LTE Congestion Management

Enabling Innovation and Improving the Consumer Experience

January 2015

Table of Contents

Notice

Overview

The United States leadership in global 4G Long Term Evolution (LTE) deployment and dominance in mobile computing technology and applications all have been achieved under a light-touch regulatory environment that spurred investment, innovation and vast consumer benefits. Today, providers are encouraged to experiment and innovate to better serve customers, and regulators have refrained from micromanaging network management techniques as they do so. The blinding speed at which technology and the wireless market are evolving and the important role mobile broadband plays in the economy should give pause to those who are motivated to constrain this dynamism through rules and regulations that dictate network design and operation, or presume to understand how wireless technology will work in the future.

Examples of such rules are identified in a recent paper by New America Foundation's Open Technology Institute (OTI) titled, "Mobile Broadband Networks Can Manage Congestion While Abiding By Open Internet Principles." The OTI paper examines a nascent capability in LTE, quality-of-service (QoS) management, suggesting how it could be used to manage congestion, and proposes rules by which operators would implement congestion management.

Rules that anticipate or dictate how wireless network management might work in the future, particularly with respect to congestion management, will inhibit industry innovation and make it more difficult for operators to deploy new network management approaches.

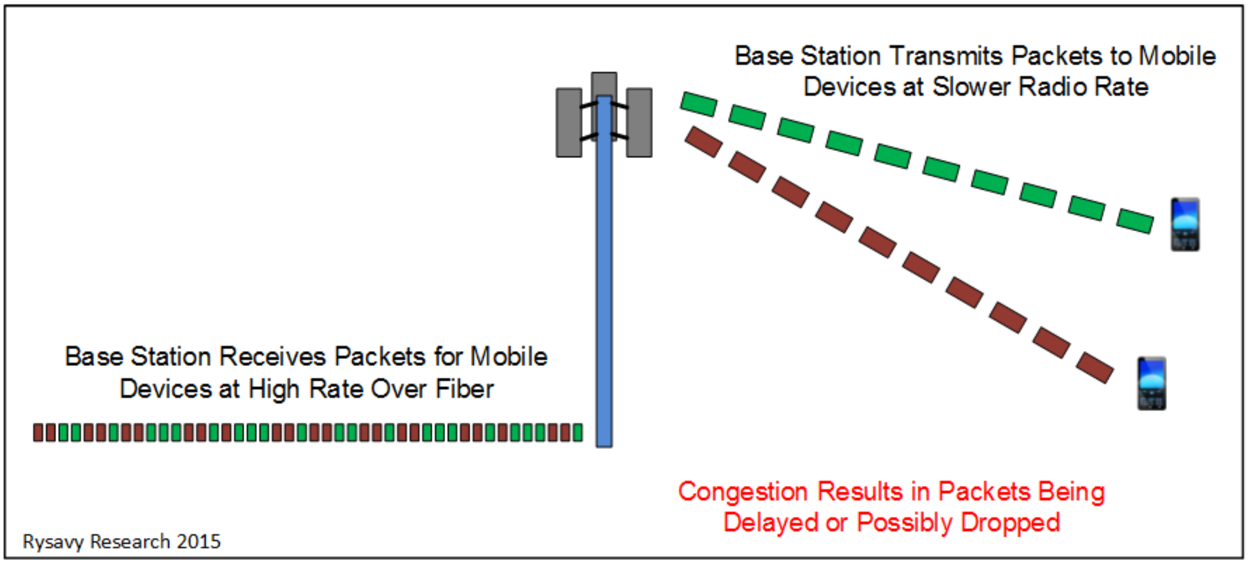
Any remaining doubts about the fundamental differences between wireless and wireline broadband networks are dispelled by this OTI paper. The congestion management scheme it proposes apply only to wireless networks, employing capabilities designed specifically for LTE technology. No such congestion management schemes are being considered, nor are needed, for wireline networks.

Congestion Management Background

Congestion occurs when demand for network resources is greater than network capacity. Analogous situations are highways with too many cars or water supplies with too many users. For wireless networks, effects depend on the degree of congestion and the type of application, but range from applications operating more slowly, for example Web pages taking many seconds to load, to applications failing entirely, for example an attempted purchase transaction timing out.

Figure 1 depicts packets arriving from the Internet over a high-speed fiber connection faster than the base station can transmit the packets to mobile devices, resulting in packets being dropped or delayed. This effect is beyond the operator's control, beyond the ability of the best-engineered network, because demand in excess of capacity has inevitable negative consequences. Operators invest heavily in networks to avoid congestion by deploying more spectrum when possible, installing more cell sites, using more efficient technology, and offloading onto other networks such as Wi-Fi. Congestion can also occur on the uplink, but in most networks, downlink traffic significantly exceeds uplink traffic, and so is more prone to congestion.

Figure 1: Congestion at a Base Station



A new approach for addressing congestion is to use quality-of-service mechanisms that are part of LTE. These mechanisms do not increase capacity, but by prioritizing traffic, can allow certain applications to operate reliably, or more reliably compared to others, even when the particular cell is congested.

The OTI paper, for example, assumes operators will use QoS for this purpose and makes a number of recommendations with respect to implementation and monitoring to satisfy network neutrality principles. These recommendations are problematic for the following reasons:

1. No operator has yet developed any plans to use QoS in a widespread manner for congestion management, nor even plans on how to make QoS control available for mobile broadband applications in general, if at all.
2. QoS is being considered for certain applications–including specialized services such as voice over LTE (VoLTE)–so it is a mistake to view any QoS capabilities as being primarily focused on congestion management for general-purpose Internet access. Dictating how QoS should operate at this stage will only curtail innovations that could have a dramatic impact on consumer offerings and the consumer experience.
3. Managing QoS is complex. Determining business models and appropriate usages, and whether to develop application and network interfaces for third-party applications, will be a multi-year process.

QoS is a powerful tool with many knobs and switches that controls how traffic flows through a wireless network. Neutrality rules that involve government deciding whether and when QoS or other network management approaches should be used will freeze innovation. The industry needs to be able to experiment with advanced network capabilities, especially those that have not been used before, such as QoS management. Competition will be undermined by limiting how QoS works and by mandating and monitoring the way operators implement QoS. LTE QoS is a tool for operators to differentiate themselves from one another and to provide mechanisms to provide carrier-grade voice and video service in lieu of circuit-switched voice and video.

To understand the problems that will arise requires a closer look at the LTE Quality-of-Service Architecture.

LTE Quality-of-Service Architecture

Two concepts define LTE quality-of-service: parameters of traffic flows and policy management. Traffic-flow parameters include whether bit rates are guaranteed or not, priority relative to other traffic flows, maximum amount of packet delay, and packet error loss. LTE specifications define thirteen different quality-class identifiers, each with different parameters.[1] Policy management refers to a centralized way that operators can potentially apply QoS to different applications or users.

The first wide-scale service that uses LTE QoS is not Internet-access service but instead is VoLTE. VoLTE is a specialized service that absolutely depends on voice calls having a guaranteed bit rate and high priority. Operators are also developing priority services for emergency situations.[2] But beyond those two instances, QoS management is a capability under investigation. In particular, operators have not determined whether and how to expose QoS capabilities to broadband Internet applications. Creating such interfaces would be complex and expensive. The OTI paper suggests using a trusted interface called Rx[3], however this interface is intended for telecom operators, not for third-party application developers.

---

[1] For details about LTE QoS, refer to 3GPP TS 23.203. *Technical Specification Group Services and System Aspects; Policy and charging control architecture (Release 12),* 2014, available at http://www.3gpp.org/DynaReport/23203.htm. Specifically, see Table 6.1.7, "Standardized QCI characteristics."

[2] For example, see *U.S. Department of Homeland Security*, Wireless Priority Service (WPS), http://www.dhs.gov/wireless-priority-service-wps.

[3] "The PCRF is typically programmed by the wireless carrier, but can also be configured to receive policy rules from an edge provider through the Rx interface (a trusted interface).9 The PCRF also receives charging information from the network and can provide charging information back to the edge provider. In this way, the PCRF is capable of fulfilling its role for applications operated and managed by the wireless carrier or for applications provided over-the-top by edge providers." Page 9.

While the notion of applying QoS, such as guaranteeing bit rate, is appealing, in a capacity-constrained network with dynamic load and capacity, operators are constrained in how they differentiate traffic flows by the need to provide excellent overall network performance to all their subscribers. Inherent challenges of managing QoS include:

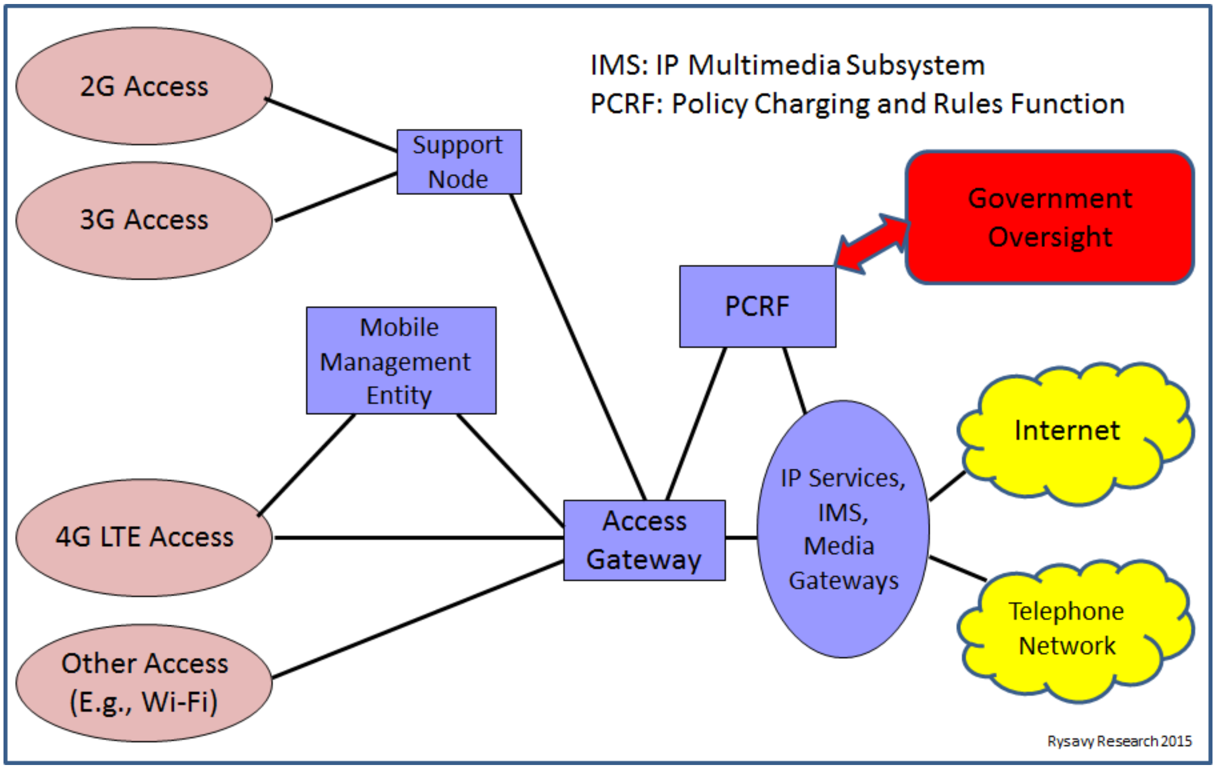
- **Variable Network Capacity.** Capacity depends on many factors, including geography, size of cell, percentage of subscribers indoors, amount of spectrum available, and backhaul constraints.
- **Variable Demand.** Demand is affected by the number of users in a cell at any moment in time and the types of applications they are using.
- **Admission Control.** Wireless broadband networks, indeed most Internet access, operates on a best-efforts basis in which multiple users share the access network. Guaranteeing bit rates for managed services such as high-quality voice requires admission control, a complex process by which resources can only be assigned if bandwidth is available. For QoS applications needing guaranteed bit-rate, if the cell does not have sufficient capacity, it must deny access to that application at that moment in time.
- **Impact on Operator-Managed Specialized Services.** Making QoS available to broadband Internet applications, especially ones based on guaranteed bit rate, could interfere with operators' ability to provide their own managed services, such as VoLTE.
- **End-to-end Integration.** Even though LTE defines QoS methods, for end-to-end application operation, QoS has to integrate with external networks, such as the Internet, which currently do not implement QoS traffic management.

For these reasons, operators will have to use QoS selectively, if they choose to use it at all for broadband Internet access. History provides perspective. Wireless technologies going back to 2G General Packet Radio Service (GPRS), initially deployed around 2000, had QoS capabilities specified and available, as did 3G technologies, yet no operator deployed any services or applications that used QoS. Similarly, even though QoS protocols are available for Internet Protocol (IP) traffic management, the Internet operates almost entirely on a best-efforts basis with no QoS negotiated across end-to-end connections.

Enforcing transparency, if such rules were put in place, is also problematic. For example, the OTI paper proposes that LTE congestion management could be executed through policy rules in a node called the Policy Charging and Rules Function (PCRF) and that the government should monitor these rules.[4] Doing so will require new government infrastructure that interacts with the PCRF, as shown in Figure 2, and would represent an unprecedented intrusion of government into wireless network operation.

[4] For example, "There will be challenges in transparency. There will be many policy rules, and they may be complex, making it more likely that automated tools maybe necessary to read and analyze the rules. The verifiers must be trusted to be neutral and thorough, as well as protective of proprietary information." Page 32.

Figure 2: Government inside the Mobile Operator Network Business



The proposal to use the PCRF for congestion management and regulating its operation, as proposed by OTI, raises a vast number of technical issues.

Technical Issues with Regulating LTE QoS for Congestion Management

The idea that "like" applications should receive "like" QoS treatment in congestion situations, as proposed by OTI, generates numerous problems and thorny questions.[5]

- **What is the definition of congestion?** Wireless networks are shared networks. Any usage by any person impacts any other person in a coverage area. Because no standards or definitions exist,

[5] For example, "In this neutral framework, an unaffiliated application can be provided QoS; 'like' applications are treated in a 'like' fashion; and the LTE network provides QoS to latency-sensitive and/or high-bandwidth applications that benefit from it or require it to run consistently and effectively in congested environments." Page 5. Also, "1) Industry standards bodies or another industrywide process approved by the FCC create generic QoS profiles related to latency sensitivity or other attributes that need similar QoS treatment, and make them open to all like applications, such as toll-quality voice and video communications." Page 5.

government and industry will have to define precise terms and measures for congestion, which likely will be arbitrary.

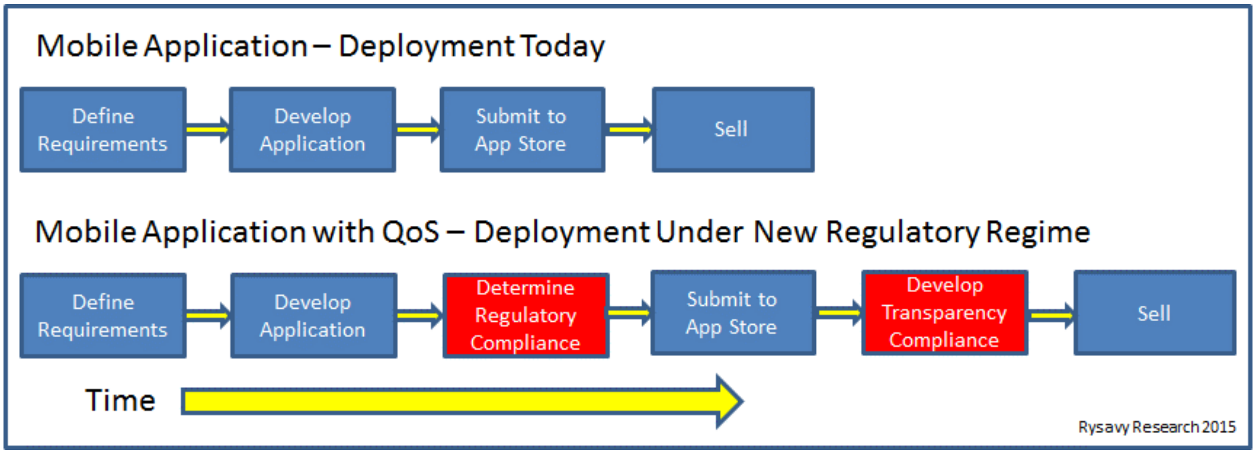
- **What are "like" applications?** Applications differ in many dimensions. Video applications, for example, may have completely different functions. One may be doctors diagnosing medical emergencies, one may be educational, one may be entertainment, and one may be gaming. Are these one or four categories? If one, the rules will make no sense, but if four, hundreds, if not thousands, of categories may have to be defined.
- **Who defines the categories?** Will government define the categories, or industry, or both? Will an entire new bureaucracy be required?
- **What about hybrid applications?** In applying QoS, different QoS parameters could be applied to different functions, such as one treatment for voice and one treatment for video. For some multimedia applications, voice should have higher priority (e.g., a video conference) but in others, video might need higher priority (e.g., medical diagnosis). How will these be categorized?
- **How will operator-deployed specialized services that need QoS be handled?** VoLTE is the first operator service that will use QoS. Operators, in the future, may wish to offer other specialized services that depend on QoS. Do these fall under the rules? By subjecting them to rules concerning the availability or use of QoS, would the development of specialized services and additional consumer choices be denied?[6]
- **How will QoS for purposes other than congestion management be discerned from QoS for congestion management?** QoS can be used for multiple purposes. For example, a user may desire a discounted service plan that blocks video, which could be implemented by a policy in the PCRF. Does this policy have to be reviewed and managed as a form of congestion management?

Additional questions and complexity will arise once government and industry begin to tackle implementation. A new bureaucracy would be required for classifying applications and for determining whether or not operator policies are congestion-management related. Such micromanagement by regulators would be a major shift from the current ability of operators to experiment and roll out new

[6] For example, the OTI paper states, "As described above (page 5), industry standards bodies, or other industrywide processes approved by the FCC, should create generic QoS profiles for categories of applications that are consistent (and transparent). These generic profiles should be developed and implemented once the wireless carriers start to offer application-specific QoS for a particular type of application—for example, voice. Since we understand wireless carriers are already offering VoLTE services and operating application-specific QoS for it, voice should clearly be established as a generic profile. With voice established as a QoS profile established, the QoS settings used for the wireless carrier VoLTE service should also be available for use by any edge provider voice applications in a like manner." Page 22.

services, creating a new permission-based approach that interjects government into the mobile-application innovation cycle. The process of developing mobile applications will become complex and unwieldy, as shown in Figure 3, requiring applications that use QoS features to be categorized before they can be deployed and for infrastructure to be programmed to recognize them before they can be sold.

Figure 3: Mobile Application Deployment with and without QoS Regulatory Regime



Some of the potential adverse consequences of government-regulated QoS are that:

- The FCC becomes involved in the day-to-day minutiae of managing operators' networks.
- Due to the regulatory burden, operators may not even make QoS mechanisms available through application and network interfaces for broadband Internet.
- Any application or service sensitive to QoS, including specialized services that don't even use the Internet, will take longer to develop.
- Many innovative applications or services will never be developed.
- Operators are constrained from using QoS to differentiate their services from each other, undermining industry competition.
- Imposing rules based on a snapshot of today's capabilities could freeze how networks could evolve in capability in the future.
- The U.S. becomes less competitive than the rest of the world in mobile application development.

QoS Rules Impact on 5G

The QoS rules will also impact the evolution of mobile wireless technology. Current generations of technology have transformed our economy, but future technology, such as 5G, will have an even greater impact. Even as 4G LTE itself is still evolving, the world is in a race to see what companies can take leadership in 5G. Any QoS rules could negatively affect U.S. ability to compete in this crucial race, particularly as QoS architectures, along with congestion-management methods are likely to keep evolving.

Government-mandated QoS requirements would have to be incorporated into any specifications development, delaying such standards development, potentially even restricting the capabilities of these standards. Once products are available, regulatory requirements will have to be incorporated into U.S. network deployments. As a consequence the U.S. may have to deploy a version of 5G not harmonized with the rest of the world and may lag the rest of the world in 5G deployment, potentially causing the U.S. to cede global leadership in mobile broadband.

Conclusion

Quality-of-service management in 4G and 5G networks is a powerful but complex capability that will enable new types of applications and services. Numerous considerations demand an experimental approach to application deployment and business models that use LTE QoS management. Using QoS for congestion management on consumers' mobile Internet access services is a conceivable approach, but not one that operators are considering at this time.

For all these reasons, rules that control QoS management will interfere with the delicate unfolding process of QoS-management adoption. Implementing the rules will require a bureaucracy to classify applications, complicating and delaying mobile application development and deployment. In addition, enforcing the rules through transparency requirements will inject the U.S. government into network management practices. Imposing such unneeded regulatory complexity will undermine U.S. ability to compete in the global mobile broadband industry.

About Rysavy Research and Mobile Future

Peter Rysavy is the president of Rysavy Research LLC, a consulting firm that has specialized in wireless technology since 1993. Projects include analysis of spectrum requirements for mobile broadband, reports on the evolution of wireless technology, evaluation of wireless technology capabilities, strategic consultations, system design, articles, courses and webcasts, network performance measurement, test reports, and acting as expert in patent-litigation cases. Clients include more than seventy-five organizations.

Peter is a broadly published expert on the capabilities and evolution of wireless technology. He has written more than 150 articles, reports, and white papers, and has taught more than forty public wireless courses and webcasts. He has also performed technical evaluations of many wireless technologies including cellular-data services, municipal/mesh Wi-Fi networks, Wi-Fi hotspot networks, mobile browser technologies, wireless e-mail systems, and social networking applications.

From 1988 to 1993, Peter was vice-president of engineering and technology at Traveling Software (later renamed LapLink) where projects included LapLink, LapLink Wireless, and connectivity solutions for a wide variety of mobile platforms. Prior to Traveling Software, he spent seven years at Fluke Corporation where he worked on data-acquisition products and touch-screen technology.

Peter is also the executive director of the Portable Computer and Communications Association (PCCA, http://www.pcca.org), an industry organization that evaluates wireless technologies, investigates mobile communications architectures, and promotes wireless-data interoperability. Peter Rysavy graduated with BSEE and MSEE degrees from Stanford University in 1979. More information is available at http://www.rysavy.com.

Mobile Future is a coalition of cutting-edge technology and communications companies, consumers and a diverse group of non-profit organizations, working to support an environment that encourages investment and innovation in the dynamic wireless sector. Our mission is to help inform and educate the public and key decision makers in business and government on the broad range of wireless innovations that are transforming our society and the nation's economy.
http://www.mobilefuture.org