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Technical Underpinnings for the "Net Neutrality" Debate: A Nortel Position Paper

By John Roese, Chief Technology Officer

Introduction and Executive Summary

For more than a century, Nortel has been a leader in the telecommunications industry and has played a key role in developing products, systems, and solutions that have changed the nature of modern communications. The company has been an industry innovator, for example, in the revolutionary transitions from analog to digital, from copper to fiber, from wired to wireless, and from circuit-switched voice to voice over IP (VoIP), to name a few.

Today, Nortel does business in 150 countries and is a recognized leader in delivering communications capabilities that enhance the human experience, ignite and power global commerce, and secure and protect the world's most critical information. Our next-generation technologies, for both service providers and enterprises, span access and core networks, support multimedia and business-critical applications, and help eliminate today's barriers to efficiency, speed, and performance by simplifying networks and connecting people with information. For more information, visit www.nortel.com.

We provide this background information to demonstrate the foundation of our expertise on many of the issues critical to the "net neutrality" debate. Through this position paper, Nortel seeks to add its perspectives to the discussion on "net neutrality," which all parties agree is an ambiguous topic, fraught with divergent definitions and polarized opinions. Moreover, the outcome of this debate could impact the future of the Internet and the critical investment needed to support it.

It is for these reasons that any dialogue regarding the potential regulation of the Internet under the topic of "net neutrality" must be based on a solid understanding of the fundamentals of today's Internet – a vastly different infrastructure than its earlier incarnations as a transport mechanism for the web traffic of academia and consumers. Today's Internet – which has been able to evolve and flourish in the relative absence of regulatory restrictions – is an intelligent infrastructure that is the backbone and foundation of much of the world's commerce. It is also an infrastructure that continues to grow in terms of capability and capacity – and it must continue to do so because of the escalating demands being placed on it.

Up until now, the United States Congress and the Federal Communications Commission (FCC) have wisely refrained from burdening this still-evolving medium with regulations, except in those cases where the need for policy action has been clear and could be tailored to address a specific concern. Nortel believes that there is no need for policymakers to change this philosophy. The Internet has benefited greatly from the relative absence of regulatory restrictions, and the future of the Internet is very much dependent on continuous innovation to meet the increasing demands being placed on it.

To continue to thrive, the Internet must remain free from any barriers that hinder the ability to introduce innovation and intelligence. Furthermore, a restrictive regulatory environment could have the unintended effect of dissuading companies from investing in broadband networks and other related infrastructure that is essential to support the evolution of the Internet.

In terms of the "net neutrality" dialogue, Nortel believes it is therefore critical that a common understanding exists among decision makers around four fundamental realities of today's Internet. Each of these realities is discussed in more detail in the main body of this paper.

The Four Fundamental Realities of Today's Internet

1. It is the convergence point for historically separate networks and functions.
2. It is the backbone of global commerce.
3. It is intelligent, providing much more than just bandwidth to applications and services.
4. It provides all parties with the substantial ability to gain economically.

Nortel also believes that for the Internet to flourish, it must be allowed to follow a set of five key principles that are foundational to any discussion about the future of the Internet. In order to encourage needed investment in advanced infrastructure essential to support the Internet, these principles must exist in an environment free from regulatory restrictions.

Each of these principles is explained in more detail in the main body of this paper.

The Five Foundational Principles of the Future Internet

1. Except for security or stability reasons, no lawful destination should be restricted from a network user.
2. Service providers need the flexibility to meet users' expectations that the converged legacy networks (e.g., Voice over IP and Video on Demand) will provide levels of service over the Internet that are at least equivalent to that experienced when they were delivered over separate networks. In order to allow this flexibility and achieve these results, only the least restrictive levels of regulation (if any is in fact required) should be considered.
3. The bandwidth a subscriber purchases should be unrestricted and unencumbered on the ingress link to the network; the network should have reasonable over-subscription ratios; and there should be no expectation of assured bandwidth for all traffic on the Internet.
4. Quality of Service (QoS) and Class of Service (CoS) should always be permitted, because they are indispensable tools in operating a stable, secure, and effective Internet. Any mechanism that explicitly controls and assures control plane traffic – e.g., operations and management tools, protocols, and interfaces that allow the network to maintain a stable topology – must be allowed and encouraged.
5. Marketplace competition should be allowed to work effectively to determine and deliver fair value for a fair price.

The complete discussion in the pages that follow expands on these principles and raises issues that should be understood and included in a meaningful dialogue on "net neutrality." In addition, this position paper highlights a few of the numerous examples that demonstrate that technology innovation and network intelligence are beneficial and welcomed by users and network operators. Policies for Internet access and use must support these fundamental principles that have allowed the Internet to evolve and flourish. And, they must encourage continuous innovation to ensure that the Internet remains an open, flexible network able to meet the needs of the ever-expanding base of consumers and businesses that rely on it.

Nortel's Position on "Net Neutrality"

The Realities of Today's Internet

For any meaningful dialogue to occur about the future of the Internet, it is essential that there is a common and well-grounded understanding of the fundamentals of today's Internet – a vastly different infrastructure than when it was simply a transport mechanism for the relatively small amount of traffic of the academic community and consumers. Let's look first at the realities of today's Internet.

1. Today's Internet is the convergence point for historically separate networks and functions.

The single most significant factor driving disruptive change in the telecom industry today is "convergence," which is impacting everything from business models and technology investments to price points and industry structures.

In the past, individual networks were largely independent and were deployed to deliver a specific service (such as voice, data, or wireless). The public switched telephone network (PSTN), for example, was historically a dedicated and purpose-built network based on circuit-switched technology that was independent of the data-oriented Internet. Service providers today, however, are converging their various purpose-built and technology-specific networks onto one next-generation network – intelligent, packet-based networks that interconnect with other service providers' networks to comprise today's Internet. This new Internet is enabling providers to signifi-

cantly reduce the cost of running multiple networks, and to create a new platform for innovation in a dramatically different and much richer services environment.

In addition, the technology discontinuity of shifting from circuit-switched networks to packet-based networks is simultaneously driving the decoupling of services from the underlying infrastructure and facilitating the integration of services. This, in turn, is eliminating boundaries in terms of technology platforms, access devices, geography, and even the classification of service providers themselves under the "traditional" categories.

In order to make these services as reliable and robust as when they were on dedicated independent networks, a converged network must be able to support voice (which requires low latency) as well as the roaming requirements of mobile users.[1] Thus, in a converged IP network with legacy network traffic types (e.g., Voice over IP, Video on Demand), service providers must have the flexibility to meet users' expectations of at least the equivalent levels of service over the Internet that they experienced when those services were delivered on separate, dedicated networks. In order to allow this flexibility and achieve the desired results, only the least restrictive levels of regulation (if any in fact is required) should be considered.

The industry is investing in innovative solutions to address the network challenges created by the convergence of legacy networks and the Internet, as well as the convergence of multitudes of existing devices (fixed and mobile, and voice, data, and video). The 3rd Generation Partnership Project (3GPP), for example, has developed an architectural framework, called the IP Multimedia Subsystem (IMS), for delivering multimedia services to end users. [IMS is an architecture that makes multimedia applications possible across wireless and wireline terminals. This is accomplished by having an IMS control plane that isolates the access network from the services, enabling fixed mobile convergence (FMC) within a single IP network.]

Decoupling services from the network infrastructure also means that services no longer are offered only by those providers who "own" the infrastructure. As a result of the greater flexibility of the networks and the wide variety of service providers, new services are being brought to market at a much faster rate than when implementation of new services was tied to changing the infrastructure. New service providers can, and indeed already are, riding the existing networks of facilities-based service providers (who continue to bear the responsibility for the infrastructure/connectivity costs) to offer consumers voice and multimedia services to compete with the traditional and innovative service offerings of the facilities-based service providers.

2. Today's Internet is the backbone of global commerce.

As a result of convergence, the Internet – once simply the transport mechanism for carrying relatively low-demand Telnet, e-mail, and file transfer traffic from the academic community – is today the foundation of much of the world's e-commerce. The Internet has become the common transport for everything from the business interconnects of private networks to the heart of e-commerce in both business to business (B2B) and business to consumer (B2C). As a result, any dialogue dealing even indirectly with the regulation of the Internet must consider that policies will impact not only consumer applications but also business and e-commerce applications that share this network.

3. Today's Internet is intelligent, providing much more than just bandwidth to applications and services.

A key premise in the end-to-end transparent "net-neutrality"-based Internet argument is the assertion that most beneficial technological innovations originate at the "edges" of the network, and that freezing the architecture of the Internet as a large, relatively unsophisticated router of data packets will continue to drive innovation at the network's edges. For example, David Isenberg's "Rise of the Stupid Network" encourages those at the edge to innovate since, in his view, network-based services are slow to change[2].

That assertion is far from reality, however. Today's Internet is an intelligent infrastructure (edge and core), and any assumptions that removing such intelligence would enhance the Internet are flawed, and demonstrate a lack of understanding of modern network operation.

To make services such as voice, data, and video as reliable and robust as when they were carried on dedicated independent networks, the Internet has adapted to add intelligence in the form

[1] Wireless broadband networks already are an important part of the Internet, and Nortel expects their role to grow even more in the future. Mobility capabilities that are a primary feature of many wireless broadband technologies require (centralized) intelligence in the network, especially for fast handover or when seamless mobility over a very wide area is required.

[2] David S. Isenberg, *"The Rise of the Stupid Network"*, Computer Telephony, August 1997, pg 16-26

of Quality of Service (QoS), Class of Service (CoS), and security systems, as well as a host of other packet manipulation technologies that are today critical to the operation of even the most basic elements of the Internet. Policymakers potentially addressing Internet regulation must understand that a removal or restriction on this kind of network intelligence would lead to a divergence of networks back towards the fragmented telecom world of a decade ago, as well as risk reversing both the economic and usability gains that have directly enhanced consumer and business markets.

Examples of innovations in today's Internet

The following are examples of innovations that have been adopted in today's Internet to solve problems of security, performance, and network management.

a. Virus/Worm Blocking applications

Today's network operators regularly block worms and viruses to protect their users. This beneficial and benign blocking is well accepted and welcomed by the Internet user community. For example, the e-mail worm MyDoom – first sighted in January 2004 – was one of the fastest-spreading e-mail worms and, according to mi2g, caused nearly $40B in economic damages and affected up to one million computers.[3] Filtering by Internet service providers and widespread publicity about the worm curbed the spread of MyDoom.

b. Traffic shaping

Traffic shaping techniques are being used today to constrain availability of bandwidth for specific applications or users in order to prevent debilitating degradation of bandwidth for other users and applications. Many IP networking vendors – e.g., F5 Networks, Juniper Networks, and Packeteer – offer products with packet-shaping capabilities. Rogers Cable (Canada)[4] and PIPEX Communications (UK)[5] are examples of Internet Service Providers (ISPs) deploying traffic-shaping techniques in their networks. Most ISPs consider traffic shaping to be a necessary technique to protect users from being adversely impacted by applications (e.g., peer-to-peer video) that consume large amounts of bandwidth.

c. Web proxies

Some multimedia applications, such as audio and video streaming, are sensitive to jitter (fluctuation in transmission of packets) and end-to-end delay. Content distribution networks (CDNs), such as those offered by Akamai Technologies, Inc., replicate content close to users, and thus avoid network impairments (such as packet loss and delay) by sending content over much shorter paths and thereby avoiding the need to transit multiple service providers' networks. This practice of building overlay networks (over the Internet) to enhance users' quality of experience is welcomed by Akamai's customers because it enables adaptations for high-bandwidth applications, such as streaming video. Akamai's approach allows content providers to use network intelligence to locate content closer to the consumer, which improves response time and enhances the consumer experience. Litan et al suggest that Akamai's significant revenue increase in 2006 is an indication of the growth of applications needing higher levels of quality of service and the market's acceptance of Akamai's and CDNs' approach to "augmenting" the Internet to meet that need.[6]

d. Load balancing

Load balancing is commonly deployed by ISPs and is fundamental to the operations of domain name services, data centers, and other functions critical to the performance of the Internet. For example, in situations where there are multiple possible servers, load balancing routes packets to the least-congested server. This practice ensures that no one server becomes overloaded, allowing network providers to offer a consistent quality of experience to their subscribers.

Virus blocking, traffic shaping, web proxies, and load balancing are a few of the many examples of innovation that are not confined to the edge segment of the Internet. Innovation is best leveraged when and where it best delivers value. Nortel believes that intelligence at both the edge and core are key characteristics of today's Internet, and that any limitation placed on the ability to leverage innovation by defining where or how such intelligence can be used will limit the value of that innovation.

QoS and CoS

Quality of Service (QoS) and Class of Service (CoS) are other important tools that are a fundamental part of today's network.

[3] http://www.mi2g.com/cgi/mi2g/frameset.php?pageid=http%3A//www.mi2g.com/cgi/mi2g/press/010204.php

[4] http://www.theglobeandmail.com/servlet/story/RTGAM.20051208.gtjkcolumndec8/BNStory/einsider,Technology/home

[5] http://www.pipex.net/products/hosting/custom/

[6] R.E. Litan and H.J.Singer, Unintended Consequences of Net Neutrality Regulation, J. Telecom & High Tech. Law, Jan.2007.

It is generally recognized, for example, that the Internet is oversubscribed,[7] and in some cases cannot offer the quality of service that users expect.[8] TeleGeograpy, a market research group, suggests that Internet traffic is growing faster than capacity: average traffic across the Internet increased 75% last year, while capacity grew 47%.[9]

Bandwidth over-provisioning – i.e., providing enough bandwidth capacity to always exceed current user requirements – has been proposed by some as a simple solution in the current "net neutrality" debate. The advantage of this approach is that Internet end-to-end transparency is maintained.[10] However, this solution is not viable in today's global economy due to the economics of providing broadband consumer access across different geographies that have differing demographics and government policies.[11]

In addition, the bursting of the Internet bubble demonstrated the fallacy of the "if you build it, they will come" approach to network capacity. Nor have the proponents of the "over-provisioning solution" for "net neutrality" explained who will pay for the extensive investment in new facilities. Furthermore, history has shown that it is difficult to predict the emergence of new applications and the demands on network capacity.

An alternative solution to simply building more and bigger "dumb pipes" is to apply QoS mechanisms for applications that require special handling, i.e., the ability of the network to provide some level of assurance that the application's traffic and service requirements can be satisfied. For example, voice is sensitive to latency,[12] jitter, and packet loss, while video is sensitive to latency and packet loss.

Nortel believes that smarter, more efficient alternatives should be allowed and encouraged, and that Internet users must be given the choice to request specific QoS and CoS[13] when accessing particular applications, (e.g., video streaming or VoIP). "Best effort" delivery should always be made available as an option for users who desire it, but CoS and QoS should never be prohibited, because they are valuable and efficient tools in providing users with the desired quality of experience.

In addition to enhancing capacity, much of the innovation in the intelligence now incorporated in the Internet has resulted in new services and capabilities, such as identity management (who you are), location (where you are), presence (whether you are available or busy), and proximity (whether you are nearby). These services, when implemented in the infrastructure core, create trustworthy services that enhance the user experience (ability to control what experience you want), safety (E911, for example), and even advertising revenue (targeted advertisements).

All of this innovation has been funded in an open and flexible technology environment, free from strict technical regulation. If we begin to mandate and regulate technology transport, the unintended consequence would be a limitation of adjacent service innovation or a destructive expansion of the regulations to adjacent spaces. Participants in this debate should fully understand the total Internet "ecosystem" prior to considering focused activity in any one element, because the interplay between the parts is what makes the Internet so exceptionally useful.

4. Today's Internet model provides all parties with the substantial ability to gain economically.

Much of the "net neutrality" debate is based on the incorrect assumption by "net neutrality" advocates that the operators' control of the Internet limits the revenue opportunities of applications providers and other parties. A deeper understanding of the true economic relationship among the Internet and broadband access providers suggests otherwise.

[7] Cf.: Bret Swanson, The Coming Exaflood, Wall Street J., January 20, 2007.

[8] The head of Google TV technology unit, Vincent Dureau, told delegates at the Cable Europe Congress in February 2007 that vendors are racing to develop home networking boxes that will allow high-definition (HD) video streams which could ultimately cripple the Internet itself. (cf.: Web video to TV will cripple the Internet, Google warns, http://www.telecomtv.com/news.asp?cd_id=7729)

[9] Is the Internet Ready to Break?, April 4, 2007, http://www.baselinemag.com/print_article2/0,1217,a=205078,00.asp

[10] Internet2 experience suggests that network upgrades to accommodate even extremely demanding applications, e.g., Hi-Def video conferences, can be achieved more effectively, cheaply and reliably by simply adding more capacity (Gary Bachula at US Senate Commerce Hearing, 2/7/06 http://commerce.senate.gov/pdf/bachula-020706.pdf). Please note that Internet2 has abundant capacity (up to 1 Gbps), and Internet2 Abilene network study was conducted in 1998-2001; current routers have more QoS functionality in hardware.

[11] Prudential Equities analyst Richard Klugman estimates that Verizon takes a pre-tax loss of $2,200 for each FiOS customer added, primarily due to installation costs. Including capital costs, Klugman estimates Verizon is losing more than $4,500 per new subscriber.; ref.: Verizon's High-Speed Network: If They Build It, Will You Come?, http://knowledge.wharton.upenn.edu/article/1689.cfm

[12] The human ear is very sensitive to latency during a two-way conversation; latency exceeding 200 msec is annoying since it causes echo and conversation overlap.

[13] The CoS (Class of Service) feature allows network users to define the priority of different applications. It enables the user's network to differentiate between traffic types, and thus to ensure delivery of higher priority traffic ahead of lower priority traffic.

H. Kafka, Vice-President, Network Architecture, AT&T Services, Inc. speaking in his previous role as Chief Architect of the BellSouth network, said that the average residential broadband subscriber consumes about 2 Gigabytes per month, adding approximately $1 to the costs of the broadband access provider. Downloading feature films consumes an average of 9 Gigabytes per month and adds about $4.50 to the costs of the access provider; IPTV, at 224 Gigabytes per month, adds costs of roughly $112; and if IPTV is to deliver HD, under current technology the added cost jumps to some $560 per month.[14] Broadband access providers need to recover the cost of upgrading the network, a matter of concern for Wall Street when analyzing broadband infrastructure investments.

Most broadband access providers in the United States charge their subscribers a flat monthly rate. This provides a significant cost advantage when delivering video over the Internet (at zero additional cost for subscribers with broadband access). Delivery and return of a DVD via the United States Postal Service costs Netflix $0.82 and $4.00 for a VHS tape.[15] Both broadband service providers and content providers stand to benefit if the broadband service providers charge the content providers less than the $.82 (or $4.00) that "mail" costs them today (and with the added feature that the content is delivered to their customers faster). As this simple example illustrates, the current Internet model affords all parties a substantial ability to gain economically from QoS and CoS.

Broadband access providers require viable business cases to justify their infrastructure investment. These business cases are supported by the intelligence and control that governs today's Internet – the very elements that some propose be restricted. Regulatory restrictions on the facilities-based service providers' ability to offer and charge for QoS or CoS may have severe unintended consequences and hobble the rapidly developing new technologies and business models of the Internet. Furthermore, a restrictive environment could have the unintended effect of dissuading companies from investing in broadband networks.

Principles that are Fundamental to the Internet's Future

Based on the foregoing observations about the reality of today's Internet, Nortel believes there are five key principles that are fundamental to the future of the Internet. In order to promote investment in needed infrastructure, these principles must exist in an environment free from regulatory restrictions. A restrictive regulatory environment could have the unintended effect of dissuading companies from investing in broadband networks and other related infrastructure that is essential to support the Internet.

1. Except for security or stability reasons, no lawful destination should be restricted from a network user.

• The FCC Broadband Policy Statement and the TIA Broadband Internet Access Connectivity Principles comprise constructive non-regulatory frameworks consistent with this principle. We believe that Internet users should be able to access the lawful content of their choice, that no lawful destination should be restricted from a user unless security or network stability is jeopardized, and that purchased bandwidth should be unrestricted and unencumbered.

• Packets destined for private IP networks are outside the scope of the "net neutrality" debate, because enterprise traffic is already subject to service level agreements (SLAs).

2. Service providers need the flexibility to meet users' expectations that the converged legacy networks (e.g., VoIP, VoD) will provide levels of service over the Internet that are at least equivalent to that experienced when they were delivered over separate networks. In order to allow this flexibility and achieve the desired results, only the least restrictive levels of regulation (if any in fact is required) should be considered.

• In order to make these services as reliable and robust as when they were on dedicated independent networks, the converged network must be able to support voice (which requires low latency), as well as the roaming requirements of mobile users.[16]

• Policymakers addressing Internet regulation must understand that a removal or restriction on this kind of network intelligence may create a divergence of networks, returning us to the fragment-

[14] Telephony Online, OFC: BellSouth Chief Architect warns of HD VOD costs, Mar 7, 2006, http://telephonyonline.com/iptv/technology/BellSouth_VOD_costs_030706/

[15] Digital killed the video store, http://www.physorg.com/news9834.html

[16] Mobility capabilities require (centralized) intelligence in the network, especially for fast handover or when seamless mobility over a very wide area is required.

ed telecom world of a decade ago, and risking the reversal of both the economic and usability gains that have greatly enhanced consumer and business markets.

3. The bandwidth a subscriber purchases should be unrestricted and unencumbered on the ingress link to the network; and there should be no expectation of assured bandwidth for all traffic on the Internet.

• Users should have unrestricted access to lawful content on the Internet.
• "Best effort" delivery should always be made available as an option for users who desire it.

4. Quality of Service (QoS) and Class of Service (CoS) should always be allowed, because they are indispensable tools in operating a stable, secure, and effective Internet. Any mechanism that explicitly controls and assures control plane traffic – e.g., operations and management tools, protocols, and interfaces that allow the network to maintain a stable topology – must be allowed and encouraged to facilitate stability of the system.

• Intelligence at the edge and core are key characteristics of today's Internet, and policymakers should not attempt to mandate where to place such intelligence.
• Some applications (e.g., real-time video) may require special treatments, and Internet users or content providers must be given a choice to request specific QoS and CoS when accessing these particular applications.

5. Marketplace competition should be allowed to work effectively to determine and deliver fair value for a fair price.

• The Internet is thriving with minimal regulation and there is no reason to change this hands-off policy.
• Any government-mandated changes are potentially fraught with unintended consequences that could be detrimental to the future utility and stability (or possibly even existence) of the Internet.
• Marketplace competition in the provision of broadband access is robust and provides the most effective check on price, while also spurring the diversity of services offered

In Summary

The future of the Internet is dependent on continuous innovation to meet the evolving and increasing demands being placed upon it.

To date, Internet innovation has been funded, and should continue to be funded, under an open and flexible technology environment, free from unneeded and counterproductive regulation. If, instead, the Internet's technology, transport and innovation were restricted by regulations, the unintended consequence would be a limitation of adjacent service innovation, or expansion of the regulations to adjacent spaces, along with a dampening effect on investment. Any dialogue regarding regulation of the Internet must take account of the total Internet "ecosystem." The interplay among the components of the Internet is what makes it so exceptionally useful.

John J. Roese is Chief Technology Officer (CTO) for Nortel. As CTO, Roese is responsible for leading the company's overall R&D strategy and execution and for directing future research across all product portfolios. He also works closely with the Chief Strategy Officer on emerging technologies, market opportunities and strategic partnerships. Roese is the functional leader of Nortel's 12,000 scientists, engineers and designers worldwide.

Roese sits on the boards of the One Laptop Per Child association and ATIS, and is actively involved in the IEEE and IETF, as well as other standards bodies. He has co-authored a number of IEEE standards and related documents. In 1998, Roese published "Switched LANs: Implementation, Operation, Maintenance" (McGraw Hill). He is the named inventor on 16 granted and pending patents in areas of policy-based networking, location-based networking, routing, switching and network management.

Roese holds a Bachelor of Science in Electrical Engineering (BSEE) from the University of New Hampshire. He is based at Nortel's R&D headquarters in Ottawa, Canada.

In the United States:
Nortel
35 Davis Drive
Research Triangle Park, NC 27709 USA

In Canada:
Nortel
195 The West Mall
Toronto, Ontario M9C 5K1 Canada

In Caribbean and Latin America:
Nortel
1500 Concorde Terrace
Sunrise, FL 33323 USA

In Europe:
Nortel
Maidenhead Office Park, Westacott Way
Maidenhead Berkshire SL6 3QH UK

In Asia:
Nortel
United Square
101 Thomson Road
Singapore 307591
Phone: (65) 6287 2877

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