The Migration to NGN and the Evolution of IP Interconnection

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The Evolution of IP Interconnection: An economic perspective

- Lessons from the economics of PSTN interconnect and Internet peering
- Challenges to the traditional European model of wholesale PSTN/PLMN interconnection arrangements as networks evolve to an NGN environment
- What challenges are likely for Quality of Service?
- What might future IP interconnection arrangements look like?
- What are the key issues for European regulator authorities?

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The Evolution of IP Interconnection: An economic perspective

- Introduction: PSTN, Internet, NGN
- Interconnection: Fixed and mobile telephone networks
  - Wholesale
  - Retail
- Interconnection: Internet
  - Wholesale (peering and transit)
- Differentiated QoS (delay, jitter, loss) and Network Neutrality
- Conclusions

The Evolution of IP Interconnection: An economic perspective

- Many operators, especially incumbents, look to migrate to NGNs.
  - Enhance economies of scope and scale.
  - Accelerate time-to-market for new IP-based services.
- NGN represents a marriage of PSTN and Internet.
  - Different technology.
  - Different culture.
  - Substantially different regulatory traditions.
- What should happen when these disparate worlds collide?

- There is no significant base of NGN interconnection to date, but the economic theory of the PSTN and of the Internet provides insights.

The Evolution of IP Interconnection: An economic perspective

- PSTN – regulated arrangements.
  - Regulation to address market power.
  - Termination fees in the absence of regulation will tend to be very high, for both large and small operators.
  - Lack of interconnection implies a connectivity breakdown.
- Internet – “Coasian” private arrangements in most cases.
  - Peering: two providers exchange traffic only for their respective customers, often with no explicit charges.
  - Sharing of facilities costs for interconnection may be unequal.
  - In most countries, no regulation of peering.
  - Lack of interconnection usually does not imply a loss of connectivity, but may have implications for costs.

The Evolution of IP Interconnection: An economic perspective

- The migration to IP-based NGNs breaks the strong historical linkage between the *service* and the *network*, thus enabling the emergence of independent service providers.
- Implications for regulation in support of competitive entry:
  - NGN introduces new forms of competition.
  - Does not necessarily eliminate traditional market power.
  - May enable the emergence of new competitive bottlenecks.
- Traditional interconnection arrangements represent an attempt to use *wholesale* payments (between network operators) to correct for imbalanced *retail* payments (between service providers). To the extent that the network and service providers are different firms, this system will break down for a variety of technical and practical reasons. Moreover, the reason for existence of current arrangements must be called into question.

PSTN/PLMN: Retail

- Retail arrangements
  - Calling Party Pays (CPP): the recipient pays nothing.
  - Receiving Party Pays (RPP): rarely used, not interesting.
  - Flat rate: prevalent in Bill and Keep countries, and Internet.
  - “Buckets of minutes”: effectively a banded flat rate plan.
- Flat rate retail arrangements are attractive going forward.
  - Better reflect costs in an industry with high sunk costs.
  - Consumers greatly prefer flat rate.

PSTN/PLMN: Retail

- Calling Party Pays (CPP): the party that initiates the call pays for the call, usually based on the duration of the call; generally, the party that receives (terminates) the call pays nothing.
- CPP arrangements reflected the historical perception that the caller is the primary beneficiary of the call, and also the main *cost-causer*.
- This concept has been challenged in recent years
  - Clearly, the receiver also benefits.
  - If the receiver saw no merit in the call, he or she could simply hang up; thus, after the first minute, caller and called party can be viewed as (equal) partners in the call. (Cf. Jeon, Laffont and Tirole, and the principle of *receiver sovereignty*).

PSTN/PLMN: Retail

- In the world of the IP-based NGN, origination and termination are likely to become less relevant over time. (Cf. de Graba).
  - Somewhat arbitrary.
  - Easily manipulated if there were an incentive to do so (analogous to “refile” arrangements).

The economics of interconnection – retail

- Consumers tend to greatly prefer flat rate (or “buckets of minutes”) plans over usage-based plans such as CPP (Cf. Odlyzko).
  - AT&T Wireless’s offer of Digital One Rate (1998)
  - America Online’s flat rate Internet access (1995)
- In the United States, flat rate / bucket plans are increasingly prevalent at all levels:
  - Mobile services
  - Fixed services, including long distance
  - Internet access
- Flat rate plans are also gaining in Europe, but often exclude calls to off-net mobile phones.

The economics of interconnection – wholesale

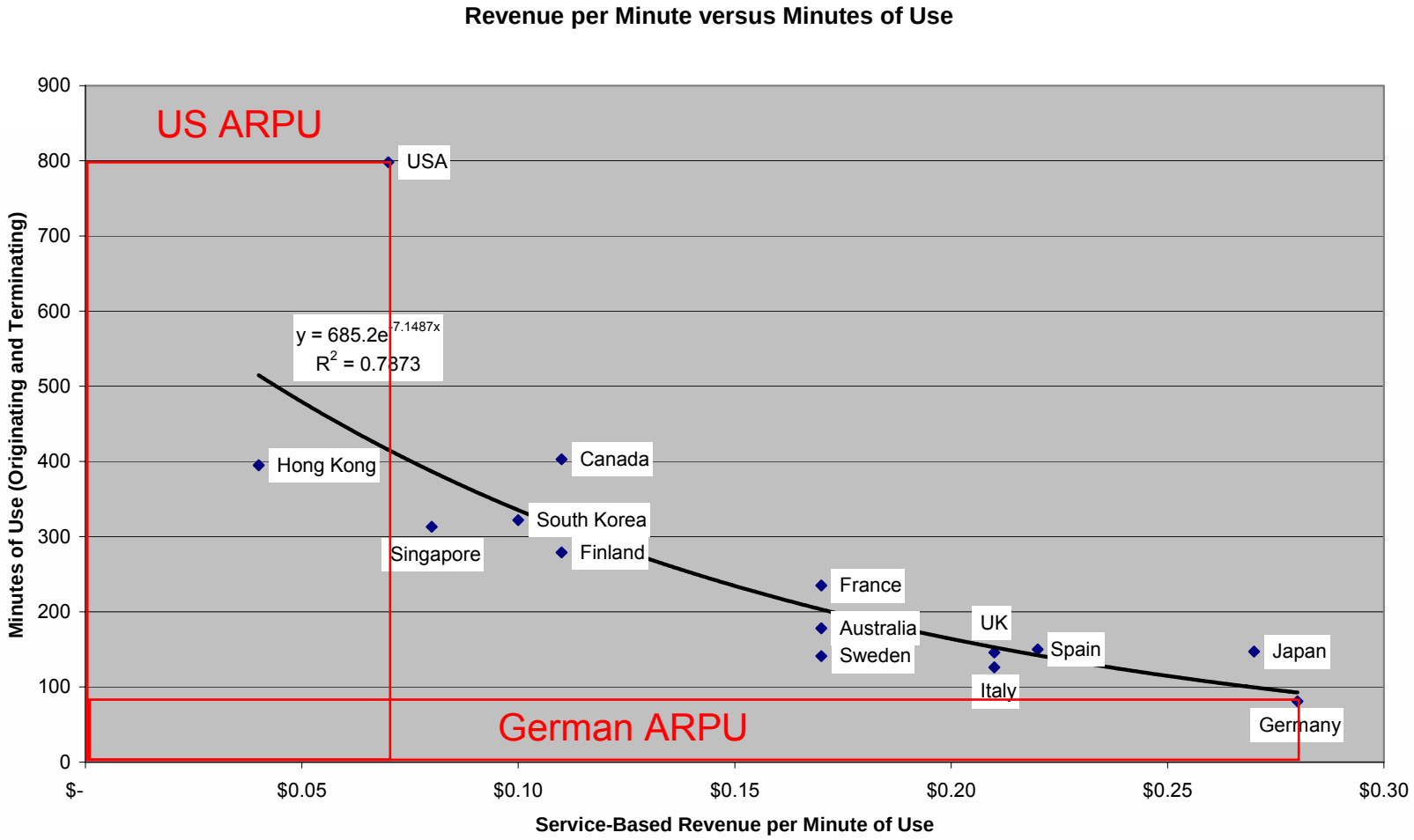
- Calling Party's Network Pays (CPNP): the calling party's network (the originating operator) makes a wholesale payment to the receiving party's network (the terminating operator). This is the prevailing pattern in Europe and in most of the world.

- "Coasian" arrangements: negotiated interconnection, subject to few or no regulatory obligation for payments between the networks. Often, networks choose to have no payments ("Bill and Keep").

PSTN/PLMN: Wholesale

- In an unregulated CPNP system, carriers will tend to establish very high termination charge levels (the *termination monopoly)*.
  - Smaller operators will be motivated to set termination fees even higher than large operators.
  - Problem is addressed in the EU by regulating all rates.
  - No end to regulation is in sight.
- Termination charges at the wholesale level interact with retail pricing arrangements.
  - The termination fee generally sets a floor on the retail price.
  - Where termination fees are high, they generally prevent flat rate or “buckets of minutes” plans from emerging.

Linkages between wholesale and retail: Mobile services



Source of data: U.S. FCC, *11th CMRS Report*, July 2005, Table 12, September 2006, based on *Global Wireless Matrix 4Q05*, Merrill Lynch.

PSTN/PLMN: Penetration

- Most authors (not all) contend that CPNP leads to higher mobile penetration than Bill and Keep.
- There is reason to believe that it leads to *faster* mobile penetration.
  - Operators are motivated to subsidize consumers in order to terminate calls to them at prices well in excess of cost.
    - Handset subsidies.
    - No monthly fees.
    - Pre-paid cards with low administrative burden.
  - A case of “giving away the razor in order to sell blades”.

PSTN/PLMN: Penetration

- One must be cautious in interpreting penetration data.
  - Mobile penetration in 17 Member States is nominally in excess of 100%; for the EU as a whole, it is 103.2% (per the *12th Implementation Report*), measured against *total* population.
  - Nonetheless, per Eurobarometer survey data, 20% of households in Europe do not have access to a mobile phone.
  - CPNP systems encourage multiple subscriptions more than Bill and Keep, because of on-net/off-net price differences.
- Bill and Keep countries can achieve quite respectable levels of penetration.
  - Singapore: 98%
  - U.S.: 71%, and gaining 5-6 points per year.

PSTN/PLMN: Summary

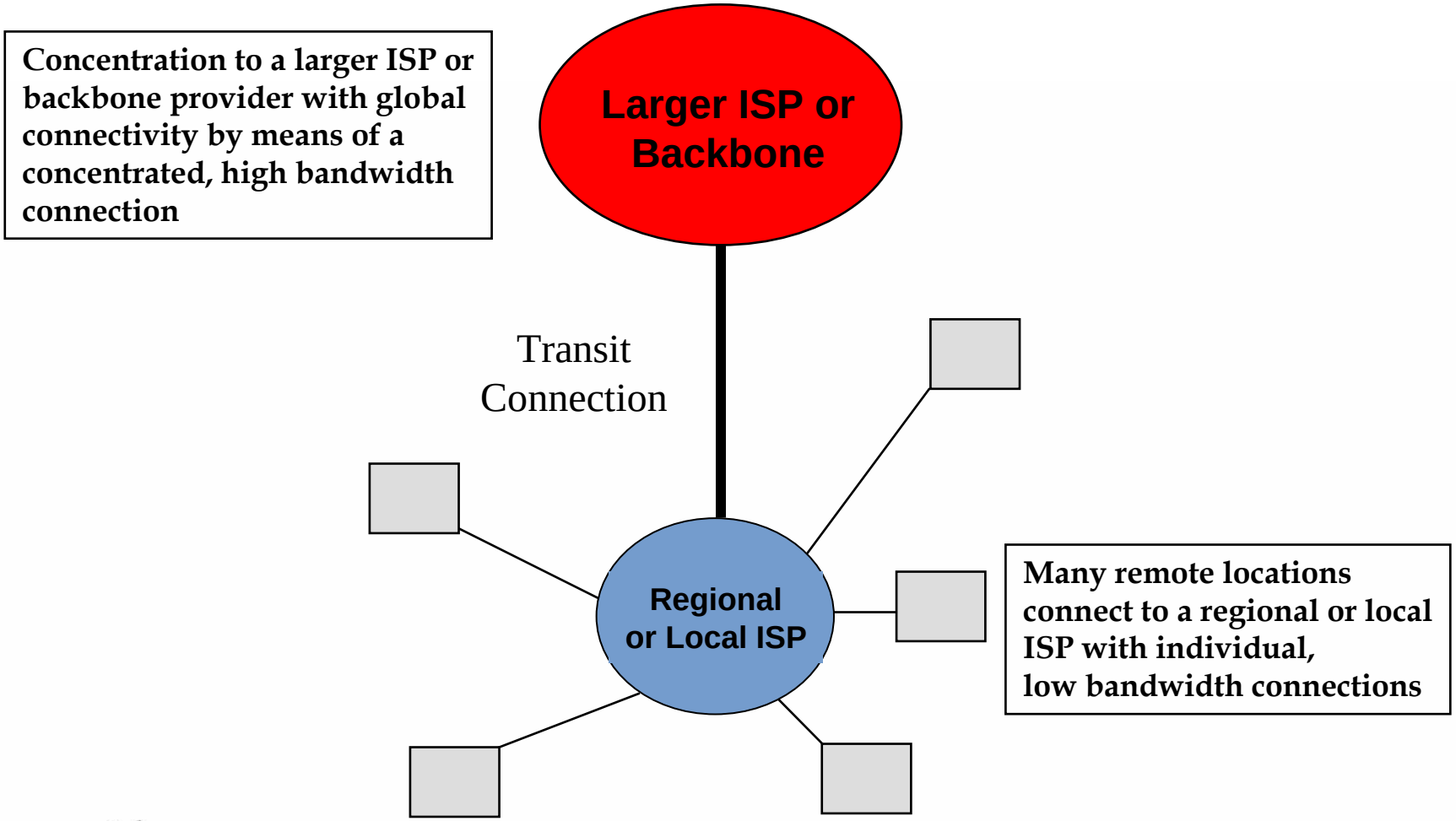
- CPNP with high mobile termination rates tends to lead to:
  - Subsidies for mobile adoption, and thus rapid penetration.
  - High retail prices.
  - Exclusion of calls with high termination from flat rate plans.
  - Low usage.
- Rapid penetration is beneficial (but needs no stimulus in the EU15); the other aspects are harmful.
- The economic rationale for CPNP is weak in an NGN world.

- CPNP with high termination rates practically mandates CPP retail arrangements; low or zero termination rates place no constraints on retail arrangements.

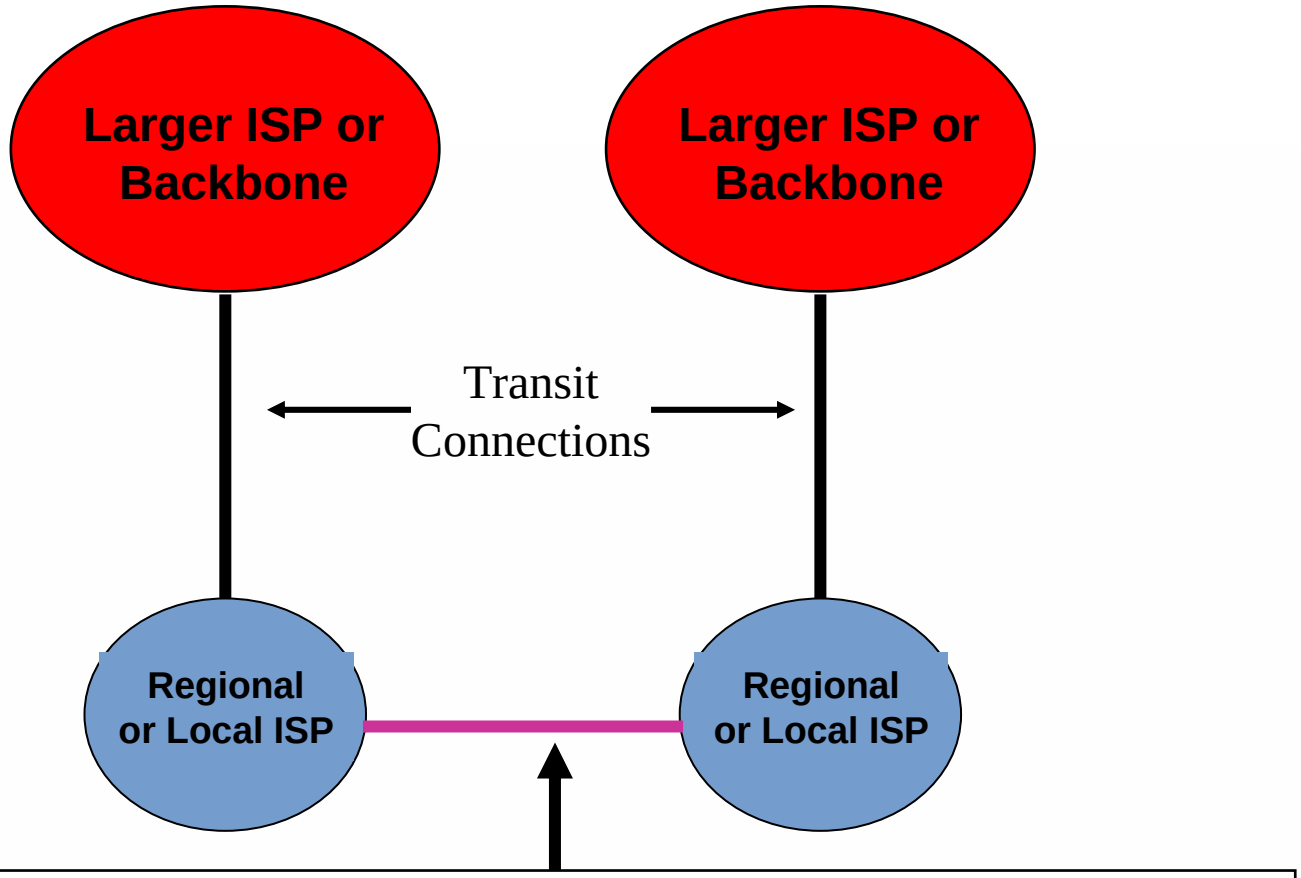
Internet: Wholesale

- An extensive economics literature exists about interconnection in the traditional PSTN world.
- An emerging literature deals with interconnection in the world of the Internet.
- We are in the early stages of understanding the relationships between the two, and the implications for emerging NGNs.

Internet: Peering and Transit



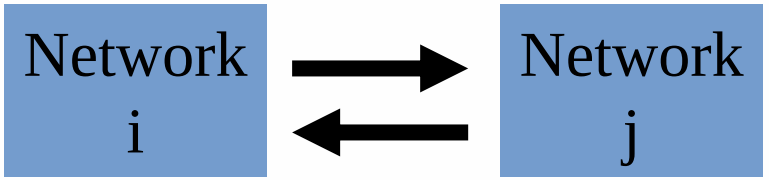
Internet: Peering and Transit



This peering connection will tend to exist if the cost of the connection to each ISP is less than the money each saves due to reduced transit traffic.

Internet: Wholesale

- Define:
  c_o as cost of origination
  c_t as cost of termination
  a as an access charge levied on the sender
- Due to shortest exit, $c_t > c_o$
- Then
  cost for the originating network is $c_o + a$
  cost for the terminating network is $c_t - a$



The model extends in a straightforward way to accommodate multiple levels of quality of service (QoS).

Source: Laffont/Marcus/Rey/Tirole, "Internet Interconnection and the Off-Net-Cost Pricing Principle"

Internet: Wholesale

"A key difference with this telecommunications literature is that in the latter there is a missing price: receivers do not pay for receiving calls; … The missing price has … important implications:

… The operators' optimal usage price reflects their *perceived* marginal cost. But when operators do not charge their customers … for the traffic they receive, operator *i* 's perceived marginal cost of outgoing … traffic is … the unit cost of traffic is the on-net cost *c*, augmented by the expected off-net "markup". …

In sum, the missing payment affects the backbones' perceived costs, and it reallocates costs between origination and reception."

Source: Laffont/Marcus/Rey/Tirole, "Internet Interconnection and the Off-Net-Cost Pricing Principle"

Internet: Wholesale

Coasian arrangements: Backbone peering versus U.S. Bill and Keep.

	U.S. Mobile Operators	*Backbone ISPs*
Obligation to Interconnect	Applies to all carriers.	No regulatory obligations in most countries. Some backbone ISPs adhere voluntarily to guidelines or to principles of non-discrimination.
Constraints on fees charged	Must by law be equal in both directions.	Generally unconstrained.

Source: WIK

- Both systems are Coasian, yet they depend on very different framing conditions.
- Why do they reach the same outcomes from different starting points?

The Evolution of IP Interconnection: An economic perspective

- Migration to IP and NGN implies huge challenges for the CPNP model of interconnection.
  - Minutes of use correlate only weakly with cost.
  - In a world of independent service providers, it becomes impractical to use the *service* to subsidize the *network*.
  - Who placed the call becomes arbitrary.
  - Practical difficulties with measurement.
  - Countless opportunities for arbitrage, to the extent that wholesale payments do not track underlying costs.

Internet: VoIP

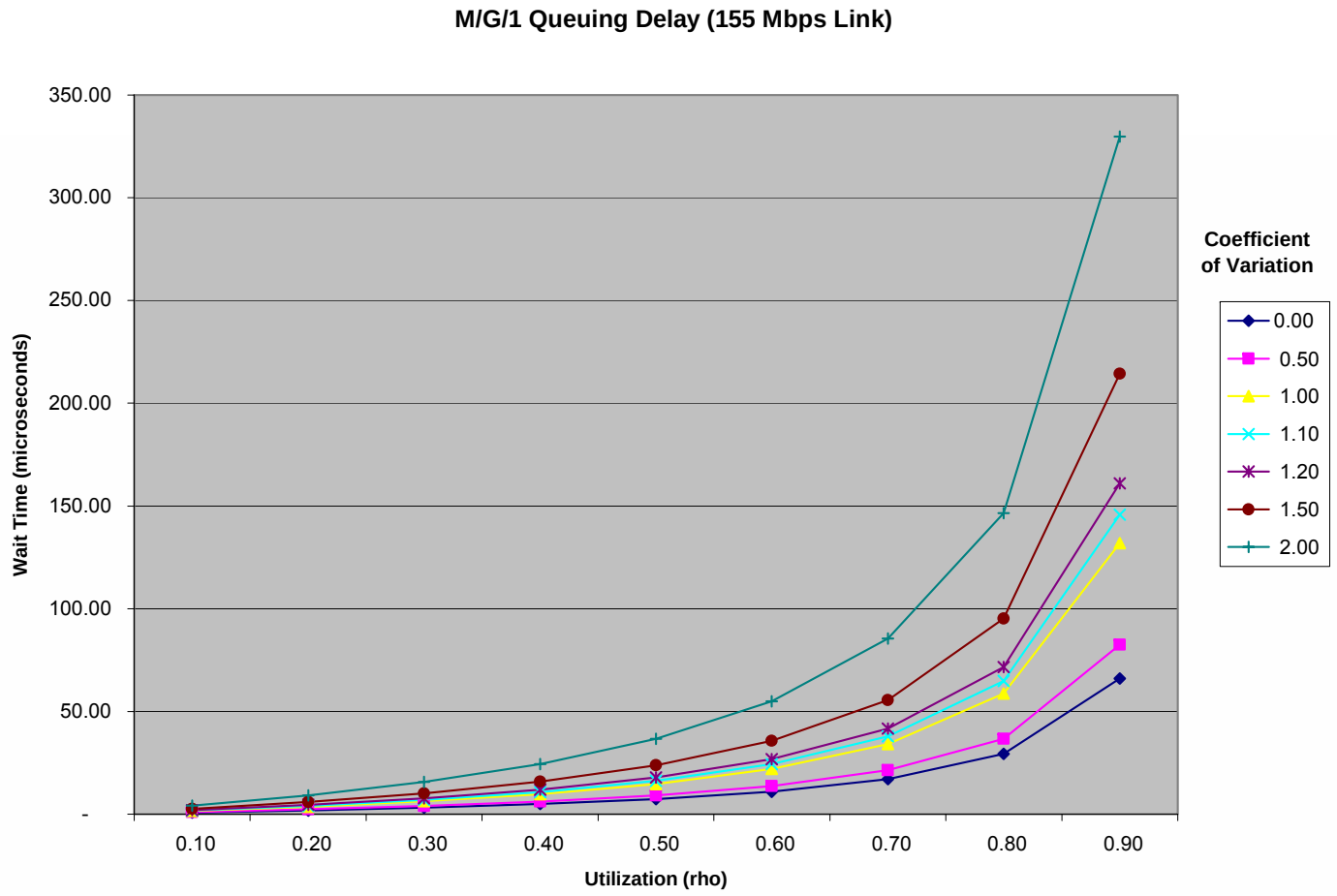
- Does IP interconnection equate to voice interconnection?
- Fixed PSTN: As networks migrate to IP-based NGNs, IP peering does not automatically imply the ability to use VoIP to connect to the fixed incumbent's voice services.
- Mobile PLMN: The GSM-A already provides an IP backbone for interconnecting mobile operators, the GRX/IPX.
  - Carrier ENUM services are linked to this infrastructure.
  - SIP services will probably be linked to this infrastructure.
  - GRX/IPX use IP, but are not externally accessible.
- Fixed incumbents, and even more so mobile operators, will likely resist external IP interconnection. Mobile operators in particular have considerable means to resist.
- Tentative conclusion: Interconnection ≠ Interconnection

Differentiated Quality of Service (QoS)

- At a technical level, QoS is not fundamentally hard.
  - DiffServ is technically trivial.
  - MPLS in a single network is technically trivial.
  - Cross-provider MPLS is only marginally harder.
  - Even RSVP is not that hard. My company, BBN, had working production RSVP-compliant networks in 1995!
- In terms of the basic economics, QoS is not fundamentally hard.
- Differentiated QoS *within* a network is, in fact, commonplace.
- Nonetheless, there is no significant roll-out *between* networks.

➢ ***WHY NOT?***

Differentiated Quality of Service (QoS)



M/G/1 queueing analysis of the performance of a single link

(with clocking delay of 50 µsecs (284 byte packets) and a 155 Mbps link)

Differentiated Quality of Service (QoS)

- For real time services such as voice telephony traffic, it is important that mean delay and variability of delay be held to low values.
  - Delay in excess of about 150 milliseconds causes “collisions”.
  - Buffering can address variability as long as the mean and variance are not too great.
  - The buffer then represents a fixed increment to the propagation delay.
- For circuit speeds of 100 Mbps and up, queuing delays in a properly designed network will generally be well under a millisecond per hop under normal operating conditions.
- Fixed propagation delay (speed of light) will often dominate variable queuing delays under normal operating conditions.

Differentiated Quality of Service (QoS)

- IMPLICATION: Most of the time, and under normal conditions, variable delay in the core of the network is unlikely to be perceptible to the VoIP user.
- FURTHER IMPLICATION: Consumers will not willingly pay a large premium for a performance difference that they cannot perceive.
- Packet delay is more likely to be an issue:
  - For slower circuits at the edge of the network
  - For shared circuits (e.g. cable modem services)
  - When one or more circuits are saturated
  - When one or more components have failed
  - When a *force majeure* incident has occurred

QoS – billing and accounting challenges

- In an NGN world, the network service provider (the ISP) will not necessarily be the application service provider. A VoIP service or an IPTV provider will not necessarily be a network provider.
- The network provider will have only limited visibility into third party applications running over its network (and the user could further reduce visibility by encrypting the data).
- The unaffiliated application provider may have extensive visibility into the application that it provides, but only limited visibility into the use of network resources.
- Usage-based billing will be possible only to the extent that the usage can be rigorously and unambiguously measured.

QoS – billing and accounting challenges

- How will providers and customers ensure that service commitments are met? Whose statistics will govern?
- Competitive providers are reluctant to share statistics about their respective networks with one another, and peering agreements typically restrict the ability of the providers to disclose information about one another‘s networks to third parties. Can sufficient information be disclosed to customers?
- How will responsibility be allocated if a customer’s traffic fails to achieve its committed service level specification? Traffic data can legitimately be interpreted in more than one way. Will it be possible to administer payments and penalties rigorously and fairly?
- How can providers prevent fraud? How can they distinguish between fraud and legitimate use?

Differentiated Quality of Service (QoS): Network Externalities

- Some capabilities are worth vastly more, as more consumers adopt them. Nothing succeeds like success. This property is known as a *network effect* or a *network externality*.
- The societally optimal value of adoption of such services is not necessarily where the market would settle without “help”.
- Different services have gotten past this *initial adoption hump* in different ways:
  - telephone - universal service
  - VCRs - widespread deployment for time shifting antedated the emergence of a rental industry.
  - CD players - vertical integration with recording studios
  - black and white television - industry / government standards

Cf. Rohlffs, *Bandwagon Effects in High-Technology Industries*, 2001.

Differentiated Quality of Service (QoS): Network Externalities

- Technical challenges, or economic challenges?
- Revenues
  - Limited customer willingness to pay a substantial premium.
  - Limited benefits until widely deployed (network effects).
- Costs
  - Agreements needed with many peering partners.
  - Economic transaction costs to negotiate each agreement.
  - Measurement, management and dispute resolution challenges.
- The business case is difficult to “prove in”.
- Implies difficulties in getting past the initial adoption hump.

Differentiated Quality of Service (QoS): Network Neutrality: A global issue, or U.S.-specific?

"The chief executive of AT&T, Edward Whitacre, told *Business Week* last year that his company (then called SBC Communications) wanted some way to charge major Internet concerns like Google and Vonage for the bandwidth they use. "What they would like to do is use my pipes free, but I ain't going to let them do that because we have spent this capital and we have to have a return on it," he said." *NY Times*, March 8, 2006

Differentiated Quality of Service (QoS): Network Neutrality: A global issue, or U.S.-specific?

- Many U.S. scholars view this as merely a *potential* threat going forward.
- Others experts (especially Lessig and Wu) have argued that current U.S. practices already systematically violate network neutrality:
  - Charging extra for a static IP address.
  - Cable access agreements that restrict the duration for which IPTV can be provided.
  - Restrictions on encryption (VPN) over broadband Internet access, unless the consumer subscribes to more expensive ("business") service.

Differentiated Quality of Service (QoS): Network Neutrality: A global issue, or U.S.-specific?

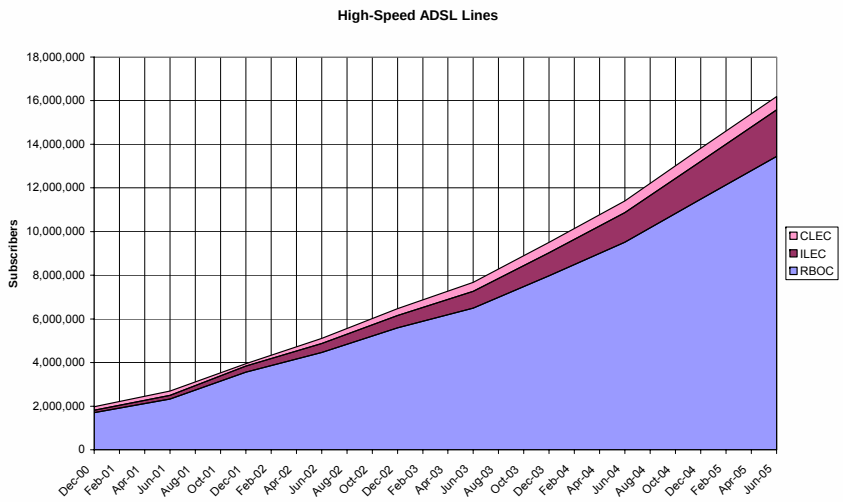
- Many of the concerns that have been raised in regard to network neutrality relate to behaviors that, in the absence of market power, would tend to *enhance* consumer welfare.
  - Some would appear to represent legitimate price discrimination.
  - Others enforce the economic property of *excludability* (the ability to prevent someone from using a service that he did not pay for) in support of price discrimination.
- Other violations of network neutrality, however, could imply some form of economic foreclosure, which should be viewed as being anticompetitive.

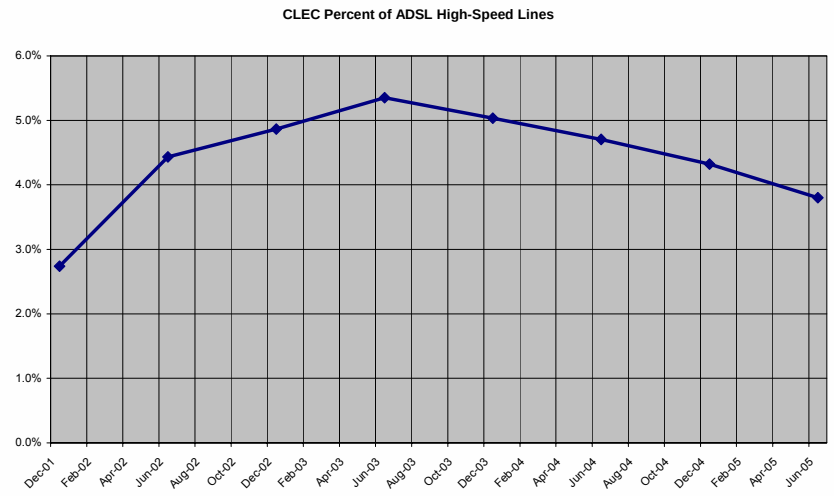
Network Neutrality: Why now? Why in the U.S.?

Three simultaneous developments: a “perfect storm”.

1. Collapse of the U.S. wholesale broadband Internet access market; consolidation into a series of non-overlapping geographically distinct duopolies.
2. A series of mega-mergers, with no meaningful undertakings imposed on the parties:
   - SBC/AT&T
   - Verizon/MCI
   - AT&T/Bellsouth
3. FCC withdrawal of regulation, including traditional obligations of nondiscrimination, with no economic analysis and no consideration of the implications of possible market power.

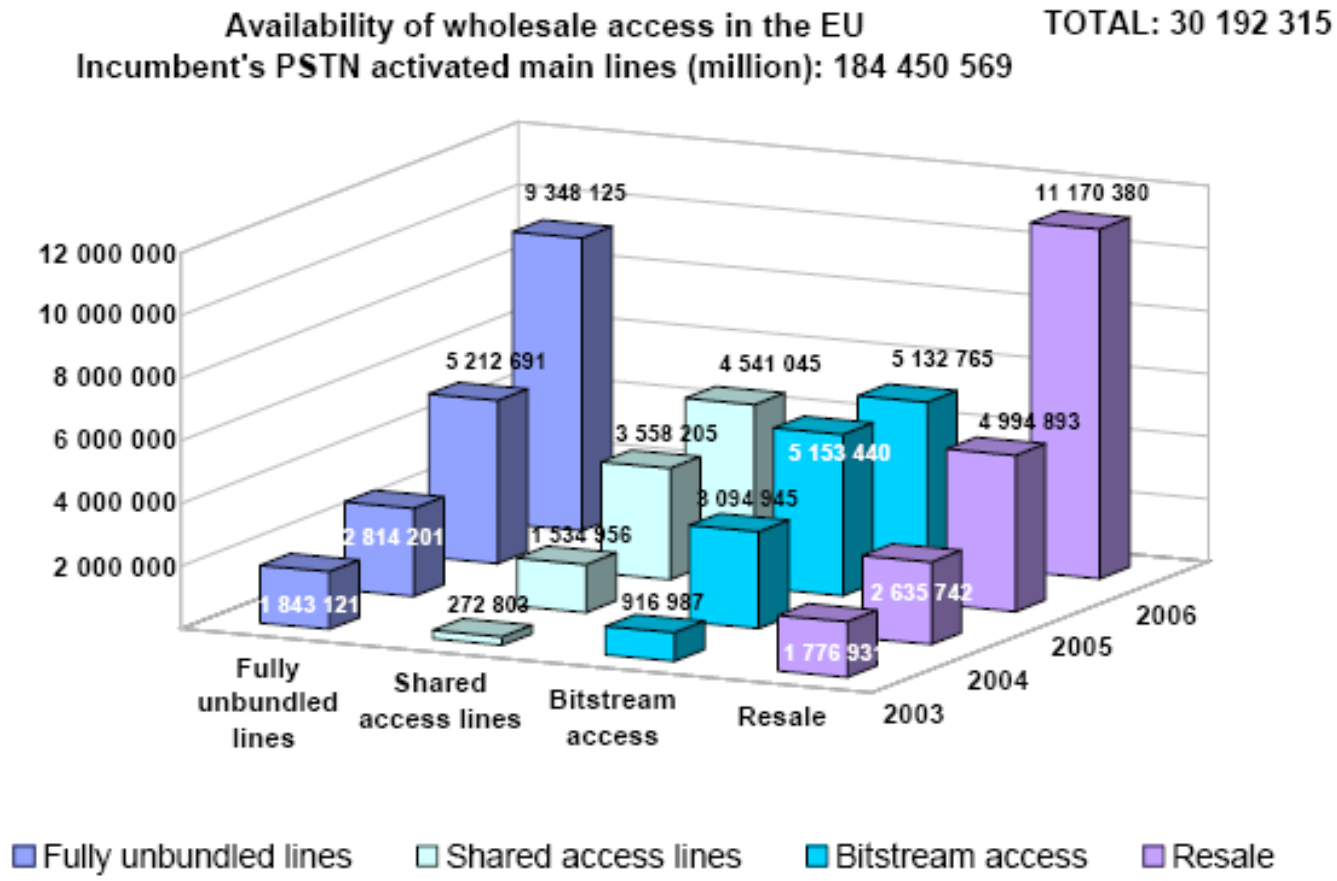
U.S.: DSL Lines





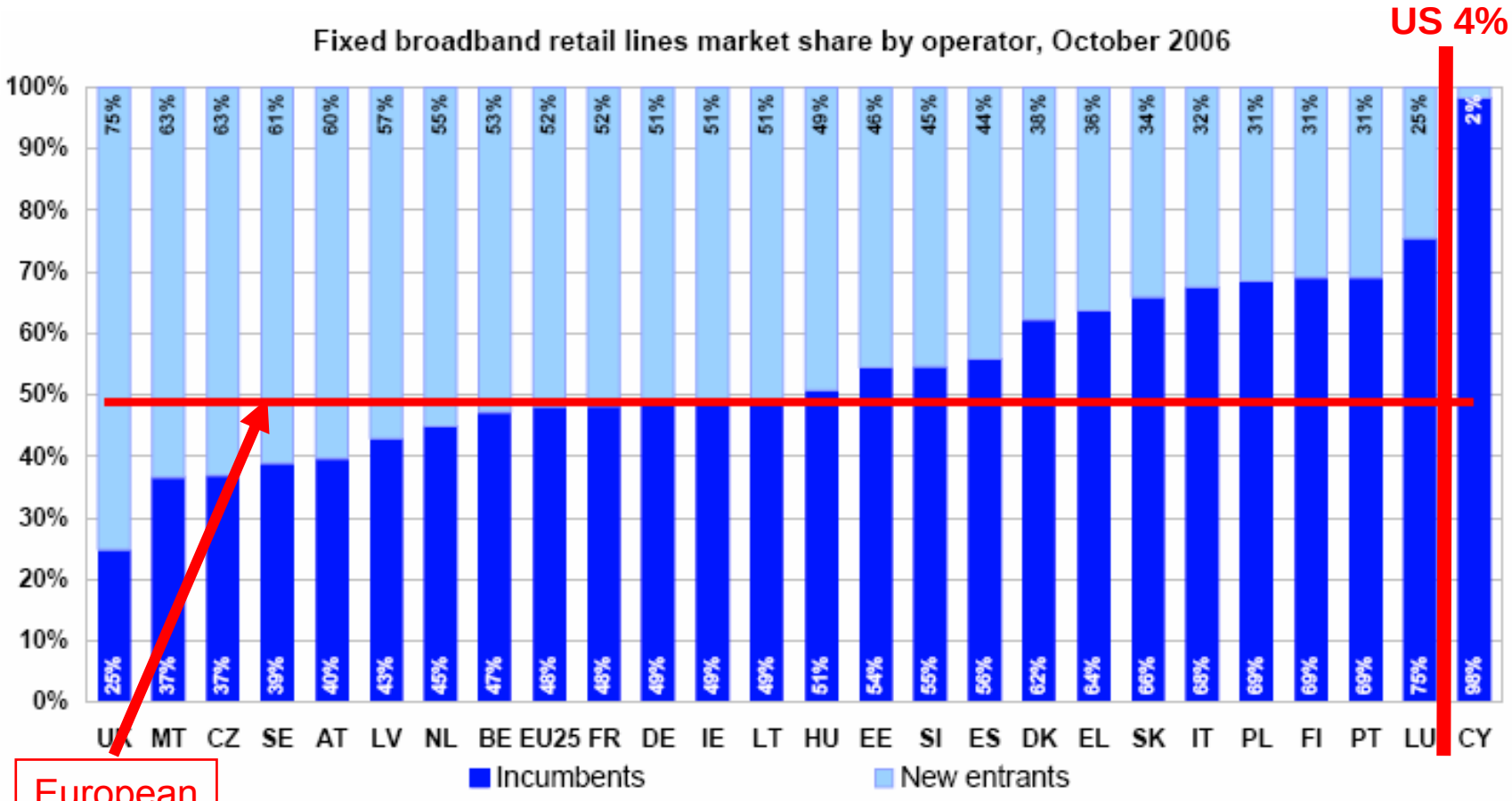
Source: FCC reports based on Form 477 carrier data

Europe: Wholesale third party DSL access



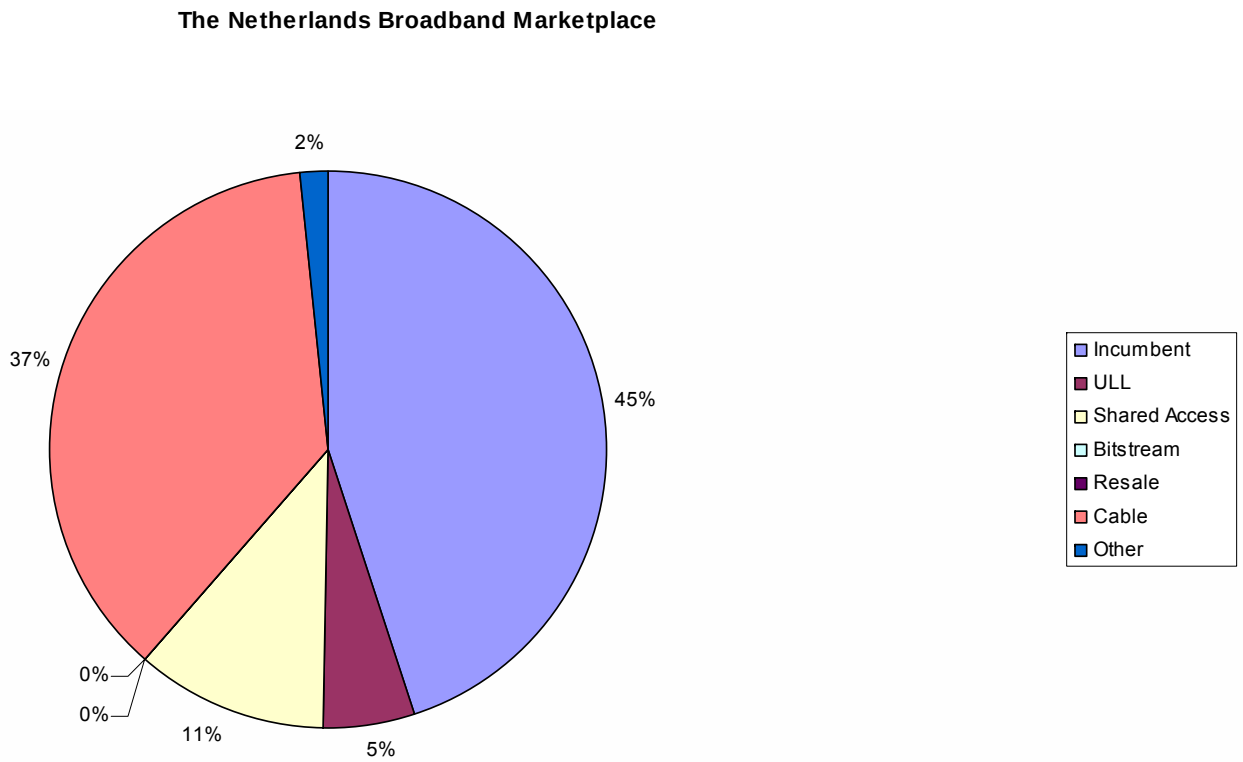
Source: European Commission 12th Implementation Report (10/2006)

U.S. – EU Comparison: DSL Lines



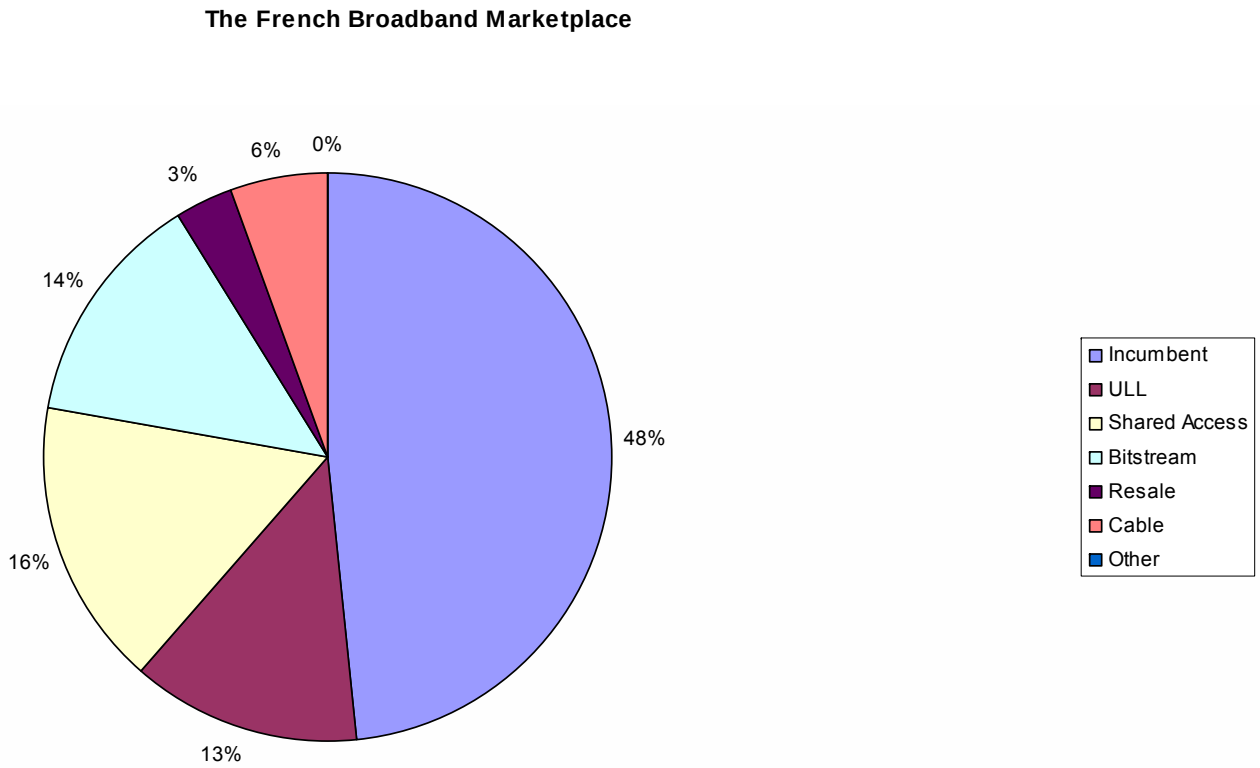
Source: European Commission 12th Implementation Report

The Netherlands Broadband Market



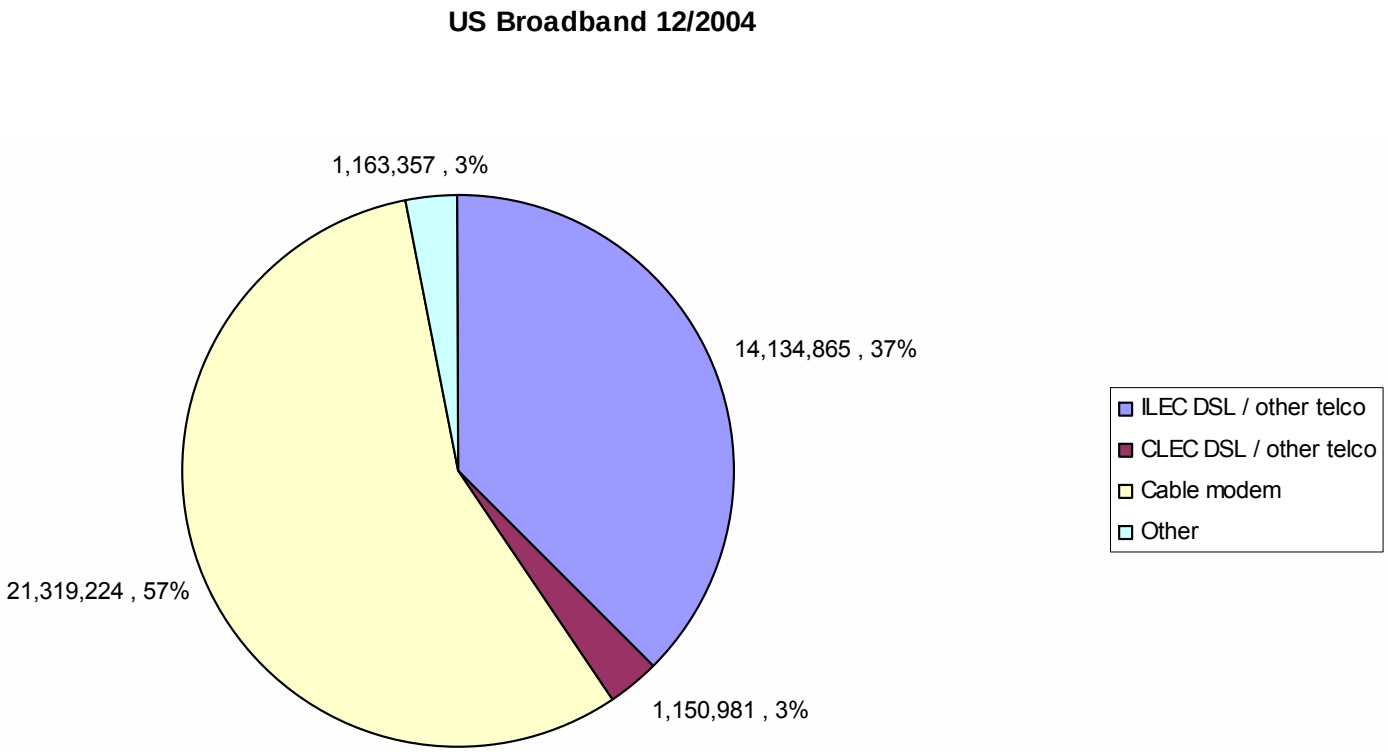
Source: European Commission 12th Implementation Report (10/2006)

The French Broadband Market



Source: European Commission 12th Implementation Report (10/2006)

The duopolistic U.S. broadband market



Derived from data from FCC reports based on Form 477 carrier data

Network Neutrality: FCC withdrawal of regulation

- Effective permanent exemption from SMP remedies for cable modem service and for DSL when integrated with Internet access.
- No obligation to unbundle Fiber to home or MDU.
- Elimination of shared access for DSL.
- Elimination of wholesale and *nondiscrimination obligations* for wired broadband Internet access.

➢ No economic analysis worthy of the name in any of these proceedings.

Network Neutrality: Implications for European policymakers

- Detailed *ex ante* regulatory solutions to network neutrality are likely to be difficult, and might do more harm than good.
- The first line of defense for European policymakers should instead be to avoid the problem altogether by maintaining the competitiveness of the underlying markets (especially broadband).
  - Europe today enjoys a far more competitive broadband market than does the United States.
  - On the average, about half of all retail DSL lines in Europe are provided by competitive entrants (per the *12th Implementation Report*).
  - Most consumers have access to more than two providers.
  - For these purposes, it is not necessary that the competitor have its own dedicated faciilties, as long as the incumbent cannot degrade them.

Network Neutrality: Implications for European policymakers

- The European system already provides multiple “softer” remedies, should they be required:
  - Incumbents are often subject to *ex ante* nondiscrimination obligations.
  - Article 5 of the Access and Interconnection Directive.
  - Publication of quality metrics pursuant to Article 22 of the Universal Service Directive.
  - Application *ex post* of competition law.

Summary

- Provided that underlying markets for Internet transit and for consumer broadband Internet access are effectively competitive (or effectively regulated), a “Coasian” IP interconnection regime of private unregulated arrangements is likely to be more efficient, and more consistent with consumer welfare, than a regulated regime.
- Conversely, where these markets are not effectively competitive, mandates for interconnection at the IP level and/or network neutrality may prove to be unavoidable, particularly once existing PSTN interconnection is withdrawn. The migration to NGN potentially creates new sources of market power, at the same time that it creates new possibilities for competition.
- If access to end users is highly concentrated, the largest player might not be motivated to connect to its competitors.

Summary

- Where deployment of mobile services are substantially complete, there are clear costs to maintaining CPNP.
  - CPNP tends to lead to high retail charges, and to low use.
  - Stimulating adoption when penetration approaches or exceeds 100% (e.g. EU15) provides no genuine benefit to consumers.
  - Cross-subsidies from fixed to mobile distort the development of the market, and may inhibit the evolution of the fixed network.
- CPNP faces significant challenges as networks evolve to IP/NGN.
  - Minutes of use correlate only weakly with cost.
  - In a world of independent service providers, it becomes impractical to use the *service* to subsidize the *network*.
  - Who placed the call becomes arbitrary.
  - There are practical difficulties with measurement.
  - There are countless opportunities for arbitrage, to the extent that wholesale payments do not track underlying costs.

Summary

- The migration time from PSTN to NGN represents an opportunity for policymakers to consider alternatives to CPNP.
- Maintaining CPNP, but with substantially lower termination rates (ideally less than 0.02 €) might however provide a better balance between stimulating mobile penetration and encouraging use of services (cf. India).
- Lower termination rates might pave the way to later migration to better alternatives.
- Evolution of the mobile network might be different from the fixed.
- Differentiated QoS is generally a positive development, but consumer willingness to pay a premium remains unclear.
- Network neutrality is a potential concern, but is unlikely to be as problematic in Europe as it has been in the United States.

Papers

“Interconnection an an IP-based NGN environment”, a chapter in ITU’s *Global Trends 2007*, presented at the ITU Global Symposium for Regulators, Dubai, 6 Feb 2007, available at: http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR07/discussion_papers/JScott_Marcus_Interconnection_IP-based.pdf.

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