

# Background for net neutrality case study

## I. COMMUNICATIONS TECHNOLOGY

### A. Convergence

In operation since the 1890s, telephone networks have traditionally offered voice service. In the past 25 years, most telephone companies have deployed fiber in portions of their networks, and transitioned from analog to digital transmission in the network backbone. With the extra capacity and capabilities this provides, most telephone companies now offer voice service, video conferencing, and Internet access. Most of the Internet backbone runs over telephone networks. In addition, many telephone companies have recently announced plans to offer video service.

Cable video networks were the next significant entry into the field, and were designed to offer broadcast video service. Since their introduction in the 1970s, subscribership to cable and DBS networks has increased to about 86% of US households. Earlier networks were analog and broadcast-only systems. Recently, many cable systems have migrated to digital transmission, which allow for a vastly increased number of channels, Internet access, and telephone service.

Cellular networks were introduced in the 1980s, and were initially designed to offer voice service. The first generation of cellular phones were built on an analog platform, but the second and third generations are digital. In the US, there is now an average of about 1.7 cell phones per household, and the number of cellular phones has recently eclipsed the number of wired phones. Future wireless networks are expected to transition to an architecture that more closely resembles the Internet, and wireless data services are expected to grow quickly.

The Internet, created in 1969 by the Department of Defense Advanced Research Projects Agency, was designed to offer file transfer service. Taking advantage of openly published rules of operation and freely distributed software, many research and educational institutions attached their computers to the Internet during the 1970s. The network has largely blossomed, however, due to the introduction of personal computers during the 1980s and the development of the World Wide Web in the 1990s. In the US, approximately 58% of households have Internet access<sup>1</sup>. The Internet is now in the process of transitioning toward an architecture that can more efficiently support real-time applications such as voice and video.

These four technologies (telephone networks, cable video networks, cellular networks, and the Internet) began to merge in the 1980s, with the introduction of optical fiber and advanced computer capabilities. Economic and regulatory forces have reinforced the technical trends. Recent trends are based on an increased desire for multimedia involving voice, data, and video. A flurry of mergers between communications

companies has resulted, bringing together content providers, broadcasters, cable TV networks, local and long distance telephone networks, wireless networks, and Internet service providers.

Most networking technologists expect that the technical differences between telephone networks, video networks, cellular networks, and the Internet to diminish in future years, with all of these networks becoming capable of efficiently supporting a combination of voice, video, and data services.

Convergence is a principal cause for net neutrality's timeliness, since the motivation for differentiation between different Internet traffic lies in the carriage of voice and video traffic.

### B. Technological developments

We turn now to a brief discussion of technological developments, due to convergence, that underlie the net neutrality issue. We start by considering the requirements of different types of applications. Applications differ in terms of the time scale on which users interact with the application. In real-time applications such as telephone calls or video conferencing, the information sent through the network must be received within a few tenths of a second after it is sent, or the perceived performance will be poor. In non-interactive applications such as email, a delay of tens of seconds is usually still considered good performance. There are also applications with intermediate levels of interactivity, such as web browsing, in which a delay of a few seconds is usually acceptable. Applications also differ in terms of how they define good performance. Voice and video applications tend to base performance on *loss* (percent of packets never received) and *delay* (seconds from source to destination), while less interactive applications tend to base performance on *throughput* (bits per second received).

Traditional Internet transport uses *best-effort service*, in which the network attempts to transmit each packet from source to destination as quickly as possible. All users and all applications sharing a network link share the capacity of that link on a first-come first-served basis in the Internet network layer, without regard to the source or destination of the traffic and without regard to the type of application the packet supports<sup>2</sup>. The result is that congestion on a link degrades the performance of all users and all applications that pass through that link.

Best-effort service is often fine for applications whose perceived performance degrades slowly with increased congestion, e.g. email, file transfer, and web browsing. In contrast, real-time applications such as telephone calls and video conferencing require a particular performance level (or better)

<sup>1</sup>Approximately 73% of households that have Internet access use broadband.

<sup>2</sup>Technically, some applications are subject to congestion control measures in the Internet transport layer. However, these measures do not discriminate based on source, destination or application type.

to be usable; for these applications, best-effort service is often not sufficient to maintain acceptable performance.

In response, there have been recent technological developments in the Internet which provide differentiated service to different Internet traffic. One type of such differentiated service is to place a limit on the bandwidth used by certain Internet traffic. This approach, often called *traffic shaping*, is appropriate when there is a class of Internet traffic that tends to consume relatively large amounts of capacity, is viewed as low priority to the organization, and whose performance degrades smoothly with congestion.

Another type of such differentiated service is to label Internet traffic with distinct *priority* levels. At each router, in the Internet network layer, traffic with higher priority levels experiences better performance than traffic with lower priority levels. From the user's view, this priority approach is roughly similar to USPS PriorityMail service in that the packages go through the same system as First Class mail but experience lower loss and delay.

Finally, a third type of such differentiated service is to *reserve* network capacity for certain traffic classes and to limit the traffic in these classes. At each router, in the Internet network layer, such selected traffic shares a reserved portion of the network capacity; since this capacity is actively managed, the traffic experiences guaranteed acceptable performance. From the user's perspective, this reservation approach is roughly similar to a toll or carpool lane<sup>3</sup>.

The priority and reservation approaches are generically known as *Quality of Service* (QoS) mechanisms. Both QoS approaches give the selected traffic enhanced performance. In contrast, traffic shaping can be viewed as intentional *degradation* of the selected traffic class. It is worth noting that these QoS mechanisms are implemented at the Internet network layer; the consequence of this approach is that QoS must be provided at *every router* along the path from source to destination<sup>4</sup> in order to be effective.

In both traffic shaping and QoS, the decision of which traffic to enhance or degrade can be based on (1) the type of application, (2) the source, (3) the destination, (4) consumer payment, or (5) application provider payment. For example, if priority service is given to all voice and video traffic, or if traffic shaping is applied to file sharing traffic, then application type is the basis for the decision. If capacity is reserved for all voice and video traffic to/from consumers for a fee, then consumer payment is the basis. If capacity is reserved for all traffic to/from application providers for a fee, then application provider payment is the basis.

As traffic shaping and QoS mechanisms have become available in network equipment, many ISPs have adopted their use for various purposes. Some ISPs currently use QoS to guarantee acceptable quality for their own VoIP service. Many universities use traffic shaping to limit file sharing traffic to a small proportion of the organization's network capacity in order to protect the performance of other traffic viewed as more important to the organization's mission.

Use of these mechanisms is expected to grow with technology convergence. Most of the large carriers have announced plans to deploy QoS mechanisms, often in coordination with deployment of fiber and video service. In the near term, priorities or reservations will be used for selected traffic that both originates and terminates within the carriers network, or that transits onto the public switched telephone network. In this case, a carrier's own network management can provide acceptable performance to limited traffic classes using QoS techniques. In the long term, we expect that QoS will also be applied to selected traffic that originates or terminates (but not both) within the ISP's network and transits onto another carrier's portion of the Internet. In this case, acceptable performance may only be provided through cooperation with other carriers offering QoS.

We expect the initial use of QoS will be to support a carrier's own VoIP and video services. It is unclear whether carriers will offer QoS to competitors' applications, on the basis of application type, consumer payment, and/or application provider payment.

We believe these developments are at the core of the issue of net neutrality. Specifically, we are concerned about the basis on which differentiated service may be used to support real-time applications and applications that require relatively large amounts of bandwidth. In contrast, we are *not* concerned about applications that are less interactive and require little bandwidth, such as most web-browsing; we do not foresee best-effort Internet transport degrading to the point where such applications do not receive acceptable performance.

In addition, as networks converge, it is becoming less clear what portion of the integrated network is considered to be the public Internet and what portion is considered to be a private network. Specifically, in the case of traffic that does not transit onto another carrier's portion of the Internet, the distinction between Internet traffic, VoIP traffic, and video traffic may be more a matter of user perception than of technical distinction. This causes a fundamental problem with separate regulation Internet traffic, telephone traffic, and video traffic.

## II. OVERVIEW OF RELEVANT COMMUNICATIONS LAW

### A. History

U.S. federal communications law was separately developed for telephone networks, cable video networks, and cellular networks. Only recently has communications policy started to address the Internet.

Regulation of telephone carriers started with the Communications Act of 1934, and continued with a number of significant updates over the years. Before 1996, policy was based on the assumption that local phone service was offered by a set of local monopoly carriers. The Telecommunications Act of 1996 removed barriers between local and long distance telephone service, and allowed competition between local and long distance carriers. However, communications law regarding common carriers has always principally focused only on voice service, and has not effectively addressed video or data service.

Regulation of cable carriers was largely laid down in the Cable Communications Policy Act of 1984 and the Cable

<sup>3</sup>Technically, it is similar to a toll lane in which the traffic is managed so that congestion never occurs in the toll lane.

<sup>4</sup>or at least at every congested router.

Television Consumer Protection Act of 1992. The policy was based on the likelihood of a set of local monopoly carriers; there was little video competition before the introduction of direct broadcast satellite video service. Communications law regarding cable carriers has always principally focused only on video service, and has not effectively addressed voice or data service.

There has been much less federal regulation of the Internet. Although this falls within the domain of the Communications Act of 1934, there are no provisions that uniquely address Internet access and services, in contrast to common carriers and cable carriers. The Federal Communications Commission (FCC) is tasked with creating regulations that interpret and implement laws passed by Congress relating to communications. In the absence of any explicit statutes regarding Internet access or services, the FCC has recently declared that Internet access is not subject to common carrier regulation.

Convergence between voice, video, and data services is therefore a fundamental challenge to communications policy. Many of the topics in the 2006 communications bills stem from convergence, including video franchising, net neutrality, VoIP, municipal broadband, universal service, broadcast flag, and white spaces. Despite this trend, Congress has yet to fundamentally consider creation of a communications policy that recognizes convergence.

This fragmented approach to communications policy is a principal cause for net neutrality's timeliness. The FCC's decision to excuse Internet access from common carrier regulation removed from Internet access several prohibitions on discrimination included in common carrier regulation. This lifting of discrimination constraints triggered the push for net neutrality.

## *B. The Communications Act*

The relevant Federal law is contained in the Communications Act of 1934, as updated by various Acts since its original introduction. Title I states general provisions applicable to all communications activities, and is perhaps the only title currently interpreted as applying to the Internet. Title II states much more detailed provisions applicable to common carriers, namely telephone companies.

In addition, there are relevant ideas that are embedded in other titles; in particular Title VI states provisions applicable to cable communications, which includes some limits on vertical integration between carriers and application providers. We briefly summarize the relevant portions of each.

Title I is largely concerned with establishing the Federal Communications Commission (FCC) and its operation. The FCC has the authority to create regulations that interpret and implement laws passed by Congress relating to communications. Title I, however, has also been interpreted by the courts to give the FCC limited ancillary authority to create regulations on types of communications not covered by the other titles. As a result, whenever communications are not deemed to fall under Title II (telephone carriers), Title III (wireless carriers) or Title VI (cable carriers), the only authority the FCC has stems from Title I. In addition, Title I includes a provision

which instructs the FCC to forbear from applying regulations unless they are in the public interest and required to ensure just and reasonable practices.

Title II regulates telephone carriers. Section 201 requires common carriers to offer service upon request and to interconnect with other carriers, and mandates that charges and practices be just and reasonable. Section 202 bars common carriers from unjust or unreasonable discrimination and from giving undue or unreasonable preference. Section 203 requires common carriers to post public lists of their charges. Section 205 gives the FCC authority to proscribe just and reasonable charges. Sections 251 and 252 regulate interconnection, and requires incumbent local exchange carriers to interconnect with other carriers on rates, terms, and conditions that are just, reasonable, and nondiscriminatory and in a manner that is at least equal in quality to that provided to itself. In addition, there are many other provisions in Title II that are not pertinent to the discussion here.

Title VI regulates cable carriers. While most of the title is not pertinent to the discussion here, section 628 discusses the relationship between cable carriers and content providers. In particular, it addresses cases of vertical integration, in which a cable carrier has an attributable interest in a content provider. The section prohibits unfair methods of competition or unfair acts or practices, and certain types of discrimination in prices, terms, and conditions of sale.