Call Capacity for Voice over Internet Protocol on Wireless Mesh Networks

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Abstract-This paper describes work in progress on call capacity optimization for voice over Internet Protocol on wireless mesh networks. In a developing country such as South Africa, evidence has shown that rural inhabitants find it difficult to afford the voice services offered by cellular networks. Voice over Internet Protocol is known for its affordability relative to cellular voice services, therefore deploying such services for rural communities will not only benefit rural inhabitants but also offer economic advantages to service providers. We are interested in the provision of voice services with rural wireless mesh networks. Unfortunately voice on mesh networks can experience packet loss and delays that cause reduction in voice quality. Transmission of small voice packets over wireless mesh networks imposes high overhead that leads to a tremendous decrease in call capacity. Therefore, we aim to study the performance of voice over 802.11 wireless mesh networks and evaluate packet aggregation mechanisms that merge small voice packets into a single large packet, in order to preserve voice quality with more calls. We will implement and evaluate packet aggregations mechanisms on a 'mesh potato' network with iterative cycles of laboratory experiments using a network simulator to collect data for performance evaluation.

Index Terms— WiFi 802.11, Quality of Service (QoS), Voice over Internet Protocol (VoIP), wireless mesh networks, packet aggregation.

I. Introduction

This paper describes work in progress concerning call capacity optimization for voice over Internet Protocol (VoIP) on wireless mesh networks (WMNs) by using optimization techniques such as packet aggregation. VoIP services are increasing in popularity due to ubiquitous Internet availability. For instance, Skype recorded more than 10 billion minutes of call time in its first year of deployment. This tremendous volume is due to cost-effectiveness achieved by VoIP and that its deployment is easy [1]. VoIP over wireless networks can also be used at homes and offices, in both developed and developing countries such as South Africa. Of particular interest to us are wireless mesh VoIP projects like Village Telco (www.villagetelco.org). A village telco is a community based telephone network that is based on a suite of open source applications that enable entrepreneurs to set up and operate a telephone service in a given area, urban or rural. Mesh networks are also inexpensive and easy to deploy.

A village telco can be designed for a rural community with a collection of 802.11bg mesh routers, known as 'mesh potatoes', that use an FXS port to connect an analog phone to a VoIP network, e.g. with Asterisk. Thus, end-users in rural communities can make 'free' VoIP calls using mesh potatoes connected via a village telco, and can make prepaid PSTN breakout calls provided a gateway is in place. However, this cheap and convenient VoIP over wireless mesh has its downfalls. For instance, maintaining QoS for VoIP traffic in a mesh network can be difficult. Packet loss can be deleterious due to interference when using unlicensed bands, and also high overheads of the TCP/IP stack. Research has shown that on a wireless mesh network with 2Mbps link speed, the number of calls reduces from 8 calls in a single hop to one call after 5 hops [2]. This major call capacity reduction is caused by the transmission of so many small voice packets over 802.11wireless mesh networks. Our challenge is to learn how to deal with such a problem.

The rest of the paper is organized as follows. The next section describes related work. Section III proposes methods to learn how to increase call capacity. Finally, Section VI concludes the paper and identifies future work.

II. Related work

Research has shown that one of the major reasons why the number of calls decreases as the number of hops increases is high overhead in the lower layers of the OSI stack, and that MAC layer headers are the dominant factor that causes high overhead [3][4]. Other research has shown that there are several mechanisms to reduce high overhead, e.g. header compression using a scheme called Robust Header Compression (ROHC) [5]. ROHC can reduce a 40 byte RTP/UDP/IP header to a 2 byte connection ID that can be used for only one hop. IP-based adaptive packet concatenation (IPAC) is a packet aggregation scheme that aggregates packets based on the quality of the link [6] (see Figure 1). This work showed that a good quality link can carry larger packets while a poor quality route may drop the packets if it carries packets that are too large.

Packet aggregation is classified as end-to-end or hop-by-hop [2]. End-to-end packet aggregation is done at every source. That is, packets sent toward a common destination are aggregated together. In hop-by-hop aggregation, packets are aggregated and disaggregated at every hop by adding a forced computation delay at every hop.

Research has exposed limitations of the distributed coordination function (DCF) of IEEE 802.11ab in supporting VoIP calls over a wireless LAN in [7]. 802.11 DCF is a MAC technique that assists in preventing collisions by employing CSMA/CD. The study focused on the upper bound on the number of simultaneous VoIP calls that can be supported in a single hop running DCF. Calculations using mathematical methods were done for three standard codecs namely ITU'S G711 a-Law, G723.1 and G729. In this study with a G711 codec, a 20ms payload entailed a maximum of 12 connections and a 28ms payload had a maximum of 40 connections. Therefore increasing the size of the payload was found to be a solution to increase call capacity. Conclusions were drawn that the larger the payload per frame in a wireless mesh network, the more the number of supported voice calls could increase. This study showed that smaller voice payload packets can decrease the number of supported medium quality calls and increasing the payload per frame is a desirable solution.

III. METHODS

We wish to explore such techniques, as described in the previous section, on mesh potatoes for a typical village telco deployment environment. Iterative cycles of laboratory experiments will be conducted on a simulated mesh network using simulation tools such as ns-2/ns-3. We also intend to conduct similar experiments on an actual mesh network with mesh potato devices.

A mesh potato runs OpenWrt and there are QoS scripts that are used or installed inside OpenWrt to maintain QoS. We would like to develop a mechanism that will increase call capacity while the QoS scripts still maintain QoS. Modification will be done on the QoS scripts inside OpenWrt such that the packet aggregation technique improves call capacity while voice packets are not lost. Factors such as packet loss, latency and jitter will be measured to ensure that QoS is not compromised when this packet aggregation technique is implemented.

Packet aggregation techniques implemented on wireless mesh networks have been shown to increase call capacity tremendously [2]. Therefore we propose examining packet aggregation algorithms (see Figure 1) on mesh potatoes.

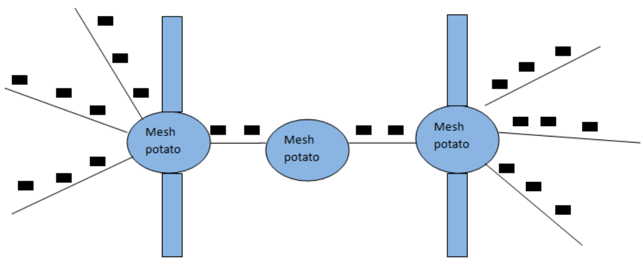

Figure 1 illustrates small voice packets from different calls being aggregated to form one large packet and then being disaggregated.

Research has shown that high protocol overhead is mainly caused at MAC layer 2 and also at layer 1. Thus aggregation at the IP layer of the TCP/IP stack can help relieve overhead [4]. The use of packet aggregation mechanisms will result in a decrease of protocol overhead thus increasing the number of supported calls. Our goal is to learn which packet aggregation mechanisms will work best for a mesh potato network.

IV. CONCLUSION AND FUTURE WORK

VoIP has been described in related work as an affordable protocol when deployed over mesh networks with attendant QoS challenges. We want to improve VoIP capacity on wireless mesh networks composed of mesh potatoes. This paper has provided a description of the drawbacks of VoIP traffic over wireless mesh networks. Research has shown that MAC layer overhead is the dominant factor that reduces call capacity. We will experiment with hop-by-hop packet aggregation techniques on mesh potatoes to increase the number of VoIP calls supported.

Research has shown that a good quality route can carry a large aggregated packet while a poor quality route can suffer higher packet loss if large packets are transmitted over it [6]. Therefore for future work we would like to determine the ideal aggregated packet size in order to maintain VoIP quality. Header compression has been shown to be also one of the effective techniques to increase the number of calls supported. Therefore we would like to compare header compression techniques with packet aggregation on a mesh potato network to discover the call capacity management techniques that are most effective on those devices.

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