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Evaluating the Energy Efficiency of Modern VoIP Applications

Athanasios Paraskelidis
Lecturer
School of Computing, University of Portsmouth
UK

Mo Adda
Principal Lecturer
School of Computing, University of Portsmouth
UK

Mr. Thilina P.R. Manana Dewage
Security Consultant
Newpoint Servicios Especializados
Spain

Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209
Email: info@atiner.gr URL: www.atiner.gr
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Evaluating the Energy Efficiency of Modern VoIP Applications

Athanasios Paraskelidis
Lecturer
School of Computing, University of Portsmouth
UK

Mo Adda
Principal Lecturer
School of Computing, University of Portsmouth
UK

Mr. Thilina P.R. Manana Dewage
Security Consultant
Newpoint Servicios Especializados
Spain

Abstract

With consistently increasing cost of energy and the increasing attention for reducing carbon, the need of less energy consumption solutions are inevitable. The reduction of Carbon footprint in the communication platforms has been identified as one of the main considerations in the future communication systems. This is due to the increasing participation by governments, lawmakers and regulators to encourage organisations and general public to use Carbon neutral or less Carbon consumption products. Research on energy efficient applications for mobile and stationary computer systems has been quite limited so far and only recently has started to be under focus.

The current research paper focuses on developing a less energy consuming voice, video and text communication platform to reduce the overall carbon footprint in organisational level. The first step was to develop a VoIP application (Green Talk) from scratch and this would offer users all the basic communication features (text, audio, video) like other well known such as "Skype" and "Google Talk" offer. The developed application goes through a number of tests in an attempt to calculate its power consumption during text, voice and video communications. During the experiments, a specific procedure was followed in an attempt to ensure that the most accurate results would be gathered. A software tool, Joulemeter, is used to estimate the computer's power use but also the power impact of a specific application. Once the results for "Green Talk" are complete the end product is evaluated against publicly available communication platforms such as “Skype” and “Google Talk” to validate the energy consumption and carbon usage. Based on the gathered results, when "Green Talk" is configured to provide the same quality of audio and video communications as the other two applications, it's power consumption proves to be significantly lower. The difference might seem to be insignificant for a single computer but if this is scaled up to the million users of "Skype" and "Google Talk" worldwide, the energy savings and the smaller carbon footprint of "Green Talk" are by no means negligible.

Keywords:

Corresponding Author:

Introduction

The rapid development of the internet based voice communication has consistently proved the direction of the future communication infrastructures. The expansion of internal communication systems requires an efficient, manageable, secure, cost effective and much greener communication platform for the industry. The performed experiments in this paper mainly focuses on the advantages of using such a platform to reduce the carbon footprint in the organisational level. By the term carbon footprint is described the measurement tool to monitor and calculate the impact of the human activities to the environment.

The proposed communication platform focuses mainly on the small and medium enterprises such as colleges, universities, state agencies or any prospective organisation that desires to use greener communication platforms. The main problem faced is the lack of competitive greener communication platforms. At present, vendors such as CISCO Systems and AVAYA Inc provide industry related VoIP products. These VoIP integrations provide a substitute for the existing internal communication systems though the actual system installation and maintenance do not address the respective carbon usage. Most of the modern hardware based communication systems use direct and indirect carbon related product at their manufacturing facilities. The organisations, which are keen to use greener internal communication platforms, face a lack of cost effective products for their requirements. This paper addresses such issues by providing a software based communication platform that can be used on top of the existing network infrastructures.

As a growing trend, the environment unfriendly human activities must be controlled and managed effectively to reduce their impact to the environment. To achieve this, new technologies and methods can be used. The proposed software based communication platform will help to reduce the use of hardware products that can increase the carbon footprint. This assists prospective organisations to use and enhance their carbon management in line with the respective government policies.

Literature Review

A softphone (*soft*ware tele*phone*) is an application program that enables voice over Internet Protocol (VoIP) telephone calls from computing devices. In the enterprise, softphones are sometimes referred to as *soft clients*. Most softphone applications work in conjunction with a headset and microphone, a specialised VoIP phone, sometimes called a hardphone, or by using a device called an analogue telephone adaptor, such as magicJack, that enables VoIP calling from a standard telephone handset.

Although softphones are most often associated with mobile or home users, office workers are also choosing to use softphones as a convenient replacement for traditional desk phones. Two of the most famous softphone applications are Skype developed by Microsoft and Google Talk developed by Google Inc.

According to Mercier (2013), on April 2013 Skype (2013) proudly announced that their users spend a total amount of 2 billion minutes per day on Skype and on February 2013 Skype announced that there were more than 280 million active users each month. Using these two numbers, this means that the average daily time spend on Skype calls is 7 minutes per active users. The numbers are immense and that shows the popularity of softphone applications for desktop or mobile users. Generally in life, when something is so popular it does not always mean that it is and cost effective. In cases of applications that run on computer system, the cost is closely related to the amount of energy an application consumes when it is running and consequently to the amount of carbon emissions produced from such an activity.

Taking into consideration the amount of users these applications attract and the ever increasing energy costs, there two questions that come into our minds. The first is, how much power Skype and Google Talk (2013) consume during every day use and the second is whether there is an alternative VoIP solution that would consume less energy than the other two. The existing research related to a topic like this is limited. Most of the researches try to measure and compare the energy efficiency of different VoIP architectures such as client-server (c/s) and peer-to-peer (p2p).

Baset & Schulzrinne (2010) identified the key components that are implemented on servers in a c/s VoIP system and by super nodes in a p2p VoIP system like Skype. They presented a model for understanding power consumption of c/s and p2p VoIP systems. They performed a number of experiments to determine the power consumption of different components of c/s and p2p VoIP systems. The model, analysis, and measurements indicate that for VoIP systems used as a replacement for always-on PSTN system, the power consumed by hardphones and connected network devices (broadband modems, home routers, and enterprise switches) overwhelmingly dominate the total power consumed by the VoIP system. Moreover, when comparing c/s and p2p VoIP systems, our results show that even when super nodes consume relatively small power for system operation, the p2p VoIP system can be less energy efficient than a c/s VoIP system. Further, we demonstrated the presence of NATs as the main obstacle to building energy efficient VoIP systems.

Nedevschi et al. (2008) have developed models describing the relative power efficiency of c/s and p2p architectures for generalised network applications. Most networked applications use either a largely centralized architecture (e.g. iTunes) or a p2p architecture (e.g. BitTorrent). The popularity of centralized Internet applications such as Search and web portals has fuelled the growth of large data centres. Modelling and minimizing the power consumption of large data centres is the hot new research area (pun intended). However, no attention has been paid to the power consumption of p2p systems.

Valancius et al. propose a new, distributed computing platform called Nano Data Centres (NaDa). NaDa uses ISP-controlled home gateways to provide computing and storage services and adopts a managed peer-to-peer model to form a distributed data centre infrastructure. To evaluate the potential for energy savings in NaDa platform they pick Video-on-Demand (VoD) services. They develop an energy consumption model for VoD in traditional and in NaDa data centres and evaluate this model using a large set of empirical VoD access data. They find that even under the most pessimistic scenarios, NaDa saves at least 20% to 30% of the energy compared to traditional data centres.

In our approach, initially we compare the two applications, Skype and Google Talk and measure their power consumption when using their capabilities such as instant messaging, audio and video chatting. The next step is to develop our own VoIP p2p based application called Green Talk able to satisfy the same functionality requirements inside the same networking environment such as a Local Area Network.

One of the first steps of our research was to identify the best protocol to be used and would enable us to build a power efficient VoIP application. Camarillo (2001) suggests that the Session Initiation Protocol (SIP) consumes less energy that other protocols such as Bearrer-Independent Call Control (BICC), H.323, and Media Gateway Control Protocol (MGCP). As a result the selected protocol used for developing Green Talk will be SIP.

Design and Implementation

One of the first steps of our research was to identify The constant reduction of the cost per bit rate and the growth of capacity and network availability made the idea of use the internet for voice communication over the existing PSTN architecture. Therefore, the need of a protocol that defines the set of rules for voice transmission over a packet based network is inevitable. Session Initiation Protocol (SIP) and Real-Time Protocol (RTP) defined such standards for signalling and media transmission in VoIP environment.

SIP has been identified as simpler and less weight protocol over its counterpart. This affects to the overall energy consumption of the system. In addition, SIP consists of various features that can be implemented to enhance the VoIP applications. As an open standard, SIP RFCs are updated with new features, and based on the requirements the developer can implement the functionalities. The link between signalling and media can be implemented via SDP (Session Description Protocol). On the other hand, H.323 provides a much advanced and reliable platform for communication from LAN to WAN architectures. As an ITU (International Telecommunication Union) protocol, the standard is maintained by the organisation and improvements will only proceed with the collaborative partners of the organisation. In addition, the lack of client side development tools assists to concrete the use of SIP over H.323 for the proposed development process.

The media transmission is implemented using RTP streams. The main reason behind the selection is that RTP is a tailor made protocol for media transmission over IP networks and it addresses the Quality of Service issues such as jitter and latency in the VoIP regime. In addition, the protocol itself provides the cross functions with its signalling protocols such as SIP and H.323 in collaboration with SDP.

Due to the SIP based p2p implementation complexities, the proposed system is integrated with the SIP server component to provide SIP Request and Responds signals between users. The registrations data is stored in a centralised database and the client applications will effectively communicate with the database in order to register and verify the authentication data for the participating users. In addition, SIP server components contacts the user agent client in the Login process to notify the available online users in the network. Figure (1) shows the basic operational illustration of the SIP and IP protocols.

The programming language used to develop Green Talk is Java (2007) as its SIP stack is recognised as a one of the decoy industry standard for such developments. This is due to the unique advantages and support available under Java developments. Under JAIN-SIP, Java defines its SIP stack with general signalling functionalities and advanced SIP services such as servlet, proxy, registrar and location server components. The basic architecture of the stack can be defined as follows.

The user agent client is be implemented with the relevant functions to query a database developed using MySQL and the main reason for using it is its availability under the General Public Licence (GPL). Finally, the development was done with the use of Netbeans 6.9 Integrated Development Environment (IDE).

Testing

Great attention was given to the tools that could be used in order to measure the energy consumption of the three applications. The available software based tools used is Joulemeter (2011) developed by Microsoft Research. No hardware based tools were used as the price of this type of equipment is very high. Joulometer was selected because it is freely available, is not hardware dependent and is compatible with the operating systems used for testing. Figure (2) shows the set up of the test bed used for the experiments.

The resources used for the experiments are:

- Laptop 1: 2.19 GHz AMD Athlon 64 Processor, 1GB RAM, Windows XP SP3
- Laptop 2: 1.60 GHz Intel Pentium Processor, 2GB RAM, Windows Vista
- Switch: A Netgear 4-port switch with wireless capabilities
- 3 pieces of cat5e cables, 20 meters in length each, running at 100Mbps

All three applications were tested in sequence and the same procedure was followed in order to guarantee the most accurate results. During the testing, two users were performing specific tasks such as an audio conversation and a video conversation. The duration of each task was 120 seconds long. Joulometer was initiated once users had logged in to the VoIP service. Three scenarios were tested for each three applications and these were:

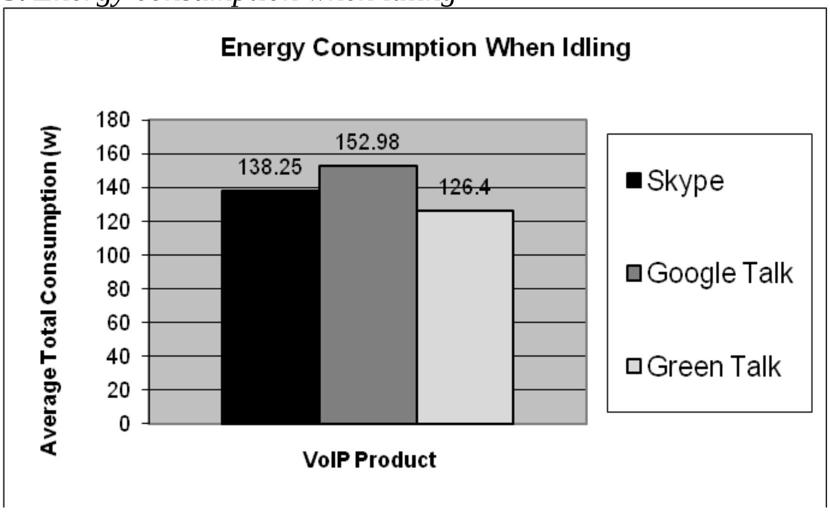
- Device sitting idle for 120 seconds
- Two users initialised an audio session for a period of 120 seconds
- Two users initialised a video session for a period of 120 seconds

It's worth to mention that the web camera used for the video sessions was an onboard camera of low definition and the microphones were also onboard. The video and voice codecs used in the tests for Green Talk were the well known and broadly used G.723 and H.263. The results of the test are presented and discussed in the following section.

Results and Discussion

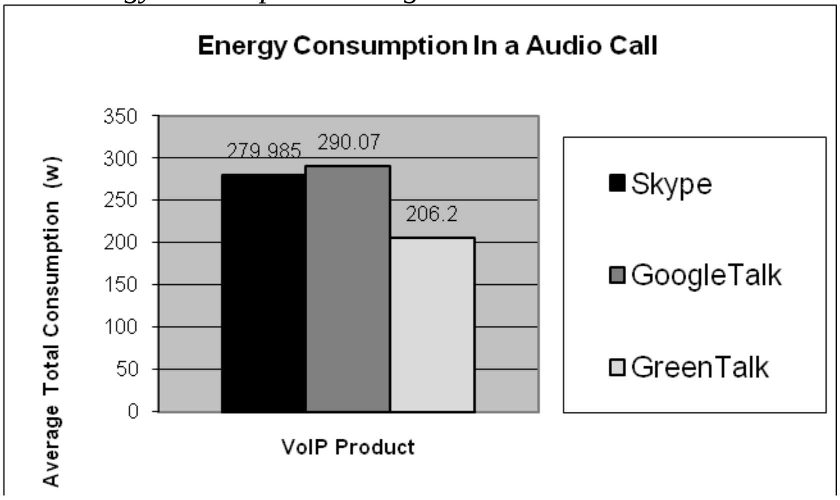
The presented results show the total energy consumption of the computer during the three testing scenarios and include the energy that was consumed by the screen, the CPU, the motherboard and the hard disk.

Figure 3. *Energy consumption when idling*



The results in figure (3) show the total amount of energy that was consumed from the pc system after the user has logged in and the applications remained idle without peforming any action. It is shown that when Green Talk runs in idle it is consuming 126.4 Watts of electricity, much less than any of the other two applications. On the other hand, the highest consumption is from Google Talk 152.98 Watts and Skype is coming second with a consumption of 138.25 Watts within 120 seconds running time. In simple terms, Green Talk is consuming 17.4% less energy than Google Talk and 9.3% than Skype.

Figure 4. *Energy consumption during an audio call*



In Figure (4) is displayed the power consumption when the three applications are establishing an audio session for a period of 120 seconds. As expected the average consumption has been increased for all of them and this is because now the computers are making use of more resources such as the CPU the hard disk and the RAM. In this scenario all three application are making use of their voice codec in order to convert the human sound into digital signals and these to be transferred over the network. Green Talk's average consumption was 206.2 Watts, Skype consumed in 279.99 Watts in average and Google Talk consumed 290.07 Watts over a 120 seconds period. Comparing these three values between them, we can easily recognise the performance gap between the three contestants increases with Green Talk in favour. Green Talk consumes 28.91% less energy than Google Talk and 26.35% less than Skype.

Figure 5. *Energy consumption during a video call*

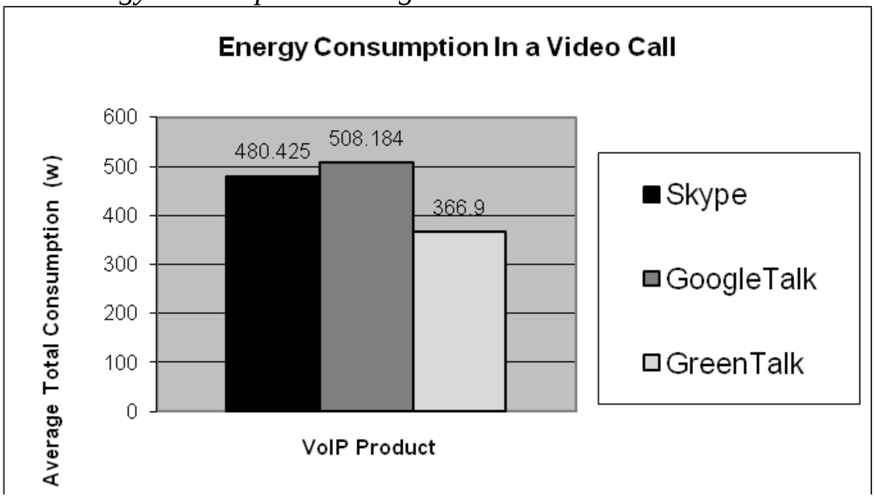


Figure (5) shows the consumed energy when a video call is taking place. As in the audio call, the energy consumption is further increased when all three applications are initialising a video session for the same reasons explained. During the 120 seconds period, Green Talk has an average consumption of 366.9 Watts, coming second is Skype with 480.425 Watts and the biggest consumer is Google Talk with 508.184 Watts. Trying to compare the three applications, we can see that Green Talk is consuming 23.6% less than Skype and 27.8% less than Google Talk.

One way to ensure that our application is working properly and provides the same quality we had to run of tests on the network traffic that was produced from the three VoIP applications. The tool used was Wireshark (2013) and measurements were taken by following the same testing procedures as in energy consumption. VoIP applications must use the UDP or TCP for their transmission regardless of the Application layer protocols. Thus, measuring the TCP or UDP packet transmission in an agreed time will give a rough idea about latency, jitter and packet loss.

Figures (6) and (7) demonstrate the QoS measurements for Green Talk and Skype. According to these, Green Talk manages to achieve a 90% similarity in quality against Skype. Skype produces an average number of 105 packets per second for a video call. On the other hand Green Talk produces an average of 90 packets per second at any given time. Green Talk uses UDP for transmission in the transport layer and SIP, RTP in the application layer. The video and voice codecs used throughout the testing were the well known and broadly used G.723 and H.263.

Figure 6. *Packet analysis for a Skype generated stream*

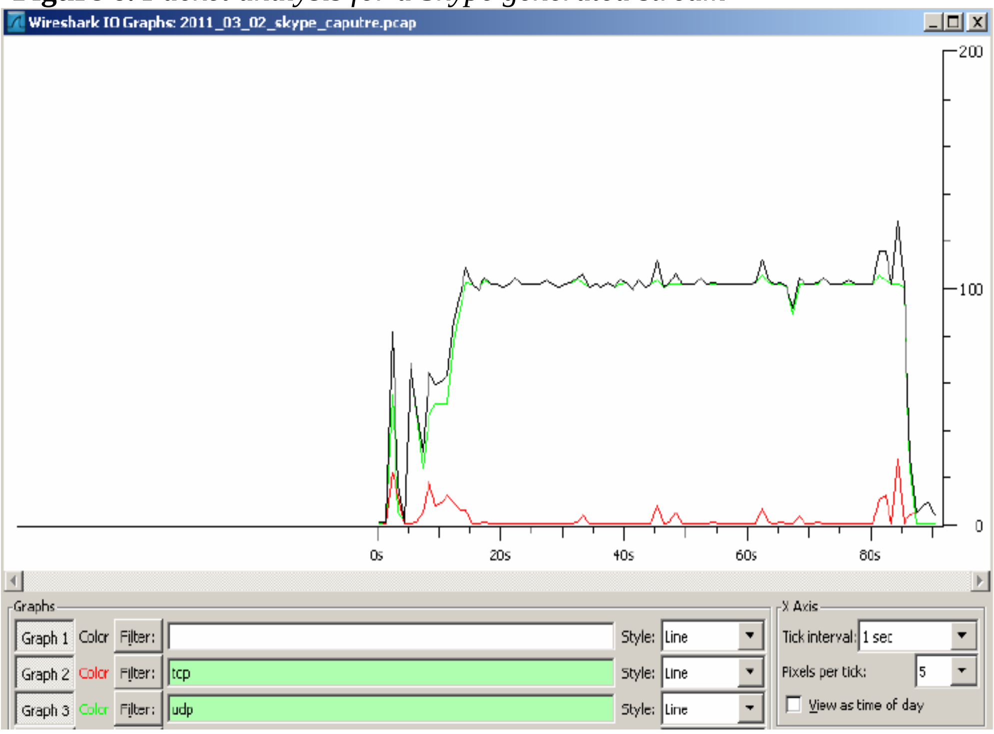


Figure 7. *Packet analysis for a Green Talk generated stream*

Conclusion

In this paper we evaluated the performance of Skype and Google Talk famous VoIP applications against Green Talk. Green Talk is an application that was designed and implemented from scratch using Java and the Session Initiation Protocol. It provides the same basic functions as the two famous applications such as instant messaging, voice and video calls. The results showed that Skype and Google Talk are more energy consuming that Green Talk and during the three testing scenarios. The scenarios calculated the power consumption in idle state, during a voice call and a video call. The duration of the tests were 120 seconds. Although the differences in actual energy consumption could be considered minimal, if you scale this up to the amount of users who currently use this applications, the gains in energy saving are really noteworthy. Further tests could be performed in the future with more VoIP applications for desktop PCs but could further expand in the mobile devices arena. Power consumption in mobile devices is more crucial than desktop PCs and further tests could identify new programming methods and platforms able to improve energy consumption in the mobile world.

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Figure 1. *Operational illustration of the SIP and IP*

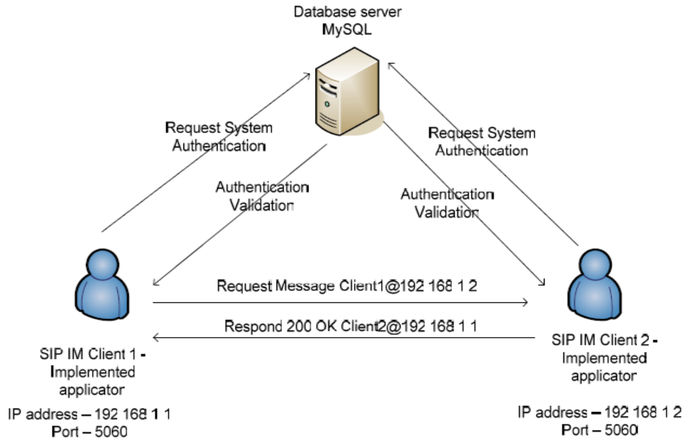

Figure 2. *Set up of the test bed*