

# Home traffic modelling

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## Abstract

IP networks are used for different purposes and the services that utilize the network generate traffic with different characteristics. This paper describes various purposes that IP networks can be used for. This paper examines the traffic generated by different applications and builds two different models based on the results of the analysis. These traffic models can be later used when planning an IP-based home network. One of the models can be used for family homes and the other model for student campuses. Home users have always generated IP-traffic by browsing the Internet and by playing online games. P2P traffic and the bandwidth consumed by it increases all the time, because file sharing and other services such as Internet radio that are provided on top of P2P. Voice over IP (VoIP) and IP television (IPTV) are becoming more popular all the time and the needs for such services are considered when the models are constructed. The statistics of a campus network provide information about bandwidth utilization of different protocols for the analysis. Because IPTV is not yet widely in use, statistics are based on the television watching habits of people of Finland and transformed to correspond the IP-traffic it would cause.

This paper describes how much and what kind of network traffic is generated by Finnish home users. The resulting traffic models can be used when later designing a home network or a campus network. The data gives an overview of the bandwidth consumption of different applications as well.

KEYWORDS: home traffic model

## 1 Introduction

Times when families only had one computer connected to Internet and when only one user could browse web pages at a time are over. The number of computers in a household is increasing and the services provided on top of IP are increasing rapidly. As network speeds develop, the bandwidth utilization of applications is also growing. The bandwidth consumed by the number of different applications that can be used simultaneously might exceed the bandwidth offered for one household and some adjustments to the used applications or the network need to be done. This paper gives an overview of the traffic generated by the home users and the resulting traffic models can be used when designing future networks.

Different applications and the protocols they utilize have different requirements for the underlying network. The traffic they generate is either constant bit rate or bursts depend-

ing on the state of the application. For some of the protocols it is crucial that packets are not dropped and that there is not much delay between packets, for example fast paced online games. On the other hand there are also applications that can work perfectly with the bandwidth that is left for them to use, these include applications used for file transfer. The models combine these different traffic types into one bandwidth utilization scenario per model.

The structure of the paper is as follows. Chapter 2 describes all examined protocols and the use of those protocols for different applications and services. After that chapter 3 describes bandwidth utilization based on available statistics. Then chapter 4 describes the models that are constructed. Finally the models are build in chapter 5 based on available information. Chapter 6 is for conclusions and suggestions.

## 2 Description of protocols and their applications

This chapter describes the protocols and their applications. This means the bandwidth usage and characteristics of the traffic caused by different protocols. Previous work done to measure the bandwidth utilization of different protocols is analysed in this chapter.

### 2.1 IPTV

IPTV can provide services such as video on demand (VOD) and digital broadcast TV. Those services are provided on top of IP. The video is compressed utilizing MPEG-2 or MPEG-4/H.264 codec. MPEG-4/H.264 is a successor of MPEG-2 and this paper concentrates on it. The bandwidth utilization of MPEG-4/H.264 is from 2Mbit/s to 8Mbit/s depending on the resolution of the video, where a standard definition requires 2Mbit/s and a high definition 8Mbit/s. The traffic generated by MPEG-4/H.264 is continuous and sudden drops in the bit rate decrease the quality noticeable. [6][8][17]

### 2.2 VoIP

VoIP is used to provide telephone services in IP networks. Audio is compressed utilizing the G.711 or the G.723.1 codec. This paper concentrates only on the newer G.723.1 codec. Utilizing it, the average bit rate for a VoIP call is 17.066 kbit/s for both, software based clients and IP phones. As long as the call is up, the G.723.1 coder generates fixed rate traffic. Actual voice data is only transmitted when needed. [12]

## 2.3 HTTP

HTTP is used mainly for transmitting web pages from a server to the user. However some new protocols can be configured to use HTTP for data transfer. The reason for this is the ability of HTTP to traverse firewalls when some unknown protocols get blocked by them. HTTP is a stateless protocol and the traffic it generates is bursty. A case study of the HTTP traffic generated by 50 users in one hour states that the traffic generated reached the maximum of 1GB in total. This means an average bandwidth consumption of 5.825 kbit/s per user. [9][4]

## 2.4 Bittorrent

Bittorrent is a widely used peer to peer (P2P) file sharing protocol. Most of its applications upload data to other peers at the same time when downloading. This makes it very bandwidth intensive. Bittorrent will consume as much bandwidth as is available for it unless it is limited by the user or unless there are not enough other peers with fast enough connections to download from. A bittorrent tracker was studied for a month and based on the results of that the average download speed of a peer was 30 Kbit/s with 90 per cent of the users having a download speed below 65 Kbit/s.[10]

## 2.5 Online game traffic

Online games utilize different amounts of bandwidth depending on the game type. The traffic of two different game types, namely massive multiplayer online roleplaying (MMORPG) games and first person shooter (FPS) games, is examined. FPS games are fast paced and therefore they require low latencies in order for them to be playable. On the other hand in MMORPG games latency times are not so crucial.

A study conducted at a LAN party shows that a FPS game, namely Counter Strike, generates traffic at a rate of 15.7 kbit/s on the client side. Of all the packets sent from a client machine, 99 per cent were in the range between 60 and 110 bytes. On the server side the traffic generated has the rate of 16.4 kbit/s for each client that is connected to the server. These rates show that a total of 32.1 kbit/s of bandwidth is consumed by a client.[5]

Another study made of a MMORPG, namely ShenZhou Online, describes its bandwidth utilization which is 7 kbit/s for a client. This includes both the upload and the download rate, meaning the packets generated and sent by the client and the packets received by the client. The packets are small as was the case with Counter Strike. 98 per cent of client packets have a payload size smaller than 32 bytes.[3]

## 3 Bandwidth utilization based on available statistics

This section examines available usage statistics of different applications. The statistics are gathered from one university campus, namely Helsinki University of Technology, and from the national statistical institute of Finland, namely Tilastokeskus. Therefore these calculations show the usage

Age	Bill	Population	Minutes
15–24	24.2	12.46	5.22
20–30	30.1	12.66	6.4
45–60	30.8	54.93	1.37

Table 1: Daily phone usage of different age groups

of different application only in Finland. [16][13] Based on these statistics and the results of bandwidth utilization of different protocols studied in the previous chapter, this chapter calculates the total bandwidth utilization of each application per day. The results are further divided into categories by the age of users. Three different age groups are used. People in the youngest group are aged between 15 and 24 years, students are aged between 20 and 30 years, and adults between 45 and 64 years. Surprisingly there are no differences in free-time spend using Internet between men and women.[11]

Online games are divided into two categories, first person shooters(FPS) and massive multiplayer online role playing games (MMORPG). Even though the traffic analysis for MMORPG is based on the game ShenZhou Online, a game, namely World of Warcraft, is used to determine the user base for MMORPG. Games that use Steam as the connecting software to the game servers are used to determine the user base for FPS. We assume that players of online games play a game that falls into one of these two categories. The total time spend on online gaming is then further divided into time spend playing FPS games and time spend playing MMORPG games. The numbers correspond to the percentual amount of players of those games. [1][2]

Game	Players	Percentage
Steam	2834000	26.16
World of Warcraft	8000000	73.84
Total	10834000	100

The television watching statistics are used to determine the bandwidth utilization of IPTV in an IP based network. In this paper we use the standard definition resolution for the calculations. This resolution will consume 2Mbit/s of bandwidth. The time spend watching television varies between age groups.

The models assume that all land lines are replaced by VoIP capable phones. Therefore time used for VoIP calls is calculated by mapping all phone calls called from land lines in Finland during year 2005 to VoIP calls utilizing the G.723.1 codec which bandwidth consumption is 17.066 kbit/s. The total amount of minutes for calls originating from land lines was 7 475.1 billion during year 2005. 61 per cent of those calls were made by home users and 39 per cent from company owned lines. This gives us 5 157.8 billion minutes of phone conversations originated from land lines and they will be converted to VoIP calls. We compare the phone bills of different age groups in year 2004 and distribute the called minutes based on these statistics. Table 1 shows the percentage of the phone bill of the total value. This is further multiplied by the percentage of the population the age group forms in Finland to get the actual minutes the age group spends speaking at the telephone per day. These minutes are further used when calculating how much bandwidth they would consume when phoned utilizing VoIP. [15][7][14]

### 3.1 15 to 24 years

Statistical data available for this age group comes in two forms: television watching habits of 15 to 24 years old people and free-time spend in Internet by people aged between 15 and 39 year. These are the most accurate statistics available at the time. Time spend on watching television is 1 hour 45 minutes per day and free-time spend in Internet is 6 hours 5 minutes per week, that is 52 minutes per day.

The time spend watching television is mapped to time spend watching IP television. Similarly use of telephone services is mapped to use of VoIP. This age groups generates an average of 5.22 minutes of VoIP traffic. After these mappings this age group generates 2 hours and 42 minutes of IP traffic per day.

20 per cent of the users use P2P software and 39 per cent play online games. We assume that of the total time used in Internet 39 per cent is used for playing games and 20 per cent for downloading and uploading utilizing the Bittorrent protocol. The usage of different application and the bandwidth consumption of those applications is shown in table 3.1.

### 3.2 Students 20 to 30 years

Students between 20 to 30 years spend free-time in Internet 52 minutes per day. They watch television from 1 hour 45 minutes to 2 hours and 13 minutes. We calculate an average value of these two, which is 1 hour 59 minutes per day. Again the time spend watching television is mapped to time spend watching IP television and as a result we get a total of 171 minutes of IP traffic. After this we map the time spend on telephone to VoIP traffic and end up with a total of 177.4 minutes of IP traffic.

31.5 per cent of this group plays online games. We assume that from all the time spend in Internet 31.5 per cent is spend on playing these games. Therefore the amount of bandwidth consumed by them is calculated by multiplying the time spend playing games with the bandwidth consumption of the games. This age group uses telephone services each day for 6.4 minutes per person. This value is calculated as if it would generate VoIP traffic in the network.

The statistics of the campus network, namely Trinet, show that http traffic utilizes 19.5 per cent of the total incoming traffic and 7.4 per cent of the total outgoing traffic, hence consuming the most bandwidth of all protocols. Next in the statistics is Bittorrent protocol that utilizes 9 per cent of the outgoing traffic and 7.4 per cent of the incoming traffic. The 1 day average of incoming traffic is 70 Mbit/s and the 1 day average outgoing traffic is 48.9 Mbit/s for the whole network which includes 3188 hosts. This will give us a per host average that is 22.5 kbit/s of incoming and 15.7 kbit/s of outgoing traffic. The total bandwidth utilization of http protocol is 5.55 kbit/s per host and for Bittorrent protocol the same value is 3.01 kbit/s per host. These values are daily averages and for the total bandwidth consumed during a day we further calculate the bandwidth consumption of IPTV, online games and VoIP. The results are in table 3.[16]

Application	Total (Mbit/day)
IPTV	14280
Online Games(MMOPRG)	4.96
Online Games(FPS)	8.06
VoIP	6.4
Bittorrent	253.97
HTTP	468.23
Total	15021.62

Table 3: Bandwidth utilization of students

Application	Total (Mbit/day)
IPTV	23880
Online Games(MMOPRG)	1.18
Online Games(FPS)	1.92
VoIP	1.37
Bittorrent	1.89
HTTP	11.61
Total	23897.97

Table 4: Bandwidth utilization of adults

### 3.3 Adults 45 to 64 years

Adults between the age of 45 and 64 years spend on average 3 hours 19 minutes per day watching television and 39 minutes per day on using Internet. Hours spend watching television are mapped to hours spend watching IPTV, similarly as with the two other age groups. This age group also generates an average of 1.37 minutes of VoIP traffic per day.

2.75 per cent use P2P software and 10 per cent play online games. Again we make the assumption that of all the time spend in Internet 2.75 per cent is spend utilizing P2P software and 10 per cent playing online games. The daily bandwidth usage of different applications is shown in table 4.

## 4 Description of Models

There are two different models that are constructed. The first model is a model for a family's network utilization. The second model is a model for a university campus and it describes the network usage habits of the campus. These models were chosen because the network usage habits of students differ from other groups and there is actual data of these habits. On the other hand a family model will give us a overview of the traffic generated by common users. The structure of the models is described in detail in this chapter.

### 4.1 Family model

The family consists of four persons in total, two adults and two children. Adults are aged between 45 and 64 years and the children are aged between 15 and 24 years. Members of the family use the network for VoIP calls, watching IPTV, playing online games, downloading files and surfing in the Internet.

Application	Time(minutes/day)	Bandwidth(kbit/s)	Total Bandwidth Consumption (Mbit/day)
IPTV(low resolution)	105	2048	12600
Online Games(MMORPG)	15	7	6.15
Online Games(FPS)	5.3	32.1	9.97
VoIP	5.22	17.066	5.22
Bittorrent	10.4	30	18.28
HTTP	21.3	5.825	7.27
Total	162.22	1330.54	12646.89

Table 2: Daily bandwidth usage of age group 15–24

## 4.2 Campus model

The users of the campus model are students aged between 20 and 30 years. The network is mainly used for similar purposes as in the family model, only the statistics gathered are mapped for the corresponding age distribution.

## 5 Home traffic models

Data presented earlier in this paper is used and this sections builds the models described in the previous chapter. The lack of information prevents us from building accurate models that would use daytimes in the presentation of data. Therefore we only concentrate on the characteristics and amount of traffic generated.

### 5.1 Home traffic model for families

The traffic model for families includes the traffic generated by two children and two adults. All the traffic is summed to get the total amount of traffic generated by the whole family. Table 5 shows the results of the calculation.

The results show that most of the bandwidth consumed is by IPTV. This is no surprise because transferring audio and video utilizes more bandwidth than transferring web pages consisting mostly of text. Also television is still a more popular media than Internet and time spend watching it exceeds time spend in Internet. The bandwidth consumption of IPTV is constant and it means that at least two Mbit/s need to be reserved for it per watched channel. These results assume that any two of the family members do not watch the same program at the same time. Therefore the calculation is not as realistic as it could be.

If IPTV is left out, Bittorrent is the most bandwidth consuming application. Online games in total utilize more bandwidth than HTTP. It is explained by the fact that young people play more online games than others and this model includes two young persons.

### 5.2 Home traffic model for students

We have already calculated the average amount of traffic one student generated. This model is more realistic than the family model because the households include less persons than with families. Therefore there is less overlapping with the television related statistics. Table 6 amount of traffic that a campus of 3000 students would generate.

Again IPTV consumes most of the bandwidth like in the family model. Surprisingly Bittorrent utilizes less bandwidth

Application	Bandwidth (Mbit/day)
IPTV	72960
Online Games(MMOPRG)	14.66
Online Games(FPS)	23.72
VoIP	13.18
Bittorrent	40.34
HTTP	37.76
Total	73089.66

Table 5: Traffic generated by a family

Application	Bandwidth (Gbit/day)
IPTV	41835.14
Online Games(MMOPRG)	14.53
Online Games(FPS)	23.61
VoIP	18.75
Bittorrent	744.05
HTTP	1371.77
Total	44008.65

Table 6: Traffic generated by a campus of 3000 students

than HTTP, which consumes the most bandwidth after IPTV. Online games on the other consume much less in this model than in the family model. Students use telephone services most of all the age groups. Therefore bandwidth utilized by VoIP is also more than in the family model.

## 6 Conclusions and suggestions

Two traffic models, one for families and the other for student campuses, were studied in this paper. Based on these models we can draw some conclusions of the characteristics and bandwidth utilization of the traffic. IPTV utilizes most of the bandwidth. The bandwidth consumption of IPTV is hundred times as much as the bandwidth consumption of the other applications studied. Of the other applications HTTP and Bittorrent utilize the most bandwidth. Using VoIP is not so popular yet and it does not utilize much bandwidth compared to other application. This might change in the future as VoIP phones are replacing land lines. Online games are popular among the young age groups but they do not consume much bandwidth. On the other hand they are really bandwidth sensitive and require good latency.

IPTV, VoIP and online games are bandwidth sensitive in the way that lack of bandwidth will lead to usability problems. Therefore the traffic caused by them should be prioritized when implementing traffic shapers and constructing

networks. HTTP and Bittorrent traffic on the other hand are not so bandwidth sensitive. For both of them it is enough that data gets transferred, but there are no constant bandwidth requirements.

Further study on this field could concentrate on the bandwidth utilization during different day times. Different upload and download models could also be build. This would give Internet service providers some insight of different broadband plans they might want to offer to customers. Also the time used for different tasks like downloading files or using VoIP services could be studied on a more thorough level. There has only been a few studies conducted on this field so far, leaving still many questions open for future studies.

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