Internet Traffic Analysis: A Case Study From Two Major European Operators

Moufida Feknous, Thierry Houdoin, Bertrand Le Guyader, Joseph De Biasio
Orange Labs,
2, avenue Pierre Marzin,
22300 Lannion, France
moufida.feknous@orange.com
thierry.houdoin@orange.com
bertrand.leguyader@orange.com
joseph.debiasio@orange.com

Annie Gravey,
Telecom Bretagne,
Technopole Brest-Iroise, CS 83818,
29238 Brest, France
Annie.gravey@telecom-bretagne.eu
Jose Alfonso Torrijos Gijón,
Telefónica I+D
D. Ramon de la Cruz, 84
28003 Madrid, Spain
jgijon@tid.es

Abstract— **Network and service operators nowadays use probes located in their networks in order to improve their knowledge on traffic evolution. The limited set of managed services like IPTV enable the use of well controlled rules for network dimensioning but this is not the case for public Internet originated traffic. Due to the growing success of services delivered by Internet players, a close attention given to customers' usage is mandatory to make accurate forecasts in order to avoid future network congestion. The present paper proposes a detailed analysis based on real Internet traffic captured on fixed (xDSL, FTTH) and mobile networks of Orange France and Telefónica operators. Internet traffic profile (traffic evolution over the time) for fixed and mobile networks is described. The paper discusses the relation between access technologies and traffic profiles. Additionally, it clarifies how both fixed and mobile residential customers access Internet services. This provides insight on the applications generating the major part of the traffic (i.e. video streaming, peer-to-peer, file downloading, etc.) and on the proportion of traffic generated by the "heavy users".**

Keywords—IPTV, Internet traffic, xDSL, FTTH, heavy users, fixed and mobile networks, video streaming, file downloading, P2P.

I. INTRODUCTION

More and more, Internet residential customers have an appetence for real-time video applications, like video streaming, in competition with traditional applications such as file downloading and peer-to-peer (P2P). In the United States, Netflix video service represents about 32.7% of the total downstream Internet traffic during busy hours [1]. In 2012, Korea Telecom (KT) decided to block the Internet access to connected-TVs as they were becoming responsible of a drastic increase of Internet traffic volume in South Korea compared to traffic volume generated by IPTV [2]. Nowadays, Internet video applications are the major contribution to data traffic on mobile networks [3] [4].

In France, Internet commercial offers up to 1Gbit/s are proposed on FTTH access network. So, it is necessary to identify the users' applications in order to avoid future potential bottlenecks and to guarantee an optimal Quality of Experience (QoE) to the users. This knowledge will allow the operators to dimension their networks and the peering links corresponding to their offers.

Several papers already presented Internet traffic measurements analysis in fixed [5] [6] [7] [8] and mobile networks [9]. The present paper provides a detailed analysis of Internet traffic data observed by two major European operators, considering both wireline broadband access technologies (xDSL, FTTH) and wireless (Mobile and Wi-Fi) access networks.

In this paper, Internet traffic captured on Orange (in France) and Telefónica (in Europe) networks is analyzed and Internet profile is defined for xDSL, FTTH and mobile Internet customers. The impact of mixing access technologies is discussed and heavy users' impact on total Internet traffic volume is analyzed.

The fixed (resp. mobile) Internet traffic data used for this analysis has been captured in October 2013 (resp. November/December 2013) for Orange, and in March 2013 for Telefónica [10].

Section II describes the probes used for these measurements and details the customers' daily traffic profiles whatever the type of network. It also specifies the notion of busy hours previously defined in [11]. Section III details the major Internet applications in upstream (US) and downstream (DS) direction for fixed and mobile networks. It illustrates some common Internet tendencies on fixed and mobile networks. Section IV illustrates the impact of mixing ADSL and FTTH customers on their respective Internet traffic evolution. Moreover, it analyzes the weight of heavy users in the network. Some conclusions are given in section V.

II. INTERNET PROFILES ANALYSIS OF RESIDENTIAL CUSTOMERS

A. *Traffic probes*

In an operational network, traffic measurements are mainly performed according to two methods. The first one is an active method based on the observation of some specific test flows of IP packets intentionally sent in the network.

The second one is a passive method in which all the transmitted IP traffic is captured and analyzed in real time. For this analysis, traffic probes are passive (using port mirroring for Telefónica network) and allow a detailed analysis of the traffic. In fixed networks of each operator, traffic probes are located between aggregation and core network and in mobile networks, probes are located between Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN).

The probes capture all packets from customers and first identify which customer is responsible for each packet and second to identify which application is used by the customers by using a DPI (Deep Packet Inspection) engine. In case of Orange probe, the DPI engine is able to recognize traffic from about 500 applications which are further aggregated in about twenty application categories (P2P, streaming, file downloading, etc.). And in the case of Telefónica, the probes can identify more than 700 protocols and multiple applications categories.

In the case of Orange fixed networks, the average number of residential customers under measurement was approximately 2500 for FTTH and 5000 for ADSL. Concerning Telefónica fixed network (ADSL and VDSL), the average number of customers was approximately 100.000. In Orange mobile network, Internet traffic observation is made on almost all Orange mobile customers and in Telefónica mobile network, the probes capture the traffic generated by approximately 1.500.000 customers.

B. *Downstream and upstream profile analysis for fixed customers*

The traffic measurement allows the operators to access a profile analysis over 24 hours. This section shows Internet data profiles in the case of xDSL and FTTH customers.

Thanks to this analysis, it is possible to clearly define the notion of "busy hour" as given in [11]. Internet activity knowledge is the opportunity to program in consequence maintenance actions and firmware updates (e.g. customer devices) during low activity periods [5].

- *Upstream profiles for xDSL and FTTH customers*

We have measured the upstream Internet traffic volume for FTTH / ADSL Orange customers between the 7th and the 13rd of October 2013. We have also done the measurements for xDSL Telefónica customers between the 23rd and the 29th of March 2013.

Fig.1 shows the normalized traffic volume, in relation with the maximum value, averaged over a week for each operator. For Orange customers, the upstream normalized volume is given hour per hour (aggregated traffic during 1 hour was provided by Orange) and every 3 hours for Telefónica ones (aggregated traffic during 3 hours was provided by Telefonica). The volumes generated by Orange customers (FTTH and ADSL) achieve a maximum during the time period [7pm – 10pm] which represents a "busy hour" period. These measurements show there is no real difference in the upstream Internet profile according to the day of the week. In the case of Telefónica network, the volumes reach their maximum between 6pm and 9pm. Fig.1 also shows a shift of one hour between Orange and Telefónica whatever the day of the week.

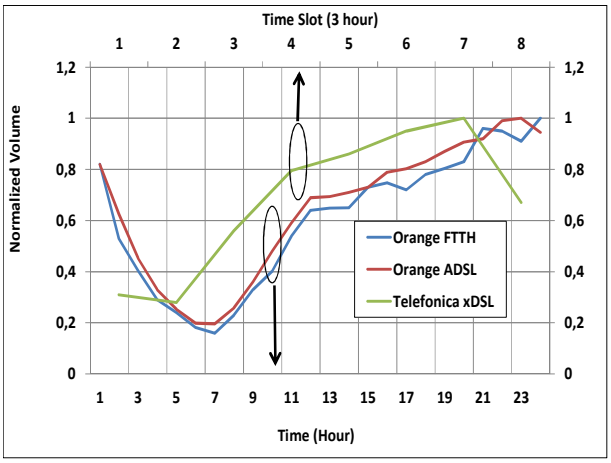

Fig. 1. Daily average upstream Internet profile for fixed Orange / Telefónica customers, observation performed on October and March 2013 respectively

- *Downstream profiles for xDSL and FTTH customers*

Fig.2 summarizes the daily average downstream Internet profiles for FTTH / ADSL Orange and xDSL Telefónica customers.

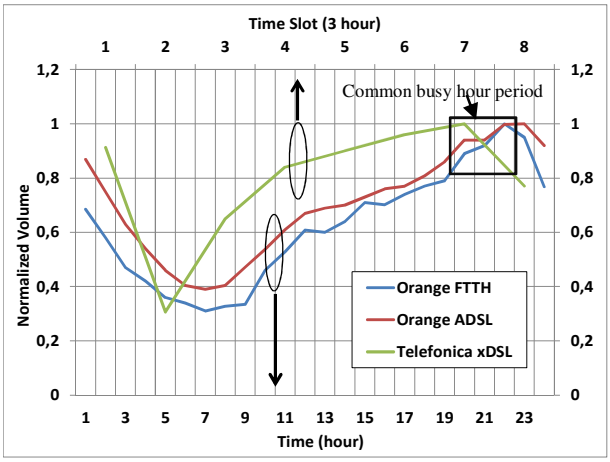

Fig. 2. Daily average downstream Internet for fixed Orange / Telefónica customers, observation performed on October and March 2013 respectively

According to our observation over a week, the average downstream Internet volume generated by Orange FTTH / ADSL customers reaches a maximum during the time period [7pm-11pm]. In the case of xDSL Telefónica customers, the maximum of traffic is observed during the time period [6pm – 9pm]. These results do not depict a real difference between Orange and Telefónica customers: the common "busy hour"

period [7pm – 9pm] can be defined (cf. Fig.2).In addition, the profile shape remains the same whatever the day of the week and the involved technology. Fig.2 illustrates a classical fixed European residential customer traffic profile as the traffic load increases during the day and reaches a maximum after the working day when people are at home after 7pm generally.

C. *Downstream and upstream profile analysis for mobile customers*

- *Upstream profiles for mobile customers*

Fig.3 is representing the daily average upstream Internet traffic profiles in the case of Orange and Telefónica mobile customers between the 28th of November 2013 and the 4th of December 2013 for Orange and between the 23rd and the 29th of March 2013 for Telefónica. We can see that, the traffic generated by Orange mobile customers during the week-day reached a maximum during two time slots. The first one is during the time period [12pm-2pm] and a second time slot is during the time period [5pm-7pm]. The first one represents a lunch break. In this time period, the customers use their mobile to watch a video streaming, web browsing, chatting with friends and checking e-mails. The second time slot of busy hours occurs at the end of the workday (e.g. in public transport). Week-day and week-end profiles of Orange customers are quite different. During the week-end, the daily average upstream volume achieves a maximum during the time period [6pm-7pm]. Week-end customers' profile is flatter than the week-day one as customers connections are more distributed over this time period. Whatever the day of the week, Fig.3 shows that the average volume generated by Telefónica customers achieves a maximum during the period [7pm-9pm] which represents the slot 7.

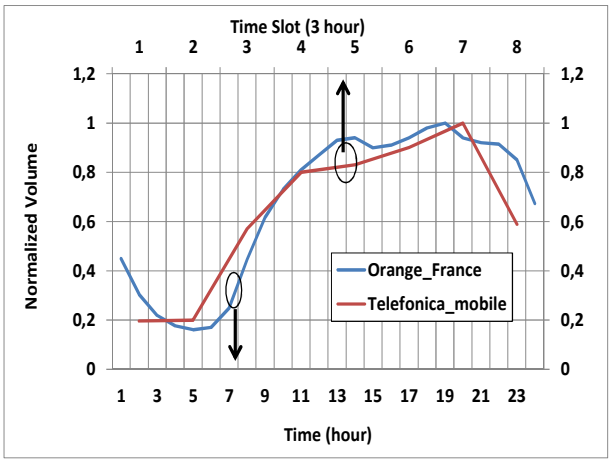

Fig. 3. Daily average upstream Internet profile for Orange and Telefónica mobile customers, observation performed for a week

- *Downstream profiles for mobile customers*

Fig.4 shows the daily average downstream profile of Orange and Telefónica customers in mobile network. In Orange mobile network, the volume generated by all customers reaches a first maximum during the lunch period [12pm-2pm] and a second one during the period [7pm-11pm]. The traffic shape is similar whatever the day of the week.

Fig.4 indicates that the daily average volume generated by Telefónica customers achieves a maximum during the time slot7 [6pm-9pm]. Also, we can easily notice that the time slot [7pm – 9pm] is a common "busy hour" period for Orange and Telefónica. The results also depict that there is a difference in the downstream traffic shape between Orange and Telefónica as the second maximum found in Orange mobile network does not appear on Telefónica mobile one.

Volume generated by the upstream mobile traffic represents the tenth of the volume generated in the downstream. This asymmetry is mainly due to the usage mode difference. Indeed, in upstream, mobile customers mainly use web browsing applications which generate a low traffic volume. In downstream, mobile customers mainly use video streaming which generates more traffic than web browsing.

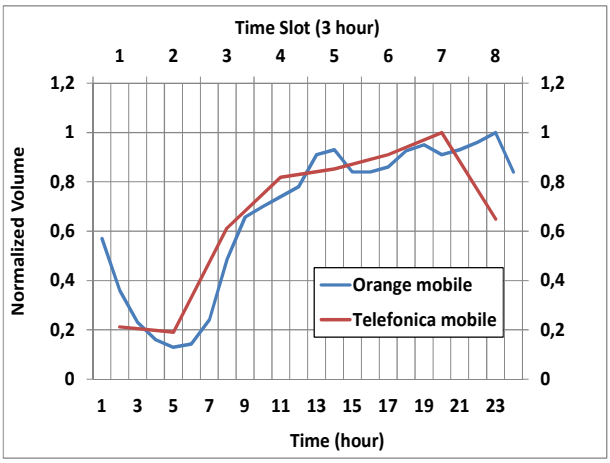

Fig. 4. Daily average downstream Internet profile for Orange and Telefónica customers, observation performed for a week

- *Mobile versus fixed profile*

Seeing figure 5, we can first observe that for the Orange FTTH/ADSL fixed network, the upstream traffic volume declines by 60% between night and day, whereas the downstream traffic volume declines by 80%. The permanent flow of P2P traffic which represents 78% of the FTTH upstream internet traffic composition (Cf. table 1) can explain this difference. We do not observe this phenomenon for the mobile network because P2P applications are blocked in Orange network. Similarly, this is confirmed on figure 6 for Telefonica xDSL network where curves for upstream and downstream flow are almost overlapped.

On the other hand, on figure 5 we can observe that the customer activity over the mobile network starts earlier in the morning and the volume variation after 10am is flatter while for fixed network, the traffic progressing slowly during the day , this is due to the "every time everywhere" characteristic of the mobile network. We don't observe this phenomenon in Telefónica network. It may be due to the resolution of the measure each 3hours.

We can first conclude that, in upstream, a fixed profile is more flat than the mobile profile because the mode of use of

wireless and wireline customers is different. As mobile customers are usually at home on evenings and largely use their mobile through the Wi-Fi access of their ADSL / FTTH Home Gateway, there is a rather limited traffic on evenings on the mobile network we do not observe on fixed ones (cf. Fig. 5 and Fig. 6).

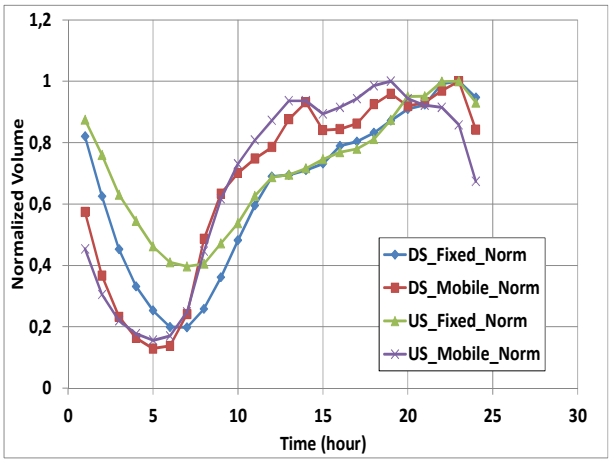

Fig. 5. Daily orange profile of fixed and mobile customers

For Telefónica, the fixed downstream (DS_Fixed_Norm) profile is similar to the mobile one (DS_Mobile_Norm), which is not the case for the profiles observed by Orange. The upstream and downstream Orange mobile traffic volumes remain quite stable over the day, with two maxima. It is not the case for ADSL and FTTH Orange customers as the traffic profile is increasing during the time slot [12pm– 9pm]. It is likely that these results illustrate the impact of residential gateways generalization in France as there is a significant impact on the offloaded traffic amount. We don't observe this phenomenon in fixed Telefónica network because the traffic is aggregated during 3 hours. However, measures' resolutions are different in both traces which may then impact traffic analysis results.

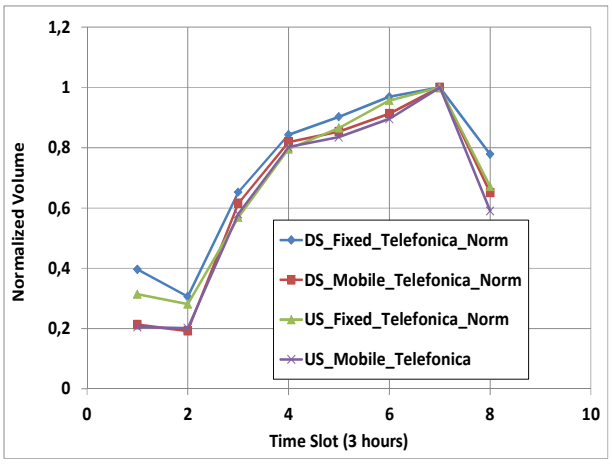

Fig. 6. Daily Telefónica profile of fixed and mobile customers

III. IDENTIFICATION OF THE MOST BANDWIDTH-DEMANDING APPLICATIONS

In this section, a specific focus is performed on Internet applications generating most of the traffic in upstream and downstream. In order to identify use cases of residential customers, it is necessary to define some categories of applications like P2P. So, P2P category gathers applications like eDonkey, eMule, Bit Torrent, etc. file downloading applications include progressive media (video, audio…) downloading, basic file downloading and software updates.

Streaming is used by many applications and allows visualizing for example a video or listening a piece of music without the need to store it completely on the end user device. With file downloading method, one content must be completely downloaded prior to be played.

A. Major use cases on fixed residential access networks

Table. I depicts the composition of Internet traffic in downstream and in upstream in the case of ADSL and FTTH Orange customers and xDSL Telefónica customers. These applications generate the most important part of the total traffic (either in upstream or in downstream).

TABLE I. DOWNSTREAM AND UPSTREAM INTERNET TRAFFIC FOR XDSL AND FTTH CUSTOMERS

	Downstream Internet traffic composition			
	Video Streaming	**P2P**	**Web**	**Downloading**
Orange FTTH	36%	16%	16%	26%
Orange ADSL	26%	12%	18%	21%
Telefónica xDSL	36%	20%	15%	3%
	Upstream Internet traffic composition			
	P2P		**Web**	
Orange FTTH	78%		5%	
Orange ADSL	48%		18%	
Telefónica xDSL	50%		18%	

Whatever the operator and the access network (FTTH, ADSL, xDSL), P2P is the application which mainly constitutes the upstream traffic. Thanks to massive FTTH deployment, new greedy applications (such as cloud storage, virtualization, etc.) could appear to the detriment of P2P applications which could revise network aggregation capacity and architecture [12].

In downstream, video streaming is now the main application generating most of the traffic (up to 36% for Orange FTTH and Telefónica customers) and can consume a high bandwidth. File downloading (resp. P2P) is the second family of applications generating the most part of the traffic in Orange (resp. Telefonica) network. Massive use of streaming video can lead to a congestion of the peering links allowing to increase the capacity of these links in order to avoid any link bottleneck.

Fig. 7 represents the transport protocol (TCP / UDP) distribution for Orange FTTH / ADSL customers. TCP

applications represent about 90% of the total downstream traffic volume. TCP is mainly involved in video streaming, web browsing and file downloading. In downstream, UDP traffic is quite low and is mainly used in P2P applications. In upstream, BitTorrent with its new Micro Transport Protocol (µTP) is based on UDP and is the application that generates the most part of the traffic

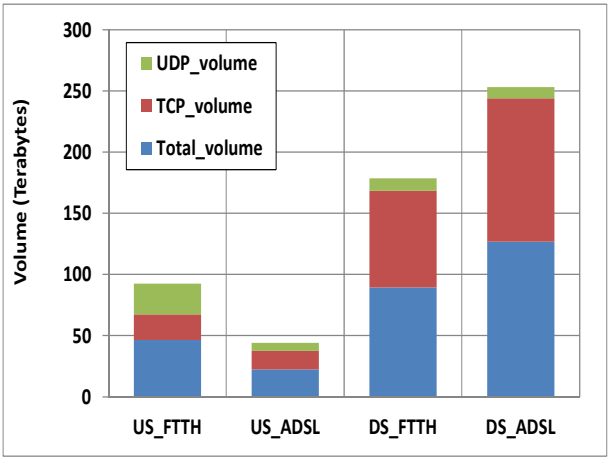

Fig. 7. Global TCP and UDP traffic volume in FTTH and ADSL access networks

B. *Major use cases of mobile customers*

Table. II describes the main applications composing total Internet traffic in Orange and Telefónica mobile networks. Video streaming is the application generating the main proportion of the traffic in downstream in Orange networks and is in competition with web browsing, which remains the application generating the main part of the traffic (up to 47%) in the case of Telefónica mobile network. In total, video streaming and web browsing represent 73% (resp. 80%) of the total downstream traffic in the case of Orange (resp. Telefónica) mobile network. In upstream, whatever the operator, web browsing is the application generating the most of the traffic (up to 59% (resp. 47%) in the context of Orange (resp. Telefónica) mobile network). P2P applications are blocked in Orange mobile networks so the traffic remains lower than 0.5% and reaches 6% of the total upstream traffic in the case of Telefónica mobile network as P2P applications are allowed.

TABLE II. DOWNSTREAM AND UPSTREAM INTERNET TRAFFIC FOR MOBILE CUSTOMERS

	Downstream Internet traffic composition	
	Video streaming	**Web**
Orange network	39%	34%
Telefónica network	33%	47%
	Upstream Internet traffic composition	
	Web	**P2P**
Orange network	59%	< 0.5%
Telefónica network	47%	6%

These results are consistent with a 2013 Sandvine report [13]. In Europe, P2P generates about 50% of upstream total traffic in fixed network. In the downstream direction, video streaming represents about 30% of total traffic followed by web browsing and P2P. In mobile network, network usage is related to web browsing and represents about 30% of total traffic generated in upstream directions. In downstream direction, streaming video and web browsing represent together about 50% of total volume.

C. *Towards a fixed and mobile convergence of use cases*

- *Some similarities between fixed and mobile networks*

Sections IV.A and IV.B showed that video streaming is the downstream main application used either in fixed networks or mobile ones and that, whatever the operator. Web browsing is the other downstream main application on mobile networks and is the third category of application to consider in the case of fixed networks. Upstream Internet mobile traffic is mainly based on web browsing while P2P application is the preponderant application in the case of fixed networks. In mobile Orange network, P2P applications are blocked, but this could change with fixed/LTE plans. But in this last case, access to Internet network is possible but would remain limited as the data is capped in the mobile network. In the upstream direction, the usage mode of fixed and mobile customers is different for both operators (Telefónica and Orange) with some similarity which is mainly the use of Web based applications.

- *Evolution of traffic volume generated by mobile customers using their fixed access*

More and more, mobile customers use the Wi-Fi interface embedded on their mobile device. This behavior also impacts the traffic data profiles of the fixed networks.

The Compound Annual Growth Rate (CAGR) of downstream average traffic volume generated by Orange mobile customers using Wi-Fi access between 2011 and 2013 represents an increase of 56%. In the same time, the number of customers using their mobile devices in fixed access networks increased by 38%. Our results roughly confirm the results presented by CISCO VNI, stating that 33% of total mobile data traffic was offloaded onto the fixed network through Wi-Fi or Femtocell in 2012 [3].

The observed CAGR is mainly due to video streaming and file downloading applications. In the case of mobile networks, a file downloading generally represents the software update of mobile operating systems. As these devices need more and more bandwidth for updating the operating system, customers prefer to use fixed Wi-Fi access. Video streaming is one of the main downstream applications in fixed and mobile networks and represents [50-70%] of the traffic generated on Wi-Fi home access points.

IV. INTERNET TRAFFIC PROFILE ACCORDING TO ACCESS TECHNOLOGY

A. *Comparison between FTTH and ADSL technologies in the case of Orange customers*

Table I. summarizes the average Internet volume generated by FTTH and ADSL customers in upstream and downstream over the observation period. It allows giving the ratio between downstream and upstream average Internet volumes and the dedicated ratio for the applications generating most of the traffic in upstream direction.

TABLE III. AVERAGE VOLUME PER CUSTOMER BY APPLICATION FOR FIXED ACCESS NETWORKS IN OCTOBER 2013.

Volume given in this table represents an average volume per customer	**FTTH customers**	**ADSL customers**
US Average Volume (Gbytes)	19.18	4.30
US P2P Average Volume (Gbytes)	14.94	2.04
DS Average Volume (Gbytes)	36.95	24.5
DS streaming Average Volume (Gbytes)	13.29	10.54
DS Download Average Volume (Gbytes)	9.51	5.02
DS P2P Average Volume (Gbytes)	5.80	2.94
DS Web Average Volume (Gbytes)	5.36	4.36
Ratio between DS Average volume and US average volume	1.90	5.70
Ratio between DS P2P Average volume and US P2P average volume	0.39	1.44

The volume generated in upstream by FTTH customers is 4.5 times higher than the average volume generated by ADSL ones. In downstream, the average volume generated by FTTH customers is 1.5 times higher than the average volume generated by ADSL Orange customers.

In ADSL access networks, the traffic is unbalanced due to the limitation of the physical capacities of the upstream channel. Therefore, it is quite logic to observe a ratio of 5.7 between the downstream Internet volume and the upstream one. Because of increased performances and capacities of the upstream channel in FTTH access networks, the downstream and upstream Internet traffics are more symmetric in FTTH (the ratio is 1.9). P2P file sharing applications take advantage of such access technologies and when the customer lets the application active, the upload volume could be very important. It is observed that, the ratio between downstream and upstream P2P volume in FTTH (resp. ADSL) is 0.39 (resp. 1.44). It illustrates that FTTH customers send out more data than they receive in P2P. On the contrary, ADSL customers receive more data than they send in P2P. This allows us to conclude that some FTTH customers are becoming P2P servers, which is particularly true in a context of coexistence of different access technologies (ADSL and FTTH). But this behavior could change if all customers become FTTH ones.

B. *Heavy users impact on traffic generation*

In the case of FTTH access networks, 80% of downstream (resp. upstream) traffic is generated by 15% (resp. 3%) of fixed customers. In the case of ADSL access networks, 80% of downstream (resp. upstream) traffic is generated by 38% (resp. 11%) fixed customers. These results are depicted by Fig.8 and Fig.9. These customers are called “heavy users”. Upstream FTTH (resp. ADSL) heavy users are almost five times (resp. 3 times) lower than downstream ones. Fig. 8 shows that the curves are especially scampered off in the case of FTTH because of the behavior of P2P applications which share contents with a few customers. The user selection criteria are based on available upstream bandwidth and the nearest user having the target content. In this case, rapidly, a few FTTH customers become P2P servers (about 3% for example).

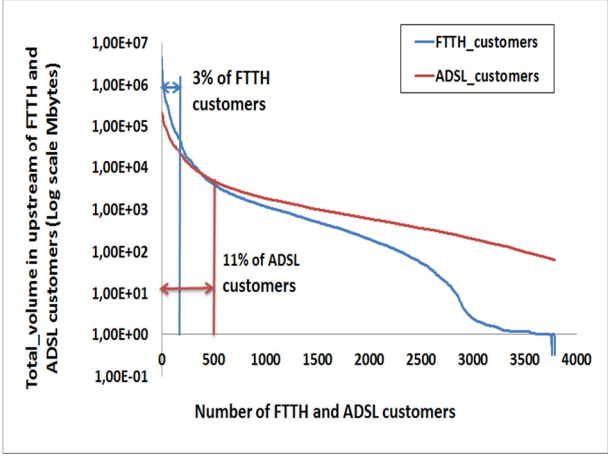

Fig. 8. Total upstream Internet traffic volume generated in a day of November/December 2013 by ADSL and FTTH customers

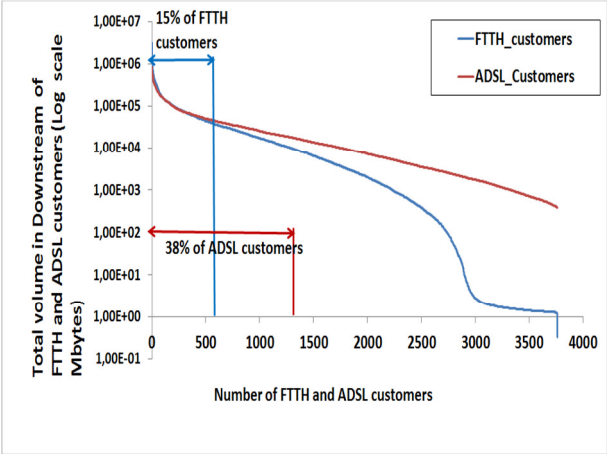

Fig. 9. Total downstream Internet traffic volume generated in a day and Identification of Heavy users

In downstream, Fig.9 shows that FTTH /ADSL curves are flatter than upstream ones as users’ behavior is mainly built on video streaming and file downloading. Also, the difference of heavy users in upstream and downstream illustrates the mode of usage done by customers on the network.

We observe that the ten first downstream heavy users are not automatically classified as the ten first heavy users in upstream meaning that heavy users do not use the network in the same way. This is the case for FTTH and ADSL. Some

heavy users load a network in upstream using P2P applications and others load a network in downstream using streaming video or file downloading.

C. Heavy users and applications used

In upstream, the traffic generated by Internet FTTH and ADSL heavy users is mainly based on P2P applications representing more than 70% of the total traffic volume. As the volume generated in upstream by FTTH heavy users is higher than traffic volume generated in downstream, we can deduce that FTTH capacity enables user to act as servers in the case of file sharing applications that turns them into heavy users. With respect to ADSL heavy users, the volume generated in upstream is lower than the volume generated in downstream because of physical properties limitations of the ADSL upstream channel. In downstream, the ADSL and FTTH heavy users almost generate the same volume.

In downstream, the main part of the traffic generated by heavy users is composed of video streaming, file downloading, P2P applications and web browsing.

V. CONCLUSION

In fixed and mobile networks, generally the time slot [7pm-9pm] is a common "busy hour" period for Orange and Telefónica customers and traffic profiles are quite similar whatever the operator. Even though probe measurements in Orange mobile network report a second busy hour between [12pm-2pm] corresponding to lunch break time.

In the case of fixed network, traffic profiles depict classical European residential customers' behavior.

In upstream (resp. downstream), 3% (resp. 15%) of Orange FTTH network customers generate 80% of upstream (resp. downstream) traffic.

On ADSL / FTTH Orange networks and xDSL Telefonica network, P2P applications generate the most of the upstream traffic. It generates 48% or more of the traffic in the case of xDSL and more than 70% in the case of FTTH. Some FTTH customers are becoming P2P servers, which is particularly true in a context of coexistence of different access technologies (ADSL and FTTH).

In downstream, video streaming, file downloading, web browsing and P2P applications represent the applications generating more than 80% of the total downstream volume in FTTH and xDSL.

Some common use cases appear in the same time on fixed and mobile networks. Video streaming is commonly used at the same time on fixed and mobile networks which is one convergent application.

More and more, mobile customers use Wi-Fi home access points to access to Internet network and that will impact on fixed networks in the future.

ACKNOWLEDGMENT

This work was partially funded by the FP7/2013-2015 European project COMBO (COnvergence of Fixed and Mobile BrOadband access/aggregation networks) under grant agreement n°317762.

REFERENCES

[1] Traffic flow on broadband Access Networks, Terry D.Shaw, PhD-Cable Labs-2012

[2] V. Flood, "Bandwidth a barrier for (Dis) connected TV in South Korea", February 2012. http://www.videoadnews.com/2012/02/13/bandwidth-a-barrier-for-disconnected-tv

[3] Cisco Visual Network Index Global Mobile Data Traffic Forecast Update, 2012-2017,February 2013\ www.cisco.com

[4] J.Ankey, "Google: Mobile devices generate 10% of all YouTube video downloads", September 2011\ www.fiercemobileit.com

[5] M.Kihel, P.Ödling, "C.Lagerstedt, A.Aurelius, "Traffic analysis and characterization of Internet user behavior", Dept.of Electrical and Information Technology,Lund University,Lund, Networks and Systems Laboratory (NETLAB) Acreo AB, Kista, Sweden, ICUMT 2010 proceddings.

[6] G.Vu-Burgier, "Analysis of the Impact of Early Fiber Access Deployment on Residential Internet Traffic",Orange Labs, Lannion, France, ITC 2009 proceddings.

[7] F.Guillemin, C.Rosenberg, L.Le, G.Vu_Burgier, "Peer-to-Peer Traffic :From Measurements to Analysis", Orange Labs, Lannion, France, Dept Of ECE, University of Waterloo, Ontario, Canada, GLOBECOME 2008 proceedings.

[8] L.Plissonneau, J.-L.Costeaux, and P.Brown, « Analysis of Peer-to-Peer traffic on ADSL », in Passive and Active Measurement vol.3431 of Lecture Notes in Computer Science , pp.69-82, Springer-Verlag Berlin Heidelberg, 2005.

[9] R.Pries,F.Wasmer,D.Staehle, K.Heck, and P.Tran Gia,"On traffic characterisctics of a broadband wireless internet access",IEEE Next Generation Internet Networks,pp..1 7, 2009.

[10] COMBO D2.3 "Traffic modelling in FMC network scenarios", December 2013.

[11] R.Han, Z.Jia, X.Qin, C.Chang, H.Wang, "Application of Support Vector Machine to Mobile Communications in Telephone Traffic Load of Monthly Busy Hour Prediction", College of Information Science University, Xinjiang Mobile Communication Company, Urumqi, China, Proceedings ICNC 2009.

[12] M.Feknous, B.Le Guyader, A.Gravey, "Revisiting Accesss and Aggregation Network Architecture", Orange Labs and Telecom Bretagne, France, CCSCI 2014 proceddings.

[13] Sandvine, "Global Internet Phenomena Report", 2013. https://www.sandvine.com