Traffic Management Techniques for Mobile Broadband Networks

Living in an Orthogonal World

August 2010

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1. EXECUTIVE SUMMARY

Broadband deployment is a central preoccupation of most if not all countries. Mobile broadband will play a significant role, particularly in developing countries, in realizing the vision of a "connected" society in which people have timely access to the people, information and services they desire.

Presently, a number of countries are contemplating what strictures if any might be appropriate to impose on broadband Internet access providers related to consumer access to content, applications and services via the Internet. In doing so, many have recognized that network management allowances need to be preserved, but what that means has been less than fully articulated.

3G Americas is publishing this white paper in order to highlight the importance of network management – and in particular traffic management or how network operators handle variable packet flows – for ensuring high quality services to consumers and overall network reliability. The significance of a basic grounding in broadband network management practices is further underscored by the fact that, as commonly recognized, *mobile* broadband networks confront a number of specific challenges. Notably, the physical layer in mobile networks is subject to a unique confluence of unpredictable and unrelated (i.e., "orthogonal") influences.

The 3rd Generation Partnership Project (3GPP) has endeavored over the last several years to standardize increasingly more robust traffic management (that is, quality of service or QoS) techniques for mobile broadband networks such as UMTS-HSPA and LTE. This paper provides a basic review of these QoS techniques, after providing an overview of mobile network architecture and the end-to-end (E2E) provision of mobile service. E2E QoS is contemplated in the 3GPP standards. However, QoS must be interpreted in light of the fact that mobile operators typically do not have full control over E2E provision of services that depend on mobile broadband Internet access.

This paper concludes by acknowledging that further innovations are needed throughout the mobile broadband ecosystem, in particular in the application development realm, in order to realize E2E QoS. Further, transparency in network management practices will be important going forward, but requires a careful balancing to ensure consumer comprehension while safeguarding network reliability. We close by observing that 3G Americas stands ready to assist interested parties in providing additional information on these new technologies and progressing innovation in the field.

2. INTRODUCTION

2.1 SETTING THE SCENE

Presently, policy makers in the Americas and elsewhere are considering whether and how to regulate certain practices of broadband Internet access providers. Known in the popular lexicon as "net neutrality," the broad concept is that these providers should not unreasonably discriminate against applications, content and services provided by unaffiliated third parties over their access networks. [A snapshot of regional policy developments in the Americas and Europe is provided as an appendix in Section 9.3 of this document.]

It is universally granted that broadband Internet access providers should be able to employ "reasonable network management" to safeguard the functioning of their networks and the services provided to their subscribers. However, there has been little explanation by policy makers to what is meant by such an allowance. There has, however, been frequent recognition of factors that distinguish management of mobile broadband networks as compared to wired broadband networks such as digital subscriber line (DSL) and cable modem based services.

At the same time, through standards bodies and elsewhere, the wireless industry has been developing techniques to ensure high quality services as mobile networks evolve to high speed, IP-based networks. These techniques are designed not only to ensure the performance of applications that have varying enabling requirements on the network, but also to allow operators to offer differentiated services to users, manage congestion that manifests itself often unpredictably, and to recoup the substantial sums that have been invested in building creating these new high speed networks.

2.2 OBJECTIVES OF PAPER

In order to aid stakeholders of all types – policy makers, media, analysts, public interest groups, broadband users, industry players and others – to better understand the need for and operation of network management techniques, we have undertaken the publication of this document. Its focus is on 3GPP networks, that is, those based on the protocols that form the basis of GSM and its evolution through UMTS-HSPA to LTE.

In addition, as a general matter "network management" is an extremely complex topic. Thus, this document concerns itself specifically with "traffic management," that is, the handling of traffic flows on 3GPP networks, in contrast with other network management techniques that operators may deploy (e.g., offloading, compression, network optimization and other important mechanisms).

2.3 TRAFFIC MANAGEMENT IN AN ORTHOGONAL WORLD

An important part of the objective in undertaking publication of this document is to highlight that service providers engage in traffic management on their networks under the constant bombardment of unrelated and extraneous, or "orthogonal," influences. Whether this consists of unanticipated congestion caused by traffic at the scene of an accident, or RF interference caused by underperforming devices in close proximity to subscribers' devices, or the unexpected popularity of certain applications or services, network operators confront a barrage of variables. The traffic management techniques developed by the industry aim to help mobile operators manage traffic flows, given the reality that they will confront varying, adverse and unpredictable circumstances impacting their networks and services rendered.

3. WHY BROADBAND NETWORKS MUST BE MANAGED

Analogies are frequently drawn between deployment of broadband networks and construction of major roads and highways. At the risk of being overworked, the analogy is nonetheless instructive. At its most basic level, broadband networks like highways involve vast financial investments for initial construction as well as regular upgrades and replacement cycles. In addition, both endeavors are subject to periodic heavy congestion which cannot be predicted in an air-tight fashion.

There are other, perhaps less frequently described parallels. As described below, a frequent response to the congestion challenges of broadband networks is to augment capacity, by adding additional bandwidth or improving efficiency. For example, in the wired broadband context, both deploying fiber closer to the user premises and cable node splitting have been used intensively and have demonstrated positive effects.

Yet these techniques, while important, are only partly effective without network management. To understand why, we can return to the analogy of roads and highways. Typical methods of augmenting capacity in this context include adding lanes in places that are particularly subject to congestion. However, as drivers well understand in instances of congestion this tactic, while helpful, only defers the problem (e.g., traffic snarls may be relieved when three lanes expand at particular stretches of road to four, but reemerge when the road contracts back to three). Improving efficiency on highways can be likened to increasing the number of passengers per vehicle. Again, while helpful, this tactic is not a full proof solution to congestion (at least not while the preference in certain societies for passenger cars compared to mass transit continues).

The explosive growth in demand on mobile broadband networks serves to punctuate these considerations. More so than in wired networks, mobile broadband networks apportion finite resources to consumers using services with varying and frequently heavy demands on network resources.

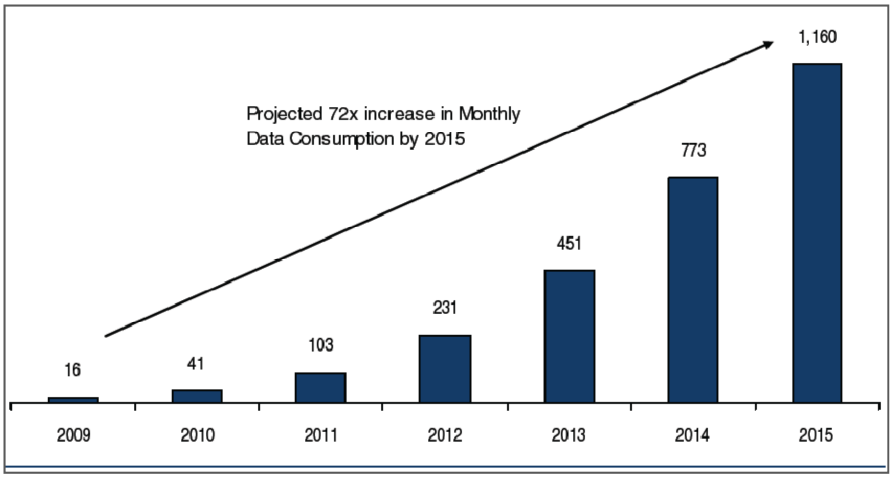
> [W]ireless IP networks do not behave like IP networks without wires — at least not yet. When wires between devices and networks are removed, a tremendous number of physical and architectural issues arise, and the wireless last mile — enabled by the use of air spectrum — becomes highly shared, with the expectation that any one subscriber uses the network infrequently. Accordingly, wireless operators have traditionally been concerned with managing the number of voice calls and minute usage that can be supported by the Radio Access Network (RAN). The addition of data to wireless networks now requires operators to simultaneously manage and optimize RAN usage (such as minutes) and traffic volume (such as bytes).
>
> Common data applications in use today were not designed with the architectural constraints of the wireless last-mile in mind. As a result, they can consume far beyond the expected share of RAN resources, even though only small amounts of volume are sent. In the limit of a deployed RAN with infinite capacity, this does not present a problem. However … very innocent-looking IP applications can cause sufficient load that can easily overload the volume sensitive and/or the minute-sensitive portions of the deployed networks. Today, data traffic has a direct and widely varying impact on network performance, a dramatic departure from the "good old days" of supporting very predictable wireless voice applications. New solutions and tools to comprehensively address wireless IP networking are therefore required.[1]

Adding capacity and improving efficiency in mobile broadband network are undoubtedly helpful and necessary in addressing the "mobile data tsunami." They are, however, only part of the solution. Network operators, like municipalities expanding roads, do not have limitless resources. Even if they did, certain applications (e.g., particular peer-to-peer applications) expand to consume all available capacity. And over-provisioning network capacity is no guarantee of success in the market if a competitor can do so more cost-effectively. Active network management, together with other strategies including demand calibration, are required to match the needs of consumers with mobile broadband networks having finite resources.

[1] Alcatel-Lucent, *Technology White Paper: Alcatel-Lucent 9900 Wireless Network Guardian*, 2008.

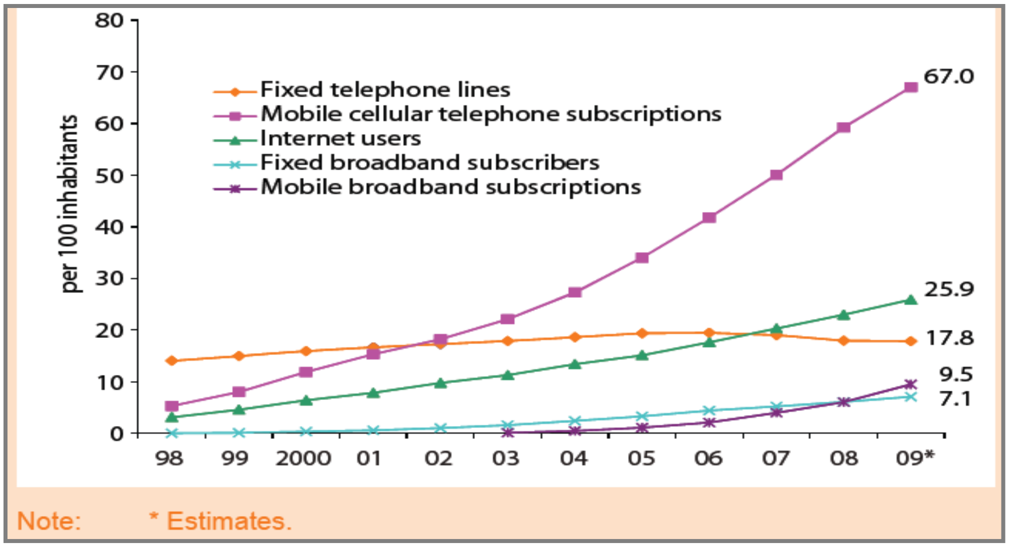
4. PARTICULAR TRENDS IMPACTING MOBILE BROADBAND NETWORKS

Although mobile broadband is a relatively recent mass market phenomenon, the deluge of reports documenting the growth in data usage on those networks may seem like yesterday's news. Even so, the news continues to astound, as illustrated by a May 2010 Credit Suisse estimate projecting a 72x increase in monthly data consumption per user in the United States by 2015.



[Source: Credit Suisse, May 2010]

There are several dimensions to mobile broadband growth. The first, as depicted above, relates to the consumption per capita. A second dimension relates to the growth in the absolute number of mobile broadband subscriptions. This growth – punctuated by the fact that in 2008 the number of mobile broadband subscriptions per 100 inhabitants eclipsed the comparable number for fixed broadband subscriptions on a global basis – has been so impressive that the ITU recently characterized it as nothing short of a "mobile miracle."

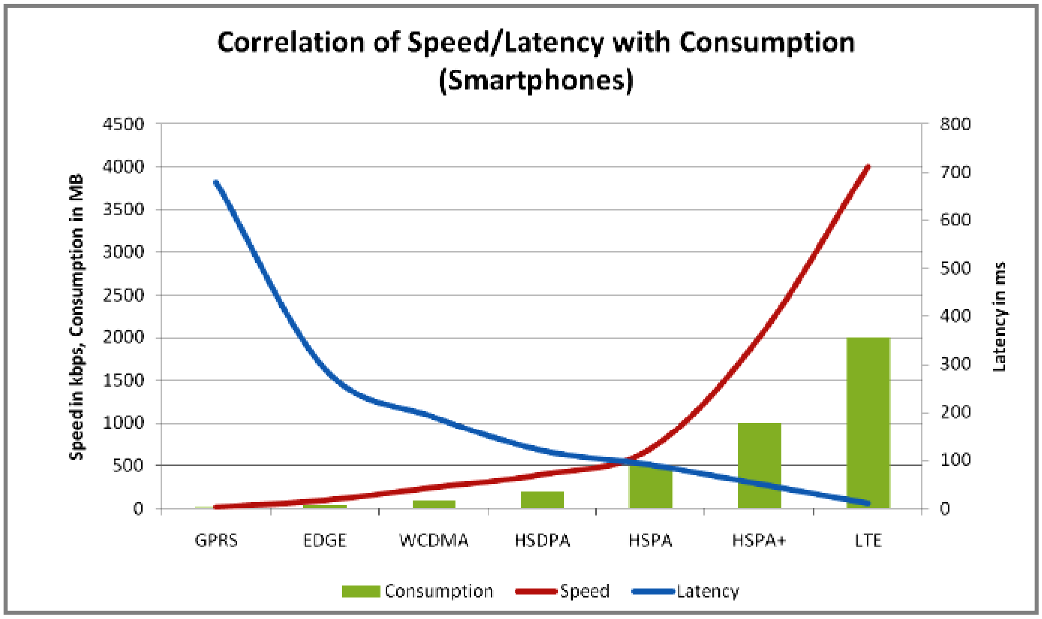


[Source: ITU, *Measuring the Information Society*, May 2010]

A third dimension relates to the number of mobile broadband subscriptions per capita. This is the most embryonic of the three dimensions, yet at the same time the potential is such that Hans Vestberg, CEO of Ericsson, predicted that there will be 50 billion connections by 2020.[2] This is but one citation to the emergence what is referred to as the "Internet of things." The vision is of a future in which individuals will have multiple devices with embedded Internet connectivity, or as Mr. Vestberg has expressed, "everything that will benefit from being connected will be connected."

Fueling the growing appetite for mobile data are various innovations in the mobile, Internet and consumer electronics sectors. In summary, these include: ever more powerful mobile broadband networks; smart phones and other devices with embedded connectivity, greater processing power, and richer user interfaces; compelling applications; attractive service plans and device pricing; increase in user generated content; and emerging machine-to-machine (M2M) applications. Many of these advantages, of course, work synergistically to spur data consumption, as illustrated below.

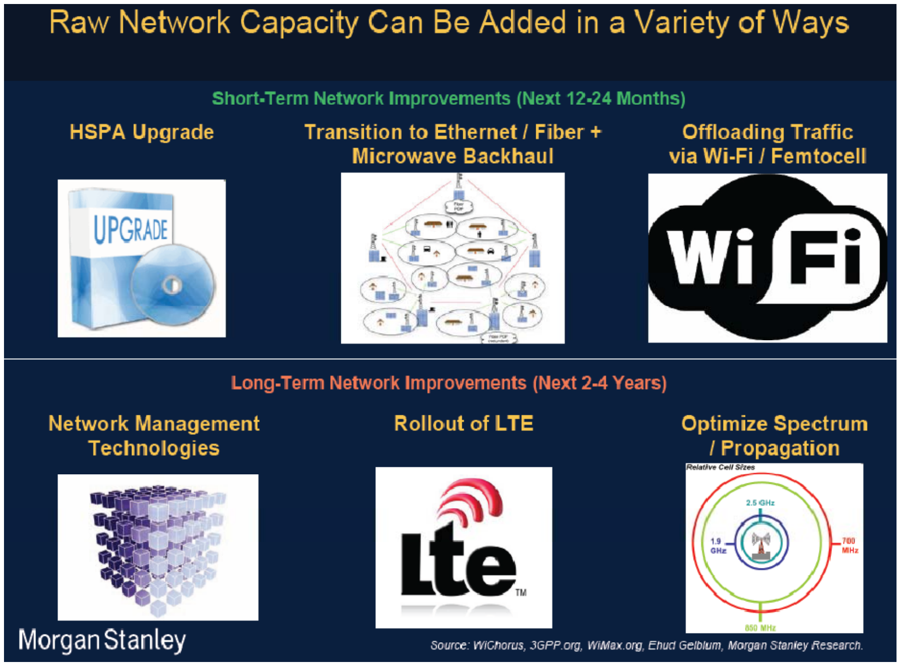
[2] Remarks of Ericsson President and CEO Hans Vestberg at Annual General Meeting of Shareholders, Stockholm, Sweden, 13 April 2010.



[Source: Chetan Sharma Consulting, June 2010]

Network operators have responded to growth in data in various ways, which can be grouped into two broad categories depending on whether the intent is to: (a) calibrate demand; or (b) augment capacity. Calibrating demand can involve numerous strategies designed to provide incentives for users to better forecast needs, including usage-based service offerings as well as graphical tools to monitor individual data consumption.

There are also a variety of mechanisms that can be deployed, some more quickly than others, to augment capacity on wireless networks. These mechanisms include deriving additional spectral efficiencies (e.g., via HSPA and LTE); improving backhaul capabilities; offloading data traffic from the WAN by means of femtocells and Wi-Fi; network optimization through leveraging the benefits of distinct spectrum bands; and new network management technologies. The illustration below depicts these mechanisms.



[Source: Morgan Stanley, December 2009]

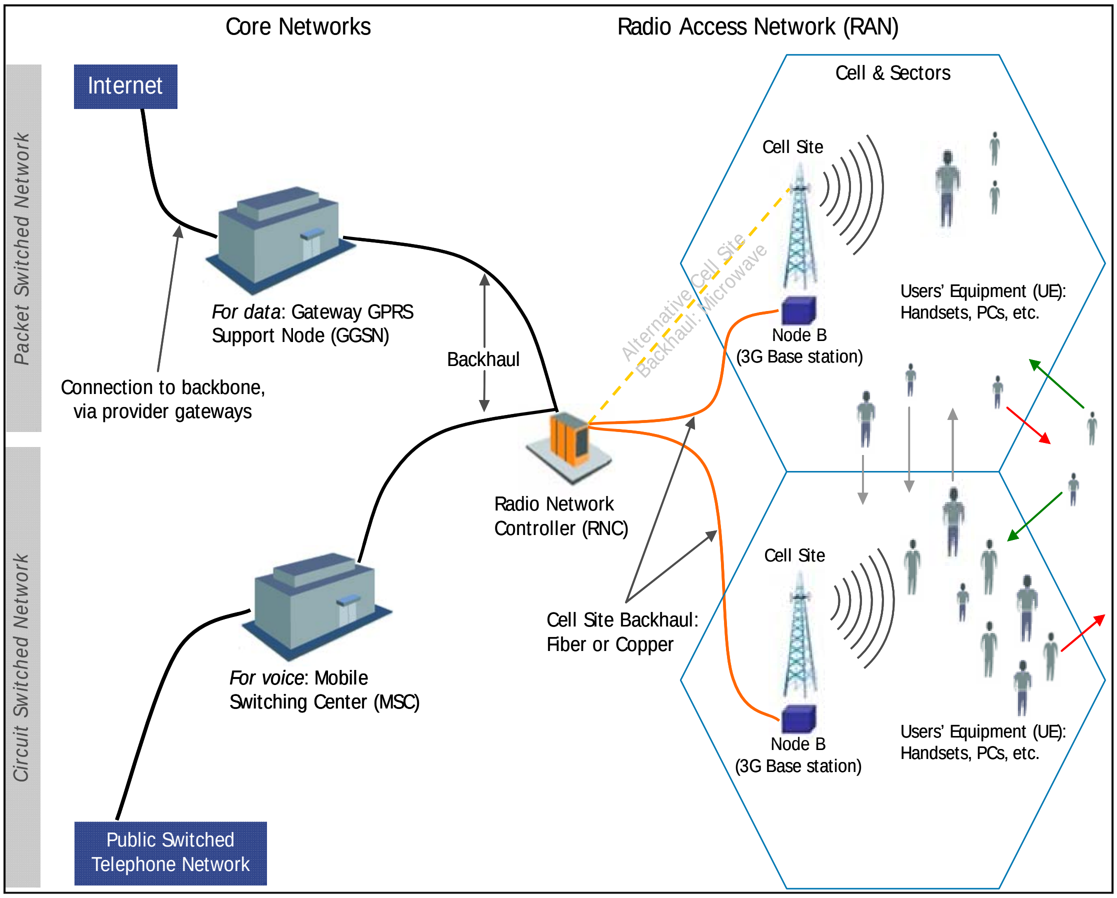
It is network management technologies, in particular traffic management, that comprise the subject of this document.

The combination of demand calibration and capacity augmentation measures will help address the terrific growth in mobile data. They should not, however, be regarded as suggesting complacency, or a singular focus on any particular tactic. The cumulative impact of the mechanisms described above will not suffice to meet demand forecasts, even in the longer two-four year term indicated. Even if initial plans for the release of additional spectrum are achieved, there will still not be adequate spectrum resources to accommodate the growth demands. For example, the U.S. plan to allocate 300 MHz by the 2015 would dramatically help to improve matters, but would still leave 65 percent of projected demand unsatisfied.[3] Clearly, this additional spectrum will need to be coupled with new innovations and strategies to brace for the impact of future mobile data growth.

[3] Credit Suisse, *Telecom Industry Themes – Profiting From the Spectrum Crisis*, 24 May 2010.

5. OVERVIEW OF MOBILE NETWORK ARCHITECTURE

The illustration below is a simplified view of the wireless 3G (UMTS-HSPA) network.



[Source: AT&T, 2010]

While there are many similarities between wireless and wired networks – and they are obviously interconnected – there are several important distinctions. The most obvious consists of the Radio Access Network (RAN), shown on the right side of the illustration above. The RAN is comprised of the cell sites/towers and the hardware and software components that control them. This represents the wireless "last mile" to the end-user, and is roughly analogous to the connection between a DSL access multiplexer (DSLAM) or cable node and the customer premises in DSL or cable modem service. The table below illustrates some of the key differences between wireless and wired networks.

	Wireline / DSL	Wireless
"Last Mile" Bandwidth: Amount Available	Constant—based on loop length from DSLAM or remote terminal ('RT') to customer premises.	Variable—based on distance from cell site to user, RF interference/signal strength, user's speed, number of users in cell, radio channel bandwidth, amount of spectrum available in the market, physics of radio wave propagation including path loss, shadowing, fading, etc.
"Last Mile" Bandwidth: Sharing	No—DSL provides a dedicated connection to the customer. *Note: Cable broadband capacity is shared by the users on a node (e.g. in a neighborhood).*	Yes—cell site capacity is dynamically shared by all users in that cell as radio resources are continually allocated to the users, including those moving in to and out of cells.
"Last Mile" Bandwidth: Potential for capacity expansion	Expandable by upgrading the wireline connection, e.g. DSL or cable to fiber-to-the-premise.	Limited by the amount of licensed spectrum available; this amount varies by market, depending on the licensing scheme (cellular/PCS/AWS/700MHz). New generations of wireless technology (e.g. 3G⇨4G) enable more efficient use of the fixed and finite spectrum capacity, but require clean spectrum.
Number of users in a specified area	Fixed and known upper limit, determined by the number of subscribers on a given DSLAM or cable node.	Variable—mobile users continually move in and out of cells, and there is no limit to the number of users that can request RAN resources in a given cell (though the cell can only serve a finite number of simultaneous users).

Key Differences between Fixed & Wireless Networks

The inherent variability in wireless connectivity, stemming from the nature of the RF connection and the mobility of users, means that some network management tasks are essential to enable the RAN to operate. For example, two network management functions of the RAN, "call admission control" and "RAN scheduling," combine to accomplish the necessary tasks of determining: (1) how many users can attach to a site at any given point in time; and (2) how to allocate the shared radio resources among users that are attached to a site. The settings and algorithms that guide these network management functions must account for many factors, such as the signal strength of the connection to a user's device (which affects the potential data speeds the user can achieve), whether the connection is being used for voice or data traffic, and the overall load on the site.

A common scenario involves users at the edge of a cell, who will necessarily have a slower connection than those closer in because of the relatively lower strength of their signals. By reducing the radio resources allocated to these users (though not to the point that their connections are dropped or blocked), the RAN can free up more resources that would otherwise be wasted, and allocate them to those users that have stronger signals and will achieve better throughput.

Similarly, because voice traffic is given priority over data traffic, when a voice user moves into a cell that currently has heavy data usage, the RAN may need to reduce the throughput to the data users in that cell to free up radio resources such that the voice user's call is not dropped during the handoff from one cell to another.

While in today's UMTS-HSPA networks, voice calls rely on a circuit-switched connection and data traffic is handled by a packet-switched network, the imminent launch of 4G networks such as LTE will introduce entirely packet-switched and Internet Protocol (IP) based networks for all offered services, voice and data alike. This will only further the need for network management techniques within the wireless network, as services like voice will require a certain QoS that can only be provided reliably and with a satisfactory level of performance via certain traffic management techniques.

Beyond the RAN, the backhaul component of the wireless network transports cell traffic, both voice and data, from cell sites to the next links in the network— the Radio Network Controller (RNC) and onto switches, gateways, and the Internet. This transport can be done over copper (typically T-1s), fiber, or microwave. As wireless networks have evolved, this backhaul capacity has steadily increased; however, the recent explosion of data usage on the wireless network means that backhaul links can sometimes become bottlenecks and thus cause network congestion. Providers are continually adding backhaul capacity across their network footprints, but network operators require some management at this network component as well to mitigate congestion.

6. END-TO-END VIEW OF MOBILE SERVICE

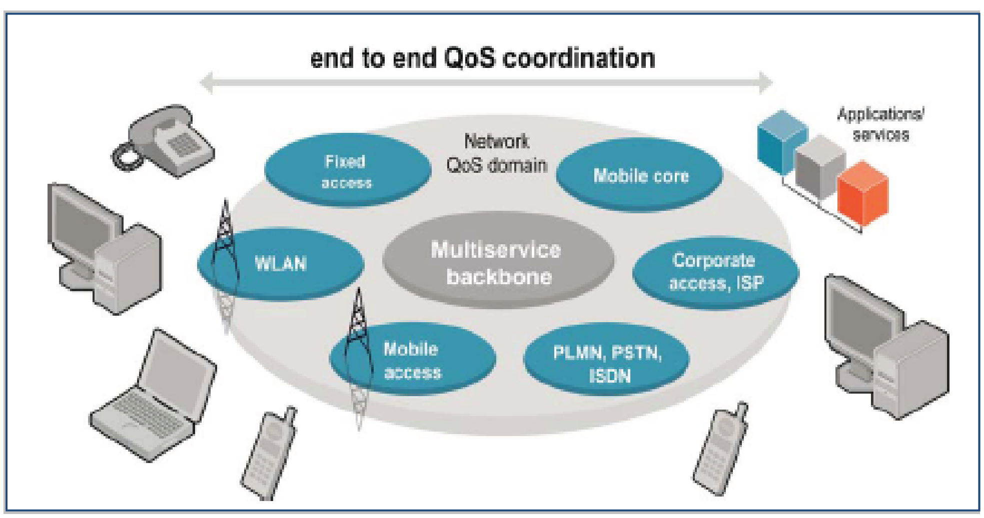
An E2E view is of mobile service is best premised from the perspective of the end-user of the service. For example, a consumer using a mobile phone to look up movie listings and purchase tickets considers the E2E service as the ability to see what is movie is playing and execute a transaction to purchase the tickets, all in as friction-less a manner as possible.

From an implementation perspective, this may involve multiple service providers, including:

- The mobile communications provider - delivering the mobile broadband access and possibly the portal to different content
- The movie theaters - providing a listing of what they are showing
- The ticket agent - selling tickets
- The bank - processing the payment

The consumer may or may not be aware of the different service providers involved in fulfilling the E2E service.

Within this end-user view, the mobile network operator is responsible for the mobile broadband access and possibly some of the offered content. In other words, the operator's "span of control" – its unfettered ability to manage performance on the network and thus the quality of the user experience – is as a practical matter cabined. Consequently, comprehensive end-to-end control over QoS is not practical for mobile operators. The diagram below depicts the multiple considerations involved in optimizing E2E service delivery on communications networks.

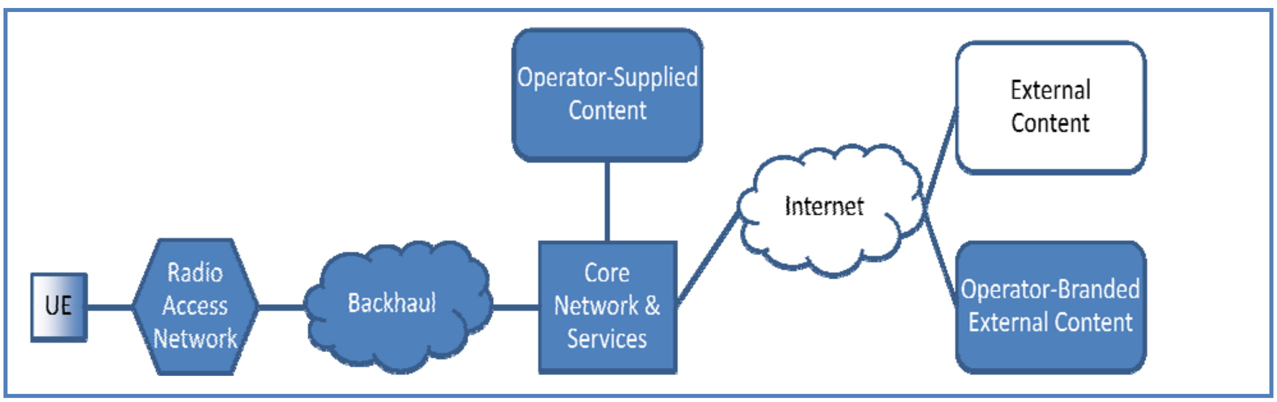


[Source: Ericsson, January 2009]

In reality, the mobile service provider will undertake all possible efforts to ensure a memorable experience for end-users, via mechanisms that can be implemented in the service elements that are under its span of control. Via commercial agreements and standards, it may also be possible for the mobile service provider to cooperate with other service providers to extend the QoS mechanisms beyond just those under the operator's control, but this cannot be assumed in all instances.

Even for certain service elements that are under the mobile service provider's span of control, however, there are frequently variables that influence the degree to which the operator can execute mechanisms within its domain to positively influence the user experience. In some cases, not only does the operator not exercise complete authority over a service element, but some service elements are subject to forces that can adversely impact the end-user experience under various circumstances.

The schematic below depicts the operator span of control concept. Note that areas in blue denote those elements that are more or less within the mobile operator's span of control. An explanation of each element follows.



E2E Service Highlighting Mobile Service Operator Span of Control

1. <u>User Equipment</u>
   The mobile service provider can have full control over the User Equipment (UE) to determine how the device functions on its network only if the UE is a certified device with tight restrictions over which applications can be downloaded. As soon as the device is opened up (e.g., a smart phone that allows users to download apps of their choosing), the mobile service operator is consigned only to various degrees of partial control of the UE's functioning. When users introduce grey-market devices, this introduces the possibility that the mobile service provider may have severely limited or even no ability to undertake network management through mechanisms that depend on

UE behavior. Even worse, an improperly modified device could potentially attempt to subvert network management mechanisms.

2. Radio Access Network

   In terms of span of control, the RAN can be viewed in two ways. On the one hand, the mobile service provider has full control over the nodes that make up the RAN. Increasingly, standards are defining greater ability to provide for network management and to control the QoS delivered.

   On the other hand, there is another aspect of the RAN over which the mobile service operator has only very limited control: the literal, over-the-air portion. Not only does the operator have limited ability to positively influence the actual Radio-Frequency (RF) environment, RF interference in the ambient environment can adversely impact the QoS and require active network management. Sometimes, tuning can mitigate RF issues, especially if the causes are static (e.g., a new building that alters interference patterns). In general, however, incidents over which the operator has no control, oftentimes caused by natural phenomena or acts of God, can always materialize.

3. Backhaul

   Where the mobile service operator owns and operates the backhaul network, it has full control over that segment and the ability to optimize network management there, using mechanisms it has deployed in the backhaul network. Where the operator leases the backhaul capacity, the mechanisms available are as a result more constrained.

4. Core Network Services

   The mobile service operator will have full control over the core network systems and services, so mechanisms can be implemented here that participate in network management and optimize the QoS.

5. Operator-Supplied Content

   Content includes both the applications as well as any digital media that are part of the customer's service subscription. The mobile service operator has full control over any content that it directly supplies (i.e., running on an Information Technology [IT] infrastructure that it controls).

6. Internet and other external networks

   The only control that the mobile service operator has over external networks is at the point of ingress/egress. With some external networks, the operator may be able to utilize different class of service parameters and strike Service Level Agreements (SLAs) that could help provide QoS assurances, but these mechanisms may not always be available.

7. Operator-Branded Content
   Unlike operator-supplied content, operator-branded content is not under full control of the mobile service operator. While the operator can certify applications to ensure that they behave properly in a wireless environment, they nonetheless do not run on IT systems managed by the operator and thus control is limited.

8. External Content
   Not only does the mobile service operator have no control over external content, poorly written applications can introduce QoS issues not only for the user of the application, but for other users as well.

Beyond the elements of the E2E service depicted above, there are external factors affecting service quality, over which the mobile service operator has only limited control. These include the following:

- End-user demand variations
  While historical patterns can help predict end-user behavior (and thus help with forecasting capacity requirements associated with airtime, payload, signaling, etc.), variations in these patterns can happen suddenly and unpredictably.

- Mobility
  While modern mobile networks are built to accommodate user mobility, unexpected fluctuations in user mobility patterns can result in a degradation of service quality.

- Badware, viruses and other nastiness

The greater the openness of the UE and the applications running on it, the less control the mobile service provider has over preventing viruses and badware. This type of software could target the individual user, affecting only the QoS of infected users, or the network itself, potentially affecting the QoS of all users.

7. TRAFFIC MANAGEMENT TECHNIQUES FOR MOBILE BROADBAND NETWORKS

The explosion in data traffic in recent years can be attributed in part to the continuous growth and proliferation of a broad range of multimedia applications. While most users may not be concerned with the details of how a particular service is implemented, users are interested in comparing the same service offered by different providers in terms of universally agreed upon parameters. These parameters focus on user-perceivable effects, rather than their causes within the network, and are independent of the specific network architecture or technology.

Important parameters from a user perspective include: E2E delay (including delays stemming from the UE's operation, the network, and servers); delay variation ("jitter") due to the inherent variability in arrival times of individual packets in packet networks; and throughput. The traffic management techniques explained below will help permit service providers to deliver service in accordance with these and other parameters, as traffic on mobile broadband networks expands and diversifies.

For the sake of clarity, when referring to "mobile broadband networks," we speak of networks that are designed in accordance with the 3GPP Releases 7 & 8 specifications for UMTS-HSPA/HSPA+ and LTE/EPS networks.

7.1 BASIC 3GPP CONCEPTS

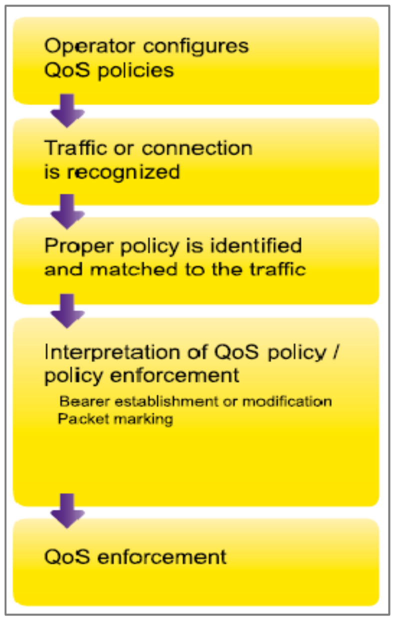
At the outset, there are a few concepts that should be introduced and explained in order to permit a fuller understanding of the 3GPP traffic management approach.

First is the fundamental concept of a bearer**.** A bearer is the basic enabler for traffic separation in 3GPP because it provides differential treatment for traffic with differing performance requirements. The concept of the bearer (and its associated signaling procedures, explained below) enable the network to reserve system resources before packet flows mapped to that bearer are further mapped onto the network.

Second, the performance requirements for a particular service carried on a bearer are generically referred to as quality of service (QoS). QoS provides metrics to guide the network in providing the necessary performance levels to various packet flows. The objective of these QoS metrics is to optimize the packet flows of distinct services or subscriber groups, and to enable subscriber and service differentiation as warranted by end-user demand.

As discussed earlier, the spatial and temporal dynamics of the radio environment coupled with the different error tolerances of various applications present unique challenges in meeting the necessary QoS requirements for supporting diverse end-user applications. In addition, standardized, simple and effective QoS mechanisms are needed for mobile broadband deployments that almost invariably involve multi-vendor sourcing.

The last concept to be introduced here is the notion of policies or sets of rules that an operator can define and enforce both within the operator's domain and potentially across other operators' domains. QoS mechanisms enable these policies to be established, matched, monitored and enforced with respect to individual packet flows on the traffic plane, as conceptualized below.



[Source: Nokia Siemens Networks, 2008]

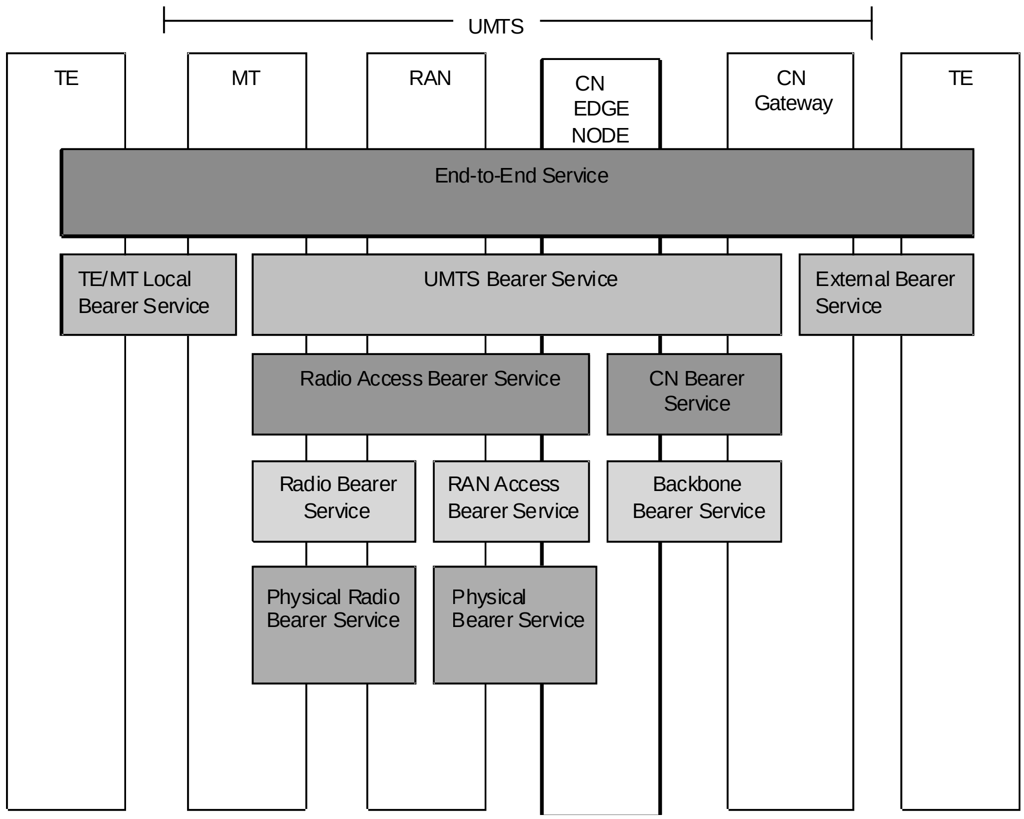
The basic elements of the 3GPP traffic management construct are explained in the following subsections.

7.2 UMTS-HSPA/HSPA+ TRAFFIC MANAGEMENT MECHANISMS

In order to support QoS requirements for a given service, 3GPP explicitly defines an E2E QoS architecture. 3GPP also introduces several bearer and processing mechanisms to ensure that UMTS can make full use of its technical attributes in order to optimize network performance as well as to offer differentiated services for consumers.[4]

[4] See in general 3GPP TS 23.107.

For UMTS-HSPA/HSPA+ networks, the QoS architecture is defined in terms of a layered framework spanning between different nodes in the network. This is illustrated below.



3GPP TS 23.107 – E2E QoS Architecture for UMTS

An E2E Service spans from one Terminal Equipment (TE) to another TE, and comprises the topmost layer of this architecture. The E2E service may specify a certain QoS provided to the user of a network service. A Bearer Service with clearly specified characteristics is set up from source to destination to comply with network QoS requirement. Every bearer service must fulfill a set of QoS requirements. Bearer services provide QoS based on services provided by the layers below them, including a TE/Mobile Terminal (MT) Local Bearer Service, a UMTS Bearer Service and an External Bearer Service.

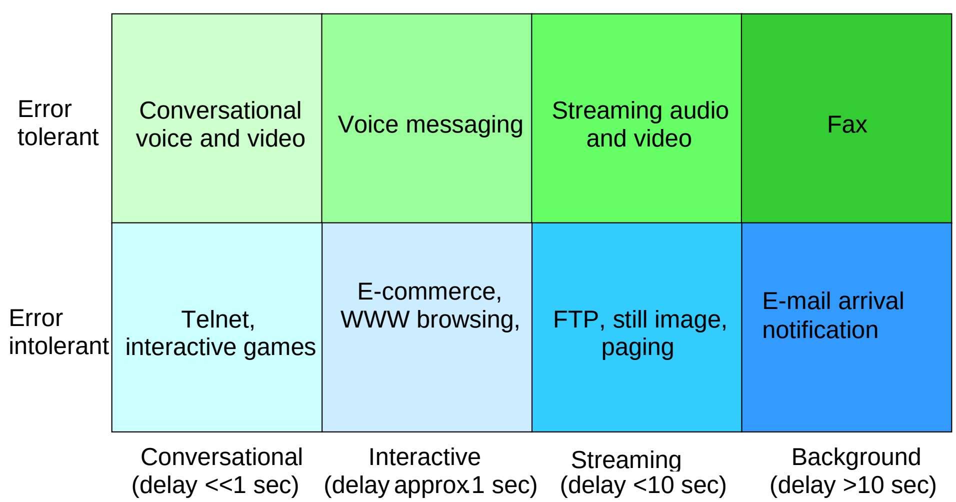
Notably, the UMTS Bearer Service enables the service provider to fulfill UMTS QoS requirements over its own networks (in other words, the UMTS Bearer Service corresponds to those parts of the network over which the operator has more or less full span of control, as discussed previously). The UMTS Bearer Service is comprised of the Radio Access Bearer Service and the Core Network Bearer Service, which in turn have sub-layers as illustrated above.

Returning to the UMTS Bearer Service, QoS attributes describe the performance characteristics of the particular service provided by the UMTS network to the user of the UMTS bearer. QoS attributes as specified in TS 23.107 include parameters such as:

- Traffic Class (Conversational, Streaming, Interactive & Background)
- Maximum bit rate (MBR) (Kbps)
- Guaranteed bit rate (GBR) (Kbps)
- Delivery order (y/n)
- Transfer delay (ms)
- Traffic handling priority
- Allocation & Retention Priority (ARP)
- Several others

The parameters related to throughput/bit rate are separately specified for the uplink and the downlink, in order to support asymmetric bearers.

UMTS QoS requirements are defined taking into account the different error sources in the RF environment and their consequent impact on various traffic types that ride on the UMTS Bearer. The main distinguishing factor between the different traffic classes is how delay sensitive the traffic is – conversational and streaming traffic are more delay sensitive, interactive and background are less so. Due to the looser delay requirements as compared to conversational and streaming classes, both interactive and background classes provide better error rates. These factors and illustrative applications are depicted by 3GPP in the following chart.



3GPP TS 22.105 - Summary of Applications in Terms of QoS Requirements

Conversational and Streaming classes are used to serve real-time traffic flows, which are very sensitive to delay, such as video telephony. In contrast, Interactive and Background classes are mainly meant for applications like web browsing, email, File Transfer Protocol (FTP) applications, news and Telnet. Because these classes are less sensitive to delay as compared to the Conversational and Streaming classes, both classes provide better error rates (i.e. are comparatively more 'error tolerant' than the other two traffic classes) by means of channel coding techniques and packet retransmissions. Packet retransmission is initiated whenever packet error, loss or order mismatch takes place, as these classes require high throughput and low error rates notwithstanding their relative insensitivity to delay.

The main difference between Interactive class and Background class is that the former is utilized primarily for applications like email and Web browsing, while the latter is intended for downloading of emails and files accomplished in the background. Because the UMTS scheduling algorithms provide higher priority to Interactive class than to Background class, background applications use network resources only when interactive applications do not need them.

The following chart provides some examples of QoS parameter ranges for typical applications in the various traffic classes (requirements shown are not exhaustive).

Application	Requirements
Speech	Tight delay per packet (i.e 50-100 ms) Guaranteed Bit Rate
Streaming	Delay requirement according buffer (1-5 s) Guaranteed Bit rate
WWW	Web page downloads within 2-10 seconds
P2P	Pure best effort Downloading typically done in the background

[Source: Nokia Siemens Networks, 2009]

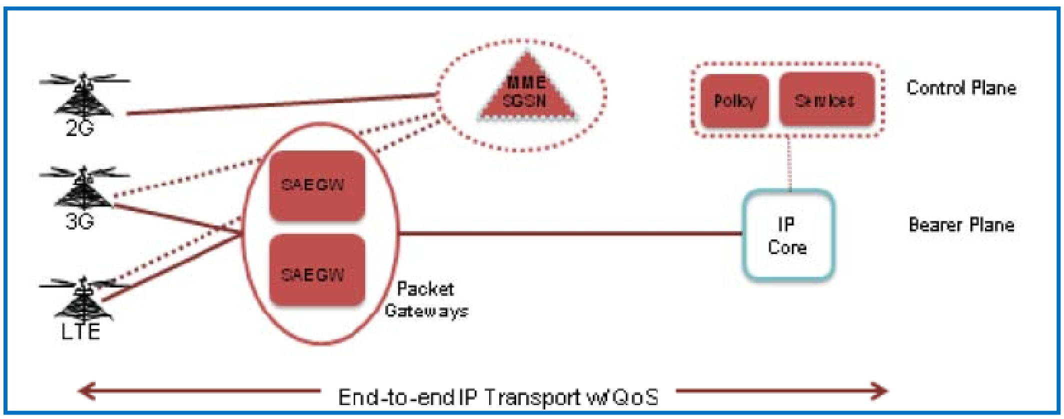
7.3 LTE TRAFFIC MANAGEMENT TECHNIQUES

The 3GPP specifications have enhanced the QoS mechanisms previously available in UMTS-HSPA/HSPA+. This evolved network, called Evolved Packet System (EPS), introduces the concept of default bearer. A default bearer is employed when the user attaches to the network in order to enhance the user experience, reduce service setup latency, and realize "always on"

IP connectivity. The QoS parameters of the default bearer include the subscription data obtained from the Home Subscriber Server (HSS). Other EPS bearers associated with the same packet data network (PDN) are called dedicated bearers, and their setup or modification can only be triggered by the network.

The impetus for specifying a network-initiated QoS control paradigm in LTE is that services are typically provided by the network operator. Therefore, it stands to reason that the network operator would typically assign the QoS level per packet flow associated with a given service. In addition, bearer level QoS parameter values are allocated by the packet core network.

LTE supports E2E QoS where bearer characteristics are defined and controlled throughout the duration of a session between the mobile devices connecting via the RAN and the Packet Gateways (P-GWs). See the following illustration.



[Source: Light Reading, March 2010]

LTE QoS is defined according to certain parameters, namely:

- QoS Class Identifier (QCI)
- Allocation and Retention Priority (ARP)
- Maximum Bit Rate (MBR)
- Guaranteed Bit Rate (GBR)
- Aggregate Maximum Bit Rate (AMBR)

The above parameters identify minimum performance attributes, for example packet delay and packet loss, that must be satisfied. In particular, QCI helps to establish access point parameters used to control bearer level packet transfer (e.g., scheduling weights, admission thresholds, queue management thresholds and link layer protocol configuration). The following table lists the standardized QCI characteristics defined in EPS.

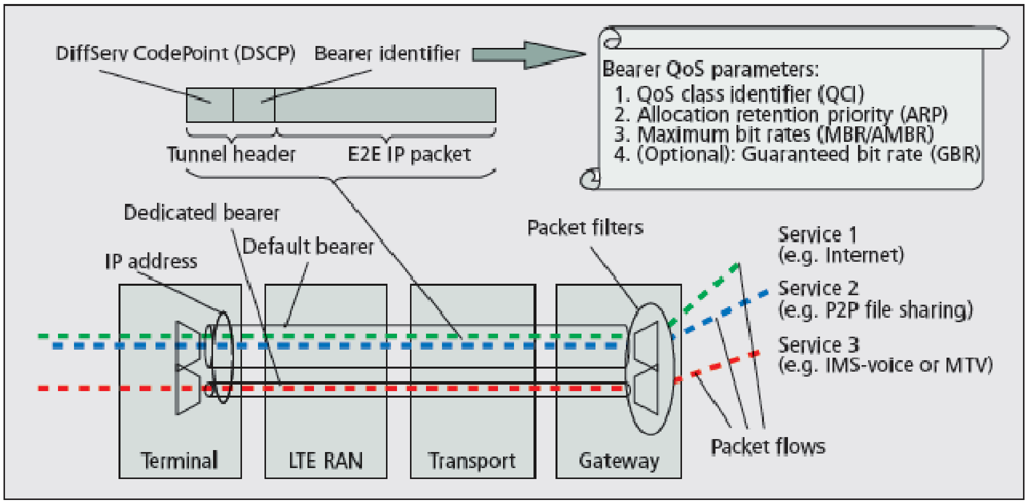
QCI	Resource Type	Priority	Packet Delay Budget (NOTE 1)	Packet Loss Rate (NOTE 2)	Example Services
1 (NOTE 3)	GBR	2	100 ms	10^{-2}	Conversational Voice
2 (NOTE 3)		4	150 ms	10^{-3}	Conversational Video (Live Streaming)
3 (NOTE 3)		5	300 ms	10^{-6}	Non-Conversational Video (Buffered Streaming)
4 (NOTE 3)		3	50 ms	10^{-3}	Real Time Gaming
5 (NOTE 3)	Non-GBR	1	100 ms	10^{-6}	IMS Signaling
6 (NOTE 3)		7	100 ms	10^{-3}	Voice, Video (Live Streaming) Interactive Gaming
7 (NOTE 4)		6	300 ms	10^{-6}	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
8 (NOTE 5)		8			
9 (NOTE 6)		9			

3GPP TS 23.401 – Standardized QCI Characteristics

ARP is used to decide the priority of admission or of packet dropping for dedicated bearers in instances of limited network resources. GBR represents the bit rate that can be expected to be provided by a GBR bearer, while the MBR indicates the upper limit of a GBR bearer.

Non-GBR bearers are used to carry best effort services and/or services whose bit rates cannot be guaranteed. To improve bandwidth utilization, EPS defines the AMBR – an IP Connectivity Access Network (IP-CAN) session level QoS parameter provided with every PDN connection. Multiple EPS bearers for the same PDN connection share the same AMBR value. Each non-GBR bearer can potentially make use of the whole AMBR if other EPS bearers are not transmitting packets. In other words, AMBR restricts the total bit rate of all the bearers sharing the particular AMBR. AMBR can be subdivided into UE-AMBR and Access Point Name-AMBR (APN-AMBR).

The following graphic helps to summarize the LTE QoS paradigm described above.



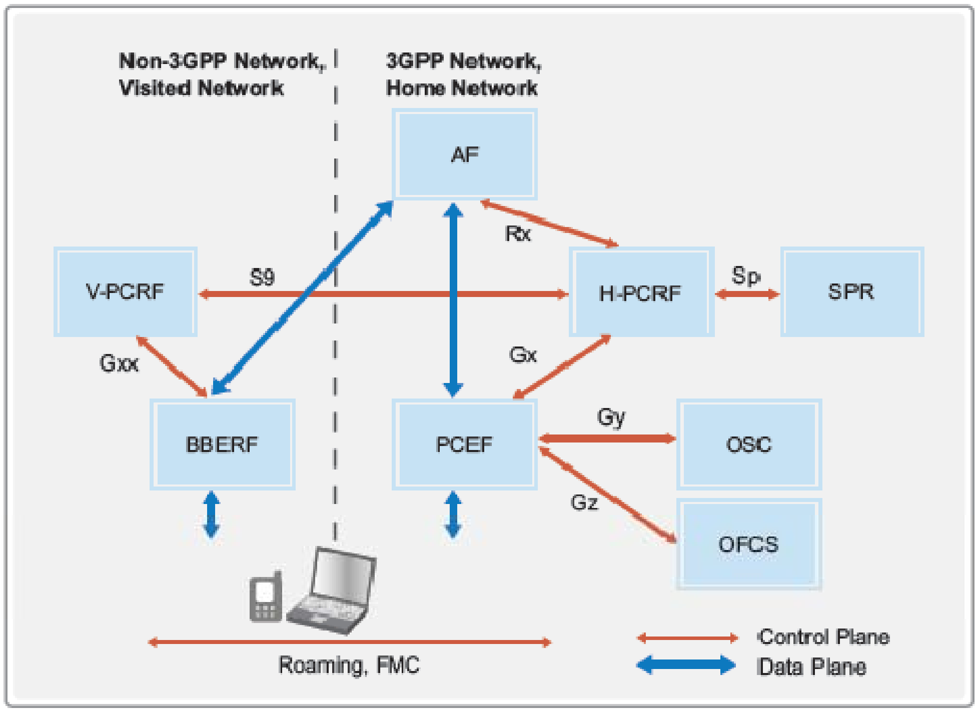
[Source: IEEE Communications Magazine, February 2009]

Finally, in order to ensure interoperability between UMTS and LTE, 3GPP provides for mapping between the EPS and UMTS QoS parameters. This is further described in Annex E to 3GPP TS 23.401.

Policy Charging & Control Architecture

The QoS framework provides the functionality needed to establish, modify and maintain a UMTS Bearer Service with a specific QoS guarantee. The QoS functions of all UMTS network elements together ensure the provision of the negotiated service between the access points of the UMTS Bearer Service.

3GPP has further provided a Policy Charging and Control (PCC) architecture which merges the service based policy and flow based charging functionalities. The PCC model thus allows for more efficient real-time control of service flows between gateway nodes. The graphic below illustrates this architecture.



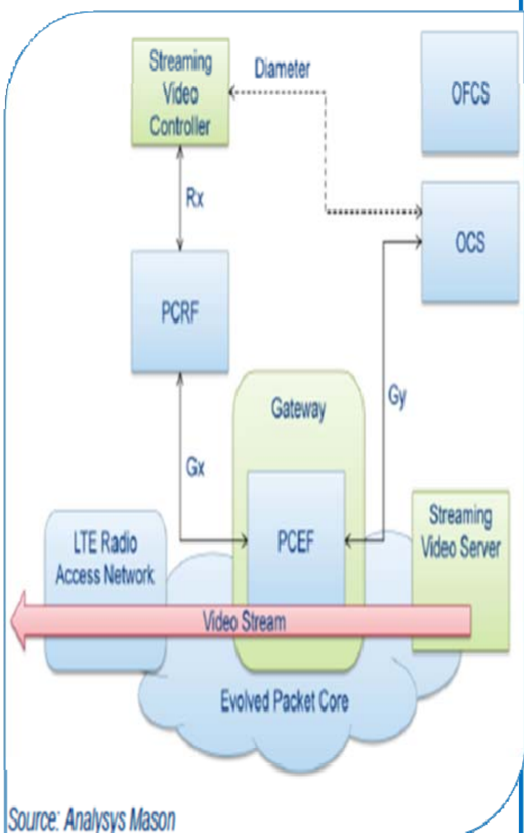
[Source: Tekelec, 2010]

In the PCC model, there are three key functional elements: a Subscriber Policy Repository (SPR), the Policy Control Resource Function (PCRF) (also referred to as Policy Decision Point (PDP) in recent 3GPP releases) and the Policy Control Enforcement Function (PCEF). Decisions made in the PCRF (both Home-routed [H-PCRF] and Visited [V-PCRF] depicted above) are based on policies established by network operators based on subscriber profiles resident in the SPR. These decisions are communicated by the PCRF to the PCEF, where they are translated into QoS rules for individual service data flows and enforced on the data plane.

New elements have been defined in Release 8 (Rel-8). First, 3GPP established the Bearing Binding & Event Reporting Function (BBERF) in recognition of the fact that Rel-8 contemplates inter-operation with non-3GPP access networks. Such networks may have different QoS and charging capabilities. Consequently, separation of the bearer defining and reporting functions from traditional 3GPP packet gateways is important in order to help realize the vision of an access-agnostic policy control architecture, including seamless handovers of services between various access networks while maintaining the subscribed-for QoS.

Next, 3GPP defined the Online Charging System (OCS) to manage credit and grant credit typically associated with prepaid accounts to the PCEF based on time, traffic volume or chargeable events. In addition, an Offline Charging System (OFCS) was defined, which receives chargeable events from the PCEF and generates charging data records (CDR') for the billing system.

To illustrate how the PCC architecture would work, we have adapted a user scenario developed by Analysys Mason on behalf of Openet.[5] It consists of a video streaming session delivered across the EPS. A two sided business model is assumed, in which a video stream can be delivered by a third-party paid for by advertising. While watching the video session, the customer decides to pay for a higher data rate without advertising, using a pre-paid video account. Specific elements of the PCC architecture are engaged to fulfill the customer's request, as depicted below.



Customer requests streaming video paid for by advertising.

⇩

Customer then decides to pay for a higher data rate with no advertising from pre-paid video account.

⇩

Fulfilling the request involves QoS modifications, accomplished by PCRF together with PCEF. (Streaming video controller appears as an **Application Function** ('AF') to the PCRF.)

⇩

Charging aspects are managed by OCS – when customer switches to non-advertising stream PCEF requests credit from OCS.

⇩

OCS checks customer's video balance and provides the appropriate credit for the IP flow.

⇩

OCS correlates charging events to ensure the customer is not charged for the data stream, but only the video.

[5] Openet, *Policy Control & Charging for LTE Services* (sponsored research by Analysys Mason), October 2009.

Interaction with External Networks

3GPP also describes approaches for negotiating resources and capabilities outside a given UMTS network and thus not under direct control of the particular UMTS operator. Specifically, 3GPP TS 23.207 contemplates inter-operator interworking with external networks, including the following (non-exhaustive) list of features:

1. Gateway GPRS Support Node (GGSN) support for Diffserv edge functionality
2. Exchange of signaling messages between network elements along the path of the IP packet flow
3. Interaction between network management entities for provision of resources, enforced in border nodes separating DiffServ administrative domains
4. Provisions for SLAs enforced by border routers between networks, in order to allocate the necessary network resources along the traffic path

8. CLOSING CONSIDERATIONS

8.1 ADDITIONAL TRAFFIC MANAGEMENT CONSIDERATIONS

The 3GPP standards acknowledge and begin to make provisions for addressing QoS in domains that are external to UMTS and LTE/EPS. These are important new innovations and the efforts need to be further intensified by all stakeholders. The configuration of devices, content, and applications not provisioned by the network operator may impact the experience not just of the particular user but potentially other users in a particular cell. These efforts to drive further innovation need to be intensified not only to guard against adverse impacts to users, but also to support and foster interoperability of third party applications with existing network platforms.

Given that mobile broadband extends and amplifies the developments occurring contemporaneously in the fixed broadband environment, wireless traffic management techniques have naturally begun by leveraging the traffic management mechanisms developed for wired networks. Mobile broadband networks, as described earlier, differ in key respects from their fixed siblings, which lead to different traffic management requirements. Among the most significant differences for purposes of traffic management is the need for more granular visibility to circumstances on the ground.

Optimally, traffic management for mobile broadband networks requires visibility to what is occurring at the cell site level, and in a timeframe that enables as far as feasible near-time actions to resolve issues as they arise. Such fine-grained visibility is needed because traffic flows in mobile broadband networks can give rise to issues depending on the site loading, application type, location, time of day and other factors. The variability of some of these factors at the cell site level is evidenced in the charts below.

Figure 2. Wireless traffic composition by application for ten heavily loaded base stations measured during the busy hour

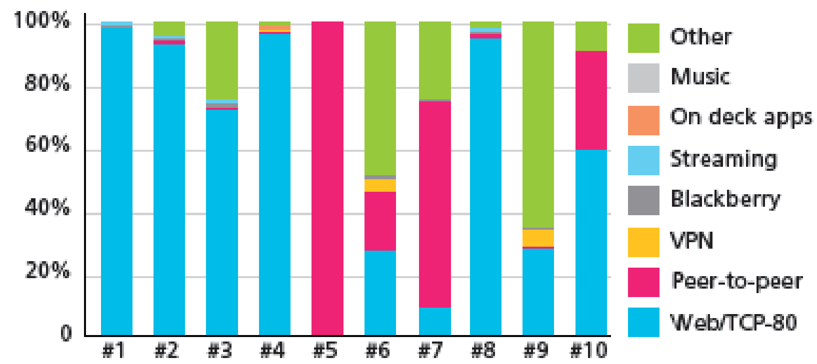
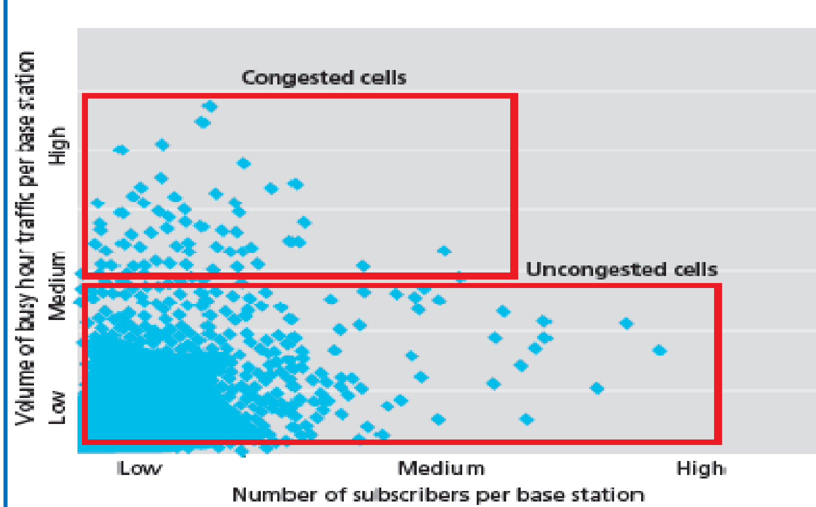


Figure 3. Distribution of traffic loads (volume and number of subscribers) across several thousand base stations



[Source: Alcatel-Lucent, May 2009]

8.2 THE IMPORTANCE OF TRANSPARENCY

Much has been written by stakeholders coming from all angles of the policy debates involving traffic management about the need for transparency in service provider practices. At its most fundamental level, this seems beyond debate. Transforming such objectives into action, however, reveals that an extremely delicate balancing act is required when it comes to network operator practices. Transparency in network management practices must be done in such a way that sufficient detail is provided to educate the user without providing so much detail so as to provide a roadmap for bad actors.

Transparency must also be accomplished via processes that do not unduly constrain the network engineer in responding in a timely and effective way to traffic flow issues. Connected to the latter point, we urge caution in overly prescriptive rulemaking in this nascent area.

8.3 THE ROLE OF INDUSTRY

3G Americas, as an organization of technical experts dedicated to the advancement of 3GPP technologies, stands ready to aid in any way it can in illuminating these technologies for interested parties. We are mindful that both in this hemisphere and elsewhere, the industry has accepted increasingly active roles in remedying service issues.[6]

Recently, a cross-disciplinary group of technical experts, academics and others convened to explore potential institutional responses to network management issues, and in particular the possibility of creating a technical advisory group (TAG) to assist U.S. policymakers by providing technical expertise concerning Internet-based services and network management issues. The workshop's report suggested that such a role could have value. The report's summation of an exchange between participants is telling for present purposes:

> One participant put forth the idea that the TAG could produce a white paper concerning quality of service. The white paper would be designed to simply educate, in essence flagging an issue and presenting all views. Other participants pushed back and again pointed out how time consuming and difficult an informational document could be to produce, especially for engineers who are not renowned, fairly or unfairly, for their ability to write.[7]

Notwithstanding, we trust this white paper makes an intelligible and helpful contribution on the topic of QoS.

[6] Examples of this include the dispute referral procedures established between the US Federal Trade Commission and the National Advertising Division of the Council of Better Business Bureaus, as well as the co-regulatory approach being utilized by Ofcom and U.K. fixed broadband ISPs.

[7] Silicon Flatirons Center, *Network Management Exploratory Workshop Report*, March 2010.

8.4 SUMMARY

Broadband deployment is a central preoccupation of most if not all countries. Mobile broadband will play a significant role, particularly in developing countries, in realizing the vision of a broadband connected society.

Presently, a number of countries are contemplating what strictures if any might be appropriate to impose on broadband Internet access providers related to consumer access to content, applications and services via the Internet. In doing so, many have recognized that network management allowances need to be preserved, but what that means has been less than fully articulated.

3G Americas has published this white paper in order to help educate stakeholders on the importance of traffic management for ensuring high quality services to consumers and overall network reliability. The importance of a basic grounding in broadband network management practices is underscored by the fact that mobile broadband networks confront a number of specific challenges, in particular that the physical layer is subject to a unique confluence of unpredictable and unrelated (i.e., orthogonal) influences.

3GPP has endeavored over the last several years to standardize increasingly more robust traffic management (QoS) techniques for mobile broadband networks such as UMTS-HSPA and LTE. 3GPP standards acknowledge insofar as possible an E2E view of QoS, that is, from the end-user's point of view. At the same time, traffic management needs to be interpreted in light of the fact that mobile operators typically do not have full control over E2E provision of services that depend on mobile broadband Internet access.

Not surprisingly, this paper concludes by observing that further innovations are needed in the mobile broadband ecosystem in order to realize E2E QoS. In addition, transparency in network management practices is important, but requires a careful balancing to ensure consumer comprehension while safeguarding network reliability. Organizations with technical expertise such as 3G Americas stand ready to assist interested parties in helping to illuminate these new technologies and progress these efforts.

9. APPENDICES

9.1 ABBREVIATIONS

2G – Second Generation
3G – Third Generation
3GPP – 3rd Generation Partnership Project
4G – Fourth Generation
AF – Application Function
AMBR – Aggregate Maximum Bit Rate
APN – Access Point Name
APN-AMBR – Access Point Name Aggregate Maximum Bit Rate
ARP – Allocation & Retention Priority
ARPU – Average Revenue per User
BBERF – Bearer Binding & Event Reporting Function
Bits/s/Hz – Bits per Second per Hertz, a measure of spectral efficiency
bps – Bits per Second
BS – Base Station
BSC – Base Station Controller
BTS – Base Transceiving Station
BW – Bandwidth
CAGR – Compound Annual Growth Rate
CAPEX – Capital Expenditure
CDMA – Code Division Multiple Access
CDR – Charging Data Record
CPE – Customer Premises Equipment
CRTC – Canadian Radio-Television & Telecommunications Commission
CS – Circuit Switched
dB – Decibel
dBm – Decibel ratio of watts to 1 milliwatt
DSCP – Diffserv CodePoint
DIFFSERV – Differentiated Services (set of protocols permitting differentiated services to users and their information streams)
DL – Downlink
DSL – Digital Subscriber Line
DSLAM – Digital Subscriber Line Access Multiplexer
E2E – End-to-End
EC – European Commission
E–DCH – Enhanced Dedicated Channel (also known as HSUPA)
EDGE – Enhanced Data Rates for GSM Evolution
eNB – Evolved NodeB
EPC – Evolved Packet Core, also known as SAE (refers to flatter IP based core network)
ePDSN – Evolved Public Data Serving Node

EPS – Evolved Packet System (the combination of the EPC/SAE and the LTE/EUTRAN)
EUTRA –Evolved Universal Terrestrial Radio Access
EUTRAN – Evolved Universal Terrestrial Radio Access Network (based on OFDMA)
EV-DO – One Carrier Evolved, Data Optimized
EV-DV – One Carrier Evolved, Data Voice
FCC – Federal Communications Commission
FDD – Frequency Division Duplex
FMC – Fixed Mobile Convergence
FTP – File Transfer Protocol
GB – Gigabyte
GBR – Guaranteed Bit Rate
Gbps – Gigabits per Second
GERAN – GSM EDGE Radio Access Network
GGSN – Gateway GPRS Support Node
GHz — Gigahertz
GPRS – General Packet Radio Service
GSM – Global System for Mobile communications
GSMA – GSM Association
H-PCRF – Home-Routed Policy Control Resource Function
HSPA – High Speed Packet Access (HSDPA with HSUPA)
HSPA+ – High Speed Packet Access Plus (also known as HSPA Evolution or Evolved HSPA)
HSS – Home Subscriber Server
Hz – Hertz
IMT – International Mobile Telecommunications
IMS – IP Multimedia Subsystem
ITMP – Internet Traffic Management Practices
IP – Internet Protocol
IP-CAN – IP Connectivity Access Network
ISP – Internet Service Provider
IT – Information Technology
ITU – International Telecommunication Union
Kbps – Kilobits per Second
LTE – Long Term Evolution (evolved air interface based on OFDMA)
LTE-A – LTE-Advanced
M2M – Machine-to-Machine
Mbps – Megabits per Second
MBR – Maximum Bit Rate
MHz – Megahertz
ms – Millisecond
MS – Mobile Station
MT – Mobile Terminal
MTV – Mobile TV
MSC – Mobile Switching Center
OFCOM – U.K. communications regulatory authority

OFDM – Orthogonal Frequency Division Multiplexing
OFDMA – Orthogonal Frequency Division Multiple Access (air interface)
OPEX – Operating Expenses
OCS – Online Charging System
OFCS – Offline Charging System
PCEF – Policy Control Enforcement Function
PCC – Policy Charging & Control
PCRF – Policy Control Resource Function
PDN – Packet Data Network
PDSN – Public Data Serving Node
PDP – Policy Decision Point (or Packet Data Protocol)
P-GW – Packet Gateway
PS – Packet Switched
QoS – Quality of Service
QCI –QoS Class Identifier
RAB – Radio Access Bearer
RB – Radio Bearer
RAN – Radio Access Network
Rel. 'X' – Release '99, Release 4, Release 5, etc. of 3GPP Standards
RF – Radio Frequency
RT – Remote Terminal (local loop termination points closer to service user)
RX – Receive
RNC – Radio Network Controller
SAE – System Architecture Evolution, also known as EPC
SGSN – Serving GPRS Support Node
SLA – Service Level Agreement
SPR – Subscriber Policy Repository
T-1 – Trunk Level 1 (a digital transmission link with signaling speed of 1.544 Mbps in both directions)
TAG – Technical Advisory Group
TE – Terminal Equipment
TS – Technical Specification
TX – Transmit
UE – User Equipment
UE-AMBR – User Equipment Aggregate Maximum Bit Rate
UL – Uplink
UMTS – Universal Mobile Telecommunications System
UTRA – Universal Terrestrial Radio Access
UTRAN – UMTS Terrestrial Radio Access Network
V-PCRF – Visited Policy Control Resource Function
W-CDMA – Wideband CDMA
WAN – Wide Area Network
WWW – World Wide Web
WiMAX – Worldwide Interoperability for Microwave Access

9.2 SELECTED REFERENCES

Standards

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- 3GPP TS 23.401, V10.0.0 (2010-06) General Packet Radio Service Enhancements for Evolved Universal Terrestrial Radio Access Network Access, available at http://www.3gpp.org/ftp/Specs/archive/23_series/23.401/23401-a00.zip

- 3GPP TS 22.105, V9.0.0 (2008-12) Services and Service Capabilities, available at http://www.3gpp.org/ftp/Specs/archive/22_series/22.105/22105-900.zip

White Papers & Other Documents

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- Silicon Flatiron Center, University of Colorado Law School, Network Management Exploratory Workshop Report (March 2010), available at http://www.silicon-flatirons.org/documents/publications/summits/SiehTAGWorkshopReport.pdf

9.3 REGIONAL POLICY LANDSCAPE

(As of August 2010)

AMERICAS

Canada

In November 2009, the Canadian regulator (CRTC) issued rules on Internet traffic management practices (ITMPs) of fixed line ISPs. This was the outgrowth of an investigation (ultimately terminated) into Bell Canada's handling of P2P traffic of secondary ISPs reliant on its wholesale broadband tarriffed offerings. The rules established requirements related to among other things transparency (noting that economic ITMPs are the 'most' transparent) and unjust discrimination/undue preferences. The CRTC noted, however, that "some measures are required to manage Internet traffic on ISP networks at certain points in the network at certain times."

The text of the November 2009 decision is available at:
http://www.crtc.gc.ca/eng/archive/2009/2009-657.htm.

At the time, the CRTC explicitly declined to reverse its existing policy of forbearing from wireless data regulation. It also commented approvingly of consumption-based billing practices. However, the CRTC indicated that it would consider the question of forbearance from regulation of wireless data services at a later time. In fact, the CRTC ruled on this issue in June 2010. It decided to amend its forbearance framework for wireless data to apply the November 2009 ITMP provisions applicable to fixed line ISPs to wireless Internet access providers as well.

The text of the June 2010 decision is available at:
http://www.crtc.gc.ca/eng/archive/2010/2010-445.pdf.

Chile

On July 13, 2011, Chile enacted amendments to its General Telecommunications Law establishing new obligations for ISPs. The legislation establishes new requirements in four areas, namely:

1. Prohibition on blocking or discriminating against legal content, applications and services (this is subject to reasonable network management)

2. Ban on blocking use of legal devices, so long as these do not harm the network or service quality
3. Supply parental controls to those who request them, and the user's expense.
4. Publication on the service provider's website of the characteristics of the service rendered, including maximum and average speeds (regulations related to this obligation are to published within 90 days of the law's enactment, i.e., on or about October 13, 2010)

The text of the law as promulgated (Oficio Nº 8874) is available at:
http://www.camara.cl/pley/pdfpley.aspx?prmID=15199&prmTIPO=OFICIOPLEY.

United States

The FCC initiated a rulemaking in late 2009 that proposed, first, to enshrine four non-binding principles it had adopted in 2005 as rules enforceable against all types of broadband Internet access providers, including mobile broadband. The proposed rules would relate to four areas and read as follows:

1. Content: "Subject to reasonable network management, a provider of broadband Internet access service may not prevent any of its users from sending or receiving the lawful content of the user's choice over the Internet."

2. Applications & Services: "Subject to reasonable network management, a provider of broadband Internet access service may not prevent any of its users from running the lawful applications or using the lawful services of the user's choice."

3. Devices: "Subject to reasonable network management, a provider of broadband Internet access service may not prevent any of its users from connecting to and using on its network the user's choice of lawful devices that do not harm the network."

4. Competition: "Subject to reasonable network management, a provider of broadband Internet access service may not deprive any of its users of the user's entitlement to competition among network providers, application providers, service providers, and content providers."

The FCC also proposed two new rules in the following areas:

5. Non-discrimination: "Subject to reasonable network management, a provider of broadband Internet access service must treat lawful content, applications, and services in a nondiscriminatory manner."

6. Transparency: "Subject to reasonable network management, a provider of broadband Internet access service must disclose such information concerning network management and other practices as is reasonably required for users and content, application, and service providers to enjoy the protections specified in this part."

While these proposed rules are intended to apply to all broadband Internet access platforms, including wireless, the FCC acknowledged that: (1) wireless broadband is not as developed as wireline broadband; (2) wireless has different network management concerns as a shared network that is more susceptible to interference, congestion, signal loss, etc.; and (3) wireless uses different business models, including bundled devices and services, and devices that provide both broadband and voice services.

All six rules are subject to reasonable network management exception. Network management is defined to include measures that address congestion, spam, viruses, unlawful transmission of content and other "reasonable" practices. This qualifier is left undefined.

Conclusion of this rulemaking has been delayed as the FCC grapples with questions related to its authority to enforce these proposed rules in the wake of an appeals court decision issued early in 2010. This decision invalidated the FCC's 2008 decision that Comcast had violated the four 2005 principles as a result of certain network techniques it had instituted to manage Bittorrent traffic.

The text of the proposed rulemaking is available at:
http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-09-93A1.pdf

EUROPE

European Commission

June 30, 2010, the European Commission (EC) published a consultation on the open Internet and net neutrality. Responses are sought by September 30, 2010 on 15 questions pertaining to: the end-to-end principle, traffic management/discrimination, market structure, consumers/quality of service, and the political, cultural and social dimensions. Responses will be fed into a report to be submitted by the Commission to the European Parliament and the Council of the European Union Council by the end of 2010, in compliance with the telecoms reform package adopted the Parliament and Council in November 2009.

The text of Questionnaire is available at:
http://ec.europa.eu/information_society/policy/ecomm/doc/library/public_consult/net_neutrality/nn_questionnaire.pdf.

France

On May 20, 2010, the French Postal and electronic communications regulatory authority (ARCEP) published a document with discussion points and initial policy guidelines on Internet and network neutrality. The document was the culmination of a preliminary examination by the Authority that lasted close to seven months and included a series of 50 interviews.

The text of the document is available at:
http://www.arcep.fr/uploads/tx_gspublication/consult-net-neutralite-200510-ENG.pdf

ARCEP closed public consultation on the document on July 13, 2010. Two days later, ARCEP announced that it had received 40 responses to the consultation. ARCEP noted that the responses mainly concern the definitions employed and the description of the current situation in the sector, as well as suggested best practices, notably for traffic management and transparency in the marketing of Internet access offers. The contributions also included comments on the initial guidelines, as much with respect to ARCEP's areas of responsibility, e.g., monitoring the data interconnection market, as to related issues such as competition, content and international governance. ARCEP is making use of these contributions to draft recommendations that it intends to release in September 2010.

Norway

The Norwegian Post and Telecommunications Authority (NPT) published a brief document setting out self-regulatory guidelines in February 2009. NPT published the guidelines with the aim of galvanizing broad endorsement; it clarified that the guidelines had no formal status and could not serve as the basis upon which to issue sanctions. Three principles comprise these guidelines:

1. Users are entitled to Internet connections with a predefined capacity and quality.
2. Users are entitled to Internet connections that enable them to:
   a. Send and receive content of their choice
   b. Use services and run applications of their choice
   c. Connect hardware and use software of their choice that do not harm the network.
3. Users are entitled to Internet connections free of discrimination with regard to type of application, service or content or based on sender or receiver address.

The text of the guidelines is available at:
http://www.npt.no/ikbViewer/Content/109604/Guidelines%20for%20network%20neutrality.pdf

Sweden

Pursuant to a government commissioned assignment, the Swedish Post and Telecom Agency (PTS) published a report concerning open networks and services. The report is structured around a value chain for the production of broadband-based Internet access and services, divided into five levels: (1) natural resources (use of and access to land, ducts and spectrum); (2) infrastructure (passive cables and masts); (3) transmission (equipment for transportation of bit-streams); (4) IP/Internet (equipment for traffic direction and IP addressing); and (5) content and services (content, services and end-user equipment). The report identifies – on each level of the value chain – challenges to openness.

PTS suggested several measures that aim to ensure openness while taking into consideration all of the interests worthy of protection, including investment incentives and network security. It proposed enhanced principles for equal treatment when establishing new infrastructure, increased access to existing infrastructure, targeted information for consumers about pitfalls and the importance of openness, as well as greater transparency regarding the possible existence of measures that restrict traffic, such as prioritization and blocking.

The text of the report is available at:
http://www.pts.se/upload/Rapporter/Internet/2009/2009-32-open-networks-services.pdf.

United Kingdom

On June 24, 2010, Ofcom published a discussion document on traffic management and net neutrality. The purpose for seeking input was to begin to assess whether Ofcom's existing and future powers (once the amended EU rules adopted in November 2009 are transposed into UK law in 2011) might be used to address traffic management concerns and what stance Ofcom should take on any potential anti-competitive discrimination. The document also asks questions about transparency and consumers' awareness of the traffic management policy of the broadband service they have paid for.

The text of the document is available at:
http://stakeholders.ofcom.org.uk/binaries/consultations/net-neutrality/summary/netneutrality.pdf.

Ofcom is seeking preliminary views by September 9, 2010, and has indicated that it will also conduct a series of roundtables with industry, citizen and consumer groups over the summer.

Another development worth highlighting is the Voluntary Code of Practice on Broadband Speeds initially published by Ofcom in 2008 and updated in July 2010. The Code applies to fixed line broadband ISPs who voluntarily become signatories and commit to adhere to its provisions. The collaborative process of formulating and updating the Code appears to be an instructive example of a "co-regulatory" approach to the issue of transparency.

Ofcom published a general statement on co-regulation in 2008, which can be accessed at
http://www.ofcom.org.uk/consult/condocs/coregulation/statement/statement.pdf.

More information on the 2010 Voluntary Code on Broadband Speeds can be obtained at:
http://stakeholders.ofcom.org.uk/telecoms/codes-of-practice/broadband-speeds-cop-2010/?a=0.

10. ACKNOWLEDGEMENTS

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