# Where is IPv6 going?

Sue Hares

CTO

NextHop Technologies


# IPv6:
# a latent overnight success
# or
# a technology that will never catch on?


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Most take 10 years

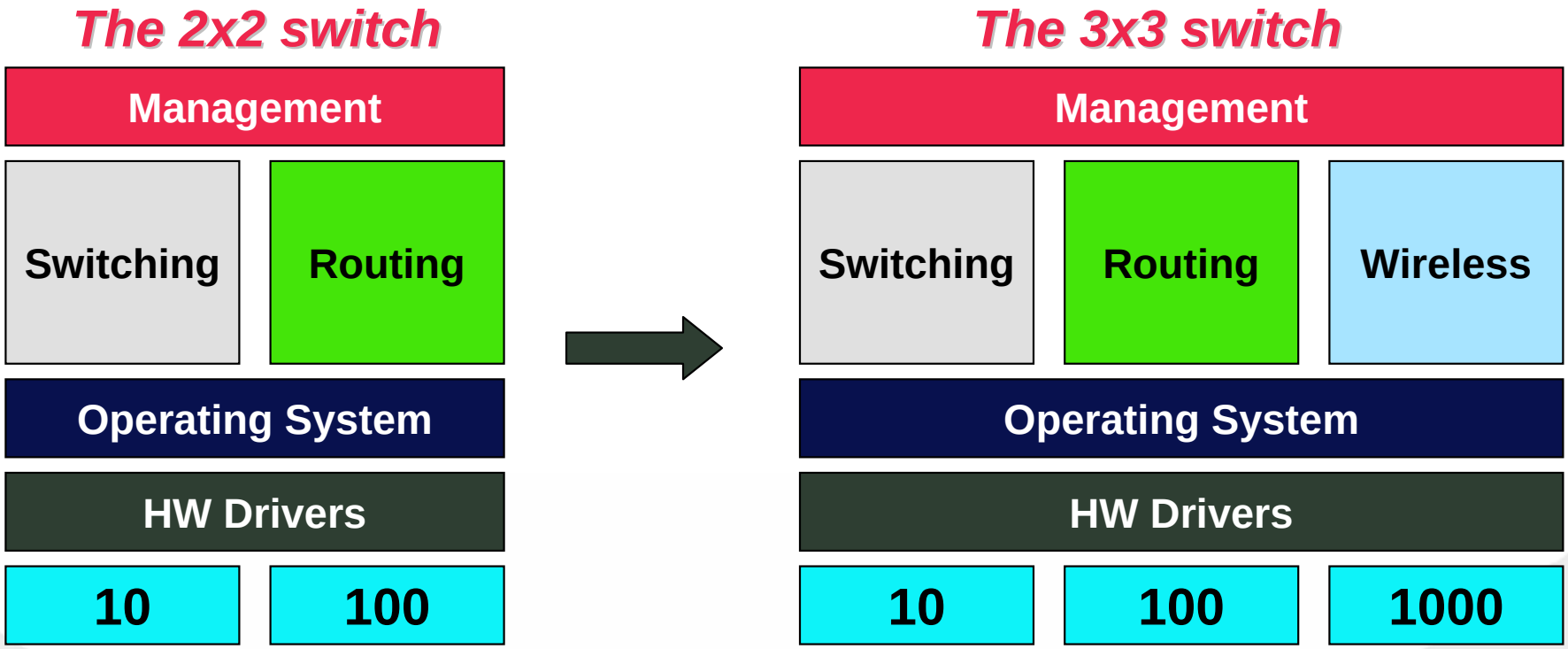
# Overnight Success

- Internet started as:
  - US government project
  - 3 Academic networks prior to the commercial Internet
    - ARPANET, NSFNET I, NSFNET II
  - Email was the 1st driver
- World Wide Web
  - Killer application for publishing information
  - Launched Internet usage from low level to high level

# What's New? (1988 vs. 2004)

- Commercial Internet is Critical Infrastructure
  - Fierce Competition for revenue, little sharing
  - Security attacks occur regularly
- Multihoming, NATs, VPNs
  - Shortage of IP address space (official rationale)
  - Enterprise-friendly demarcation (unofficial driver)
- Policy is complex
  - Multiple independent policies frustrate convergence
  - VPNs create better and more complex router configurations
  - It is critical that SLAs turn into the appropriate router configuraitons

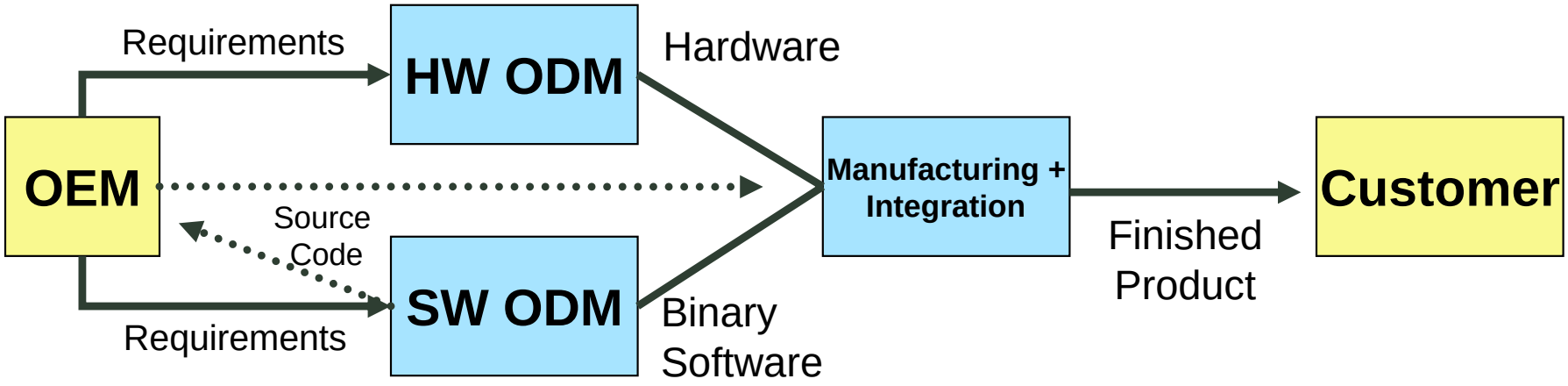
# Wireless impact




- Switching-Routing
- 10/100 Ethernet

- Switching-Routing-Wireless
- 10/100/1000 Ethernet

# Software OEM Business model

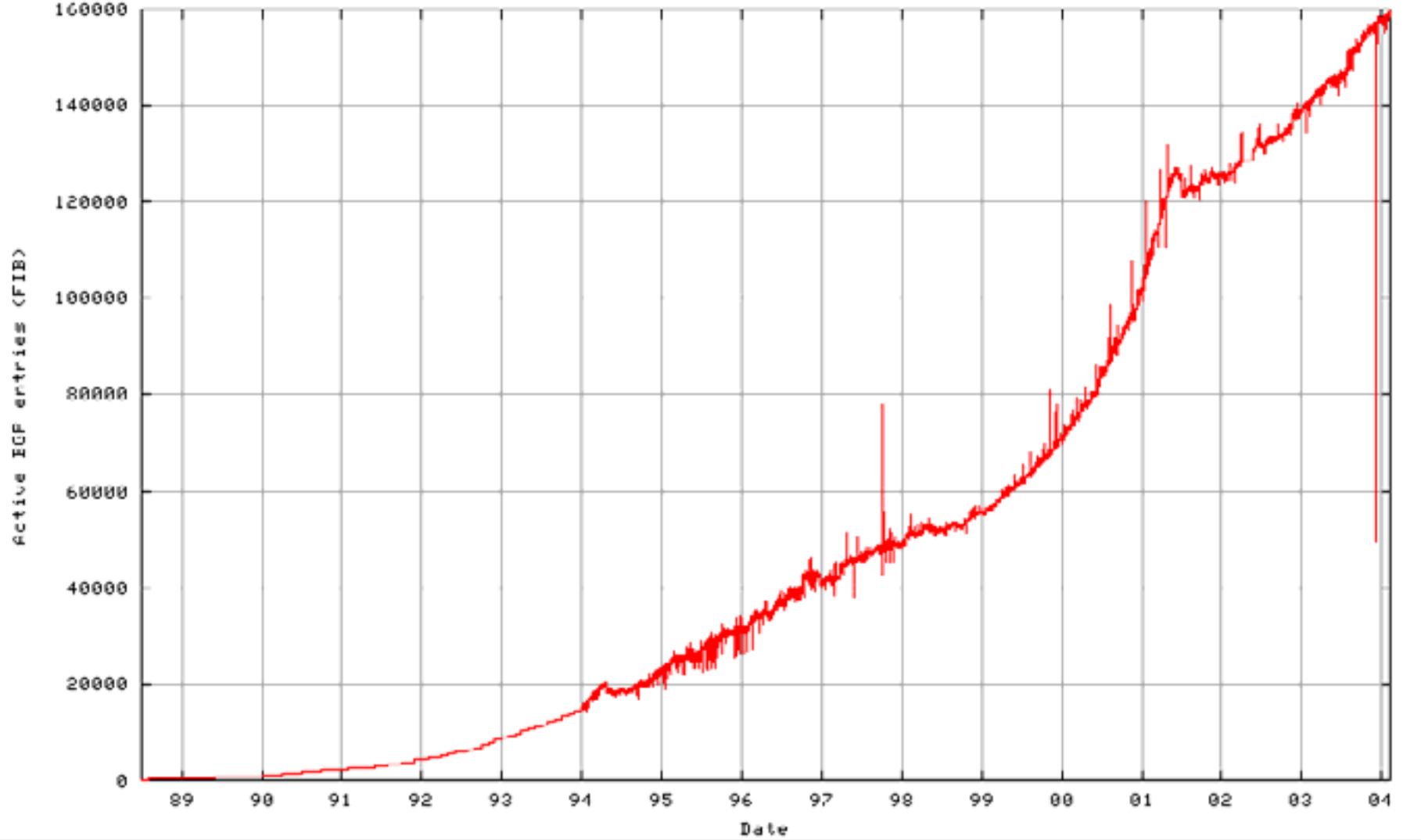



- A software ODM develops turnkey software
  - That is targeted for an OEM's chose hardware platform
- The software ODM's product can be either
  - Binary code shipped to OEM's manufacturing organization
  - Or, source code shipped to OEM's engineering organization

# IPv6 Charter in 1995

- 1991, 3 trucks and a wall
- 1993, CIDR addresses two trucks
- 1994, IPv6 for the “big” truck
- Ongoing - the configuration wall

# BGP Route Table Growth

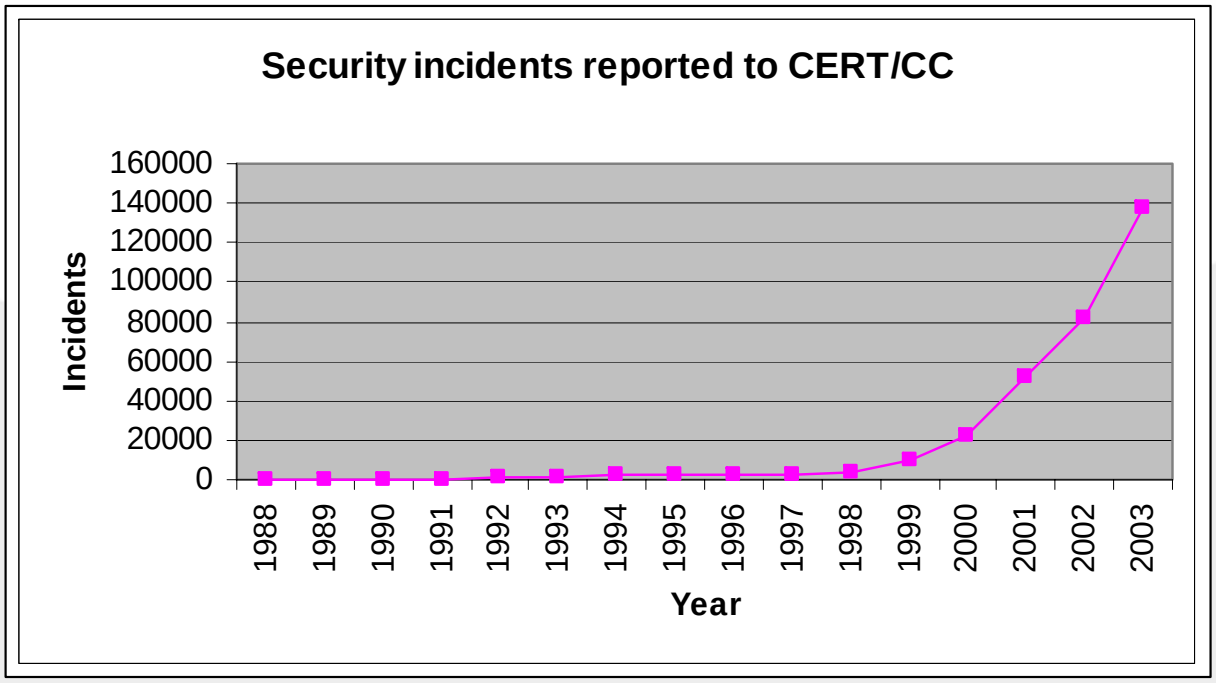


# 2002 Internet = Critical Infrastructure

**Implications of Recent Legislation on Provider Operations** – Diane Sidebottom, Dept. of Homeland Security (NANOG 30)

Security Concerns about:

- IP - How to get there
- DNS - Name to how to get there
- BGP – Policy + Routes between networks



# IP v6 Traffic is emerging

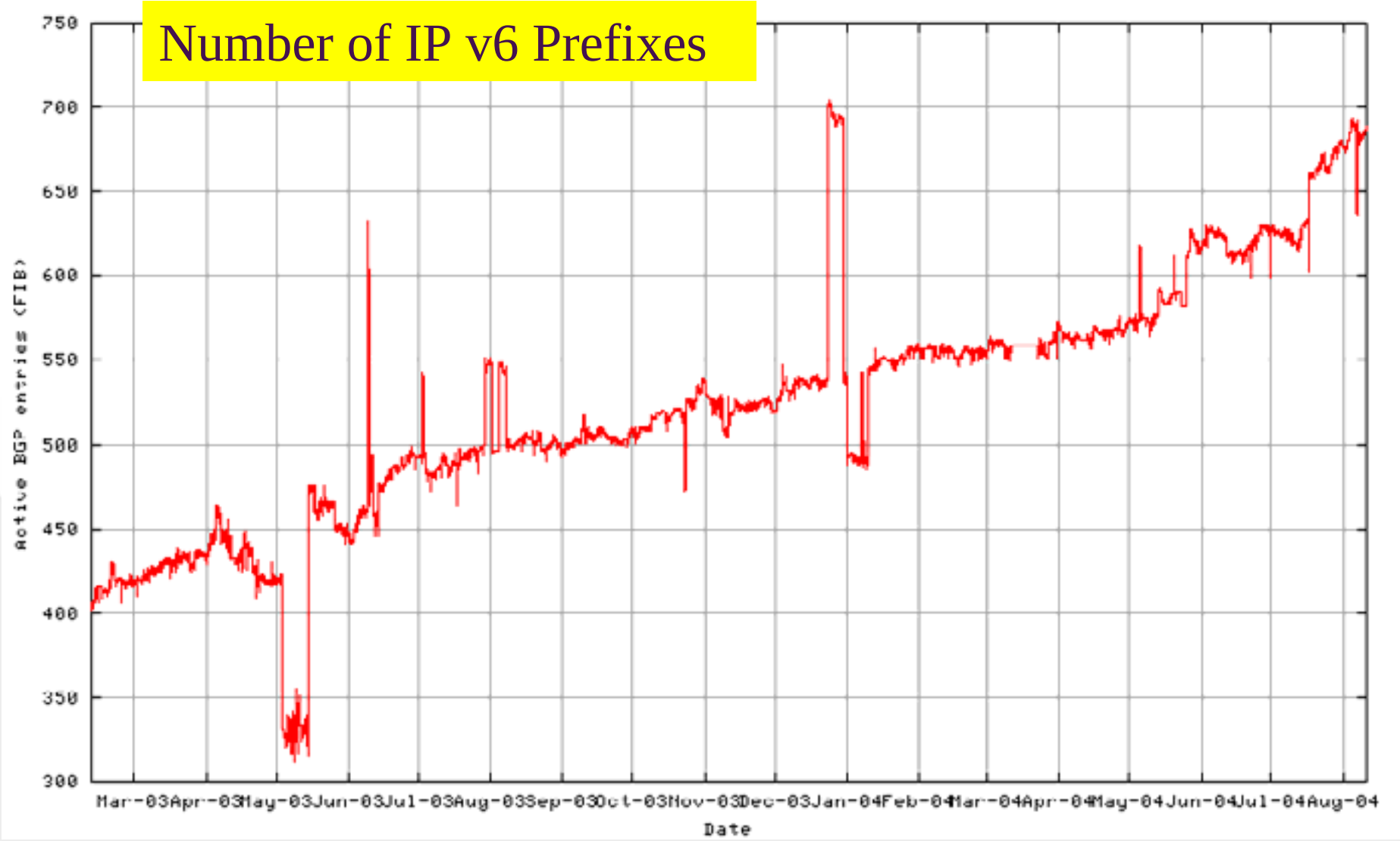
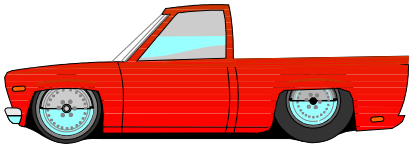



**Table from Telstra AS 1221**

# 1991: The Year of 3 Trucks & a Wall



**Problem 1**
Need better network packing

- Truck 1: Poor Utilization
  - Everyone wanted a class B network

**Problem 2**
Routers tables Overloaded with many networks

- Truck 2: Routing Table Explosion
  - 100K routes overload routers core routers

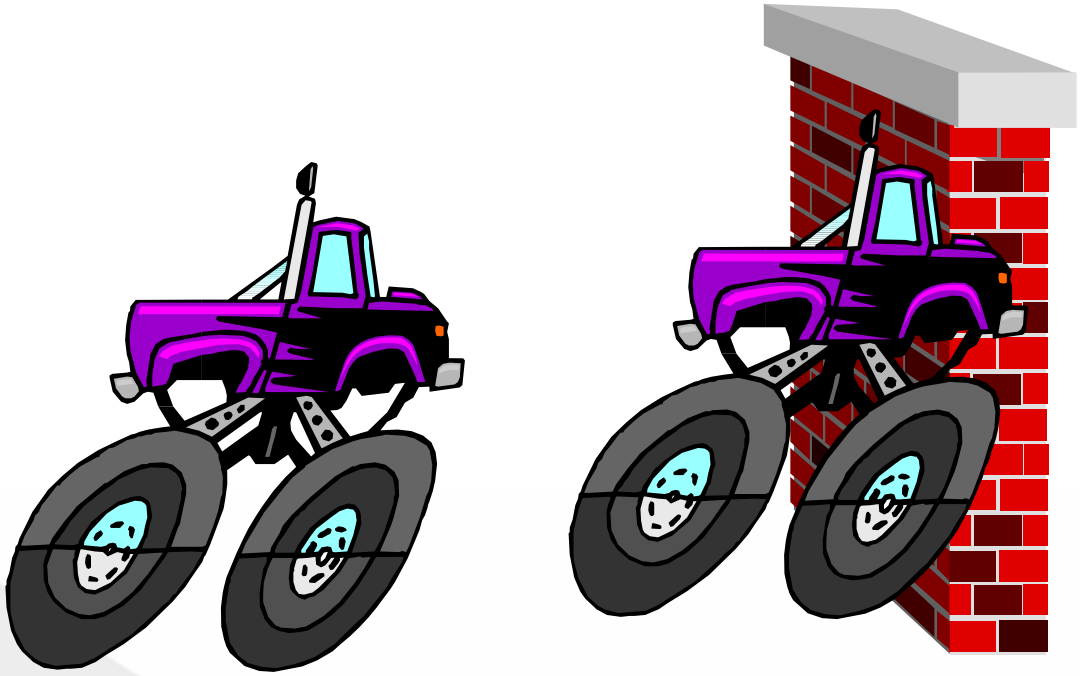
# IPv4 Address Exhaustions

Truck 3: No more IP-v4 addresses in 10-15 years

Current solutions:

- IPv6 = bigger address space with end to end connectivity
- Network Address Translation with NAT boxes as firewalls

# 1991: The wall



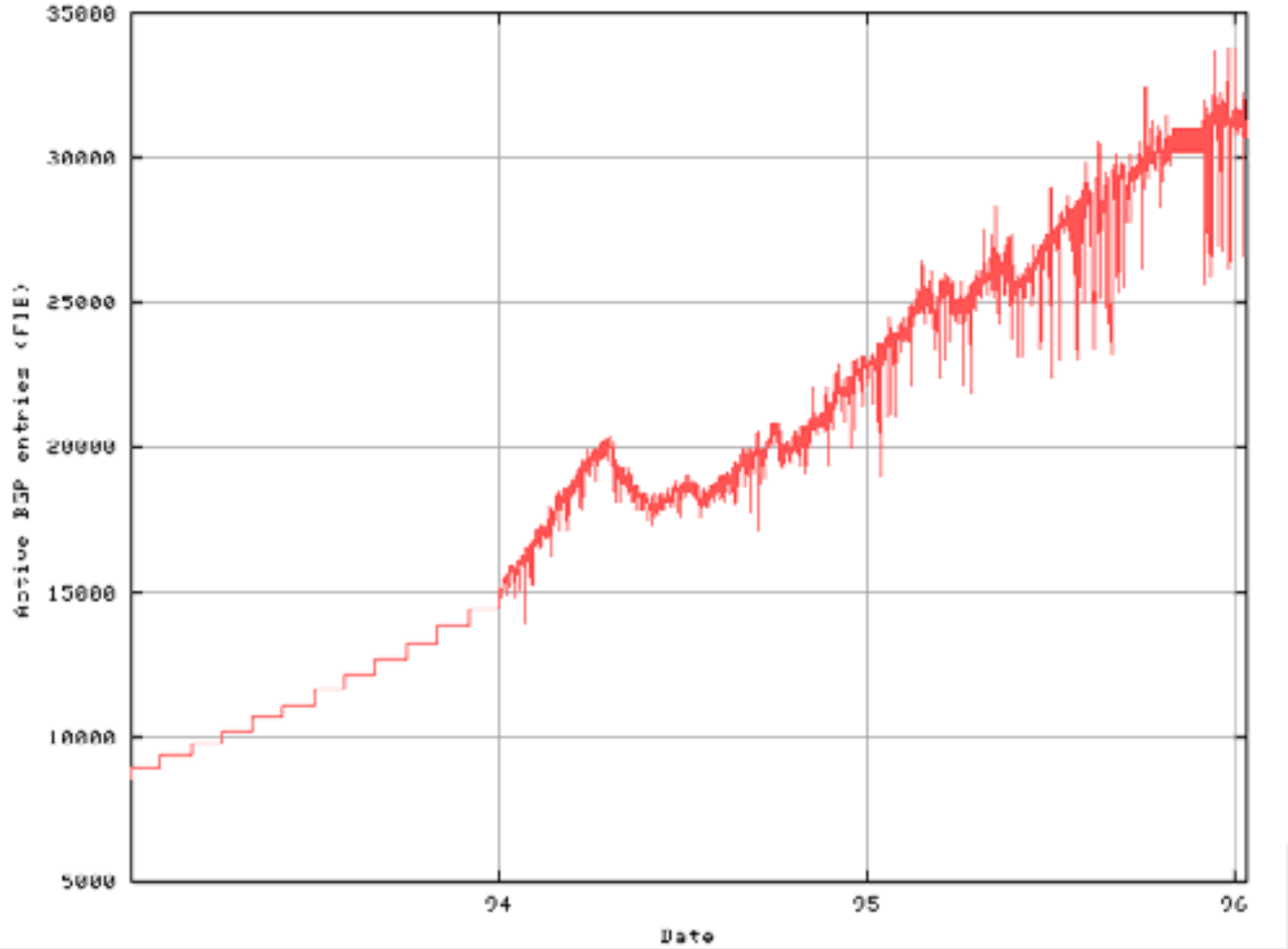
**auto-configuration**

- Network Configuration causing too many problems

2003 update

- 33% to 50% of network outages in enterprise and carriers caused by configuration errors
- Human operational costs are key concern to carriers and IT departs

# 1993: Fixing 2 trucks




- CIDR addresses the first two trucks
  - Better network packing through the "/" networks

    128.2/16, 128.5.10/25
  - Smaller route tables by using larger "/" networks
  - 128/8
- CIDR roll-out brings curve under control

# 1994: IP v6 Work Chartered

- Flushed with success, IPv6 had a simple charter
  - Fix the address exhaustion (IPv6's charter)
  - Fix auto-configuration for new protocols
    - Address assignment: DCHPv6
    - Stateless auto-configuration (IP v6)
    - VRRP v6 (Virtual Redundancy Protocol)
    - Zero configuration (long term working group)

- Not in the IPv6 charter
  - Fix routing protocols
  - Fix auto-configuration for old protocols
    - Address Assignment: DCHP
    - Virtual Router (VRRP for v4)

# IPv6 Charter Expanded

- IP mobility
- Multicast
- Security
- Service classes,
- Tunneling for private inter-networks (VPNs)
- Easy hardware forwarding
- Easy transitions between IPv4 to IPv6
- No flag day

# Forces that Drive Steadily for IPv6

- Host Products
- Router Products
- Firewall Products
- Embedded OS support
- Router Software Support

# Host Products

| Chart 1 - IP v6 in Host products[10] | |
|---|---|
| Host or unix OS | Product code |
| Apple | 2003 |
| BSDi | 1998 |
| Compaq VMS | 2001 |
| Compaq TRU-64 | 2000 |
| FreeBSD | 1998 |
| HP (HP-UX) | 2001 |
| Hitachi | 1998 |
| IBM AIX or Linux | 1999 |

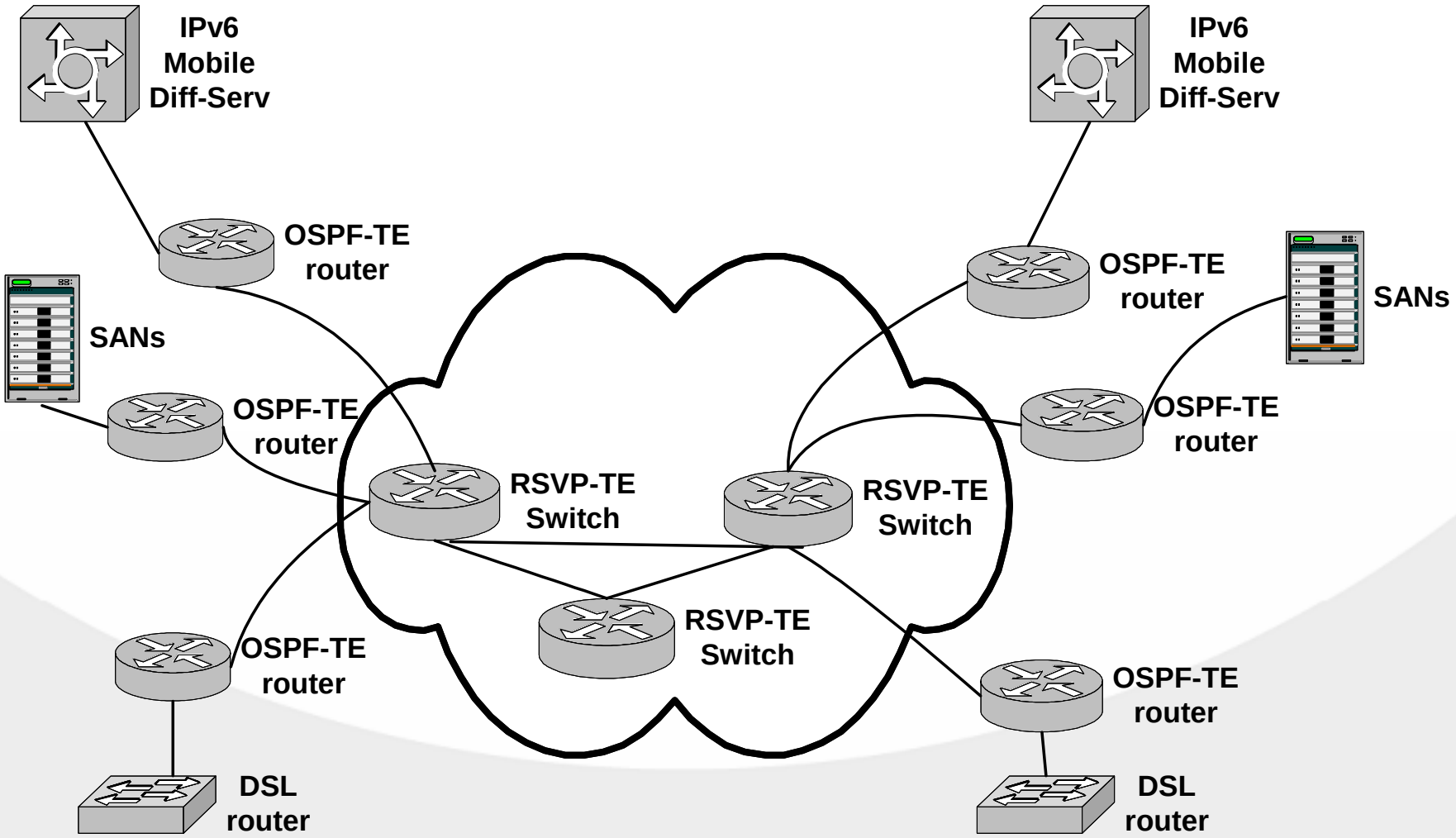
| Chart 1 - IP v6 in Host products[10] | |
|---|---|
| Microsoft 2002 | 2002 |
| Netbsd | 2000 |
| Novell (6.1) | 2001 |
| Nokia | 2003 |
| Open BSD (2.7) | 1998 |
| SCO | 1997 |
| SGI (IRIX6.5) | 2003 |
| Sun (Solaris 8) | 2000 |

http://playground.sun.com/pub/ipng/html/ipng-implementations.html

# IPv6 Support in Routers

| Chart 2 - Routers[11] | | | | | | | |
|---|---|---|---|---|---|---|---|
| Router | RIPng | BGPv6 | ISISv6 | OSPFv3 | PIM-SMv6 | PIM-SSMv6 | V6 on MPLS |
| 3COM | 1997 | | | | | | |
| Cisco 12.3, 12.2, 12.0 | 2001 | 2001 | 2001 | 2002 | 2003 | 2003 | 2002 |
| Ericsson (telebit) | 1997 | | | 2003 | | | |
| Extreme Networks | 2002 | 2002 | | | | | |
| Foundary - BigIron | 2002 | 2002 | 2003 | 2002 | | | |
| Hitachi (GR2000) | 1998-2000 | 2000 | 2001 | 2001 | 2001 | 2001 | 2001 |
| Juniper (JUNOS) | 2001 5.1 | 2001 5.1 | 2001 5.1 | 2002 5.3 | 2003 5.6 | 2003 5.6, 6.0 | 2003 5.1 |
| NEC | 2001 | | | 2002 | 2003 | | |
| Nortel (BayRS) | 1997 -12 | | | | | | |
| Sumitomo 3700 | 1997 | | | | | | |

# MPLS Usage for IPv6



# IPv6 Capable Firewalls

| Chart 3 - IPv6 Capable Firewalls [12] | | |
|---|---|---|
| **Firewalls** | **IP v6 filters** | **IPv6 Routing** |
| Checkpoint | 2002 | 1H 2004 |
| Cisco IOS firewall | 2004 | Cisco IOS 12.3(7)T |
| Cisco PIX | 2H 2004 | 2004 |
| Netscreen | 2003 (beta) | |
| Nokia | 2003 (beta) | |
| SonicWall | | |
| Watchguard | 2Q 2004 Pilot | |

# Chip Manufacture Support

- 2003 chip manufacturers
  - Intel, PMC Sierra, Agere, IBM
  - Nortel announces IPv6 chip set for new products

- IPv6 issues
  - 16 bytes versus 4 bytes increases routing tables and flow tables by 4 times,
  - NPUs support route and flow tables via SRAM and CAM hardware that requires additional power

| *Devices for 500K IPv6 Lookups* | *No. of Chips* | *Power Dissipation* | *Cost* |
|---|---|---|---|
| 21 CAM + 14 SRAM | 35 | 133 W | $5,810 |
| 6 CAM + 34 SRAM | 40 | 98 W | $2,860 |
| NPU | 1 | 15 W | $1,000 |
| Total | 36-41 | 113-148 W | $3,860-$6,810 |

***http://www.ezchip.com/html/tech_IPv6.html***

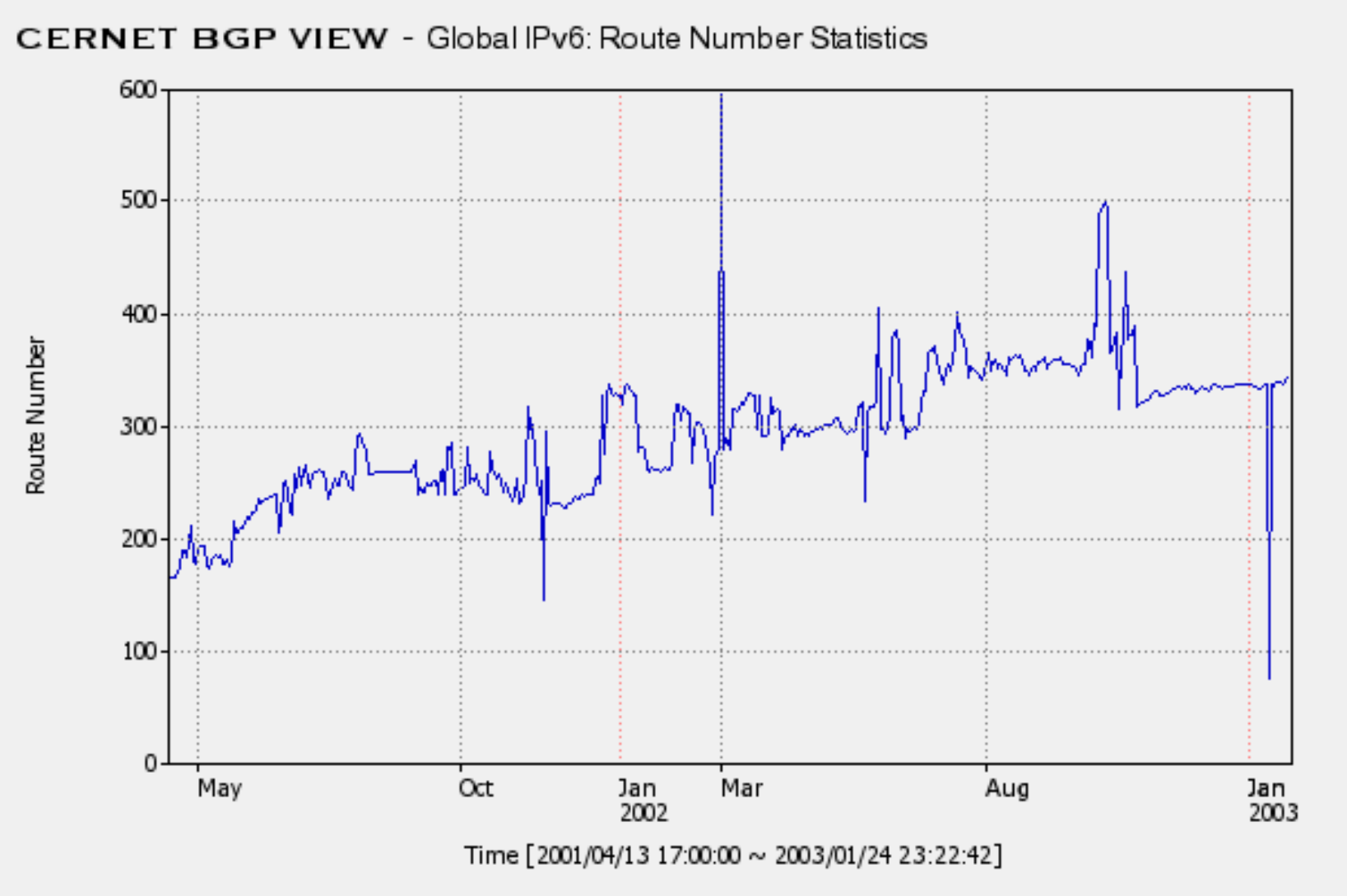
# IPv6 Embedded OS

| Chart 4 - Embedded OS support[13] | | |
|---|---|---|
| OS | Base OS product | IPv6 stack |
| 6Wind (Windriver) | Vxworks | 2002 |
| Elmic | Turb Treck | 2002 |
| Inria Rocquencourt | Netbsd, freebsd | Dev |
| Interpeak | Vxworks, OSE, Nucleus linux TCP/IP | 2001, 2003 |
| KAME | freebsd, netbsd, openbsd | 1998 |
| Linux | linux | 2000-2001 |
| Mentat TCP | VxWorks, ScoUnix | 1997 |
| Netsilicon | | Dev |

# IP Routing Software

| Chart 5 - OEM Routing Software support[15] | | | | |
|---|---|---|---|---|
| Routing Software | RIPng | MPBGP V6 | ISISv6 | OSPF v3 |
| NextHop GateD | 1999 | 2000 | 2000 | 2003 |
| IP Infusion | 2002 | 2002 | 2003 | 2002 |

# IPv6 Statistics



# IP v6 Traffic is emerging

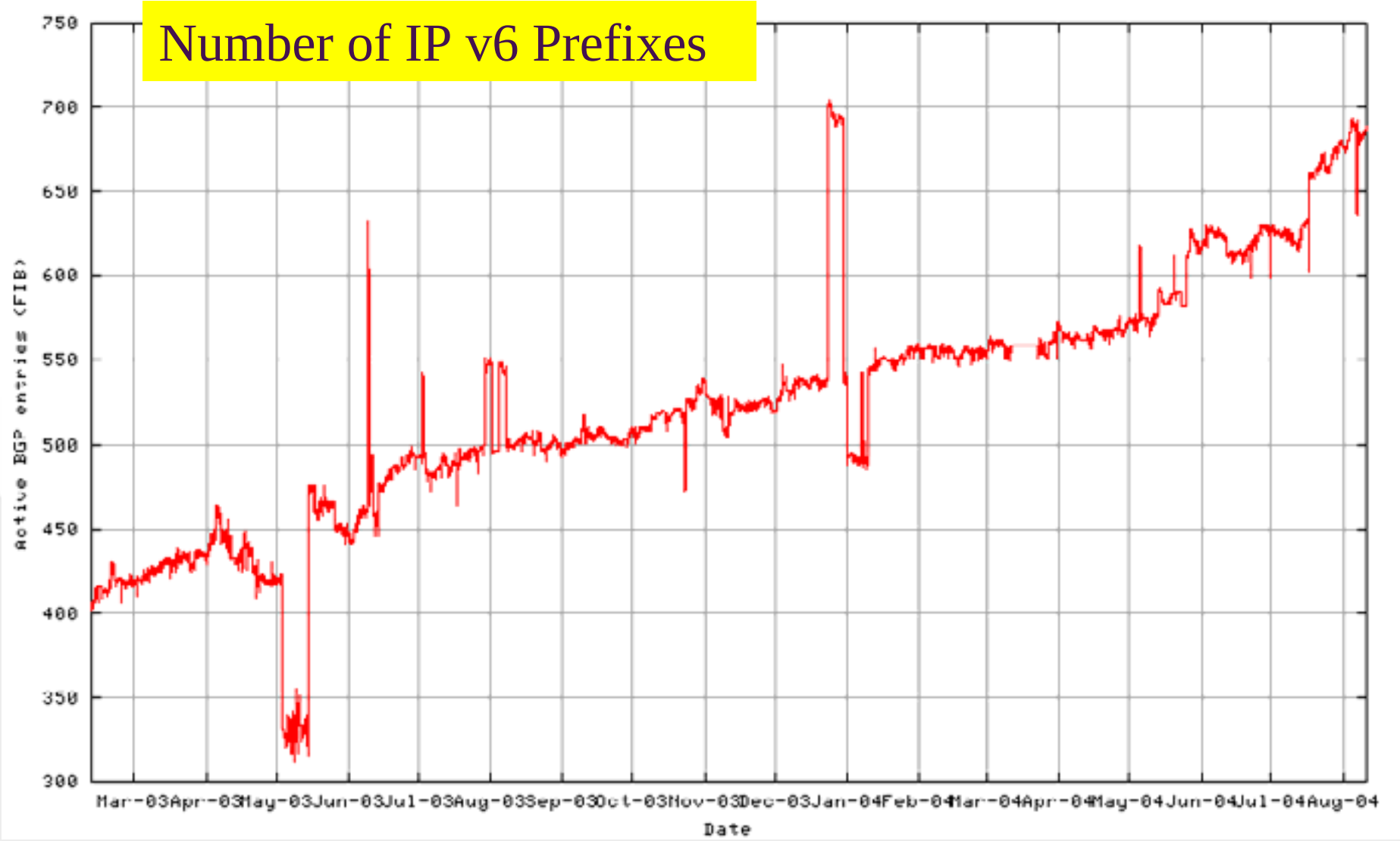
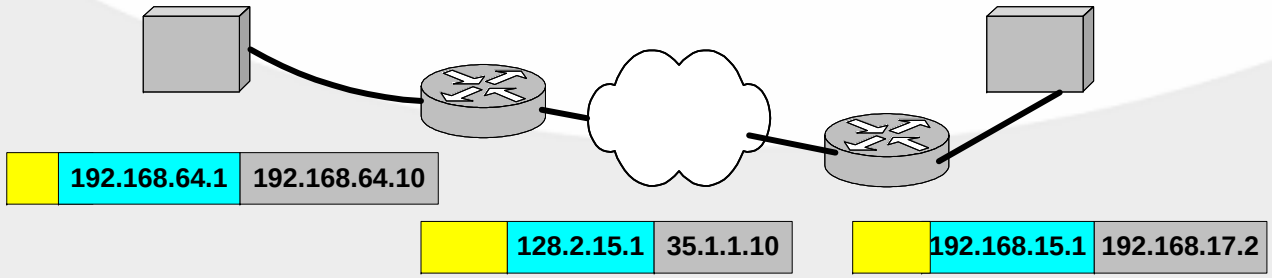



**Table from Telstra AS 1221**

# Forces That Impede IPv6's Growth

- Cost of retraining network operators for IPv6
- NAT –
  - Solves IP exhaustion but breaks end-to-end connectivity
  - Natural firewall, but impedes the entrance of new applications running over the network
  - Leads to host vendors taking lead in IPv6




NAT

# Disadvantages of NAT

- State in network
  - State in PIM, firewalls, RSVP – why not NAT?
- Slow and expensive encoding
  - Is this really true?
- Breaks applications
  - Many applications run over know http ports
- Breaks IP segmentation
  - IPv6 does away with segmentation
- Doesn’t allow open incoming connections
  - Is this problem or features?
- NAT incompatible protocols
  - SIP, IP-Sec, Mobile


# Does NAT harm the network?

- Proponents of NAT say
  - Client-server is ok under NAT
  - Peer-to-peer is not widely deployed

# Key Indicators to Watch for Change

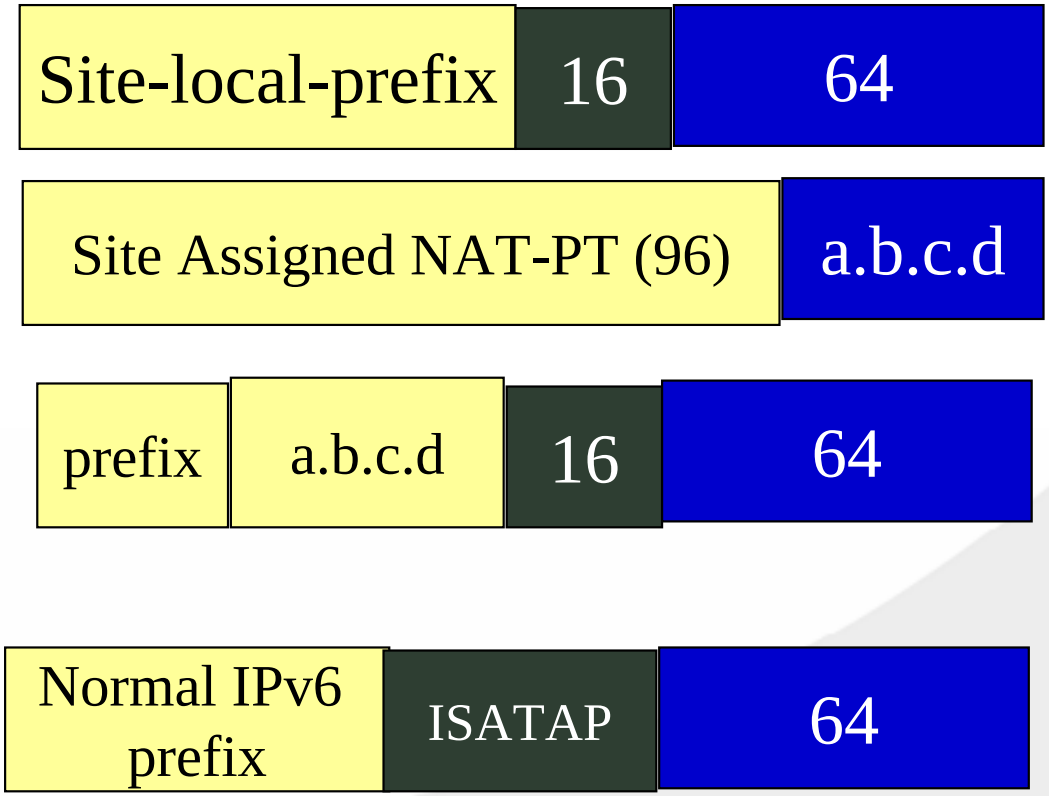
- Changes in rate of IPv4 address/route usage
  - Routes: bgp.pataroo.net
  - Addresses: www.arin.net
- Changes in the rate of IPv6 address/route usage
  - Routes: www.6bone.net, bgp.pataroo.net
  - Addresses: www.apnic.net
- Changes in IPv6 products shipped
- Increased frustration with NAT limitations

# Key Indicators to Watch for Change

- New technologies (cell phones, 802.11 usage)
- Geographical markets
  - Asia: China, Japan, India, Korea, Malaysia
- Killer applications built on IPv6 rising out of research groups
  - Internet2 (www.internet2.edu)
  - Wide (www.wide.ad.jp),
  - National Tsin-Hua University in China (www.cs.nthu.edu.tw)
  - ETRI in Korea (www.etri.re.kr, IPv6 status: http://www.6net.org/publications/presentations/lee-etri.pdf)
  - European IPv6 killer applications (watch RIPE (www.ripe.org) or Internet2 or Nordic universities)

# Deployment

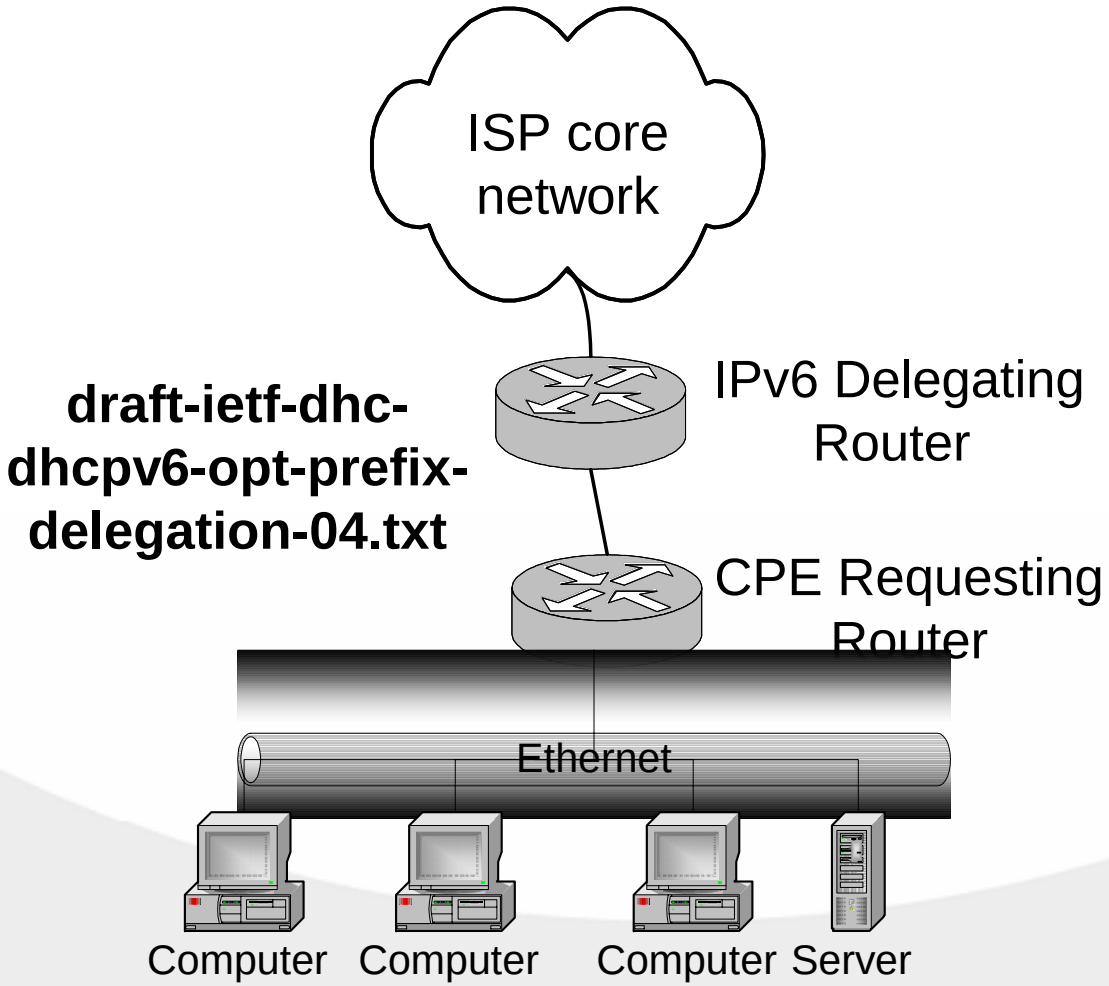
- What about the transition
  - Site local
  - Multiple address per host
  - NAT-PT v4-v6 translation
  - 6to4 global tunneling
  - ISATAP local auto-tunneling
- We'll come back to Teredo at the end



# Deployment Aids

- IPv6 address allocation
  - DHCPv6 prefix allocation
  - Solves IPv6 bootstrap
- Routing Registries have IP v6 for you
  - Can get Address and Routes
- Site local and link local addresses
- Multi-homing for IPv6

# IPv6 Delegation Software




**draft-ietf-dhc-dhcpv6-opt-prefix-delegation-04.txt**


# Q & A