribution algorithm* in the residential gateway whether the requested resources are available. Given that the resources are available, the broker accepts the terminal. To ensure that the allocated capacity in the WLAN part can be maintained, the WLAN AP resources need to be tracked continuously. As the situation changes depending, for example, on how far the terminals are away from the AP, it may be necessary to redistribute allocated resources from time to time.

The blue boxes in Figure 2 show the elements responsible for traffic control which realise the different service classes in the different network parts. The *WLAN QoS* elements and the *priority queuing* elements are dedicated to the realisation of the service classes. The *traffic policing/shaping* components enforce the compliance of the sent and received traffic to the profile of each OBAN user. This is usually done by the BRAS and optionally, in upstream direction, also at the terminal.

Conclusion

A promising approach to build a broadband mobile network is to open the broadband fixed access networks in a controlled way. It is also cost efficient, as existing access line capacity is used and made available using mass market WLAN equipment. With the upcoming VDSL technology, potentially much higher data rates of between 10–20 Mbit/s downstream will become possible. To realise an OBAN, it is necessary to look more in detail at the areas of network access, security, mobility and QoS, as the technical solutions in these areas differ significantly from a hotspot or residential WLAN network.

The QoS solution in OBAN is focused on two aspects. Firstly, bandwidth sharing between OBAN users and residential users needs to be coordinated. For efficient sharing of access bandwidth, it is necessary to include the fixed access provider in the resource management process. The second aspect concerns the differentiated handling of traffic classes in order to support real time applications, where a QoS broker is needed to control the access of OBAN users. New terminals are only admitted where enough resources are available to support the user's service profile. The methodology used to provide the same QoS in OBAN and the 3G network enhances the "always best connected" experience for the user. ■

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