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Thesis

NETWORK (NET) NEUTRALITY:

TECHNOLOGY AND REGULATORY APPROACHES

by

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ABSTRACT

The Internet is a global network that allows millions of devices to access each other and convey information and communication services. Today, the Internet is an architecture that supports triple play applications such as voice, video and data and even quadruple play with mobility and IPv6. A lot of different services are provided on the Internet including VoIP and IPTV. Network (net) neutrality issue and its technical and regulatory contexts in the Internet environment have been argued in the last decade. Net neutrality means that Internet Service Providers (ISPs) should treat all contents, data packets and applications identically regardless of source and offer equal treatment to all traffic. Net neutrality is of great significance in terms of Quality of Service (QoS), network management, investments and innovations, non-discrimination and competition and also security and privacy issues.

Keywords: Internet, network (net) neutrality, open access, regulation.

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ABBREVIATIONS

1G	:	First generation mobile networks
2G	:	Second generation mobile networks
3G	:	Third generation mobile networks
4G	:	Forth generation mobile networks
ADSL	:	Asymmetric Digital Subscriber Line
BPON	:	Broadband Passive Optical Network
CP	:	content provider
DARPA	:	Department of Defense Advanced Research Projects Agency
DDoS	:	Distributed Denial of Service
DOCSIS	:	Data over Cable Service Interface Specification
DPI	:	Deep Packet Inspection
DSL	:	Digital Subscriber Line
DSLAM	:	Digital Subscriber Line Access Multiplexer
EC	:	European Commission
EU	:	European Union
FCC	:	Federal Communications Commission
FTC	:	Federal Trade Commission
FTTB	:	Fiber to the Building
FTTH	:	Fiber to the Home

FTTx	:	Fiber to the x
GPON	:	Gigabit passive optical networks
HFC	:	Hybrid Fiber-Coaxial
IP	:	Internet protocol
IPTV	:	Internet Protocol Television
IPv6	:	Internet protocol version 6
ISP	:	Internet Service Provider
ITU	:	International Telecommunication Union
IXP	:	Internet Exchange Point
LTE	:	Long Term Evolution
Mbps	:	Megabit per second
NGN	:	Next Generation Network
NPRM	:	Notice of Proposed Rulemaking
NRA	:	National Regulatory Authority
OECD	:	Organization for Economic Cooperation and Development
P2P	:	Peer to peer
PON	:	Passive Optical Network
QoE	:	Quality of Experience
QoS	:	Quality of Service
SMP	:	Significant Market Power
TCP	:	Transfer Control Protocol

telco	:	telecom company
TFEU	:	Treaty on the Functioning of the European Union
VDSL	:	Very-high-bit-rate digital subscriber line
VoIP	:	Voice over IP
Wi-Fi	:	Wireless Fidelity

CHAPTER 1: INTRODUCTION

The Internet as a closed research network (the abbreviation of the inter-network), developed in 1969 by the Department of Defense Advanced Research Projects Agency (DARPA) in the USA, was designed for academic purposes between just a few universities at first. But, today it is in the process of transitioning towards an architecture supporting real-time triple play applications such as voice, video and data (Jordan, 2007). A number of different services are provided on the Internet including e-mail, browsing, peer-to-peer (P2P) services, VoIP (*Voice over IP*), and many others (Economides & Tåg, 2011).

The Internet, a global network designed on a set of open standards, can be described as a platform that lets end users and content providers (CPs) together and allows millions of computers or devices to access[1] a variety of information and communication services (Bourreau & Lestage, 2013 and Wong et al., 2010). Meanwhile, the role of network infrastructure owners has shifted to an essential gatekeeper position in the information society (Krämer et al., 2012).

One of the most important principles of the internet is that all the different services are transformed into homogeneous data packets for the transport over the IP networks. They are handled by protocols (*TCP-Transfer Control Protocol and IP-Internet protocol*) and sent (by routers as switching) over network infrastructures (Kruse, 2008). The TCP and IP protocols are open standards, meaning that they are non-proprietary, unlicensed, and unrestricted (Sashkin). The architectural design of the Internet is based on two fundamental principles;

[1] Access enables an operator to utilize the facilities of another operator in the furtherance of its own business and in the service of its own customers (Marcus et al., 2011).

- Messages are fragmented into data packets that are routed through the network autonomously (*end-to-end principle*),
- As fast as possible (*best-effort principle*).

This kind of nodes (routers) architecture does not differentiate packets based on their content or source. Packets are stored in a router's queue if they arrive at a faster rate than the rate at which the router can send out packets. If the router's queue is full, the package is dropped and it must be resent by the source (Krämer et al., 2012).

Historically, economic realities of high fixed costs led telecommunications industry as a natural monopoly and this phenomenon made regulation inevitable (Dixon et al. 2006). In this perspective, "network (net) neutrality" issue and its technical and regulatory contexts have been arguing and considering in the last decade in the sector and it has become the focus of attention in the regulatory debate on the Internet (Crocioni, 2011). The "network neutrality" term was first used by *Tim Wu*, a law professor, in 2003 (Marsden & Cave, 2007), although the idea of Internet neutrality can be traced back to the open access movement leading by *Lawrence Lessig* (Krämer et al., 2012).

CHAPTER 2: NETWORK (NET) NEUTRALITY

Openness on the Internet is a thing that consumers benefit from expanding levels of competition and innovation (Dixon et al. 2006). To preserve openness on the Internet, there are designed two policies; "*net neutrality*" and "*open access*". Open access mandates openness of conduits like television cable and DSL to intermediaries, while net neutrality mandates openness to advanced content like streaming video etc. (Hogendorn, 2007)

Net neutrality means that Internet Service Providers (ISPs) should treat all contents, data packets and applications identically (Brito & Ellig, 2007 and Boliek, 2011) regardless of source (Brennan, 2010) and offer equal treatment to all web traffic (Kang, 2010). It represents the idea that Internet users are entitled to service that does not discriminate on the basis of source, destination, or ownership of Internet traffic (Jordan, 2007). The idea is rooted that all traffic receives best-effort basis and without any performance guarantees (Jordan, 2009). In the context of net neutrality, ISPs don't distinguish data packets in terms of price depending on uploaders or downloaders (Economides & Tåg, 2011). Another definition is that net neutrality is a slogan that the Internet and physical means of access to it should be available to all on uniform and nondiscriminatory terms (Owen, 2007a and Owen, 2007b). Net neutrality does not allow prioritization (Reggiani & Valletti, 2011). Net neutrality also means that the Internet has no centralized control mechanisms, while ISPs want to ensure its profitability in the market (Barratt & Shade, 2007). Net neutrality refers to a principle that all data streams should be carried in a neutral manner regardless of their nature, content, and sender or recipient (Jasserand, 2013). This allows the network to carry every data and to support every kind of services and applications (Barratt & Shade, 2007). Moreover, it ensures that ISPs could not

offer content providers optional superior services for a fee, such as faster delivery (Faulhaber, 2011).

On the other hand, net neutrality does not mean an entirely neutral (Marsden, 2010) because some advocates have argued that ISPs treat all bits equally (*a bit is a bit*) while others make exceptions for malwares, spam-mails, adult content etc. Another issue is that some advocates have argued that net neutrality must apply not only to wired ISPs such as cable, DSL and fiber but to wireless broadband providers as well, while others recognize that wireless broadband has different structure (Faulhaber, 2011).

According to Noam (2011), there are ten different meanings for net neutrality:

- No different quality grades for internet service,
- No price discrimination among content providers,
- No charges to the providers for transmitting their content,
- No monopoly prices charged to content and applications providers,
- No discrimination on content providers who compete with the carriers' own content,
- Separation of conduit and content,
- Separation of layers,
- Standardization of protocols,
- No selectivity by the carriers over content they transmit,
- No blocking of the access of users to some websites.

2.1. Debates over Net Neutrality

The main question is that what problems net neutrality is designed to solve (Faulhaber, 2011). Net neutrality is a social, political and economic debate over the Internet and the duties of its carriers including telephone, cable companies and other ISPs (Lee & Wu, 2009).

The current debate over net neutrality encompasses two arguments. One group of them is "*netheads*" that they agree with the freedom of the Internet. The context of freedom is very wide like taxation, regulation or censorship. The other one is "*bellheads*" that they agree with the idea that the Internet is a business, and their facilities and services must be managed and priced to be as profitable as possible. The debate among these two groups arises when *netheads* claims government regulation to protect network from potential anticompetitive actions or monopolistic exploitation by *bellheads* who supply last-mile broadband access to the network (Taylor, 2007).

The net neutrality debate includes many issues about ISPs' rights and responsibilities regarding service pricing and network management (Schwartz et al., 2009).

According to Renda (2008), the debate has basically unveiled in four different dimensions:

I. *A technical dimension, which is* related to the features and needs of traffic shaping and network congestion,
II. *A competitive dimension*, links neutrality to competition at the various layers of broadband platforms,

III. *A consumerist dimension*, focused on the impact of net neutrality on consumer access to content on the Internet,

IV. *A dynamic efficiency dimension*, links incentives of investments in Next Generation Networks (NGNs).

According to Marsden (2010), net neutrality debate has two elements from different point of views:

- The 'positive' forward-facing element of charging more for better Quality of Service (QoS) on the NGNs.
- The 'negative' backward-facing element, degrading customers who attempt to take maximum advantage of applications over their connection.

When it comes to the "wireline-wireless" distinction, there are also two issues. In the wireline context, net neutrality regulation basically seeks to prevent ISPs from charging a fee for enhanced QoS to content providers. By contrast, in the wireless context, net neutrality regulation basically seeks to prevent a wireless operator from imposing certain limitations on equipment and usage limits on end-users (Hahn et al., 2007).

The table which is below shows that who favored and who opposed net neutrality:

Table 1: In Favor of and Opposed to Net Neutrality

In Favor of Net Neutrality	**Opposed to Net Neutrality**
Large, Internet-based companies: • Amazon.com • eBay • Google • Microsoft	Large, broadband service providers: • AT&T • BellSouth • Comcast • Verizon
Consumer/civil liberties groups: • American Civil Liberties Union • Consumers Union • Free Press • Public Knowledge	Network equipment providers: • Alcatel • Cisco • Corning • Qualcomm • 3M
Interest groups: • American Library Association • Christian Coalition of America • Computer Professionals for Social Responsibility • Gun Owners of America • MoveOn.org • TechNet • Service Employees Intl. Union • SavetheInternet.com Coalition	Interest groups: • American Conservative Union • Citizens Against Government Waste • Communications Workers of America National Association of Manufacturers • National Black Chamber of Commerce • National Coalition on Black Civic Participation • Hands Off the Internet • US Internet Industry Association
Internet pioneers: • Vinton Cerf • Tim Berners-Lee • Craig Newmark	Internet pioneers: • David Farber • Bob Kahn
Think tanks: • The Benton Foundation • The Media Access Project	Think tanks: • The Cato Institute Center for Individual Freedom • Competitive Enterprise Institute • Progress and Freedom Foundation
Academics: • Lawrence Lessig • Tim Wu	Academics: • Christopher Yoo • George S. Ford • Robert Litan

Source: Hart (2010).

2.1.1. Proponents of Net Neutrality

Proponents of net neutrality argue that the openness of the Internet with the ability to access any content, run any application, or attach any device to the Internet leads to the success

of it. This openness and freedom drives innovation and promotes free speech (Yang et al.). Most proponents of net neutrality such as application providers and consumer groups believe that ISPs should not be allowed to charge for priority access to service offerings. Openists support a policy based on open access and they argue that most innovations come from application providers, and therefore open access will maximize social welfare. Openists support a strong version of network neutrality (Jordan, 2007). In addition, openists claim that ISPs could engage in some types of undesirable behaviors like 'tiering', traffic shaping, packet sniffing, charging for predefined QoS, intentionally QoS degradation, and 'walled-gardens' (Renda, 2008). Openists believe that the Internet is best served by maintaining a 'dumb network' that does not differentiate among different types of traffic. They support a policy based on open access, where Internet infrastructure and applications cannot be bundled using either technical or business methods (Jordan, 2009).

In particular, net neutrality proponents claim that vertical integration of conduit and content of broadband networks would diminish overall neutrality of the Internet. They believe that innovation can occur when the Internet pipes are "dumb". In addition, proponents fear that broadband network owners will leverage market power in the network layer to foreclose competition and establish monopoly power in the application and content layers (Dixon et al., 2006).

Some net neutrality proponents also argue that companies providing physical components of the Internet should not be permitted to offer different qualities of service, even if prices differ (Owen, 2007). Therefore, some Silicon Valley giants like Google and Facebook support government efforts to push net neutrality regulation (Kang, 2010). In this view, broadband ISPs should be disabled from any network control and their job is simply to deliver

bits and not to manage them. Only customers and Internet content and application providers could control content, not ISPs (Faulhaber, 2011). Proponents allege that, in the absent of net neutrality regulation, ISPs will favor one supplier's content over another's (Brennan, 2010).

2.1.2. Opponents of Net Neutrality

Opponents of net neutrality like telecom companies (telco) and ISPs argue that tiered service (data prioritization) is a legitimate business model. They claim that video and audio applications on the Internet require a high bandwidth[2] on networks. Therefore, tiered service can provide enough QoS for different applications (Yang et al.). According to the opponents, there is no current problem, competition is sufficient to ensure and therefore, commercially negotiated arrangements will not negatively impact consumers, and net neutrality regulation will discourage investment in network infrastructure. Deregulationists oppose network neutrality. Moreover, deregulationists believe that ISPs are in the best position to determine the most beneficial step of the Internet. They support deregulation policy of the Internet that allows ISPs to vertically integrate, bundle services, and use traffic discrimination as well. They argue net neutrality regulation will prevent investment (Jordan, 2007 and Jordan, 2009).

According to the opponents, net neutrality proponents ignore the supply-side problems (Dixon et al., 2006). Furthermore, opponents of net neutrality claim that ISPs need to be able to discriminate in packet handling to manage congestion and latency to maintain quality of real-time services while peer-to-peer (P2P) file sharing exhausts capacity (Brennan, 2010).

[2] Bandwidth is the capacity of a channel to carry information, typically expressed in bits per second (Marcus et al., 2011).

Open-access regulation can also be seen as unnecessary and likely lead to slow the speed of broadband deployment (Wu, 2003).

Famously, Ed Whitacre, AT&T's CEO, stated about anti-net neutrality (Marsden & Cave, 2007):

- *"The Internet can't be free in that sense, because we and the cable companies have made an investment and for a Google or Yahoo! or Vonage or anybody to expect to use these pipes [for] free is nuts!"*
- *"Now what they would like to do is use my pipes free, but I ain't going to let them do that because we have spent this capital and we have to have a return on it."*

2.1.3. Light Supporters

Some scholars have also advocated the "wait-and-see approach" to avoid potentially harmful regulations (Yang et al.). Similarly, non-discriminationists believe that there are good and bad uses of traffic discrimination. They support a policy that allows vertical integration and traffic differentiation, but restricts their use to ensure that ISPs do not discriminate in a manner that extracts oligopoly rents. They argue that such a balanced approach will allow development of network that does not restrict development of applications. They would support a limited version of net neutrality (Jordan, 2007 and Jordan, 2009).

CHAPTER 3: TECHNOLOGY INFRASTRUCTURE AND SERVICES

The players in the industry mainly are content providers, broadcasters, cable TV networks, telephone networks, wireless networks, ISPs, transit operators, access operators and equipment manufacturers. Since the 1890s, *telephone networks* have been offering voice service. In a few last decades, most telephone companies have deployed fiber and shifted their networks from analog to digital. Today, most telephone companies offer voice, video conferencing, and Internet access. *Cable networks* are designed to offer broadcast video service. Similarly, many cable systems have migrated to digital transmission with more capacity. *Cellular networks* were initially designed to offer voice service in the 1980s. The first generation (1G) were built on an analog platform, but the second (2G) and third generations (3G) are digital. In the future, wireless data services are expected to grow quickly (Jordan, 2007). Although wireline broadband Internet access services are provided by companies for many years, new fourth-generation (4G) wireless broadband Internet access services are being deployed these days (Becker et al., 2010). Telephone networks, cable video networks, cellular networks, and the Internet began to converge in the 1980s with the introduction of fiber-optic network technology (Jordan, 2007).

3.1. Technology Infrastructure: Broadband Networks, NGN and Convergence

Since there is a convergence between the networks, technical differences between telephone, video and cellular networks, and also Internet would diminish increasingly, and all of these networks could serve a combination of voice, video, and data services exponentially (Jordan, 2007). Consumers would prefer to use a converged single "pipe" for all their communication needs. Performance-sensitive applications like video, games, and VoIP are

offered over such a converged IP network. Therefore, ISPs should convert their networks in order to meet these requirements (Yuksel et al., 2010).

An ISP's fixed network might be comprised of several different technologies such as (Marcus et al., 2011):

- Copper twisted-pair networks using Digital Subscriber Line (DSL) technologies like ADSL, ADSL2+ and VDSL2.
- Hybrid Fiber-Coaxial (HFC) cable networks with DOCSIS (Data over Cable Service Interface Specification) technology.
- Optical Fiber in combination with point-to-point Ethernet and/or Gigabit passive optical networks (GPON) technologies.

Copper networks typically consist of twisted-pair copper in the local loop. This can be upgraded using a DSLAM (Digital Subscriber Line Access Multiplexer) in the local telephone exchange to offer ADSL (Asymmetric Digital Subscriber Line) service. This technology can offer up to 20 Mbps downloading speed. It can also be upgraded to ADSL2+, VDSL and VDSL2 with variations. This involves both powerful DSLAMs and the placement of backhaul fiber optical cable and the DSLAM itself closer to the customer premises. At full capacity over short range, VDSL2 can provide 70-80 Mbps bandwidth (Marsden, 2010).

When it comes to the *Fiber-Optic Networks (FTTx)*, photonics technology is being used in order to provide up to 1 Gbps connection speed. DOCSIS 3.0 standard has the potential to offer fiber speeds and Passive Optical Network (PON) standards Broadband PON (BPON) and Gigabit PON (GPON) are being used as well (Marsden, 2010).

Next Generation Networks (NGNs) present enhanced opportunities to offer internet content to consumers. The Organization for Economic Cooperation and Development (OECD) states NGNs that they can be described as networks with a packet-based architecture, facilitating provision of existing and new services, open and converged communications infrastructure (Marsden & Cave, 2007). The International Telecommunication Union (ITU) defines NGNs as (Marcus et al., 2011);

> *"... a packet-based network able to provide services including Telecommunication Services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It offers unrestricted access by users to different service providers. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users."*

NGNs are multi-sided markets, where supply (application and content providers) and demand (end-users) meet on a platform provided by ISPs. In all-IP networks, ISPs act as intermediaries between end users and suppliers (Renda, 2008).

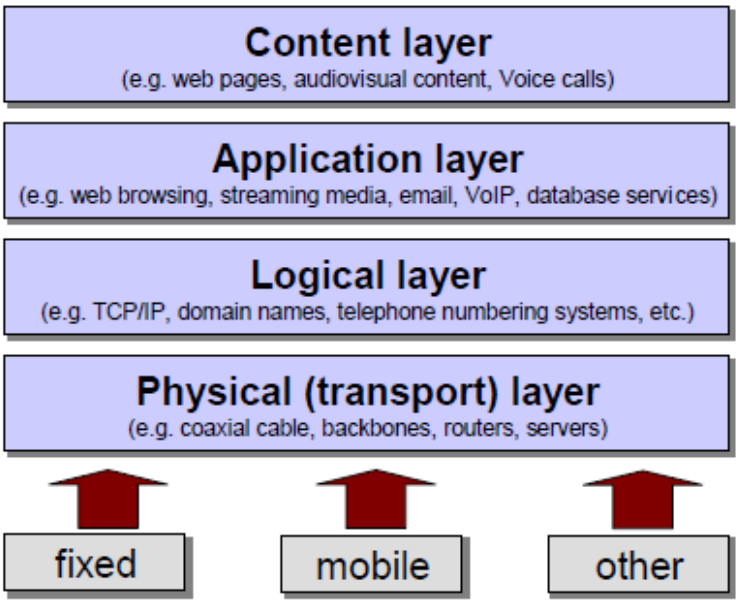


Figure 1: Layered Architecture of All-IP Network

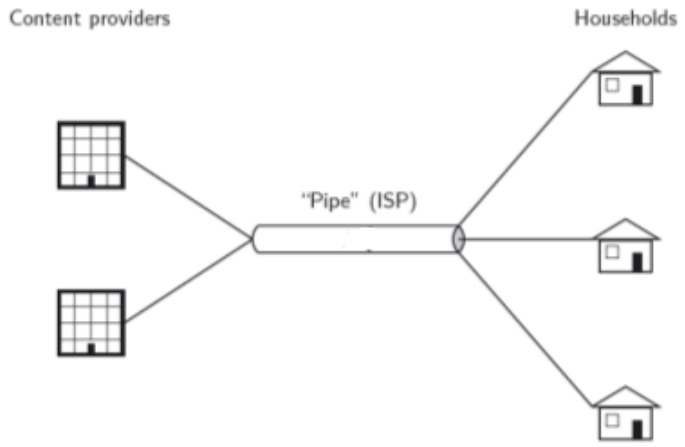
3.2. Interoperability and IP Interconnection

Internet is an acronym for inter-networks and it is a large interconnected network of networks (Barratt & Shade, 2007). Widespread adoption of TCP/IP has given the Internet a universal interoperability that allows all end-users to access Internet applications and content on a nondiscriminatory basis (Yoo, 2005). With the increasing penetration of broadband Internet access, users have begun to download increasingly more content. This content is delivered to users by ISPs that are known as access providers. Access providers earn their revenues mostly from their users, and they incur costs to operate their network and to purchase upstream connectivity from transit providers. Access providers serve its users and traffic comes from content providers (Dhamdhere & Dovrolis, 2008). Access providers are the carriers that supply last mile. The suppliers of backbone network facilities interconnect with each another to connect applications providers and customers (Taylor, 2007).

While backbones represent interstate highways, last-mile networks are the local roads. Each ISP must maintain infrastructure for conveying data packets, consisting of wires, fiber optic cable, or some others. Each network must also have *routers*, which operate in the core of the network to direct packets to their destination. *Servers* store data at the edge of the network (Yoo, 2006).

Roughly, backbone providers present fiber optic high-capacity transmission services and these providers' networks interconnect each other. Besides, content and application providers operate edge (Becker et al., 2010). As it is mentioned above, ISPs and Internet backbone providers carry traffic on a best effort basis, which in general means that the first packets into a switching point are the first packets out (Jamison & Hauge, 2008).

Simple architecture of Internet is shown below:

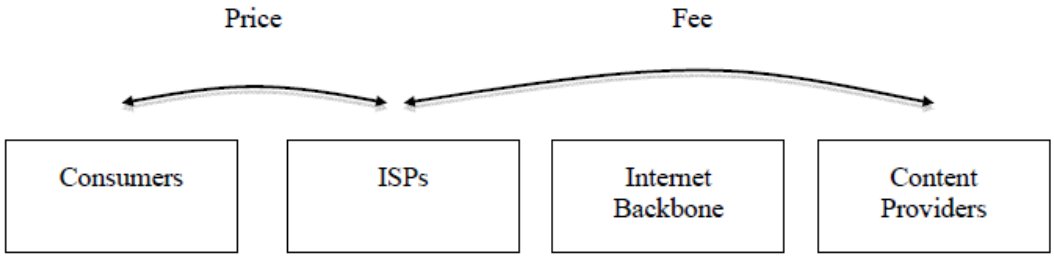


Source: Economides & Hermalin (2012), Guo et al. (2012), and Cheng et al. (2011).

Figure 2: Simple Architecture of Internet

The Internet, as an intermediary between users and content providers, requires "two-sided markets" pricing model (Lee & Wu, 2009). The platform serves as an intermediary where

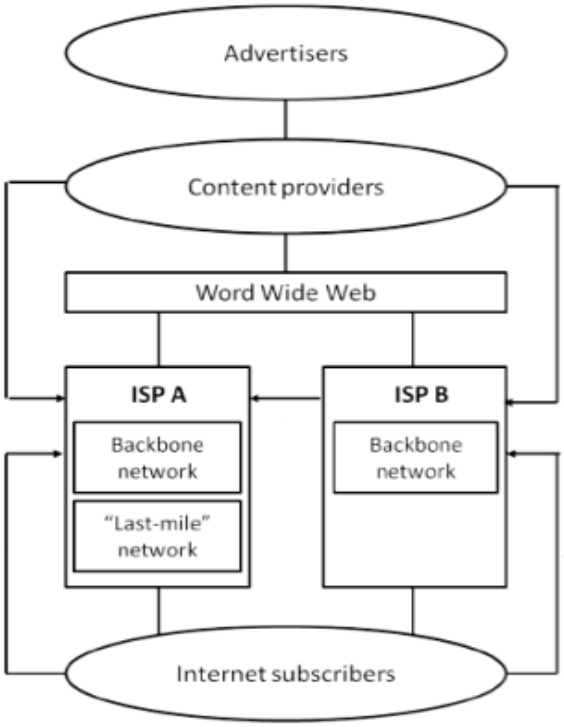
prices are used for bringing both sides of the market together (Weisman & Kulick, 2010). Users and content providers pay ISPs access and usage fees. In addition, content providers such as Google or Facebook pay for their own access and usage, and they don't directly pay the ISPs of users they reach (Lee & Wu, 2009). Users' subscription fee is the main revenue source for access ISPs (Krämer et al., 2012. The basic financial source flow of Internet is also shown below:



Source: Economides & Tåg (2011).

Figure 3: Financial Source Flow of Internet

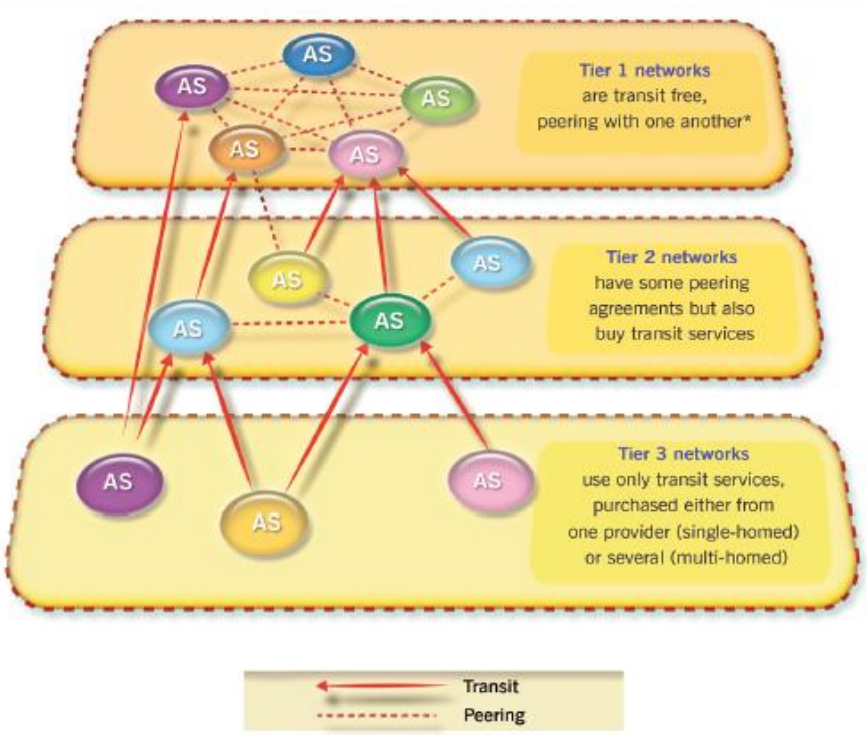
The detailed market for Internet is also represented below:



Source: Bourreau & Lestage (2013).

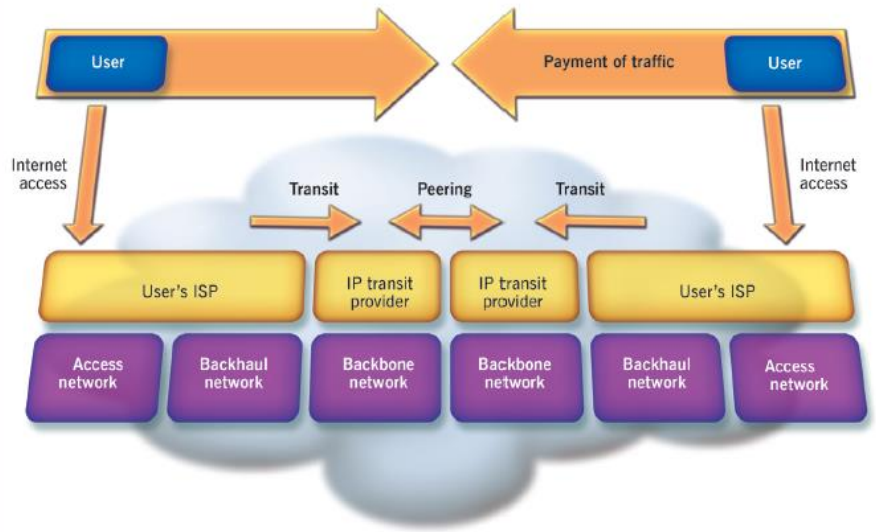
Figure 4: The Detailed Market for Internet

Carriers are required to interconnect with each other (Brennan, 2010). The importance of interconnection is a central characteristic of network economies such as the Internet. Interconnection requirements prevent incumbents from using network externalities to their strategic advantage (Boliek, 2011). The provisioning of backbone traffic and interconnection is unregulated (Becker et al., 2010). Backbones exchange traffic through a system known as *peering* arrangements (bill-and-keep system) and ISPs don't charge each other for terminating traffic. If backbones are unable to meet these minimum volume requirements, they make *transit* arrangements and ISPs pay for other backbones to terminate their traffic (Yoo, 2006 and Krämer et al., 2012). Furthermore, IXPs (Internet Exchange Points) provide a centralized hub network typology instead of requiring each ISP, regardless of size and traffic volume (Frieden, 2006).



Source: ARCEP (2012).

Figure 5: IP Interconnection (Transit and Peering)

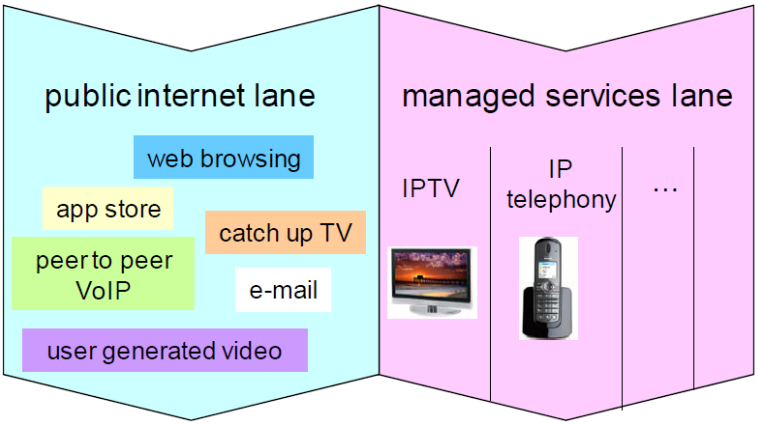


Source: ARCEP (2012).

Figure 6: Internet Architecture and Financial Structure of Internet

3.3. Services: Contents and Applications

The data volume of normal web browsing, email and VoIP services are comparably small and they are required very little bandwidth. On the other hand, there are other applications such as video conferencing, Internet Protocol Television (IPTV) and other media streaming, interactive services and P2P file sharing are required higher bandwidth (Penhelt, 2008). Moreover, in broadband platforms, end-users are especially using QoS-sensitive applications such as VoIP, IPTV, online gaming etc. (Renda, 2008). In addition, real-time and/or high-bandwidth applications such as VoIP, video streams, and online games are more sensitive to delay than others like e-mail service (Schuett, 2010 and Knieps & Zenhäusern, 2008).



Source: Marcus et al. (2011).

Figure 7: Ordinary and Managed Services on Internet

VoIP (Voice over IP) is a set of data communications protocols and technologies to enable voice to be sent over individual IP-based networks or over the Internet (Marcus et. al, 2011). VoIP services are increasingly being used as a substitute for traditional telephone service, and VoIP services represent a significant share of voice-calling minutes, especially for international calls (FCC, 2010). As it is mentioned above, some Internet applications such as

VoIP, video conferencing, telemedicine and online gaming are very time-sensitive, while some applications also require high bandwidth such as IPTV. If QoS is not guaranteed, the user experience would be disappointing (Renda, 2008). Any possible delay and jitter may degrade performance for VoIP conversations or streaming video applications (Taylor, 2007).

Both fixed and mobile access providers are likely to continue to offer content and services to their customers, bundled with broadband access. These services are often provided with guaranteed QoS like IPTV services (Marsden & Cave, 2007). IPTV is the distribution of video programming by means of the Internet Protocol (Marcus et. al, 2011). For IPTV, the impossibility to prioritize packets may determine the impossibility of providing a satisfactory experience to end users, due to the high bandwidth and very low delay requirements (Renda, 2008). Internet traffic has been increasing with Netflix. Netflix offers video on demand streaming of many TV shows and movies for a monthly subscription fee (Krämer et al., 2012).

CHAPTER 4: REGULATORY PERSPECTIVE

The regulatory tools for net neutrality like interconnection, standardization, tariffs and nondiscrimination have been evaluated as difficult to implement since telecom services vary in quality and technology has been changing quickly (Yoo, 2005). These tools are elaborately examined below in terms of country perspectives and effects on subscribers, operators and also service providers such as QoS, network management, investment decisions and innovation, vertical integrations in the context of nondiscrimination and competition and also security and privacy issues.

4.1. The US Perspectives

The US has ended mandatory unbundling by telephone companies by not requiring them to unbundle new infrastructure. Cable networks were never subject to unbundling in the US (Wallsten & Hausladen, 2009). As aforementioned above, the net neutrality roots can actually be found in the US with Professor Lessig in 2000 and Wu in 2003. They wrote a letter favorable net neutrality regulation to the Federal Communications Commission (FCC) (Jasserand, 2013). After that, the FCC encountered a net neutrality issue for the first time in March 2005. An ISP, Madison River Communications, blocked its customers from using Vonage VoIP service to gain favor of its traditional phone calls. The FCC concluded the case against Madison River Communications and the FCC has never explained what rules violated. However, Madison River Communications agreed to end the practice, and made a 'voluntary-compulsory' contribution of $15,000 (paid fine) to the US Treasury (Marcus et al., 2011 and Faulhaber, 2011).

In 2005, AT&T, later followed by other telephone and cable operators, proposed to charge content providers premium prices for preferential access to broadband transmission services (Bourreau et al., 2012).

In the same year, The FCC changed the classification of Internet transmissions from the category of '*telecommunications services*' to the category of '*information services'* (Choi & Kim, 2010). In 2005, the Supreme Court decide in "National Cable & Telecommunications Association" v. "Brand X Internet Services" dispute and the FCC ordered broadband cable and DSL services as information services under the Telecommunications Act of 1996, which was a significant regulation (Laxton, 2006). ISPs are no longer subject to non-discrimination (Njoroge et al., 2010) and of course the principle of net neutrality (Bourreau et al., 2012). This case is important because it contains the *dicta language* on the FCC's jurisdictional foundation to enforce net neutrality after cable and DSL broadband deregulation (Reicher, 2011). Then, the FCC has publicly supported the concept of net neutrality in order to regulate net neutrality through '*Title I ancillary jurisdiction'* (Laxton, 2006). *Dicta language* from Brand X, the FCC concluded that it had the "jurisdiction necessary to ensure that providers of Internet access or IP-enabled services are operated in a neutral manner (Reicher, 2011). Then, the FCC published a Policy Statement on net neutrality with four freedoms for Internet users. The FCC adopted a set of policy principles applicable to Internet providers in Policy Statement (Jamison & Hauge, 2008 and Jasserand, 2013);

i. To encourage broadband deployment and preserve and promote the open and interconnected nature of the public Internet, consumers are entitled to access the lawful Internet content of their choice (accessing lawful content).

ii. To encourage broadband deployment and preserve and promote the open and interconnected nature of the public Internet, consumers are entitled to run applications

and use services of their choice, subject to the needs of law enforcement (running applications and services).

iii. To encourage broadband deployment and preserve and promote the open and interconnected nature of the public Internet, consumers are entitled to connect their choice of legal devices that do not harm the network (connecting to the legal devices and not harmful for the network).

iv. To encourage broadband deployment and preserve and promote the open and interconnected nature of the public Internet, consumers are entitled to competition among network providers, application and service providers, and content providers (getting competition among network providers, applications and service and content providers)."

In this context, the FCC made clear that abovementioned principles are subject to "reasonable network management." Principles 1, 2 and 3 regarding nondiscrimination rule contain net neutrality principles and Principle 4 states the net neutrality competition principle (Reicher, 2011).

In 2006;

"Network Neutrality Act of 2006 states that it is the policy of the US to, among other things, maintain the freedom to use broadband telecommunications networks, including the Internet, without interference from network operators. Outlines specified duties of broadband network providers to ensure broadband network neutrality, including the duty to;

(1) Enable users to utilize their broadband service to access all lawful content, applications, and services available over broadband networks, including the Internet; and

(2) Not block, impair, degrade, discriminate against, or interfere with the ability of any person to utilize their broadband service for lawful purposes. Provides exceptions for providers, including implementing reasonable measures to manage its networks and protect network security.

The legislation states that a broadband network provider may not block, impair, degrade or discriminate against the ability of any person to use a broadband connection to access the content, applications, and services available on broadband networks, including the Internet. It ensures that broadband network providers operate their networks in a non-discriminatory manner. The bill also ensures that consumers can attach any device to the broadband operator's network, such as an Internet phone, or Wi-Fi router, or set top box, or any other innovative gadget invented in the coming years. Moreover, in order to prevent the warping of the World Wide Web into a system of 'tiered service,' the legislation will prevent broadband providers from charging new bottleneck fees for enhanced quality of service or the prioritization of bits.

If a broadband provider chooses to prioritize data of any type, it requires that it do so for all data of that type and not charge a fee for such prioritization. For instance, if a broadband provider wants to prioritize the transmission of bits representing a VoIP phone call for its own VoIP service, it must do so for all VoIP services so as not to put its competitors at an arbitrary disadvantage.

Under this legislation, it would be the duty of every broadband network operator to;

a) Enable users to access all lawful content, applications, and services available over broadband networks, including the Internet.

b) Not block, impair, degrade, discriminate against or interfere with the ability of any person to use their broadband service to access, use, send, receive, or offer lawful content, applications, or services over broadband networks, including the Internet; or attach any device to the provider's network that does not harm the network.

c) Clearly and conspicuously disclose information to users about their service.

d) Offer, upon reasonable request to any person, a broadband service to be used to access unaffiliated content, applications, services.

e) Not to discriminate in favor of itself in allocation, use, quality, or interconnection of broadband service.

f) If the broadband network provider prioritizes or offers enhanced quality of service to data of a particular type, prioritize or offer enhanced service to all data of that type without imposing a surcharge.

g) Not install network features, functions, or capabilities that prevent compliance with the requirements of this section.

The broadband provider may (exceptions);

h) Manage its network, as long as it does not result in discrimination against unaffiliated providers.

i) Offer varying levels of transmission.

j) Protect network security.

k) Offer consumer protections services such as parental controls, as long as the consumer can disable those.

l) Carry or offer a cable service that requires network management to provide enhanced service quality as long as the user may refuse to subscribe while obtaining broadband services from the operator and the offering does not violate duties above.

m) As required by law, prevent violation of state and federal law.

Complaints go to the FCC and it is required to issue within 48 hours a cease and desist order upon prima facie showing of violation until the complaint is fully resolved and, if in the public interest, the order may affect classes of persons similarly situated to the complainant or the violator. The FCC may impose fines and damages." (FCC, 2006).

In June 2007, the Federal Trade Commission (FTC) issued a report that the FTC stated lack of support for net neutrality regulation and warned potentially adverse and unintended effects of regulation. Similarly, in September 2007, the Department of Justice issued comments cautioning against premature regulation of the Internet (Musacchio et al., 2007).

Later, in November 2007, Comcast, the largest cable operator in the US, interfered with P2P file-sharing BitTorrent traffic since it is claimed that the traffic was congesting the network (Faulhaber, 2011). The complaint was received on behalf of Rob Topolski, a network engineer, amateur musician and broadband subscriber of Comcast. Topolski had discovered that no one was able to download his un-copyrighted music from BitTorrent. The packets actually were delayed by Comcast (Marcus et al., 2011). The FCC issued an order prohibiting network management practices (Faulhaber, 2011). In a 3 to 2 vote, the FCC found that Comcast had improperly slowed traffic to the BitTorrent and urged the company to stop the practice. It did not impose a fine (Kang, 2010). On the other hand, ISPs argued that these practices were essential for sensitive services to delays such as VoIP or video conferencing in order to manage

Internet traffic efficiently and ensure QoS (Bourreau et al., 2012). Comcast appealed against the decision with saying that the order was outside the scope of the authority. The court agreed saying the FCC relied on laws that give it some jurisdiction over broadband services but not enough to make the action against Comcast permissible in 2010 (Kang, 2010 and Reicher, 2011).

After that, in 2009, Apple and AT&T blocked using of Wi-Fi connectivity since AT&T's mobile (2G and 3G) services have been endorsed on iPhone mobile devices. The issue was resolved by the FCC (Faulhaber, 2011).

As of 2010, FCC' current net neutrality regulation have been determined with 'Notice of Proposed Rulemaking (NPRM)'. Accordingly, to preserve the Internet's openness and broadband providers' ability to manage and expand their networks, the FCC accepts four principles (FCC, 2010):

i. Transparency,
ii. No blocking,
iii. No unreasonable discrimination,
iv. Reasonable network management.

According to *transparency* principle, fixed and mobile broadband providers must disclose the network management practices, performance characteristics, and terms and conditions of their broadband services.

In addition, in comply with *no-blocking* rule, **fixed** broadband providers may not block lawful content, applications, services, or non-harmful devices and **mobile** broadband providers

may not block lawful websites, or block applications that *compete with their voice or video telephony services* (FCC, 2010). An ISP shall not block lawful content, applications, services, or non-harmful devices, subject to reasonable network management. This rule is interpreted to prohibit ISPs from degrading service like slowing down of applications. ISPs are also prohibited from charging a fee in order to carry an application (Faulhaber, 2011).

According to the extent of *no unreasonable discrimination principle,* fixed broadband providers may not unreasonably discriminate in transmitting *lawful* network traffic.

For mobile broadband, the FCC rules apply only the transparency rule and the no blocking, and except for the rules on discrimination and network management. This shows that mobile broadband is a different technology from traditional fixed ones (Faulhaber, 2011). Critics about wireless net neutrality is that assert that inclusion of wireless would put consumers at risk of paying higher prices for Internet access and would prevent development of wireless broadband as an alternative to DSL and cable. The FCC has announced a wait-and-see policy (Boliek, 2011). Because the roll-out of next generation mobile services is at an early stage, and the future of competition in residential broadband is unclear. Although wireless providers are offering broadband services, it is not being known how end-users will value the trade-offs between the benefits of wireless service and fixed service. The FCC believes that two largest mobile broadband providers also offer fixed service, and this might alleviate incentive to compete with fixed services. Moreover, the FCC states that mobile broadband is an earlier-stage platform than fixed broadband. However, it is an important Internet access platform that is helping drive broadband adoption. The mobile ecosystem is experiencing very rapid innovation and change, including an expanding array of smart-phones (FCC, 2010).

However, according to some scholars, the regulations proposed in the NRPM are unsupported by the empirical economic evidence and there is no economic evidence regarding absence of market failure or having market power (Brito et al., 2010).

4.2. EU Perspective

After the issue has been discussed in the US, the debate arrived to the EU (Renda, 2008). Today, some ISPs in Europe, especially offering mobile Internet access, prohibit VoIP traffic in networks by means of their terms and conditions, unless the users pay extra for it (Krämer et al., 2012). As it is known, DSL, FTTH and FTTB broadband networks have been deregulated in the US by the FCC since 2003. This extensive deregulation of broadband networks with 'regulatory holidays' were far away from the European situation. In the EU, the 2002 regulatory framework is in place as an *ex-ante* regulation and also *ex-post* antitrust laws have been applied in the sector (Renda, 2008). The EU regulatory framework aims at promoting effective competition (EC, 2011).

The EC introduced a proposal a new framework containing net neutrality provisions in 2007. The adoption of this package and the debate on net neutrality launched at the end of 2009 (Jasserand, 2013). EU Commissioner Reding stated the importance of new developments in the sector. She said that (Marsden & Cave, 2007);

> *"We are now living through a new disruptive phase of the Information Society. Some people call it Web2.0 or social networking. I can list some of the components: blogs, podcasts, wikis, social networking websites, search engines, auction websites, games, VoIP and P2P services. What is new about these uses of the Internet is that they exploit*

the Internet's connectivity to support people to network and to create content. This is a new paradigm in which users are co-producers of services."

When concluding the 2009 EU telecoms reform package, the EC set out in a declaration its commitments (EC, 2011). According to EC net neutrality declaration (EC, 2009);

"The Commission attaches high importance to preserving the open and neutral character of the Internet, taking full account of the will of the co-legislators now to enshrine net neutrality as a policy objective and regulatory principle to be promoted by national regulatory authorities [Article 8(4)(g) Framework Directive], alongside the strengthening of related transparency requirements [Articles 20(1)(b) and 21(3)(c) and (d) of the Universal Service Directive] and the creation of safeguard powers for national regulatory authorities to prevent the degradation of services and the hindering or slowing down of traffic over public networks [Article 22(3) of the Universal Service Directive]."

Moreover, the EC emphasizes;

"The impact of prioritization or of systematic degradation of connectivity could be larger on services needing real-time communications (e.g. IPTV, VoIP, in which latency is critical) and ultimately affect end-user choice."

However, the amendment Article 22(3) of the Directive 2002/22/EC does not refer to net neutrality explicitly (Penhelt, 2008). In addition, the Commission reserves its right to assess under Articles 101 and 102 of the TFEU any behavior related to traffic management that may restrict or distort competition (EC, 2011).

Significant five Directives regarding the issue in the Framework are;

- Regulating access (2002/19/EC),
- The regulatory framework (2002/21/EC),
- Authorization of networks and services (2002/20/EC),
- Universal service and consumer protection requirements (2002/22/EC) and
- Electronic privacy (2002/58/EC).

NRAs also can impose SMP remedies such as non-discrimination (Access Directive 2002/19/EC, Article 10) and transparency and disclosure of network information (Access Directive 2002/19/EC, Article 9). Accordingly, NRAs may impose obligations on the wholesale access provider to ensure that it provides others with services on the same conditions and of the same quality as it provides to its affiliates or to itself. Non-discrimination remedies will depend on the form of degradation (Marsden, 2010).

4.3. Effects on Subscribers (Consumers), Operators and Service Providers

Differentiation of networks satisfies end-users demand. In addition, network diversity can let presenting of services like triple-play possible (Yoo, 2005). In context of the Internet, there are several components, which are content, applications and services, devices and networks like fiber, DSL and cable. Therefore, consumers need competition and innovation with respect to all of these components (Dixon et al., 2006).

On the other hand, as AT&T former chairman Ed Whitacre said in 2005;

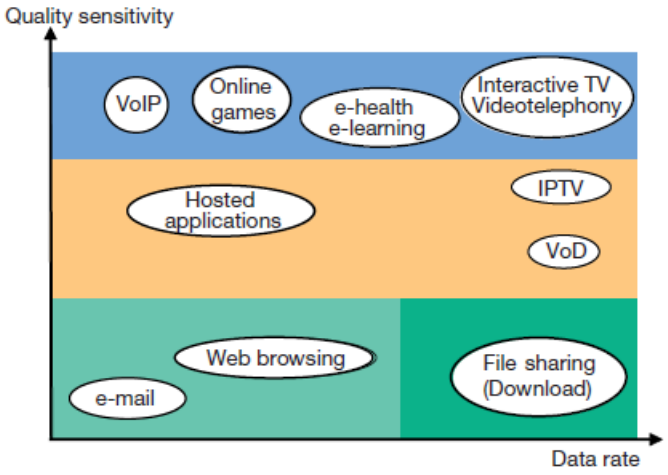
"They would like to use my pipe for free, but I ain't going to let them do that because we have spent this capital and have to have a return on it".

That is the main reason why net neutrality is of great importance in terms of every part such as subscribers and providers. Main determiners on net neutrality issue are basically QoS, network management, investments, innovation, vertical integrations, nondiscrimination, competition, security and privacy.

4.3.1. Quality of Service (QoS)

As a universal service, the Internet is required to guarantee certain QoS levels (Altman et al., 2011). As an example, Long Term Evolution (LTE) allows QoS-demand and some fixed-line ISPs offer QoS (Krämer et al., 2012). QoS (Quality of Service) often denotes measures of delay, variability of delay, and the probability of packet loss. QoE (Quality of Experience), on the other hand, is QoS as perceived by end-users, in light of the task that the end user is seeking to perform (Marcus et al., 2011).

Although network operators increase their router and transmission capacities, congestion occurs regularly. Congestion affects all users negatively by reducing their transport service quality. When the number of data packets exceeds router capacity, additional packets will be intermediately stored and then, more traffic will be dropped. Congestion is leading to increased delay, jitter and packet-loss, which may significantly reduce the quality of certain applications like VoIP and IPTV (Kruse, 2008).



Source: Kruse (2008).

Figure 8: Quality Sensitivity and Data Rate of Services

Higher QoS ensures reliability, security of data transfer, timeliness of voice signals in conference calls (Renda, 2008). There are many applications that depend on QoS to perform properly. Main examples of applications seeking QoS are streaming multimedia, online gaming, VoIP and video teleconferencing. The quality of a VoIP call is highly sensitive to both time delay and packet loss (Hahn & Litan, 2006). Although in non-interactive applications such as e-mail, a delay is usually considered good performance, in real-time applications such as telephone calls or video conferencing, the information must be received within a few tenths of a second after it is sent. There are also other applications with intermediate levels of interactivity, such as web browsing, a delay is usually acceptable (Jordan, 2007). Therefore, content charging can rely on QoS, enabling network providers to discriminate between packets in order to offer better than traditional 'best effort' approach (Marsden & Cave, 2007). In other words, in order to allow ISPs to provide different QoS level, 'best effort' based data packets carriage should be changed to prioritization of traffic (Taylor, 2007). For example, voice communication requires low latency and low jitter (Krämer et al., 2012). Therefore, according

to the net neutrality opponents, data prioritization can improve QoS and it is a legitimate business model (Yang et al.).

In QoS, traffic enhancement or degradation decision can be based on the type of application, the source, the destination, consumer payment, or application provider payment. Most of the carriers have QoS plans in the deployment of fiber networks and providing IPTV services. Some ISPs currently use QoS to guarantee acceptable quality for VoIP services (Jordan, 2007). For instance, AT&T and Verizon offer to Internet content providers faster, premium delivery of content and services to end-users and charge the content providers for the superior transmission (Jamison & Hauge, 2008). However, while the use of QoS would be to support an ISP's own VoIP and video services, it is unclear whether it would offer QoS to competitors' applications (Jordan, 2007).

ISPs might prioritize own or affiliated content or degrade and/or block content with the availability of QoS techniques and that could be harmful for the market (Krämer et al., 2012).

4.3.2. Network Management

Network management includes capacity, latency and congestion, distributing and storing content and technologies using in network (Becker et al., 2010). Net neutrality debates focus on reasonable network and traffic management (EC, 2011). Net neutrality does not mean an entirely neutral net (Marsden, 2010). Because legitimate network management is reasonable with taking into account the network architecture and technology of the broadband Internet access service (FCC, 2010). Network management is a core function for operators, even though it has been criticized in net neutrality debate (Faulhaber, 2011). Traffic management is

considered necessary to ensure the traffic flow especially when networks become congested (EC, 2011). Despite net neutrality objectives, delivery of emergency communications should be ensured. To do so, those communications need priority instead of neutrality (Ammori & Poellet, 2010). As an example, Comcast alleged that it needed to be able to limit some activities in the BitTorrent case, such as downloading massive movie files that could slow network operations for many customers.

Today, the Internet could not be utmost neutral in terms of traffic shaping and application blocking already occurs in many areas and layers of the network, mostly due to packet-sniffing technologies such as DPI-*Deep Packet Inspection* (Renda, 2008). Data packets can even be differentiated based on what type of data ISPs are carrying by means of DPI (Krämer et al., 2012). It is a set of techniques for examining and categorizing packets for any of a number of purposes (Marcus et al., 2011). Moreover, vendors such as Cisco have sold servers to ISPs with the capability of detailed tracking of their data traffic for years (Faulhaber, 2011). Many cable, fiber and DSL fixed operators ban some forms of traffic such as BitTorrent and other P2P traffic. In addition, wireless operators in Europe ban nomadic VoIP providers such as Skype (Renda, 2008).

In this case, the FCC in the US noted that net neutrality principles should subject to reasonable network management. Furthermore, the FCC allows ISPs to engage in reasonable network management practices to prevent malware, viruses, and also congestion (Boliek, 2011).

There are different types of traffic management techniques (EC, 2011):

- Packet differentiation allows different traffics to be treated differently. This differentiation guarantees a certain minimum QoS like VoIP.
- IP routing allows ISPs to route packets via different communication paths to avoid congestion or provide better services.
- Filtering allows ISPs to distinguish between safe and harmful traffics and block hazardous ones.

4.3.3. Investment Decisions and Innovation

The most possible danger associated with net neutrality regulation is the potential impact on future broadband network investments and also innovation (Dixon et al., 2006). Even former FCC chairman Michael K. Powell said that imposing net neutrality regulation would hurt investments in broadband networks (Kang, 2010). ISPs argue that net neutrality regulation reduces their incentives to invest in broadband network, and that it can cause an entry barrier for content providers. On the other hand, content providers claim that Internet is neutral since its beginning, and therefore it should be kept free and open. In addition, even though ISPs think opposite, content providers suggest that ISPs would continue to invest in broadband capacities in order to meet demand (Bourreau et al., 2012).

Some scholars claim that net neutrality is considered a price regulation because it limits the pricing. Thus, net neutrality regulation limits broadband providers' revenue opportunities and its ability to differentiate itself from competitors, and thereby reduce their incentives to invest and innovate (Becker et al., 2010). Opponents of net neutrality contend that net neutrality could reduce investment and innovation in the network, and lead to inefficient use of existing infrastructure (Wallsten & Hausladen, 2009). On the other hand, net neutrality proponents

claim that lack of neutrality could have perverse affect on incentives to invest in content (Becker et al., 2010). Moreover, net neutrality proponents believe that market power in infrastructure would decrease innovations at application level and as a consequence, it could harm consumers. According to them, when providers charge optimally for and provide premium transmission for content providers, innovation is encouraged and smaller content providers can benefit more (Jamison & Hauge, 2008). On the other hand, according to opponents, mandating net neutrality would prevent new applications and reduce QoS and also producer and consumer surplus (Penhelt, 2008).

4.3.4. Vertical Integrations

The broadband industry fits easily into this vertical structure. While the manufacturing side consists of the companies that produce webpage content and Internet-based services, such as VoIP, the retail side includes fiber or DSL providers (Yoo, 2005).

Net neutrality proponents argue that vertical integrations harm consumers (Jordan, 2007), since vertically integrated companies could make anti-competitive behaviors (Renda, 2008). The threat of abuse of market power by vertically integrated ISPs is a strong concern since there are several examples of ISPs that have blocked VoIP traffic which is in competition to their regular telephone service. A well-known example is Madison River Communications as it is aforementioned (Krämer et al., 2012). Net neutrality proponents also fear from vertical integrations that access to bottlenecks or last-mile could be monopolized (Owen, 2007).

Abusive discrimination in access to networks is usually characterized as a market failure. ISPs can discriminate against content where they are vertically integrated (Marsden &

Cave, 2007). Moreover, in the event that ISPs have market power with vertical integrations, VoIP providers have no countervailing buyer power, and this may result in undesirable outcomes such as margin squeeze (Renda, 2008). Vertically integrated broadband provider with market power could also deny access to competitors of the affiliated service (Brennan, 2010).

On the other hand, according to Yoo (2004), vertical integrations can allow network owners to promote economic welfare by allowing network owners to vary the services. Any chain of production can only be as efficient as its least competitive chain, which in the case of broadband is the last-mile bottleneck. Therefore, Yoo believes that in attempting to preserve and encourage content and applications competition and innovation, net neutrality are focused on increasing competition in the most competitive part, which means wrong. As a result, imposing net neutrality regulation can have the perverse effect of incentives to invest in the alternative network capacity. In other words, mandating net neutrality raises the danger that regulation would become the source of, rather than the solution to, market failure (Yoo, 2004).

4.3.5. Non-discrimination and Competition

ISPs shall not unreasonably discriminate in transmitting lawful network traffic over a consumer's broadband Internet access service. Reasonable network management shall not constitute unreasonable discrimination (FCC, 2010). This kind of abuse is characterized as a monopoly problem where one or two ISPs have dominance or SMP in the last-mile of end-user access. ISPs can impose discriminatory treatment on all content or, where they are vertically integrated (Marsden & Cave, 2007). If an ISP could discriminate against competitors, then that

ISP would be choosing the winners and losers in speech and innovation (Ammori & Poellet, 2010).

Due to the fact that many ISPs are vertically integrated they may have incentives to degrade the competitor's QoS to increase the demand for their own (Schuett, 2010). Net neutrality advocates that ISPs cannot target and discriminate against certain applications (Ammori & Poellet, 2010). It can be considered as a non-neutral behavior when ISPs treat VoIP traffic from one provider as different from another or more generally some bits as different from other bits (Lehr et al., 2006). Even though ISPs traditionally transported data packets on a 'best efforts' basis and without any priority treatment, but today, they can block, slow, or charge unequally for different content if they treat different packets differently (Brito & Ellig, 2007). For instance, access providers that having hypothetical monopoly can offer high QoS but refuses to sell a competitor's service at the same QoS level (Hahn & Litan, 2006). Therefore, such discriminations can both help or harm consumers depending on the circumstances (Brito & Ellig, 2007). Because network operators can use their power in order to prevent access to competitors' services or prioritize their own services (EU, 2009).

According to the net neutrality proponents, ISPs may abuse data prioritization to discriminate packets to their favor (Yang et al.). The proponents argue that network operators and ISPs might use their control over routers and transmission networks to slow down or block certain data packets in order to discriminate competing services. If operators especially incumbents blocked data packets of competitors' substitute VoIP services with exploiting their dominant position (Boliek, 2011), this would not only discriminate, but also reduce competition and economic welfare (Kruse, 2008). Because local ISPs have control over the infrastructure, it can effectively regulate the choices of the end-users if the principle of net neutrality is

abolished. This is possible because prioritizing some specific content for delivery and delay for the non-prioritized content (Guo et al., 2010).

ISPs can have incentives to content providers to pay for superior service via either lower levels of service for the same price (blocking or throttling content) or higher price for higher QoS. From content providers' perspectives, there are two basic implications. Any content provider that does not pay extra fee might have lower QoS and a vertically integrated ISP might give priority to their own packets (Marsden & Cave, 2007). On the other hand, net neutrality does not permit a higher QoS to ISPs even if that service is provided to all on a non-discriminatory basis (Boliek, 2011).

For instance, Orange and Vodafone removed the VoIP capability of Nokia N95 cell phones in UK in 2007. In addition, Deutsche Telekom AG stated that it was considering to prevent its customers from using Skype VoIP program on the popular Apple iPhone smart phone in 2009. Moreover, the success of the BBC iPlayer video platform service lead to a surge in traffic for streaming video and complaints of network congestion. Since the access provider restricted access to certain websites and P2P applications without informing customers, the Italian Competition and Markets Authority imposed an administrative fine on Tele2 Italia in 2008. Therefore the significance of the types of problems arising in the net neutrality debate is directly correlated to the degree of existing competition level (EC, 2011).

Three net neutrality rules regarding non-discrimination are (Atkinson & Weiser, 2006);

- *Transparency*,
- *No blocking* and
- *Tiering*.

Transparency is related to how providers should manage their networks (Reicher, 2011). ISPs can tell customers and application developers which services they offer with estimated bandwidth and latency in terms of transparency (Marsden & Cave, 2007). This is essential to certain applications, which cannot run with latency like VoIP (Marsden, 2007). In comply with this, fixed and mobile providers should promulgate accurate information regarding the network management practices, performance characteristics, and terms and conditions of their services (FCC, 2010 and Boliek, 2011). Transparency requirements are necessary to inform consumers of QoS and QoE (EC, 2011).

Blocking (or *throttling* or *degradation*) issue concerns whether broadband providers can block or degrade consumer access to certain applications and content (Atkinson & Weiser, 2006). ISP can block a competing service or port to avoid bandwidth intensive and often illegal usage of the Internet (Renda, 2008). Most of cable and DSL providers have claimed that they have not blocked access to any content or applications. However, the potential danger stemming from last-mile providers' ability to block access to certain applications was ignored when Madison River Communications prevented its DSL customers from accessing the ports needed for VoIP service. Later, allegations of similar interruptions of VoIP have been revealed (Yoo, 2005). Therefore, while fixed broadband providers should not block lawful content, applications, services, or non-harmful devices subject to reasonable network management, mobile broadband providers should not block lawful websites, or block applications that compete with their voice or video telephony services (FCC, 2010).

Tiering (or *access tiering*) is about different levels offer with different speeds, different prices, and different limits on bandwidth usage (Barratt & Shade, 2007). This is a typical case

of price discrimination according to QoS (Renda, 2008). By tiering, content providers and ISPs are allowed to enter into agreements where content providers pay more for superior service (Weisman & Kulick, 2010). This happens when ISPs reserve specific bandwidth to application and/or content providers that are willing to pay for enhanced or guaranteed QoS. ISPs have to engage either in packet inspection with packet inspection (DPI) in order to provide tiering (Renda, 2008). The issue addresses whether broadband providers can provide higher QoS or should have the right to charge application and content providers for higher QoS to access their networks. This can allow incumbents to protect their video and voice businesses from competition. Even if NRAs focus on promoting entries of new broadband providers and they allow wireless providers to put their networks, they might not compete with their wired counterparts as well (Atkinson & Weiser, 2006).

Another anti-competitive tool is termination fees for content providers. Since ISPs have a termination monopoly, they can use charging termination fees to those who want to get access to the user. Moreover, carriers can offer exclusive and preferential treatment to one application provider over others with establishing a type of '*walled garden*' of preferred suppliers (Marsden, 2007).

4.3.6. Security and Privacy

Cyber-security and Internet freedom are not only technical but also policy decisions. Since some applications and contents have security threats, they should be encouraged to block. P2P traffic can contain a lot of malware traffic such as viruses or distributed denial of service (DDoS) attacks or spam e-mails (Ammori & Poellet, 2010). Major concerns also include adult content and online gambling (Marsden, 2010). ISPs can monitor traffic technically, even

though individual users cannot do. By monitoring traffic, ISPs can determine DDoS or spamming bot-nets (robot networks). Then, ISPs can prevent those from the network (Ammori & Poellet, 2010).

Some regulations can allow ISPs to block or discriminate against potentially dangerous websites with security concerns. But this can result in a challenge to the freedoms and privacy. This is because there is a trade-off between security and privacy. Generally, ISPs may not trust the regulatory mandates because they may hamper efficiency and reduce their profits. ISPs also fear a public relations backlash for working too closely with government. Meanwhile, the government cannot trust the public or ISPs. The FCC has proposed a cyber-security exception to its net neutrality rule in 2009 in the US (Ammori & Poellet, 2010) since the FCC rules allow ISPs to engage in reasonable network management in order to prevent malware, viruses and traffic congestion (Boliek, 2011). Therefore, operators have rational reasons to prevent those activities (Thierer, 2004).

CHAPTER 5: CONCLUSIONS

Net neutrality and its technical and regulatory contexts have been discussing in the last decade and today, it has become the focus attention of the Internet. As it is known, Internet standards like TCP and IP direct packets based on ‘first come, first served’ and ‘best effort’ principles. Although this approach is enough for applications that are not time or latency sensitive, it has some defects for uses that depend on some data traffic such as streaming media like IPTV, online gaming and VoIP. Therefore, net neutrality has advantage non-latency-sensitive applications and contents, but disadvantage latency-sensitive applications such as video, voice or interactive gaming. On the other hand, if the broadband network providers deploy big enough pipes like FTTH, latency and QoS issues would not be problematic. But security issues and network management could survive even though operators deploy networks with more capacity.

In the absence of net neutrality regulation, the adoption of priority depends both on consumers’ and content providers’ willingness to pay for higher QoS and the costs of services. Therefore, net neutrality rules can prevent providers and consumers from demand or supply side from anti-competitive agreements. If anti-competitive behavior could not be prevented with *ex-post* antitrust laws, then *ex-ante* net neutrality regulations can become essential.

The Internet is required to guarantee certain QoS levels. Fixed and mobile providers should promulgate accurate information regarding the network management practices, performance characteristics, and terms and conditions of their services. Higher QoS ensures VoIP and IPTV reliability and also data security. The quality of a VoIP call is highly sensitive to delay and packet loss. On the other hand, ISPs might prioritize own or affiliated content or

degrade or block competitors' content with the availability of QoS techniques and that could be harmful for the market. But emergency communications need priority and should be ensured.

Imposing net neutrality regulation should not hurt investments in deployment of broadband networks and innovation. Network providers claim that imposing net neutrality regulations would harm their profits for new network investments. On the other hand, main revenues could come from big bandwidth, reliable and quality connections like IPTV.

Vertically integrated broadband provider with market power could deny access to competitors of the affiliated service. Furthermore, abusive discrimination in access to networks is also a market failure. Therefore, vertical integrations should not harm consumers in the event of anti-competitive behaviors.

Net neutrality ensures providing to all on a non-discriminatory basis. ISPs shall not unreasonably discriminate in transmitting lawful network traffic over a consumer's broadband Internet access service. Reasonable network management shall not constitute unreasonable discrimination. Legitimate network management is reasonable and it is a core function for operators.

In comply with the regulation, operators cannot discriminate, block, throttle or degrade certain traffic streams on its network and also cannot give higher priority to others. But on the other hand, QoS requires inspecting data packets going through the network in order to discriminate and identify VoIP packets and prioritize them. In this perspective, net neutrality might inhibit development of service offerings that require priority against jitter, latency

(delay) or packet loss and errors. Again, since vendors like Cisco, Alcatel-Lucent and Huawei are improving products efficiency and decreasing costs, this might help ISPs to deploy networks with more capacity.

Net neutrality regulation is important since it has a significant effect on the deployment, development and use of future wireline and wireless broadband networks. Asymmetrical regulation between fixed and mobile networks can be dangerous for net neutrality, if remedies would be needed to seen as holistic. Therefore, net neutrality principles should subject to reasonable network management. In addition, fixed and mobile broadband providers should not block lawful content, applications, services, or non-harmful devices subject to reasonable network management.

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