YouTube QoE-Aware Gateway Selection in Future Wireless Networks

Florian Wamser, Barbara Staehle, Rastin Pries,
David Stezenbach, Sebastian Deschner, Dirk Staehle
University of Würzburg, Germany
{wamser,bstaehle,pries,stezenbach,deschner,dstaehle}@informatik.uni-wuerzburg.de

I. Introduction

The evolution and growing dissemination of the wireless Internet as well as the considerable usage heterogeneity introduced by new fields of applications, raise the need for intelligent resource management in future wireless networks. This necessity is urgent as state-of-the-art wireless resource management is mostly (1) unaware of the Internet applications in the network, (2) enables best effort Internet access only and (3) does not allow application-network interaction. This has been identified as a serious drawback for modern wireless networks and results in different research activities aiming at developing cross-layer and network wide control and management concepts [1].

One approach towards a more intelligent resource management is the idea of *application comfort* (AC) based resource management [2], [3]. Application comfort quantifies how well an application is currently running and allows a prediction of the quality of experience (QoE). An AC monitoring tool running at the client and cooperating with resource management tools thus allows (1) to guarantee application-specific service levels and (2) to react prior to a QoE degradation. In contrast to conventional solutions, the use of an AC monitoring tool avoids the need of complex flow classification techniques like deep packet inspection, TCP/IP or application header analysis or the use of heuristics, as the tool simply signals the existence of a certain application to the network. Secondly, a QoE-based resource management does not need to know application-specific QoS requirements which are often not known or even changing over time as it is e.g. the case for videos with variable bite rate, but is able to adapt the network resources in dependence on the application performance.

To illustrate the benefits of AC for a network resource management architecture we propose the following demonstration: A client in a wireless mesh network (WMN) is playing YouTube videos while the YouTube AC monitoring tool YoMo [2] continuously monitors the YouTube AC at the client. We chose the example of WMNs since they are an attractive low-cost option for offering broadband wireless Internet access. Second, practically implementing resource management strategies is possible on open source mesh nodes, and third, WMNs provide an enormous potential for an improved radio resource management when application layer quality feedback is available. YouTube has been chosen as a representative future Internet application.

This work was funded by the Federal Ministry of Education and Research of the Federal Republic of Germany (Förderkennzeichen 01 BK 0800, GLab). The authors alone are responsible for the content of the paper.

In the case of a network performance degradation, the YouTube AC is decreasing. YoMo recognizes and announces this to the network resource management. In an earlier study [3] we demonstrated how a bandwidth shaping tool can be used to restrict the resource consumptions of concurring best effort flows. In this demonstration, a less aggressive solution for multi-homed WMNs will be shown. Multi-homed WMNs are on the one hand typical for wireless community networks and on the other hand offer a high degree of flexibility. Thereby, the existence of more than one Internet gateway will be typical for future wireless access networks but the related opportunities and challenges have been neglected by research so far. We exploit one of the opportunities multi-homed WMNs offer for ensuring the user experience. If several gateways to the Internet are existing, it is possible that the network reacts with a seamless TCP flow relocation to a less charged gateway. In our demonstration, several future Internet tools cooperate to ensure a good network performance and achieve the following: (1) application quality estimation by AC monitoring, (2) gateway evaluation taking into account the current utilization and, (3) seamless flow relocation with the help of a dynamic rerouting.

II. Demo Setup

In this demonstration, the usability and the advantages of an application aware resource management architecture are presented. We consider the scenario shown in Fig. 1 of a multi-homed WMN with two Internet gateways. One mesh node acts as mesh access point (MAP) for one client which displays YouTube videos. In the initial situation (dashed line), it shares one gateway with another client downloading files and thereby, reducing the bandwidth available for the YouTube flow. YoMo, which is running at the client, continuously measures the YouTube AC, which is given by the filling of the buffer level, and recognizes an imminent stalling if the buffer level falls below a threshold. In this case, it sends an alarm message to the tool Nigel (short for New Internet Gateway sELector) which is running at the MAP and able to reroute the YouTube flow to another gateway if necessary. If

Nigel receives such an alarm message, it requests the gateway status at the gateway rating controller Dory (short for Decider Over Rerouting YouTube flows) and changes the route to the best performing gateway (solid line), which is the less charged GW2 in this case.

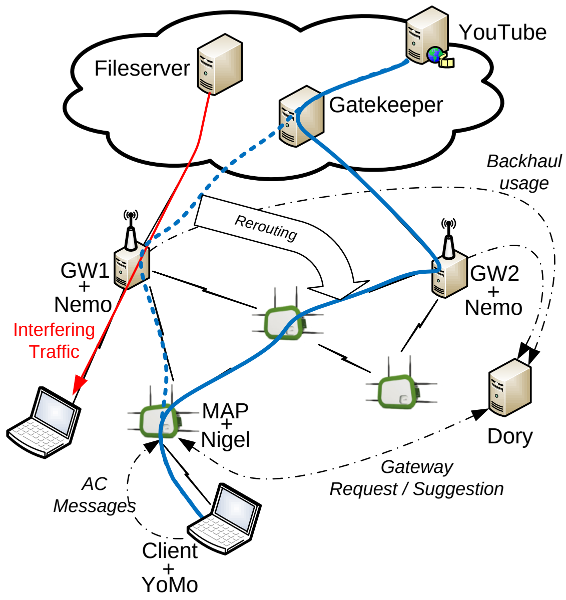

Fig. 1. Demo setup

In order to enable Dory to estimate the current performance of the gateways, an application called Nemo (short for NEtwork MOnitor) is running at each gateway and periodically sends information on the backhaul usage to Dory. This basic functionality is summarized in a sequence diagram in Fig. 2. For a seamless TCP flow switch between the mesh gateways, our architecture includes an additional element, the so called gatekeeper, a management PC located somewhere in the Internet acting as a mobility anchor for the mesh gateways.

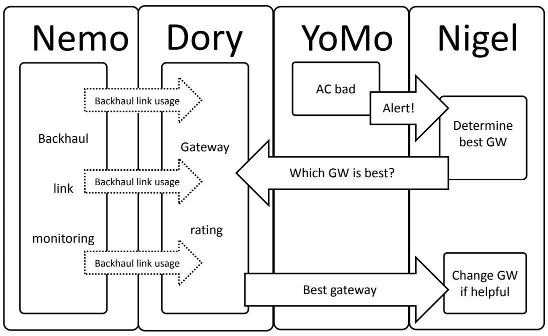

Fig. 2. Sequence diagram

Results from an experiment where an interferer reduces the bandwidth of a mesh client are shown in Fig. 3. After 15 seconds, the client flow is switched to another gateway and regains its prior throughput. For the case of a YouTube video, a similar bandwidth reduction would lead to a stalling and thereby a QoE degradation. During the demonstration, we therefore use YouTube to underline the benefits of AC aware resource management. For this purpose, we set up two test cases. In both cases, the client displays YouTube videos and initially shares GW1 with the interfering traffic generated by the second client. In case 1, the AC status is not announced to the network. Thus, the network cannot react even if the YouTube performance degradation is recognized at the client. Consequently, the YouTube video is going to stall. In case 2, the gateway rating is used to determine the most reasonable gateway. Dory is able to recognize which gateway is congested. In order to demonstrate the dynamic flow switching, in the remainder of the experiment, fluctuating disturbing traffic at the gateways is initiated. Dory signals the rating for the gateways. Consequently, if now YoMo detects again a bad YouTube AC, the network switches the flow to the best-rated gateway seamlessly. Moreover, if a gateway change is not reasonable since both gateways are congested, in this case an unnecessary gateway change is avoided. Out of the two cases, the YouTube playback will only be smooth in case 2 if one arbitrary gateway provides free resources and stall otherwise.

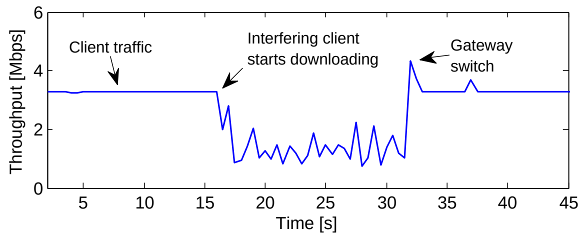

Fig. 3. Effects of interfering traffic and gateway switching on the throughput

III. Conclusion and Outlook

During our demonstration we show that the introduced tools are smoothly and efficiently cooperating and thereby preventing a YouTube QoE degradation. This guarantees a high YouTube user satisfaction even in WMNs with one or more congested gateways. Our management architecture is very lightweight and, easy to install and to maintain which makes the concept even more attractive. Future works will be dedicated to extending the concept of AC monitoring towards other applications like gaming and to examine the cooperation possibilities of different RRM tools.

References

[1] Goldsmith, A., *The next wave in wireless technology: Challenges and Solutions*, Keynote at European Wireless 2010, Lucca, Italy.

[2] Staehle, B., Hirth, M., Pries, R., Wamser, F., and Staehle, D., *YoMo: A YouTube Application Comfort Monitoring Tool*, QoEMCS@EuroITV, Tampere, Finland, June 2010.

[3] Staehle, B., Hirth, M., Wamser, F., Pries, P., and Staehle, D., *YoMo: A YouTube Application Comfort Monitoring Tool*, Technical Report 467, University of Würzburg, March 2010.