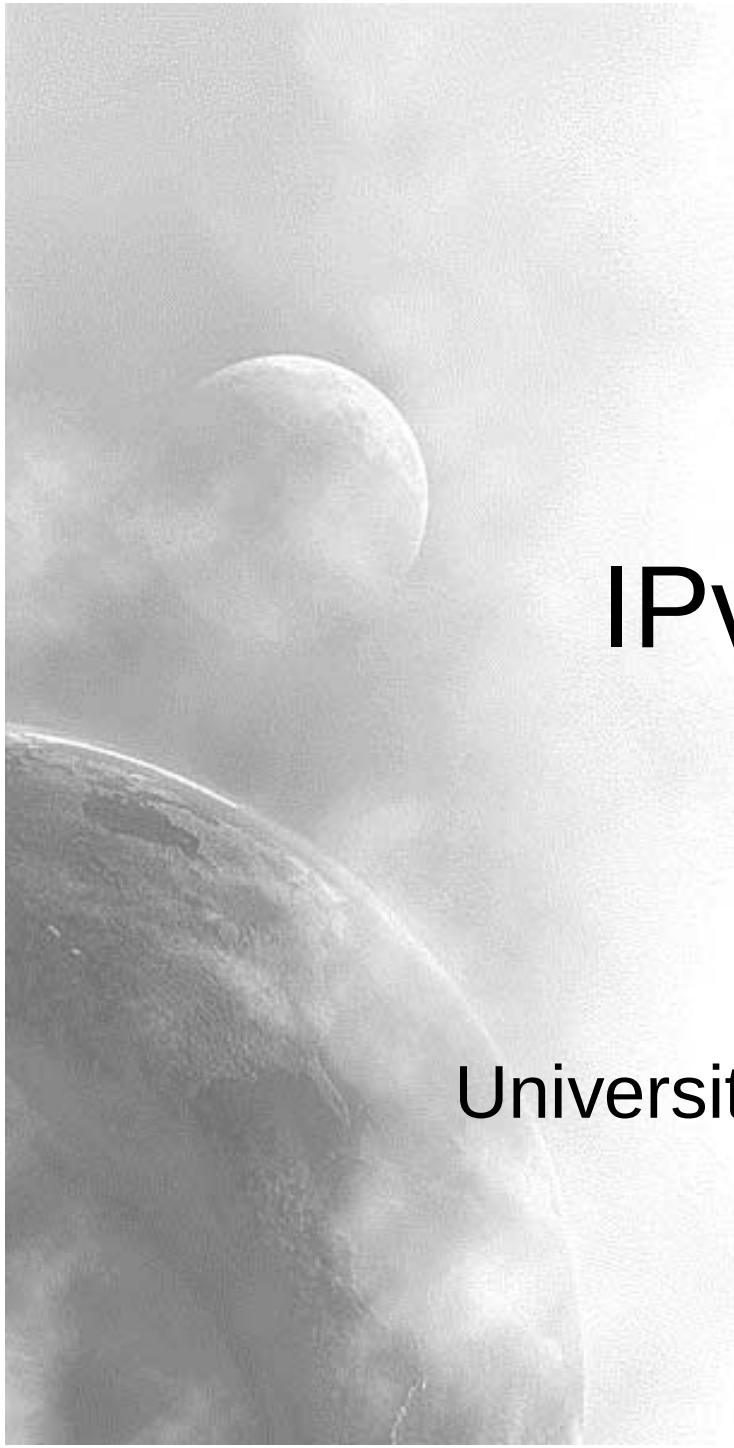

IPv6 and QoS

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Topics

- Scalability of current IP (IPv4)
- IPv6 functionality and benefits
- QoS features of IPv6
- IPv6 deployment and transition strategies
- UMTS and 3GPP: end-to-end QoS?
- IPv6 standards and implementations status
- IPv6 deployments

IPv4

- Current version of Internet Protocol is IPv4
  - in use since 1970's
  - uses 32-bit addresses, e.g. 152.78.64.100
  - address allocation inefficient and restrictive
  - IPv4 addresses hard to get
  - not designed with today's Internet in mind
  - 2^32 < population of Earth
- Can the Internet continue to grow using IPv4?

Famous quotes...

- “I think there is a world market for maybe five computers”
  - Thomas Watson, IBM, 1943
- “640K should be enough for anybody”
  - Bill Gates, 1981
- “32 bits ought to be enough address space”
  - Vint Cerf, 1977
  - yet 32 bits has survived for over 20 years

IP Everywhere

- The Internet Protocol is becoming pervasive
  - but it was designed over 20 years ago
- More and more devices are using IP
  - and they require reachability
  - places a demand on IP address space
  - 1 billion IP devices by 2003
  - requires IP routing to be scalable

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Internet Growth

- Current estimates
  - 300M users online worldwide, US/Europe-centric
  - 70M hosts connected with global IP addresses
- IPv4 with 32-bit addressing allows 4B hosts
  - but allocation has been done inefficiently
  - some institutions own a Class A address space
  - CIDR and NAT have only patched the problems

CIDR

- Classless Inter-Domain Routing
  - implemented from 1994/95
  - registries allocated blocks (16M hosts) to CIDR
  - address space allocated in aggregated fashion
  - reduces size of default-free zone routing table
- But
  - registries unable to honour large IP block requests
  - hard to acquire IP addresses from ISP

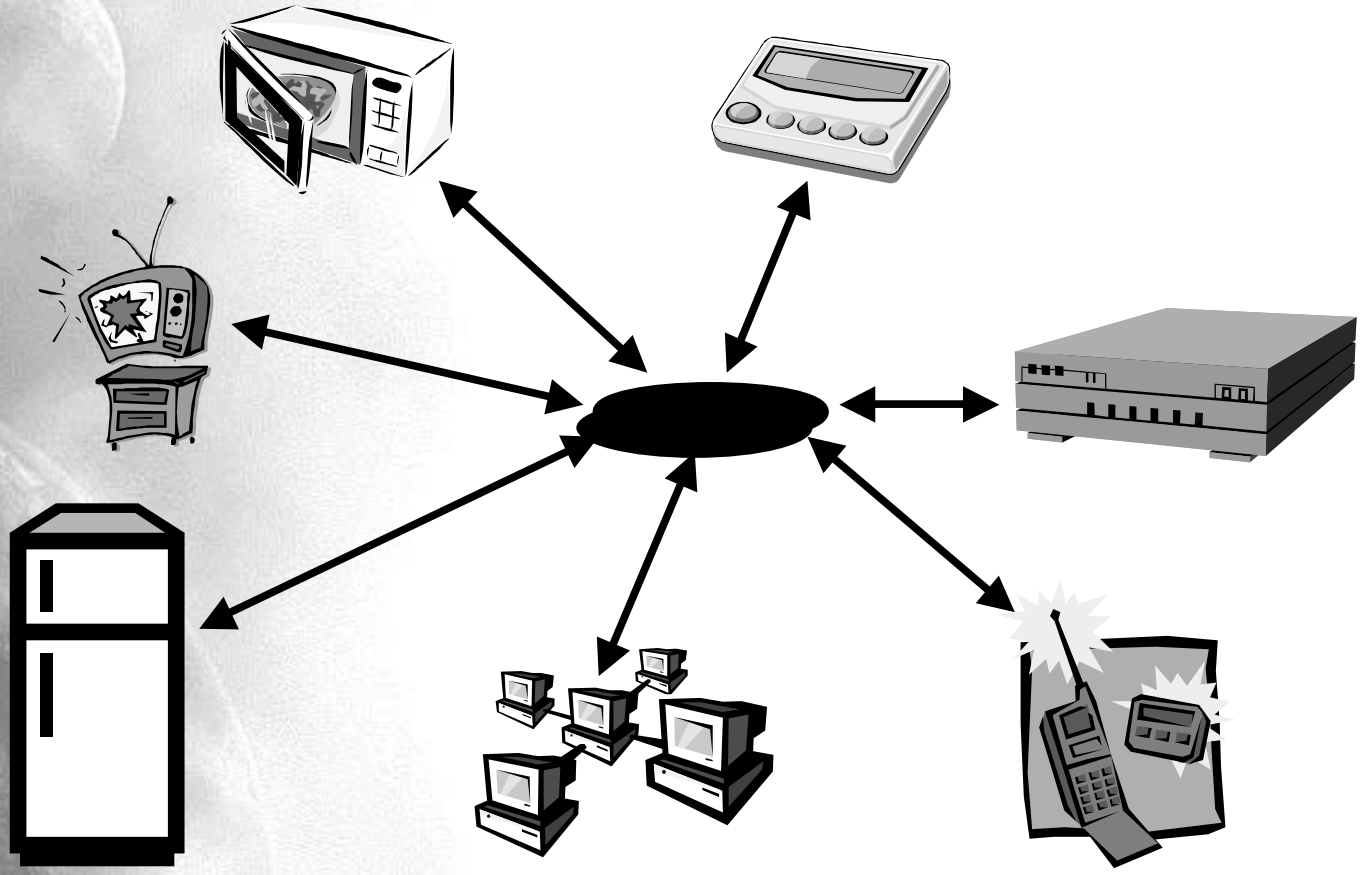
NAT

- Network Address Translation
  - hide multiple hosts behind pool of IP addresses
  - use private IP space internally
  - enforced if cannot acquire global IP addresses
  - relies on hosts behind NAT being client-only
  - NAT uses state information, so scales poorly
  - breaks end to end transparency/security model
  - problems if multiple NAT sites merged

Who wants address space?

- Third generation mobile
  - UMTS, as directed by the 3GPP
  - predictions of 1B mobile handsets by 2002/3
  - each device needs to be addressable
- Emerging nations
  - e.g. China, Asia, Africa, South America
  - missed out on IPv4 “gold rush”
- Home networking
  - consumer devices addressable by mobile user

IPv6 in the Home



New models of computing

- Always-on devices
  - ADSL, cable modems, mobile handsets,…
  - success of DoCoMo's i-mode handset
  - IP devices with built-in GPS
- Pervasive devices
  - embedded CPUs
  - with new communications media, e.g. Bluetooth
  - perhaps many per office or household
  - person to host and also host to host

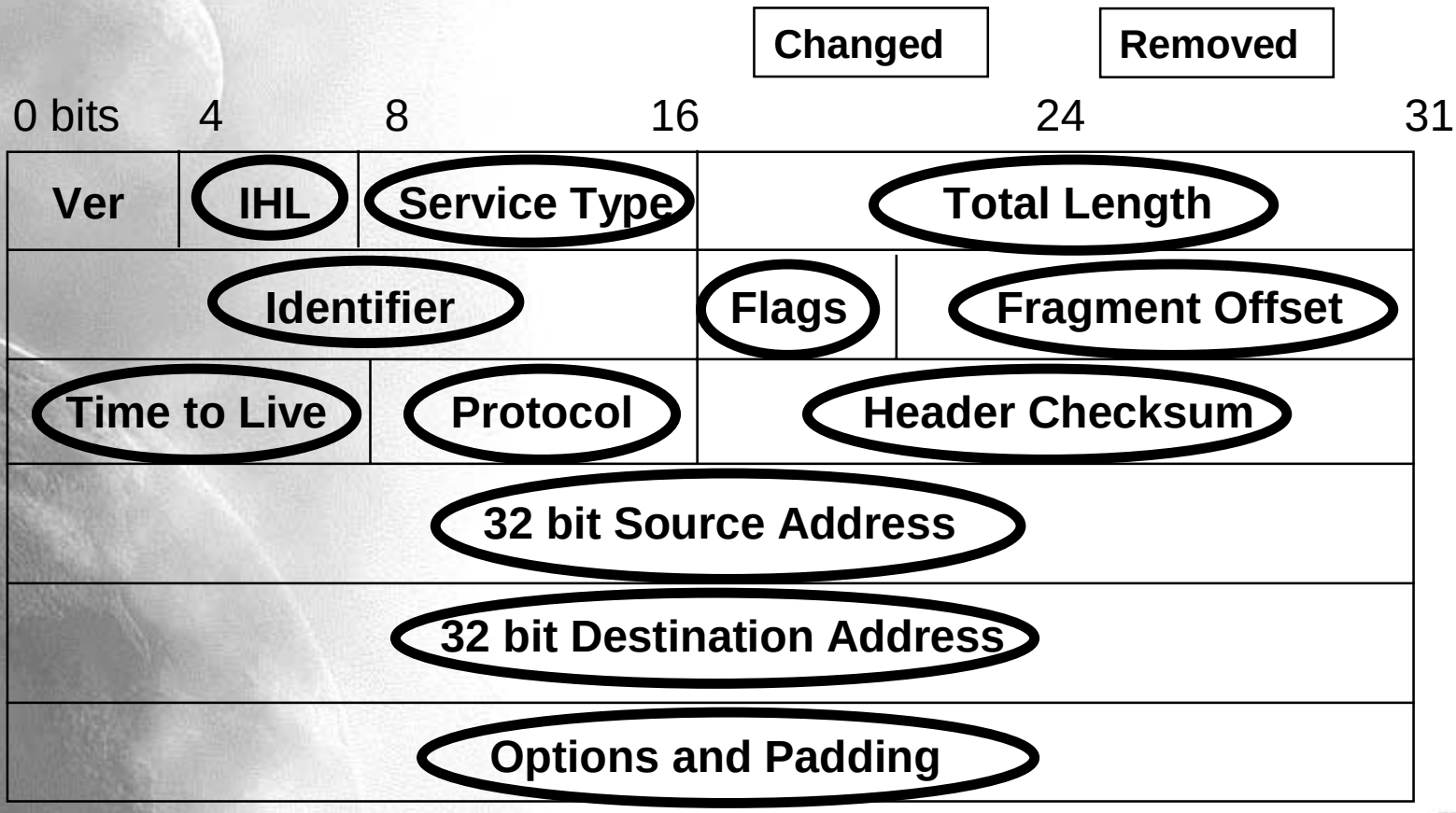
Always-on statistics

- Cable Modems
  - U.S. - 2.9M in 2000 → 12.4M in 2003
  - Worldwide - 5M in 2000 → 24M in 2003
- Digital Subscriber Lines
  - U.S. - 1.75M in 2000 → 13.9M in 2003
  - Worldwide - 4.4M in 2000 → 36.1M in 2003

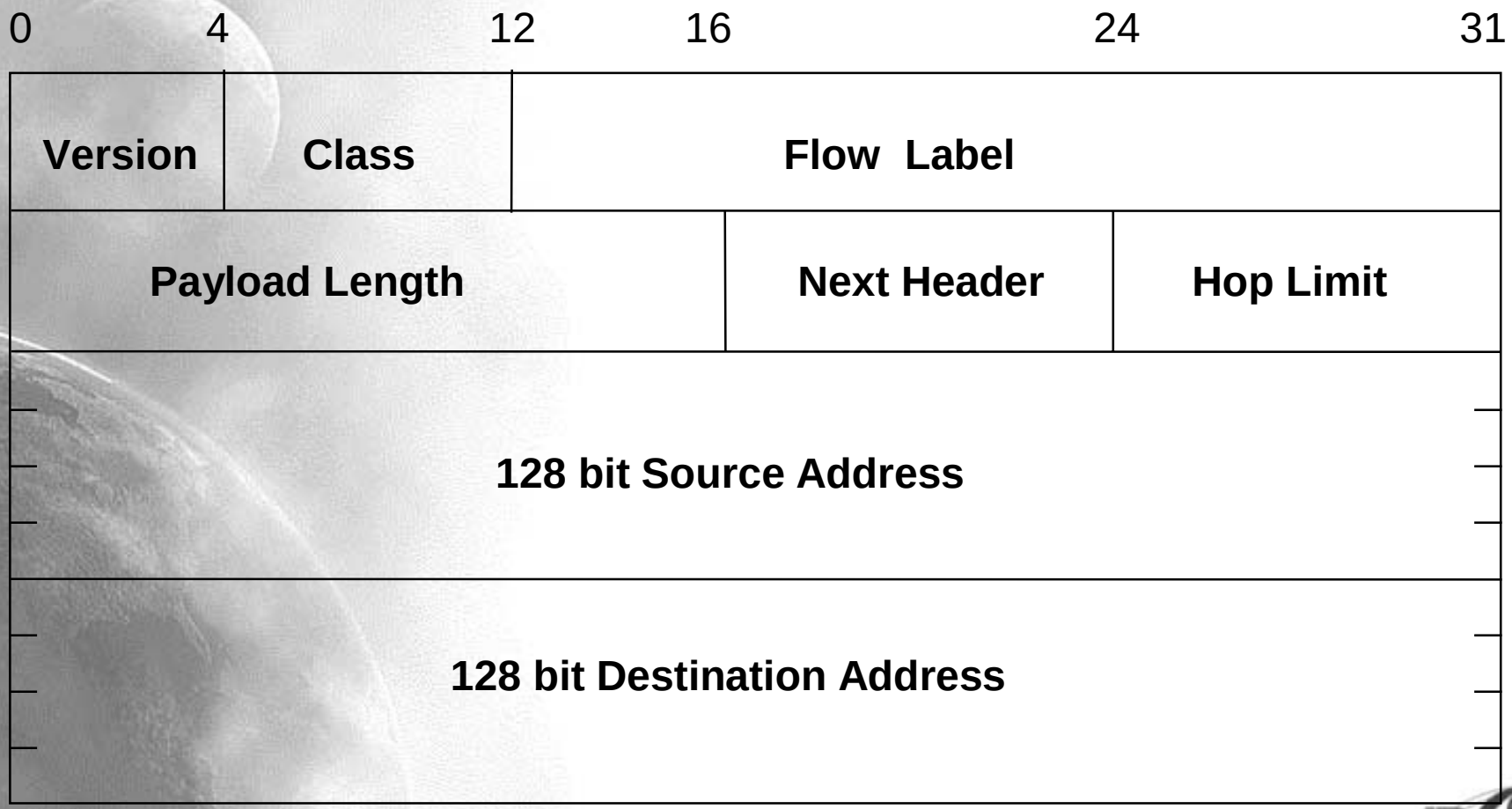
Benefits of IPv6

- Increased address space
  - 128-bit addresses
  - enables globally unique IPs for all devices
  - ARIN, APNIC and RIPE have common policies
- More efficient routing
  - aggregated address allocation from the outset
  - fixed length IP packet headers
  - “next header” construct offers expandability

Streamlined IP header



Simplified IPv6 header



Unicast addressing

- E.g. 2001:0630:80:200:a00:20ff:fe9c:1466
  - 2001 : fixed 16-bit prefix for unicast
  - TLA : 13 bits, allows 8,000+ top level ISPs
  - STLA/NLA : 19 bits network space
  - Site : 16 bits network space
  - Host : 64 bits host space
- Thus a site gets a /48 address allocation
  - similar to a Class A network in IPv4

IPv6 management benefits

- Reduced management requirement
  - stateless autoconfiguration of hosts
  - also offers support for ad hoc networking
  - but can still use DHCP(v6) if desired
  - also have privacy options for IPv6 addresses
- Improved methods to change ISP
  - router renumbering
  - new DNS methods (e.g. DNAME records)

Mobility and multihoming

- Better mobility support
  - no explicit foreign agent
  - no triangular communication via home agent
  - anycast feature allows home agent “farms”
- Multihoming enabled
  - devices can autoconfigure on many prefixes
  - multiple IP addresses per host may be the norm
  - host selects src/dst address to use

IPv6 security and scoping

- IPsec mandated
  - authorisation and encryption as standard
  - though still need key exchange/PKI methods
  - but with no NAT security functions are enhanced
- Scoped addresses
  - link-local, site-local, and global address scope
  - no concept of “private” IP space as per IPv4
  - offers better multicast scope control

QoS support in IPv6

- IPv6 header has two QoS-related fields
- 20-bit Flow label
  - geared to IntServ, but may have other uses
    - e.g. implemented in Lancaster RSVP media server
- 8-bit Traffic Class indicator
  - geared to DiffServ
    - e.g. implemented in Thomson IPv6 edge device

How does IPv6 help QoS?

- Usage problems remain the same as IPv4
  - but IPv6 is a more streamlined protocol
  - its key benefit over IPv4 is scalability
  - many features of IPv6 are IPv4 “bolt-ons”
- Consider IPv6 when implementing
  - future QoS products will require IPv6
  - methods used for IPv4 can be brought to IPv6

Current areas of study

- Other uses of the flow label field
  - may be useful for aggregated flows
- Possible additional header types
  - using the “next header” construct of IPv6

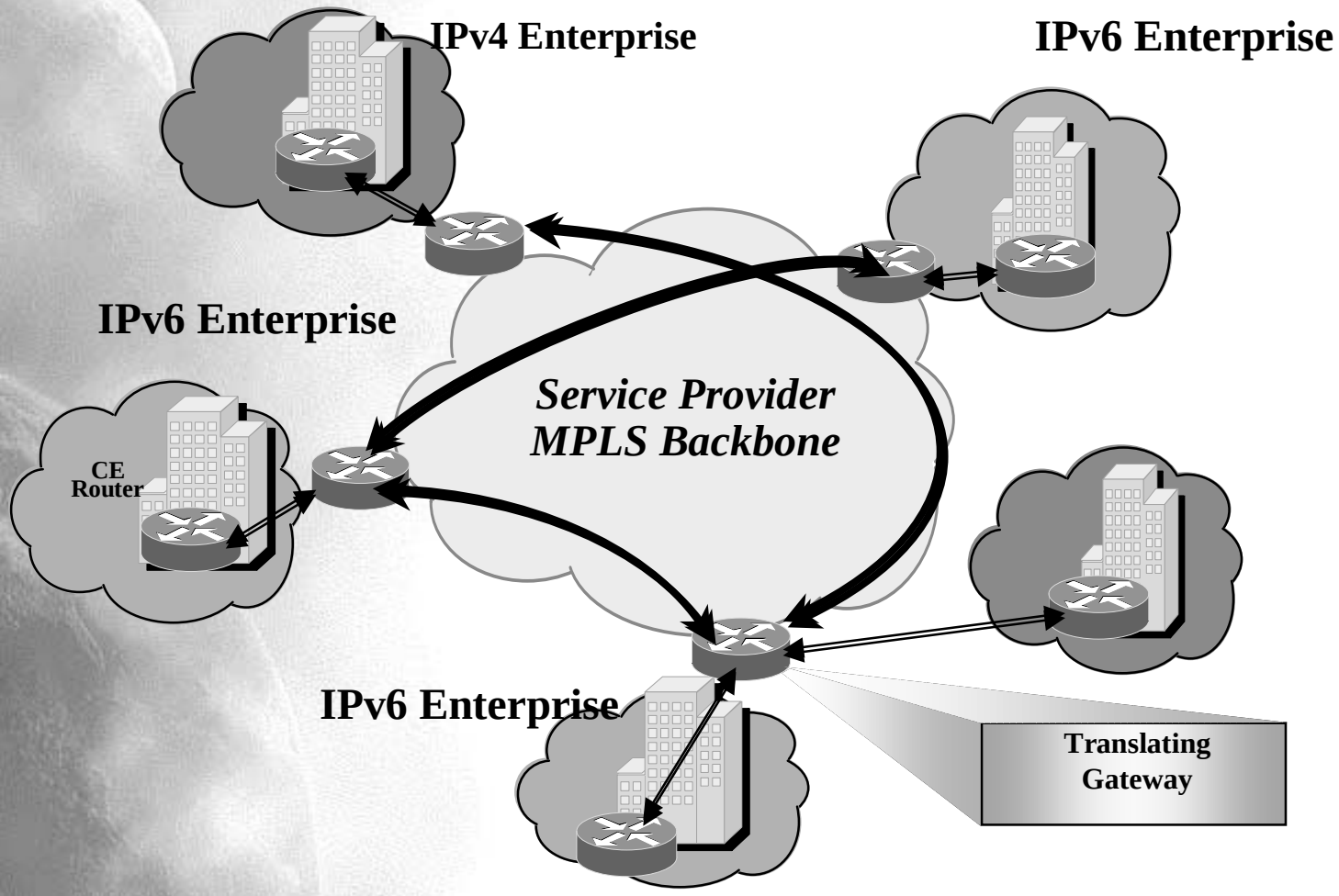
IPv6 Deployment Strategies

- Plan A: Driven by new applications
  - 3GPP/UMTS - mobile IPv6 handsets
  - Home networking - plug and play devices
  - Metering - utility services
- Plan B: Transition of existing Internet
  - IPv4 and IPv6 must co-exist
  - access IPv4 applications from IPv6 networks
    - and vice-versa

Transition from IPv4 to IPv6

- IPv4/IPv6 interworking
  - IPv6-in-IPv4 tunnels
  - Automated tunnel brokers, e.g. www.freenet6.net
  - NAT/PT and Ultima (BT)
  - Dual stack IPv4 and IPv6
    - easier if you have enough IPv4 addresses
  - Proxy methods
  - DSTM, 6to4, 6over4, ...
- Different scenarios require different tools

IPv6 over MPLS

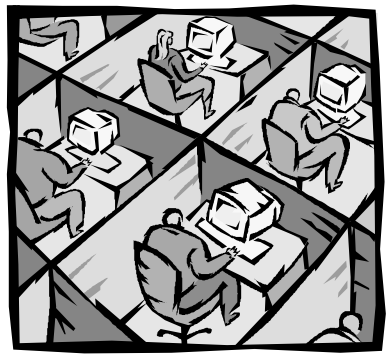


Why end-to-end QoS?

- Convergence of voice and data
  - “IP over Everything”
- Need real-time end-to-end services
  - Access to databases and directory services
  - Tailored, seamless services, per user
  - Location-based user interface
  - Migrating agent services
  - High performance visualisation experiments
- Telephony, video streaming
  - Available anywhere, anytime

IP Mobility and Access

- IPv6 enables a mobile information society
  - end-to-end security/transparency with QoS
- Key benefit is global reachability
  - scalable mobile IP methods
- Run over multiple media
  - WaveLAN, IR, Bluetooth, Ethernet, 3G



UMTS, WAP and IPv6

- WAP geared for mobile PDA devices
- IPv6 enables unique global IP addressing
  - thus all devices/handsets addressable with IP
- 3GPP partners building All-IP core networks
  - e.g. Nokia
- UMTS handsets may run IPv6
  - e.g. Ericsson multimedia handsets

3G Concept Devices

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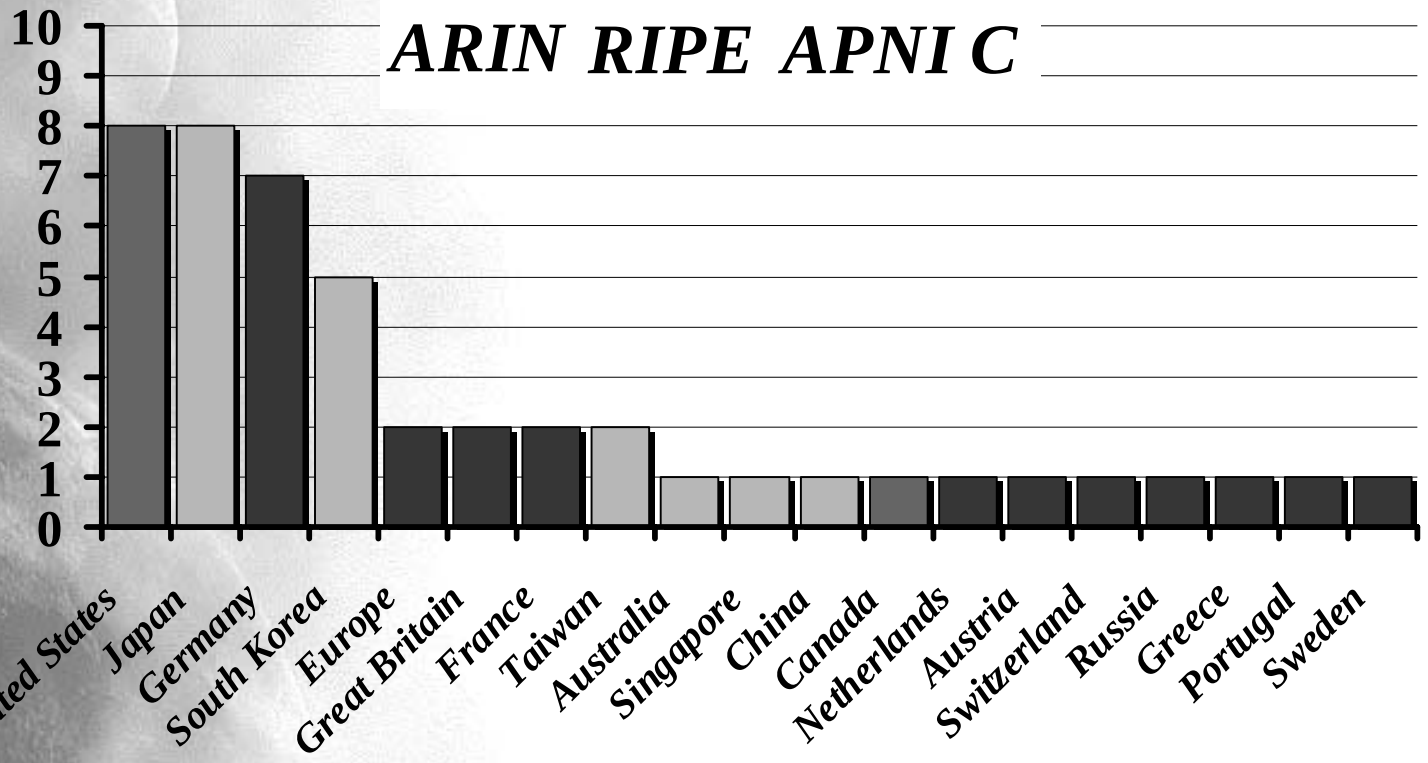
IPv6 Standards Status

- Core IETF specifications already completed
- Many (inter)national deployments exist
- Vendors are pledging commercial support
- ISPs are rolling out commercial services
- 3GPP has adopted IPv6
- Real IPv6 address space is being assigned

ICANN

- Delegating IPv6 production address space
- Allocations made via regional registries
  - ARIN (Americas), APNIC (Asia), RIPE (Europe)
- Allocating under 2001::/16
  - e.g. UK-JANET-19991019 2001:0630::/35
  - UK-BT-19990903 2001:0618::/35

IPv6 TLA allocations



RIPE IPv6 Assignments

- Began in July 1999
- UUNET, SPACENET, SURFNET, BT, SWITCH, ACONET, JANET, DFN, FREENET, GRNET, ECRC, TRMD, RENATER, NACAMAR, EUNET, GIGABELL, XLINK, TELECOM, RCCN, SWIPNET, and ICM.
- Includes academic National Research Networks
- GEANT (gathering of NRNs) is studying IPv6

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IPv6 Platforms

- Solaris 8: with IPv6 since March 2000
- Windows 2000: preview released Oct 2000
- FreeBSD: IPv6 as standard in FreeBSD4.1
- Linux: IPv6 packages available
- Compaq: Tru64 Unix v5.1
- IBM: AIX 4.3
- HP: HP/UX 11.0

IPv6 APIs

- Solaris, Linux, KAME
  - use C
  - Sun's "socket scrubber" is a handy tool
    - http://www.sun.com/solaris/ipv6/
- Many Web/Internet applications use Java
  - awaiting IPv6-enabled Java from Sun

The Quake API test

- Took 32 hours for 2 programmers from Viagenie (Canada) to retrieve the source, find where to make changes, code the changes, setup a public Quake server and play the first Quake game over IPv6.
- http://www.viagenie.qc.ca/en/ipv6/quake/ipv6-quake.shtml



IPv6 Routers

- Cisco IOS: commercial version January 2001
- Telebit: first commercial router, TBC2000
- FreeBSD 3.5 or 4.1 (KAME stack)
- Zebra (GNU router project)
- 3Com Netbuilder II
- Hitachi NR60, GR2000
- Bay Networks

Core applications

- DNS
  - BIND 9 offers native IPv6 DNS lookups
  - Viagenie preparing IPv6 root name server
- World Wide Web
  - Apache server
  - MSIE, Netscape, Mozilla and Lynx browsers.
- E-mail
  - Sendmail 8.10 has IPv6 built-in, as does qmail.

IPv6 Deployments

- Commercial ISPs
  - IIJ, NTT, BT
- International deployments
  - 6bone, WIDE (Japan), Internet 2 (US/Canada)
- European academic networks
  - JANET, DFN, Surfnet, ACONet, Renater
- European projects
  - 6INIT, QTPv6

6bone stats (Summer 2000)

- Now in 46 countries

  AR, AU, AT, BE, BR, BG, CM, CA, CN, CZ, DK, EE, FI, FR, DE, GR, HK, HU, IN, IE, IT, JP, KZ, KR, LT, MY, MX, NL, NZ, NO, PL, PT, RO, RU, SG, SK, SI, ZA, ES, SE, CH, TW, UA, UK, US, UY

- 571 networks/sites

  135 US, 66 DE, 38 JP, 28 FR, 28 UK, 20 SE, 10 CN, 9 RU, 4 MX etc.

- 68 pTLA's (backbone tier ISPs)

  recent additions:

  UUNET and Deutsche Telekom

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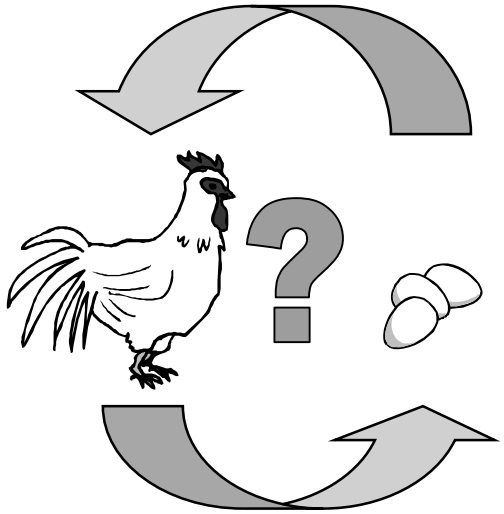
IPv6 deployment barriers

- Cost is most significant factor
  - but not so much for new applications
- Need confidence in technology
  - pilots: WIDE, vBNS, NTT, 6INIT
- Need clear benefits
  - manageability
  - scalability
- IPv4 does the job
  - but will it in 5 years, and then what cost?



6INIT

- 12 partner EU project (Jan'00 - Apr'01)
  - Pan-European deployment, 5 regional clusters
  - www.6init.org
- Applications:
  - stock exchange, news-on-demand, streaming
- IPv4/IPv6 integration issues
- Also deploying:
  - QoS (DiffServ), IPsec (FreeSWAN), VoIPv6 (SIP)
  - 6WINIT wireless follow-up project

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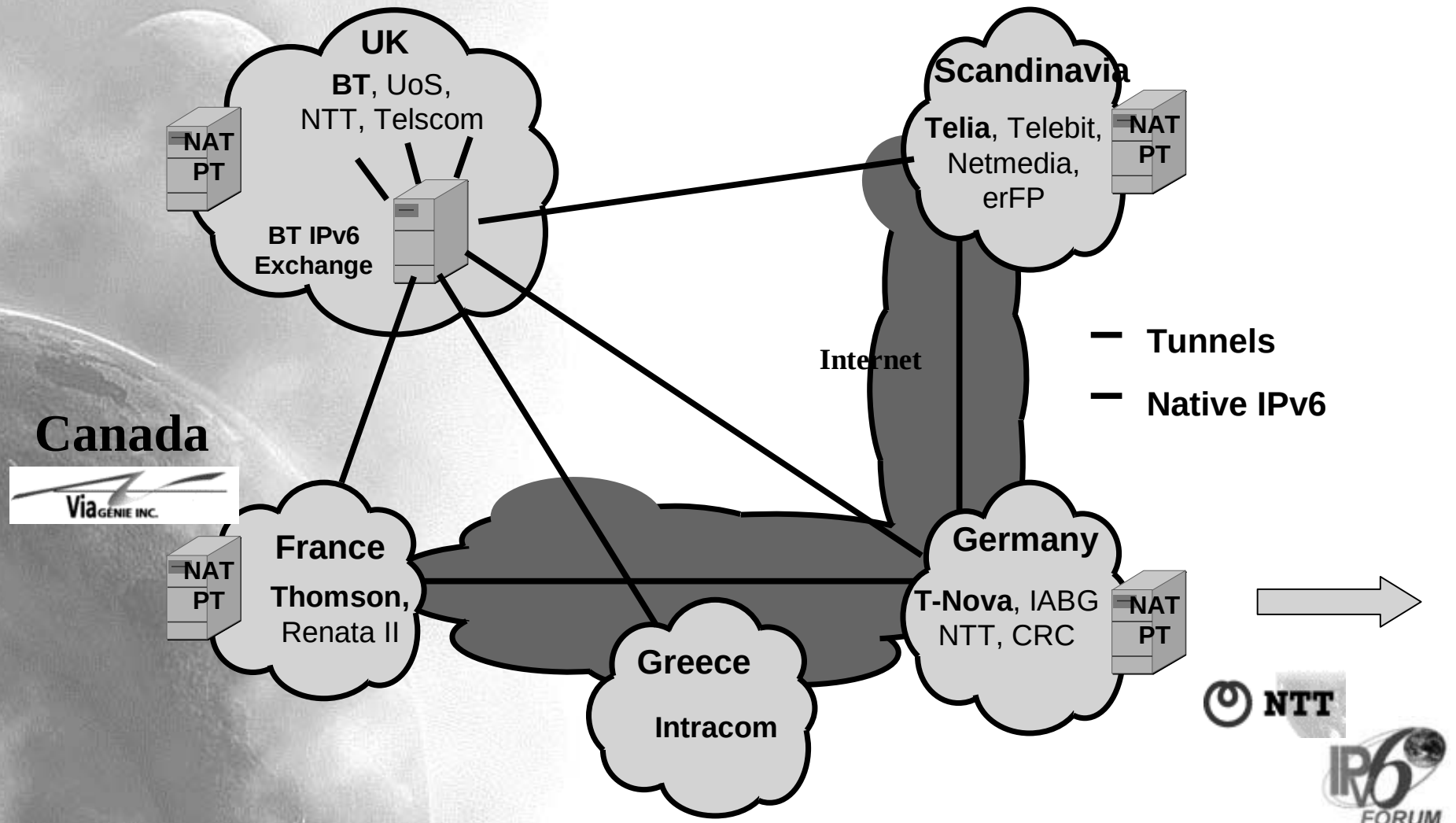
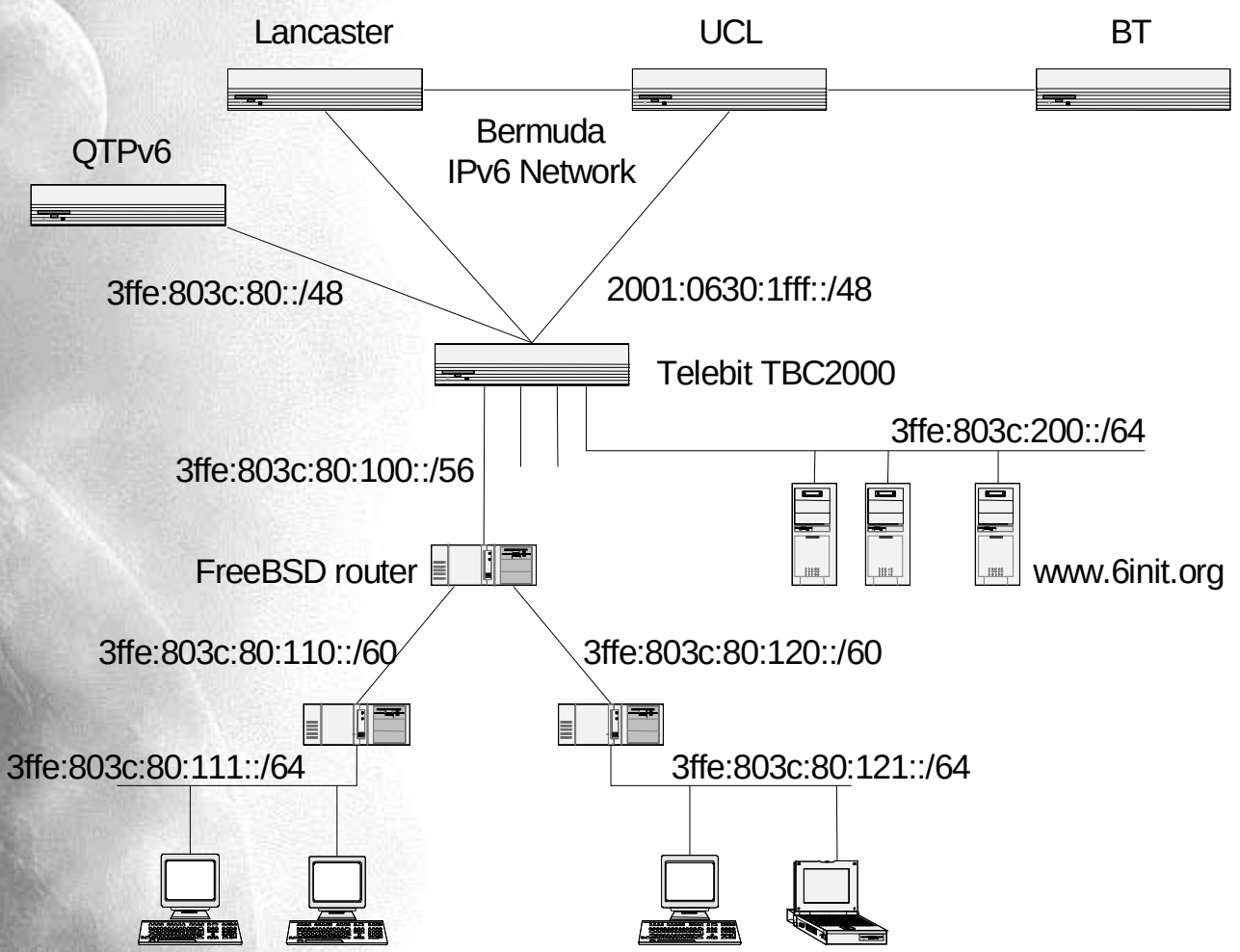
6INIT clusters



Southampton IPv6



Conclusions

- IPv6 will deploy
  - mobile and home devices may drive deployment
- IPv4 is “patched” to breaking point
- IPv6 IETF core standards are done
- Vendor and application support hardening
- QoS issues remain the same as IPv4
  - but IPv6 is a scalable protocol
  - so be prepared to implement IPv6 solutions

If you’re new to IPv6...

- Read IPv6 Forum articles
- Deploy IPv6 software
  - FreeBSD 3.5.1 with KAME stack (www.kame.net)
  - excellent for host/router/API trials
- Get connected to the 6bone
  - apply for pTLA or use www.freenet6.net
- Track standards bodies
  - ipng and ngtrans IETF working groups/e-mail lists

Sites to visit

- IPv6 Forum - http://www.ipv6forum.com
  - conference presentations and reports
  - implementation and deployment lists
- IETF - http://www.ietf.org
  - standards and draft standards
  - ipng and ngtrans working groups
- My e-mail: tjc@ecs.soton.ac.uk