P2P-IPTV World: Measure to better discover

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ABSTRACT

Triple-play (high-speed Internet, Telephone, and TV) in which IPTV is an important factor is now largely offered by many Internet Service Providers (ISP). But being a combined business model, it has some limits because of price and equipment requirements. By that reason, P2P-IPTV appeared as a competitor. With low price and does not require deluxe configuration at end-user computer, P2P-IPTV becomes more popular in recent years.

In this paper, we present a passive measurement in order to differentiate countries in the P2P-IPTV world in three aspects: the number of users, the contribution in terms of upload/download amount and the proximity logic. Moreover, in this study, we also analyze the number of ports used by one peer in the P2P network as well as the distribution of the default TTL. The results achieved help us to propose a heuristic method so that we could possibly detect the existence of NAT (Network Address Translation) in the P2P-IPTV systems.

Keywords

P2P-IPTV, Peer-to-peer media streaming, measurement

1. INTRODUCTION

Today, P2P network is no longer a new term; people all around the world used it each day to share their ebooks, music, movies and many other kinds of file. Thus, the P2P file-sharing community expanded very fast and represented as a large fraction of the traffic in the Internet [1]. The peer-to-peer network was also known as overlay network because it runs on top of another network and may have structure [2], unstructured [3][4] architecture or hybrid [5]. To this end, overlay architecture was now used for VoIP (Voice over IP) [6][7] and video conference [8]. But as users' demands have no limit, TV channels participate into this community in recent years and become one of the most talked-about subjects. Commonly known by the name of P2P-IPTV, this new member profits from the P2P network the sharing advantage. Not only by sharing the content, this type of network also uses diverse connectivity between participants in it and cumulates the bandwidth of them rather than conventional centralized resources, so audiences don't need a very high bandwidth connection at their house to watch the TV programs. Despite heritages from P2P file-sharing, TV channels have usually live content, which means video blocks with long delay are not accepted. By this characteristic, P2P-IPTV users want to watch a TV channel with an acceptable delay. That is the reason why many applications appear continuously in the Internet world now, like PPLive [9], AnySee [10], SOPCast [11], UUSee [12] and many more. Instead the fact that there are more and more P2P-IPTV software in the Internet nowadays, none of them offered documentation about the protocol used neither the source code. Hence, to overcome these difficulties, we choose passive measurement as the way to journey and discovery the P2P-IPTV world. Every clouds has a silver lightning, passive measurement gives us a perfect objective view to study the characteristics of P2P media streaming by neither modifying any traffic nor impacting any peer.

With that prudent measure method, we have analyzed 30GB of P2P-IPTV traces in order to find out the real number of users watching IPTV via P2P network. In other former articles, there were some authors who studied the same subject to us, but in their research, they did not pay attention to the Network Address Translation (NAT). This distrait caused an undercount of the P2P-IPTV population. So, to reach the real number of people in the P2P-IPTV world, we tried to detect the NAT first with our heuristic method. Then we determined the growth rate of the population in a given period of time. Furthermore, we took two independent viewpoints (in Japan and in France) from where the distance in number of hops was also measured so that we had a geographical view of the P2P-IPTV world. To this end, the rankings of different countries were also presented in both upload and download aspect in order that we understood generally about the P2P-IPTV international relation. Going into details, we investigated the contribution of many international enterprises and organizations in these countries as well. Based on the results achieved, we finally found that the upload and download amount in the P2P-IPTV world were not equal so service provides should be interested in this phenomenon.

To present the above content, the rest of this paper is organized as follows, some key concepts of peer-to-peer video streaming is mentioned in Section 2. This includes the relationship between people in the P2P-IPTV world, how do they welcome a newcomer, how can they exchange information. We will review the former studies about P2P-IPTV, such as the architecture, the active and passive measurement in the same section. Section 3 explains more precisely why we chose passive measurement to discover the P2P-IPTV world. Also, we present our experiment and the method to analyze it. Section 4 concentrates on our results and the discussion about the population, the origin of people and the distance between people in the P2P-IPTV. The behavior of each member of this world is concretely mentioned in the same section, including countries contribution and AS (Autonomous System) throughput. In the end, Section 5 resumes our work with perspectives of the P2P-IPTV and some potential approaches for the future works.

2. RELATED WORK

In this section, we briefly summarize the mechanism of the P2P-IPTV as well as its components and measurement methods, in which giving some basic concepts that we will reuse later in this paper. In almost P2P-IPTV systems, users are also seen as nodes (peers) and each time an user run his P2P-IPTV application, his node participate to the existing P2P network, then it follows the procedure below:

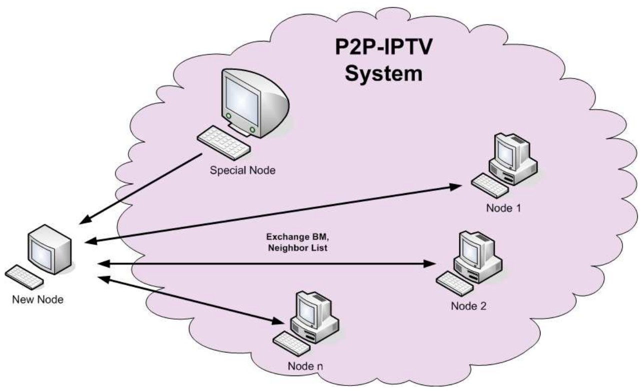


Figure 1: Participation in a P2P-IPTV system

First of all, the user chooses a channel from the channels list, available on a web-server [13] or in the P2P-IPTV software itself. Then it enrolls itself to a special node and obtains the initial list of neighbors (watching the same channel). This special node may be a tracker server [14] or may be an origin node [15] depending on the application used. After having the initial list of neighbors, the node contacts these neighbors (Node 1, Node 2,ĚNode n) for additional lists. In the end, nodes in the P2P-IPTV network exchange the Buffer Map and/or video blocks and the show begins.
To this end, the Buffer Map (BM) [16] indicates video blocks before playing and tells other nodes how to reach the blocks they want. More precisely, nodes indicate others their video blocks available for sharing at the moment (1 means available, 0 means unavailable). To this end, blocks are arranged in the BM in the order of time, blocks which will be played in a few minutes, are placed behind those have been recently played.

P2P-IPTV applications can use TCP, UDP or both to exchange information about BM and even video blocks [17]. When the new node receive updates from their neighbors

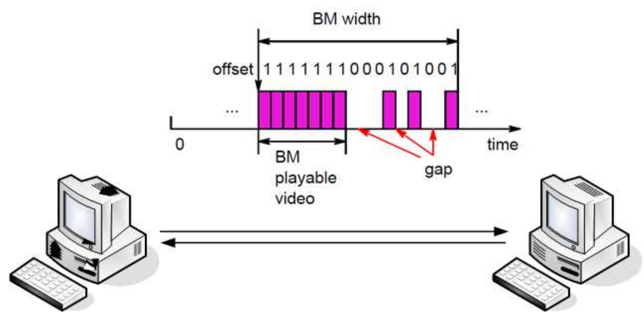


Figure 2: Buffer Map message exchange

(normally BM and/or keep alive messages), its can request the blocks needed according to the 01 chains representing BMs. While it gathers enough continuous blocks in the buffer, it can play that segment, namely, BM playable video. The maximum number of blocks a buffer can store is indicated by BM width, but one does not need to gather this number for a smooth play, nodes can decide to reject some blocks if they arrive after a given deadline. However, the more blocks rejected, the worse quality is. To avoid this phenomenon, lots of researchers tried to create new architectures for P2P-IPTV media streaming in order to provide a better media streaming service. Some examples for this approach are: NICE [18], ZIGZAG [19] (tree-based architecture), and DOTNet [20] (mesh-based architecture)
Besides, other researches did not concentrate on new architectures but on measuring existing P2P-IPTV systems [21][17], the goal of these researches was to find out particular traits of P2P-IPTV. They usually used two principals that follow:

- Active measurement: this way used crawlers with particular codes to participate an existing P2P-IPTV system, they behaved like an ordinary node on the one hand and register all messages, control packets on the other hand. Based on the information fetched, authors concluded about the surveyed system on the aspect of user join rate, session length and mathematical models for its distributions of channel size as well [22].
- Passive measurement is another way to conclude about a P2P-IPTV system. In contrast to previous way, this method used captured traces and analyzed them to have a look at the number of IPs [23], the used bandwidth [14]. Precisely, Argawal et al. [24] studied the channel startup time and the quality of service in term of number of consecutive lost blocks. Another concept were approached by Xiaojun Hei et al. [14], they took a deep look at the video rate and the duration of video TCP connections as well as arrival/departure time of peers. Following their research were Ali et al. [13] with a controlled test-bed which provided lots of information about traffic flows. Recently, Silverston et al. [17], studied 4 P2P-IPTV applications and gave a global view of the impact of peer-to-peer media streaming on the network traffic. Interested in ISP aspect, Chuan Wu et al. [12] observed the inter/intra ISP bandwidth including the percentage of throughput.

In passive measurement method, we remark that several researchers did their works with privileged authorities on the P2P-IPTV system [12] or on a controlled test-bed [13]. Also, they had advantages that they could control the whole P2P-IPTV environment and facilitated their measurement. However, by using some particular authorities, they interfered with the peers of the observed P2P-IPTV system or impacted the traffic of the network. To avoid this end, we used traces captured in the P2P-IPTV systems by normal machines (without any particular configurations) which we will describe into details in the next section.
In the one hand, the majority of former researches surveyed the P2P-IPTV population but did not concentrate on the impact of the NAT (Network Address Translation) to the number of users. More concretely, NAT hid behind it more users than only one IP that it was using. Its mechanism will be studied precisely in section 4 while we analyze the number of used ports per machine. In the other hand, although that many articles talked about the neighborhood in the P2P-IPTV world, they did not take a deep look at the distance between people in that world. Besides, Autonomous Systems, one important metric that many great enterprises are interested in, were not mentioned in these measurements. So, in the following sections we will fill these holes of the P2P-IPTV world picture and get a more complete view of the peer-to-peer media streaming.

3. METHODOLOGY

In our experiment, we inherited the traces from the test-bed in [11], which were collected objectively. That means: traces were not affected by any intentional reasons such as special privileges. Each trace contained 6 millions packets and all these packets are in PCAP format [25]. The detail of this test-bed is showed in the figure below.

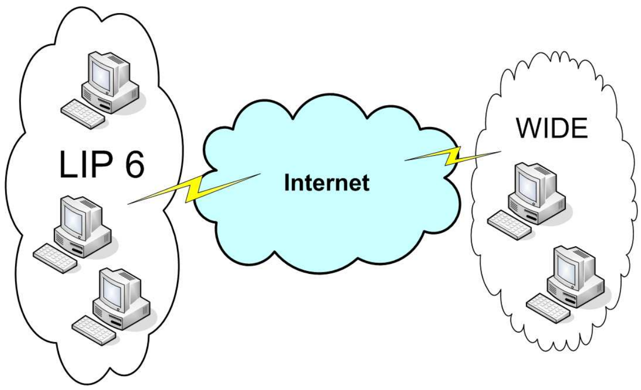


Figure 3: Test-bed to collect P2P-IPTV traces

In that test-bed, passive measurements were taken place in Japan and in France. Windump was installed on observed machines in order to collect all the packets reaching the LIP6 (Laboratoire Informatique de Paris 6) network as well as the WIDE network. In these networks, all the machines used the same P2P-IPTV software to watch live sports such as: soccer, athletics or rugby, in a period of four hours.
With the traces in hand, the filter phase began. To this end, we did not use the heuristic algorithm mentioned by Xiaojun Hei et al. [14] in which they had removed all packets smaller than 1200 bytes. It's because their algorithm had filtered unintentional P2P-IPTV signaling messages which could be helpful for our study. Instead, we checked every packet for port number and compared to those registered with IANA (Internet Assigned Numbers Authority) [26]. If any of them used well-known port, in the range 0 - 1023, and referred to the protocols such as: DNS, DHCP, ICMP then it would be removed. The reason was: these types of packets appeared in many kinds of network communications and did not show any particular characteristics of the P2P-IPTV. Thus, they were not interesting for our work and should be ignored.

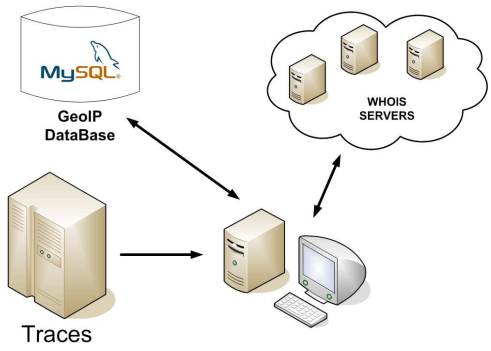


Figure 4: Traces analysis method

The rest of the traces contained important packets for our P2P-IPTV world discovery which provided us interesting information like source and destination addresses of nodes in the system, video block size, messages that a new node exchanged with the old members of the P2P-IPTV system. Profiting these information, we focused on the geographical locality of peers in the P2P network. To this end, we used the GeoIP Database [27] to detect the region origin of each address IP within the traces. This database helped us especially to understand the distribution of different countries in the P2P-IPTV community, how were the exchanges between these countries. Furthermore, while going inside each country to investigate more precisely, we did request the WHOIS servers for the Autonomous Systems to which each packet belonged. With the responses received, we regrouped by AS and looked attentively at the upload/download throughput of these Autonomous Systems. Now, let's discover the results of our analysis concerning the P2P-IPTV world, starting with the population census.

4. RESULTS AND DISCUSSION

4.1 P2P-IPTV POPULATION

In this paper, adapting to our P2P-IPTV world (which we could call "virtual world" lately in this paper) we considered the population as follow: the P2P-IPTV population is the total number of users watching the same P2P-IPTV channel in a given period of time. Notice that we should differentiate the number of users and the number of IP addresses in the P2P-IPTV network. We will see this difference little by little throughout this section. The first subsection is going to let us have a look at our virtual world and the portion of each country in it.

4.1.1 *Countries and population*

We begin with a figure which represents the overview of the countries in our P2P-IPTV world. (Fig.5).

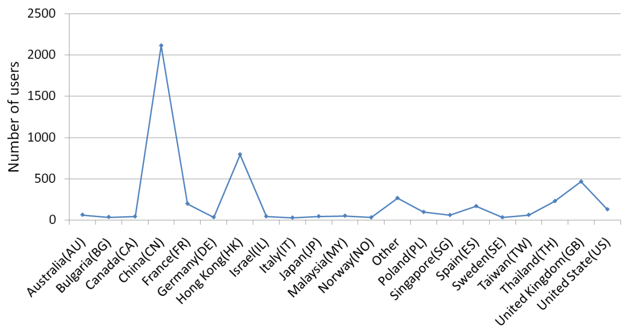


Figure 5: Traces analysis method

China (including Hong Kong), has the greatest population. It possesses 58% of the total population, an impressive contribution. The second rank is United Kingdom which possesses 9%. France and Japan, are at the 6th and 15th respectively. The country which has the least users using P2P-IPTV in our experiment is Lithuania with only one user.

But it is not the problem, the principal interest is: This number is the real number of users or not? The answer is probably no. Because in the above statistic, an IP address is considered as an user (this consideration is used by other authors in their works). However, looking at the Internet World Map below (figure 6), we find an unequal distribution of IP address in the world: Asia, possess more than a third of the world's population, receive only 14.015% of the IP space [28]. Comparing to Europe and North America (which both represent a total 77.4% of the global Internet structure), Asia suffer historically an unjustness.

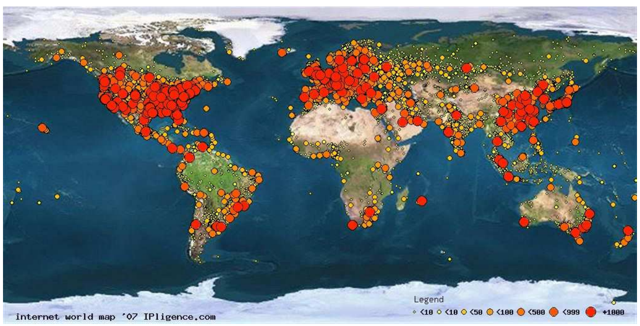


Figure 6: Internet world map

Nevertheless, we do not mention it here, what makes sense is the number 14.015%. With such a small portion of IP space and such a great population, Asia is the continent that must have an effective solution to equilibrate the number of users and the number of used IP addresses. And the solution is indisputably the Network Address Translation.

In order to detect the appearance of NAT in the middle of the communications between users, we propose a heuristic method that contains three different tests: of number of ports, of time-to-live and of the nationality. This heuristic will be studied alternately in three following subsections.

4.1.2 *NAT and number of used ports*

Before detecting the existence of the NAT, we deepen a little the NAT's mechanism [29]. The process is illustrated step-by-step in the Figure 7: when host 192.168.1.54 want to access the web server at address 204.242.16.4, the request is first passed to the NAT server, where the source address and port number are translated, and a mapping is added to the NAT table. At the external web server, the request appears to be coming from address 131.107.2.200, TCP port 4085. The web server will send the reply to this address and port number. Once received by the NAT gateway, it will look in its NAT table, and discover that since the packet's destination is address 131.107.2.200 TCP port 4085, it should be forwarded to internal host 192.168.1.12, TCP port 4085.

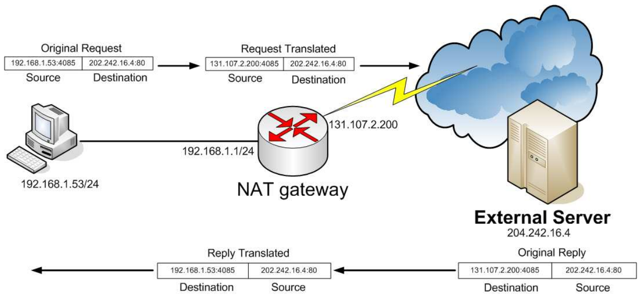


Figure 7: Network Address Translation Mechanism

Pay attention on port 4085, this port is an extra port the NAT used, instead of requiring multiple public IP addresses, it need a single (or small number of) public address, and differentiates between sessions according to port number. The more sessions are opened, the more ports will be used.

Moreover, the IPv4 spaces is exhausted by many devices, thus public IP addresses become fewer and fewer. However, most ISPs, software vendors and service providers are only just starting to consider widespread deployment of IPv6. Therefore, in this transition period, NAT is one of the life-savers to solve the IPv4 exhaustion problem. Understanding this situation and seeing through the NAT's mechanism right above, we guess about the potential existence of the NAT in our experiment: if an IP uses so many ports, that given IP could belong to a NAT gateway. The key point we should discuss here is: what does exactly "so many" means? To answer the question above, let's rephrase it: what is the maximum number of ports that a single computer uses, without NAT? We realized a statistic based on IP addresses and the number of ports each one uses. The result is shown in the Figure 8.

Things are much clear now; we can see that almost every IP address does not use more than 1000 ports. More concretely, only 30% of IP addresses open more than 1000 ports. With the mechanism of NAT we just explained, we believe that these IP addresses hide more others users behind the Network Address Translation gateway. But we cannot conclude about the existence of the NAT yet, so we do another test called Time-To-Live (TTL). This metric is not only helpful for our heuristic method to detect NAT but also useful to accommodate the proximity logic between users in the P2P-IPTV world (which is described in subsection 4.2)

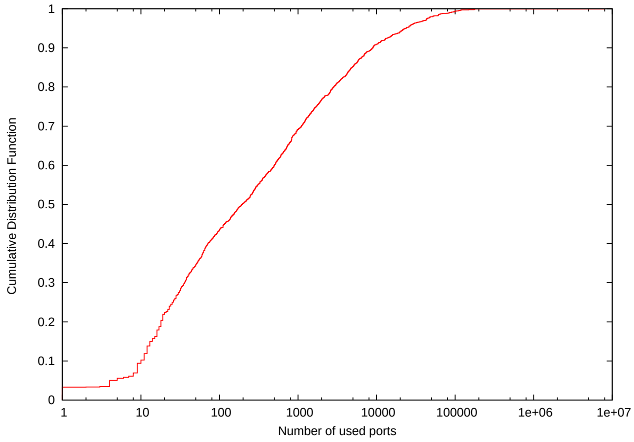


Figure 8: Cumulative Distribution Function of used ports

4.1.3 NAT and time to live

Why TTL is important to detect NAT? Remember that the majority of P2P-IPTV software work on Windows, and on Windows the TTL is 128 by default (on Windows Vista, the default TTL is 255, but at the moment the experiments were done, Vista was not released yet). So, it's very strange if we find packets with the default TTL equal to 64. We will naturally ask: why is there such strange value of TTL? The answer is: each time a packet passes an active equipment the TTL shall be decreased, and in certain cases, the equipment not only decreases the TTL but totally modifies the default TTL. That's the NAT gateway we are talking about. The network address translation gateways can rewrite the default TTL of all the packets passing through it, therefore, if we discover these modified packets we could say that NAT probably played its role here.

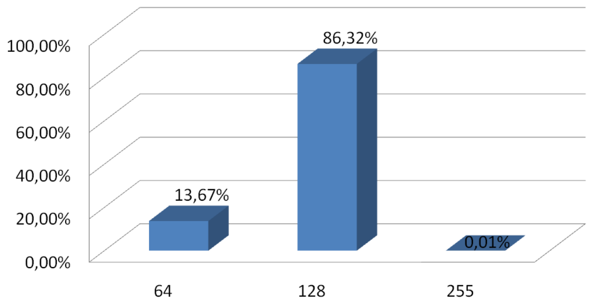


Figure 9: Distribution of the default TTL

As we see on the above figure, 86,32% of the packets have the default TTL of 128, 13,67% of the packets have the default TTL of 64 and we find just four packets (0,01%) with the value of 255. We can assume that the four packets with the default TTV value of 255 are errors or caused by other unknown modifications. By the way, 4 is a negligible in comparison to 6M packets. We concentrate more on 1M packets with the default TTL of 64, that's what we are really interested in. Like our last explanation about the TTL's modification because of NAT gateways, the 25% packets which have the default time-to-live value of 64 certainly passed the NAT. Is there a relation between these 13,67% modified packets and the 30% IP addresses (using so many ports) we mentioned before? By combining these two meaning numbers, we have more foundation to the answer to our doubt about the network translation address. Firstly, our heuristic method search all the IP addresses opening more than 1000 ports, then for each IP found, we scan all the packets containing that address. If the packets from that doubtful IP have the default TTL of 64, then we could find the NAT. Actually, as we mentioned in the preceding section, the usage of NAT depending on the IP space of each country, each continent. Thus, the next step of our method is to find out the origin of every packet in the traces.

4.1.4 NAT and nationality

In the rest of this section, we enforce our heuristic algorithm by adding the last test: we will query every IP address for the country where it comes from. This query is made by using the database (previously mentioned in Section 3) in which the IP ranges and the country are in the same line, once an IP appears in the range, we can easily extract its country name and its country code [27].
The key of the test is: if the country (where the IP addresses are from) is in Asia, so the probability of NAT's existence is very high. There are certainly many IPs (in this continent) without NAT and we don't negate it but by combining all the three tests we have done, we could still conclude something about NAT's appearance. First of all, we have found IP addresses which used more than 1000 ports. Also, we have had in our hands all the packets which had the default time-to-live of 64. Next, with every IP we can simply checkout its origin. Now, linking all the results, we find obviously the IP addresses from Asia with the default TTL of 64 using more than 1000 ports. That's what we need: these IP addresses are possibly the NAT gateways' addresses.
In conclusion, during our experiments we incorporate three criteria: number of used ports, default TTL and origin for the NAT detecting method. The sections that follow will mention different aspects of the P2P-IPTV world, they are: the proximity between people of different country, the contribution of diverse countries and even enterprises inside their territory.

4.2 DISTANCE BETWEEN PEOPLE

After examining the result of the last section, we had in mind the largeness of the P2P-IPTV world in terms of the number of users. Now, let's take another view position and investigate the world in terms of distance. Do not forget that we are talking about a virtual world where miles or kilometers do not make any sense, instead, we will measure all distances by the number of hops (hop-count). So, what is the furthest spot, the nearest spot and what is the average distance between two people in our world. These questions are subjects to be treated in this section.
One simple way to approach the subject is by its concept: Hop-count, in a data communications network, is the number of legs traversed by a packet between its source and destination [30]. And this number is calculated as follows:

$$H = DefaultTTL - TTL \quad (1)$$

But that's the formula for normal cases, without any modification of the default TTL. Nevertheless, as we mentioned previously: there are NAT gateways in our P2P-IPTV world therefore we must have another solution to calculate the number of hops for them. Before talking about this solution, let's reminisce that the size of Internet nowadays is around 30 hops [31]. So, how do the NAT, the maximum distance of the Internet and the hop-count relate with each other? Coherently, the distance in our P2P-IPTV world (hop-count) cannot exceed the maximum distance of the Internet. If we find some strange value of the hop-count (extremely high, ex: 78, 63...), then according to previous sections we can probably affirm that NAT gateways cause it. Furthermore, as we already know, NAT may change the default TTL when packets passing through it hence change the hop-count. So, once we see a too high value of the hop-count, we will find the default TTL around it which might be the value before NAT's modification. The table 1 shows the default TTL of some operating systems (OS) [32].

Table 1: The default TTL of some OS

Operating system	TCP TTL	UDP TTL
AIX	60	30
FreeBSD 2.1R	64	64
HP/UX 10.01	64	64
Linux	64	64
MacOS/MacTCP 2.0.x	60	60
OSF/1 V3.2A	60	30
Solaris 2.x	255	255
SunOS 4.1.3/4.1.4	60	60
VMS/Wollongong 1.1.1.1	128	30
MS Windows XP	128	128

We see that the default TTL values are usually: 16, 30, 32, 60, 64, 128 and 255. In this paper, we ignore the value 30 and 60 and use only 32, 64, 128 and 255. The reason is the following common OSs like Windows, FreeBSD and Linux, are setting 32 and 64 as the default TTL. Thus, we create the following formula to calculate the hop count:

- *(TTL < 32) H = 32 - TTL*
- *(32 < TTL < 64) H = 64 - TTL*
- *(64 < TTL < 128) H = 128 - TTL*
- *(128 < TTL < 255) H = 255 - TTL*

Thanks to the formula we can easily find out the distribution of hop-count (Figure 10). Furthermore, we use a counting variable for each default TTL, once 128 is used by the formula, its counting variable increase by 1, so do the counting variables for 32, 64, 255. By that method, we also have the distribution of the default TTL mentioned in the above section.

In the Figure 10, the maximum hop-count or the longest distance in the P2P-IPTV world is 35 for Japan viewpoint and 50 for France viewpoint. Unfortunately these values are equivalent to the default TTL of 255. As we have known

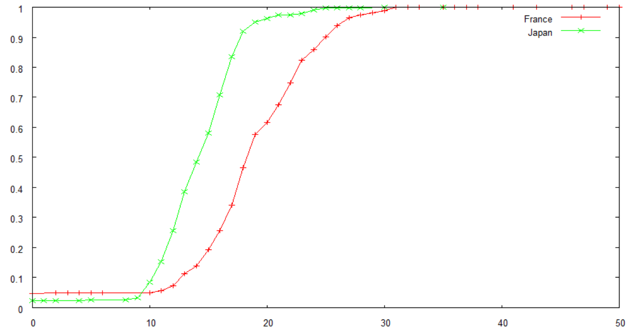


Figure 10: CDF of hop-count in Japan and in France

that the value of 255 is probably an error, the furthest distance is actually 28. This distance is between a Japanese and a Chinese, it is definitely different from the real world geography. Besides, the average distance in our P2P-IPTV system is 15 and the shortest distance is zero, between a French and another Chinese! It is really an impressive result because France and China are even in different continents. But as the virtual world is not organized like the real world, two people in the same country may have a very long distance between them because they are in two different AS. However, we will discuss more throughoutly about the AS (Autonomous Systems) later in this paper.

4.3 BEHAVIORS IN THE P2P-IPTV WORLD

In previous sections we have analyzed the P2P-IPTV world population and the distance between people in it. In this section, we will take a deeper look at entities in that world: users' behaviors and countries' behaviors. The first experiment is divided into two parts: one is based on time-slots and the other is based on the entire period of time; while the second experience is done only with the entire period of time. The reason for this difference is as follows: users join and leave at anytime, if we take just a general look, we cannot see this change, so we have to analyze more precisely with each time-slot of 2 minutes to understand the users' behaviors. However, we cannot see the whole picture of the P2P-IPTV world with only little pieces (2 minutes time-slot), so we gather them all to find out the contribution of each country to the virtual world.

4.3.1 Time-slots versus long-time period

Once more in this section, we talk about the number of users, but this time is different. This number is now related closely to the time course. We will see if users increase with the time passes or inverse. We examine also the way people send and receive; in other words, we will investigate when people in our virtual world upload and download a lot; in total, if they "prefer" to upload or to download.

First, Figure 11 shows us the growth of users over time. In the first 2 minutes, there are only 688 users, the next 6 minutes the number of users become 549 and it is the time with the fewest users of any time. After that people join little by little until reaching 1805 at the 54th minute, but then a lot of them leave suddenly in the next 4 minutes and only half of them still staying in front of their screen. Fortunately, many others users join and make the P2P-IPTV community grow

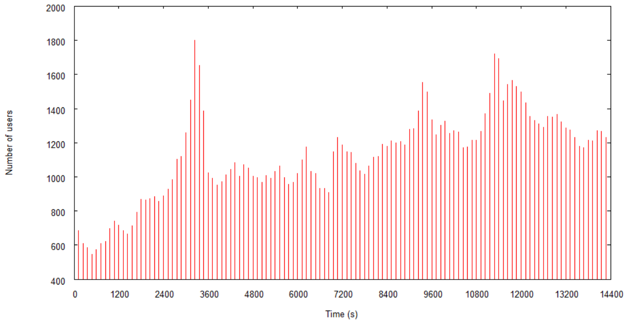


Figure 11: Histogram of number of users

slightly. Then, no important change happens in the period between the 60th minute and the 148th minute, the number of users varies from about 950 to approximately 1100. The average number of people is about 970 in the first two hours. For last two hours, the number of viewers averaged 1300 people viewing the channel, 1.4 times greater than the first 2h period. In conclusion, we assure that the population grows apparently as time passes.
Suddenly, the figure and the above conclusion make us wonder: are all these people playing the same role in this P2P-IPTV world? More concretely, are there any of them receiving (download) without sending (uploading) while others send without demand of receiving in return?

The 4 figures below (Fig. 12) will satisfy our curiosity. First, the figure on the left (Figure 12(a)) represents the first 2 minutes of the TV program, there are not too many people and almost of them demand to download. This is reasonable because when the program begins the buffer of every user is empty; but in next 10 minutes (Figure 12(b)), the situation changes a little, there are more people uploading their video blocks and the throughput is higher. Next, the change is clearer at the 54th minute when people join the most (Figure 12(c)) the density is really higher than two former figures; there, the ratio download/upload is about 50/50. In the last 2 minutes (Figure 12(d)), the upload amount is a little greater while the density of people is a little lower.
In conclusion, we remark that people in the P2P-IPTV world are represented, in the above figures, by tracks with different density. That means they are grouped by some criteria; more concretely, in this case it is the IP number. As we know IP ranges are usually assigned to different countries; hence, we can conclude that each country in this virtual world play a distinct role. Now, we will investigate the roles of countries and their behaviors in the P2P-IPTV community.

4.3.2 Countries behaviors

A comparison between the amount of upload and download of countries (Figure 13) gives us significant informations about our virtual world: China and Hong Kong together wins the 1st place in the download ranking (with 53%). Japan and France overcome the difficulty of small population taking the 2nd and 3rd ranks respectively while United Kingdom with a greater population (behind China) is surprisingly the 5th country in the download ranking. Countries like Spain, USA, Taiwan posse maximum 3% of download amount. In the upload ranking, there are many changes: United Kingdom proves its force with 18% of the upload amount to take the 1st in the ranking. Following right behind is China with 15%. France falls back to its 6th place, behind Spain (11%) while Japan posses a small portion of 3% and achieves only the 11th place in the ranking. In conclusion, these upload/download rankings show us the global view of the national affairs in the P2P-IPTV world. Unfortunately, the above order contains a limit: it considers the whole country like an entire entity. But in fact, there are many ASs of other nations inside one country's territory. Therefore, we will take a deeper look at each country and compare their real contribution, in term of ASs.

4.3.3 Autonomous Systems contribution

Today, there is not a nation which has never cooperated with the rest of the world. In other words, there are many international organizations, ISP and enterprises that cover many countries and the majority of them are represented by ASs in the P2P-IPTV world. There are about 450 autonomous systems in our experiment. But to facilitate the vision, we present only 30 ASs which contribute the most to the upload/download amount. The rest is regrouped and named under "Other".

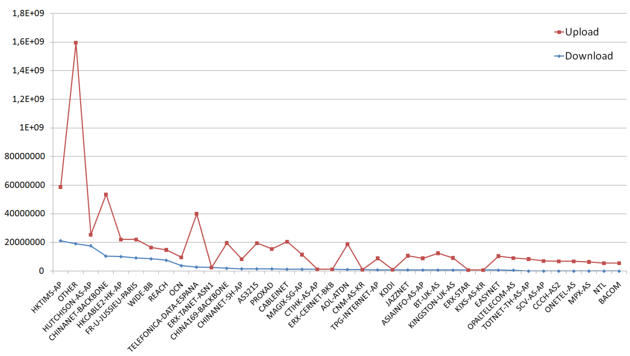
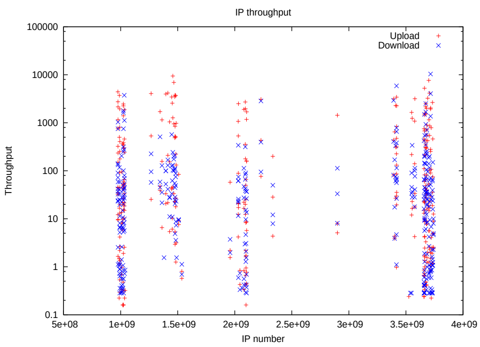
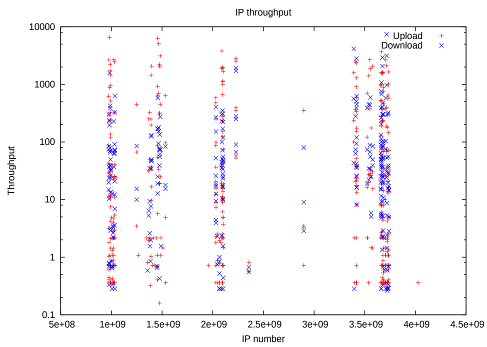


Figure 14: Upoad/Downoad per AS

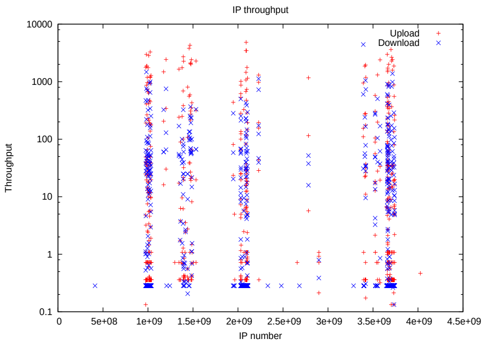
As we see in the Figure 14, the biggest download contributor of the P2P-IPTV world is HKTIMS-AP (Hong Kong General Post Office). Following just behind is the "Other" AS which contains 430 different autonomous systems. The "Hutchison Global Communications" (Telco & Internet Services Provider) is the third AS in this experiment. Here, we can see how large enterprises impact on the whole virtual world: just "GPO Hong Kong" and "Hutchison" contribute approximately 30% download amount while more than four hundred ASs contribute the 70% remaining. The WIDE system (cf. Section 3) stands 7th on the list (6%), right behind the FR-U-JUSSIEU-PARIS (7%), a member of the LIP6 network. Another autonomous system that covers Spain territory is Telefonica-Data-Espana takes the 10th place in this download curve. There are also two other famous enterprises in our downloading statistic: AOL and Kingston, these two giants help the P2P media streaming by their uploading a lot and downloading modestly (8th and 16th respectively in the upload ranking versus 20th and 27th in the download ranking). By the way, in the upload contribution picture, the quantity becomes more important than in the former. The "Other" ASs (contains 430 ASs within) uploads



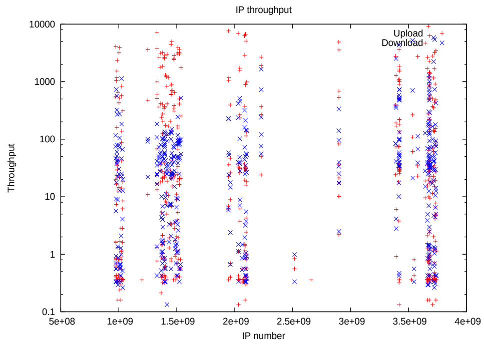
(a) t = 2 min



(b) t = 10 min

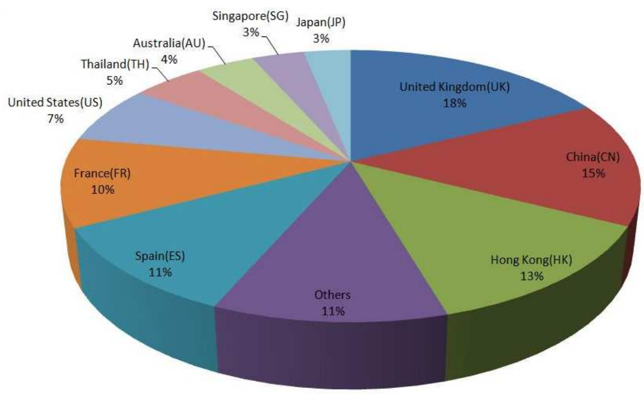


(c) t = 54 min

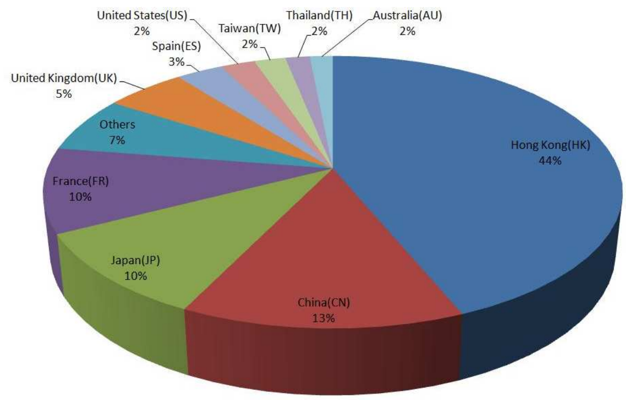


(d) t = 240 min

Figure 12: Upload/download amount of users



(a) Upload



(b) Download

Figure 13: Download and upload percentage of countries

the most to the P2P-IPTV community. HKTIMS-AP cannot keep its rank and is pulled back to the 3rd rank; instead, CHINANET-BACKBONE occupies the 2nd. The Spain AS improves on its position in the upload curve by becoming the 4th contributor in the virtual world. The two ASs of the networks on which we did our experiment (LIP6, WIDE), are in the 10th and 21th place of the upload ranking. In addition, we remark that some autonomous systems appear in the Upload Ranking but not in the Download Ranking and vice versa.
In conclusion, we can obviously see that: international enterprises and organizations in the P2P-IPTV world upload more than download. This is an interesting characteristic of the P2P-IPTV so that service providers should pay attention to balance their uploading and downloading bandwidth.

5. CONCLUSION AND FUTURE WORK

With many applications recently developed, P2P-IPTV is more and more popular. Many TV stations are beginning to air shows over Internet; furthermore, the more people watch these digital channels, the less they watch TV. Thus, P2P-IPTV menaces replacing traditional television one day. Nevertheless, until now none software developer publishes their API (Application Programming Interface) for performance testing or measurement. In coming years, when IPTV becomes an official distribution mechanism for the television channels, more documents will be destined to the public. But while waiting to that day, we still have to study the P2P-IPTV systems by active or passive measurement. To conserve the objectivity of the measurement method, we passively measured the P2P-IPTV using trace files.

In this work, we studied P2P-IPTV in different points of view: we investigated the number of users in many countries all over the world. The contribution of each country is mentioned in both upload and download aspect. Comparing between these countries, we established a ranking in which their percentage is indicated. In the approach of proximity logic, we analyzed the distance between people in the P2P-IPTV world. The value of distance is calculated by number of hops from the source to the destination. We found that the maximum distance is 28 hops while the average distance between users is 15. The hop-count in our study is based on the time-to-live (TTL) of each packet. To this end, the value of the default TTL depends principally on the operating systems in which IPTV software is installed, the Internet size and the NAT's modification as well.

Also in this paper, we presented the cumulative distribution function (CDF) of the number of used ports per machine. We stated that almost users do not use more than 1000 ports for one IP address; the rest may have a relation with the network address translation. Moreover, we studied the growth of the P2P-IPTV population with the time passes, the time when people join the most as well as the time there are fewest users. As users in the same country can belong to different Autonomous Systems, we also established the ASs rankings in both upload and download direction and conclude about the unbalance between the upload and download throughput.

In our future works, we continue developing the heuristic method to detect NAT that mentioned in this paper. Moreover, we will try to improve the measurement by eliminating inactive IPs which means analyzing only IP addresses which contribute to the network, in upload direction, in download direction or both. In the other hand, we will calculate the time needed to travel around the P2P-IPTV world (the round trip time-RTT). Then we can determine the start-up delay as well as the play-back delay in the IPTV network. This can be helpful to improve the quality of service and the quality of experience so that service providers could gain more while users have better TV channels to watch.

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