Digital Communications II: IPv6

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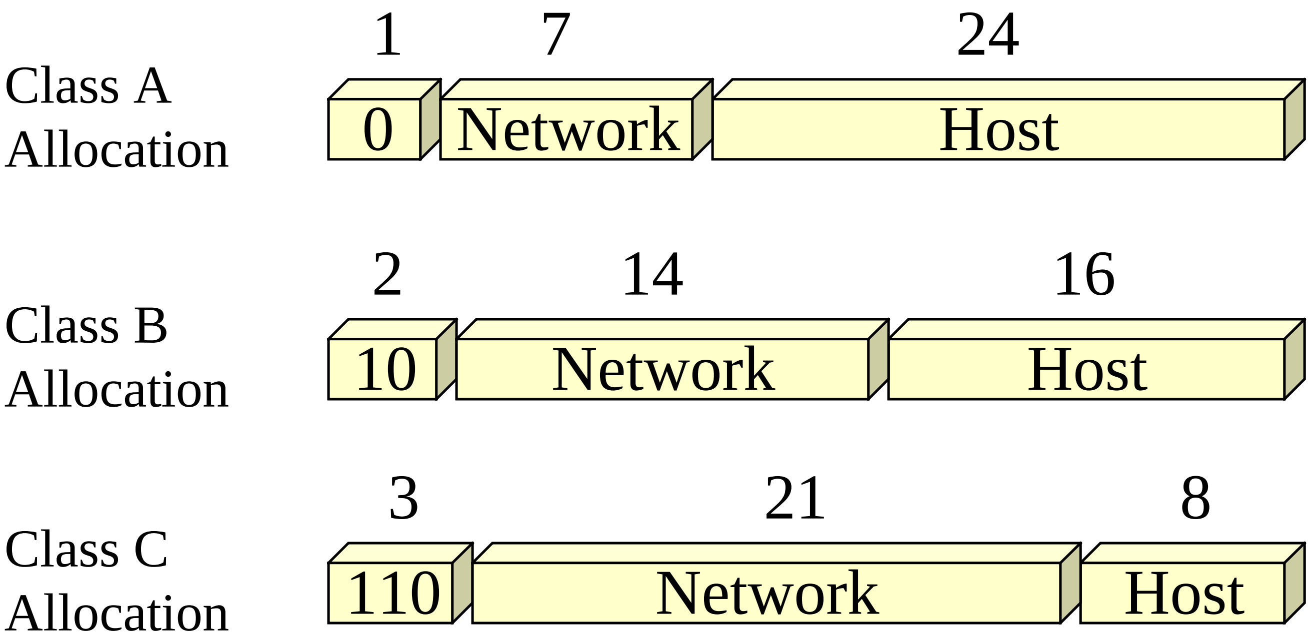
Outline

- What is wrong with IPv4
  - Some IPv4 technology
- Key differences in IPv6
  - Basic facts
  - Plus facts to understand …
  - Basic Principles

Problems with IPv4

- Address space running out
  - 32bits, poor density, growth
  - Mobile Phones
- Routeing tables getting too big
  - Core routers are default-free
  - Need an entry per network
  - Insufficiently hierarchical
- Difficulty of configuration

IPv4 Address structure

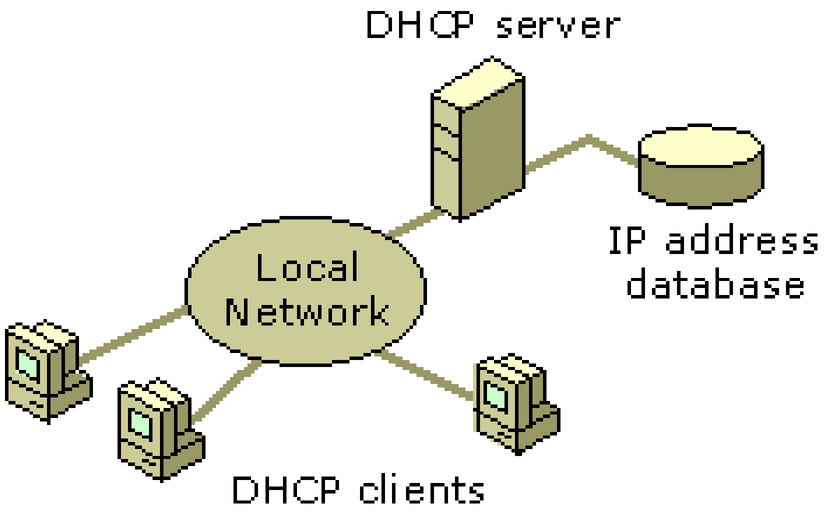


- 2^{21} means only two million organisations and core routers need to know about them all

Workarounds with IPv4

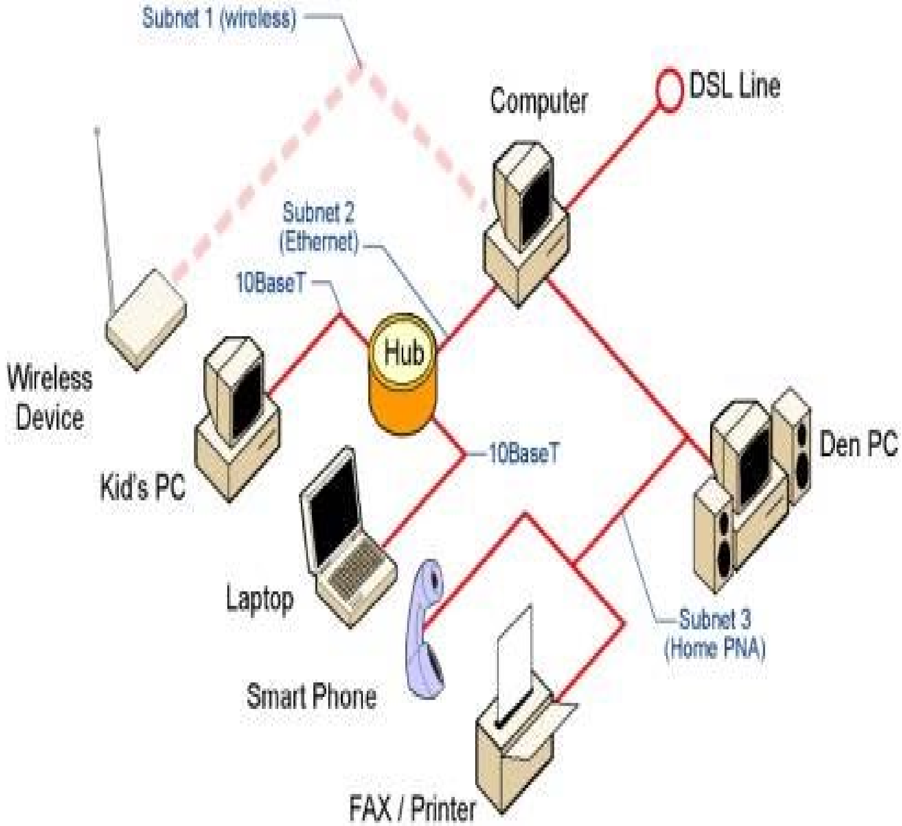
- RFC1918 private network addresses
  - 10/8, 172.16/12, 192.168/16
- CIDR (classless inter-domain routeing)
  - Too little too late. Consider JANET:
    - Single AS786. 237 different routeing entries
  - Still 70000+ routeing entries (see p65)
- NAT
- DHCP

DHCP in one slide



- Avoid static IP configuration
  - Assign dynamically
- Hosts request details
  - Identified by LL address
- Server replies
  - IP address and mask
  - Default router
  - DNS servers
  - Etc.
- IP address on lease
  - Client renews
- Naming Problems
  - Both DNS and SAP

NAT in one slide



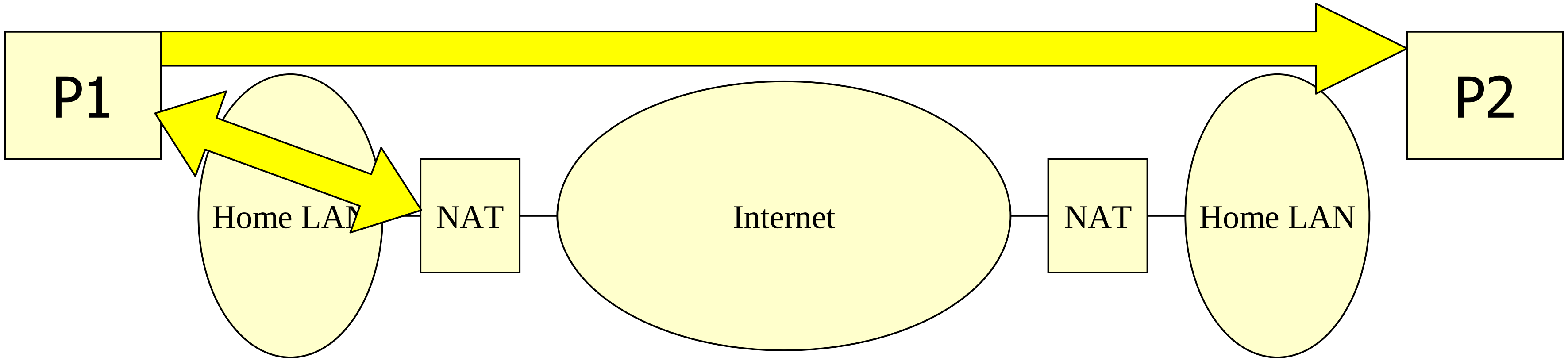
- DHCP+NAT = "Internet connection sharing"

- NAT box is gateway
  - It has a real address
  - Its address gets shared
- Translates:
  - (local,port) (its, port')
  - Maintains a mapping
  - Has to understand some protocols (ftp)
- Also APP level relay
  - Web proxy / cache
- Naming problems

Advantages of IPv6

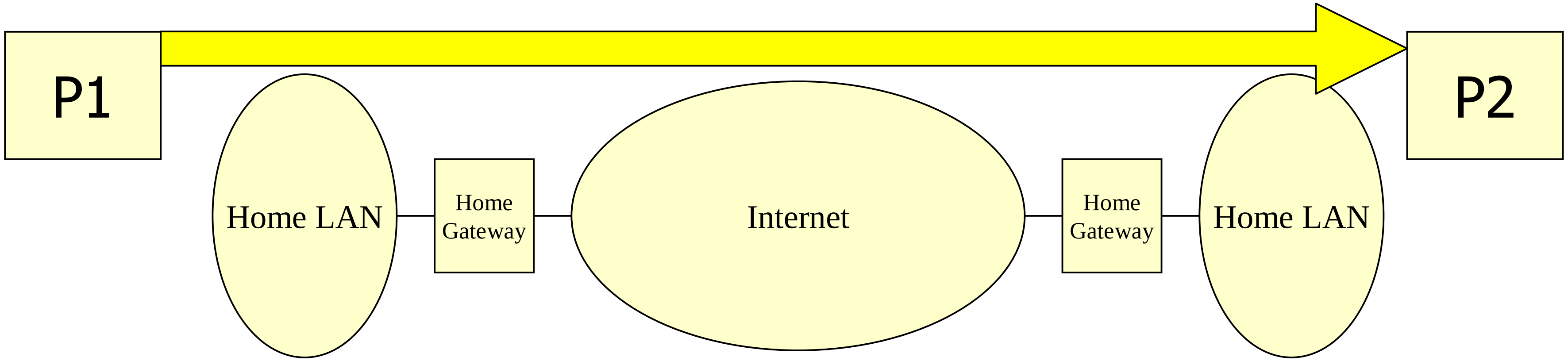
- Enormous address space: 128 bits
- Strict topology-based allocation
- More scaleable routeing
- Easier configuration
- Better security
- 15 years of experience

Problem 1: Peer-to-peer RTP audio example



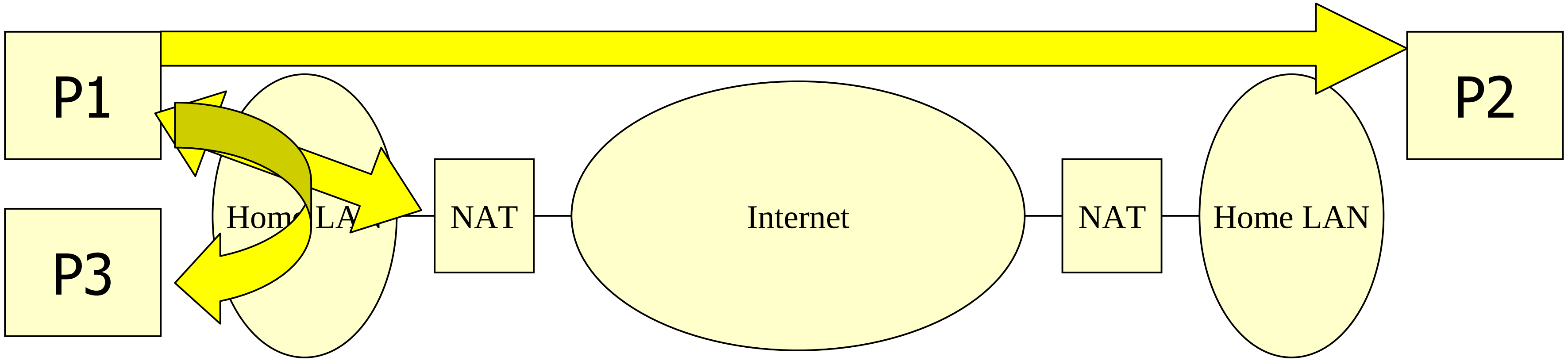
- With NAT:
  - Need to learn the address "outside the NAT"
  - Provide that address to peer
  - Need either NAT-aware application, or application-aware NAT
  - May need a third party registration server to facilitate finding peers

Solution 1: Peer-to-peer RTP audio example



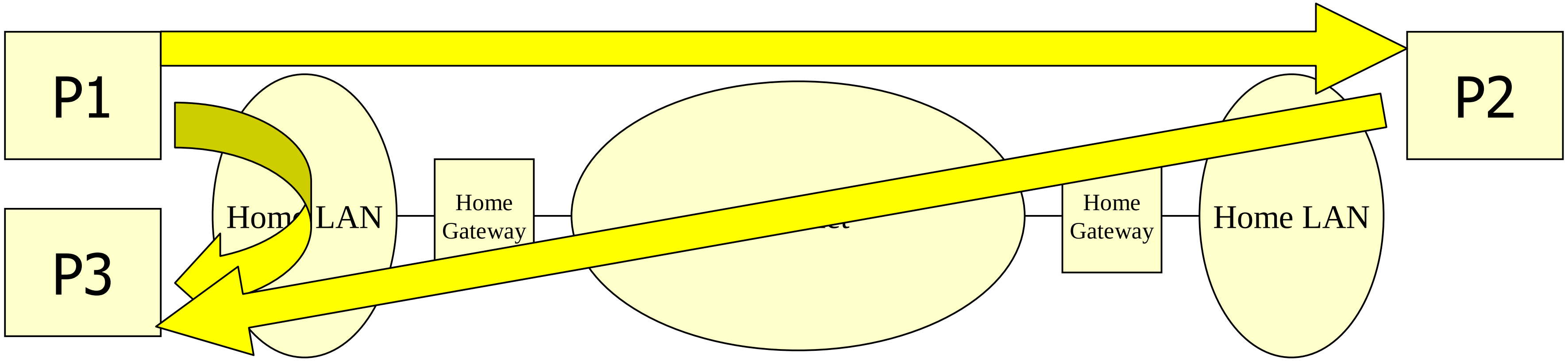
- With IPv6:
  - Just use IPv6 address

Problem 2: Multiparty Conference Example



- With NAT, complex and brittle software:
  - 2 Addresses, inside and outside
  - P1 provides "inside address" to P3, "outside address" to P2
  - Need to recognize inside, outside
  - P1 does not know outside address of P3 to inform P2

Solution 2: Multiparty IPv6 Conference Example



- With IPv6:
  - Just use IPv6 addresses

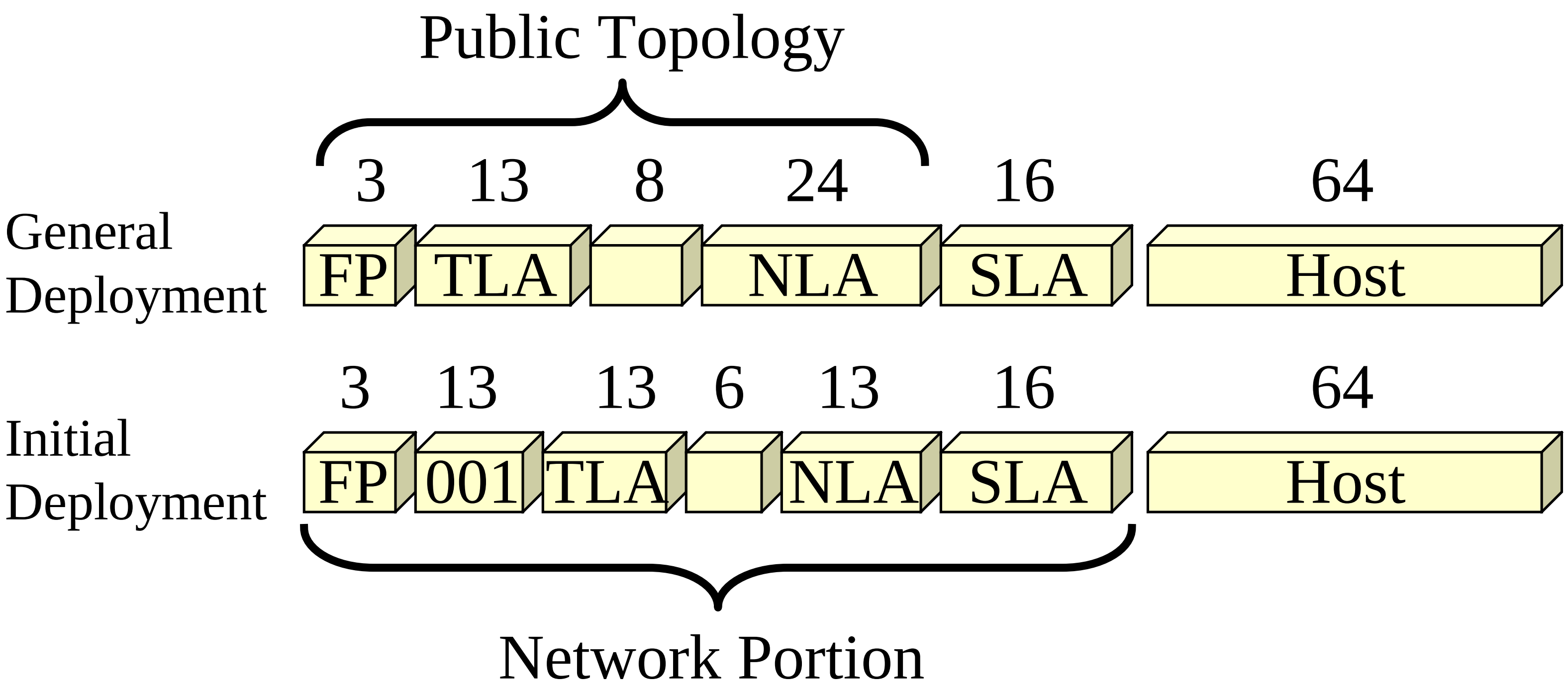
What does an address look like

- 128 bits broken up into 16 bit groups
  - Each 16 bit group written in hex
  - No 0x, remove leading zeros
  - Groups separated by ':' colon
- A single run of 0: entries elided with ::
- Last two groups allow IPv4 notation
- Heavy use of prefix '/' notation
  - 2001:618:1::2:2a0 ::/0
  - 2002:80e8:10:0:/64 fe80::/96

Topology-based allocation

- Network Service Providers get allocations from registries
  - Backbone routeing tables are small
- NSPs make allocations to ISPs
  - ISPs have small routeing tables
- ISPs make allocations to companies
  - Addresses depend on service provider
  - May have to change addresses with provider
  - Multi-provider sites need research

IPv6 Address structure



FP	Format Prefix	NLA	Next Level Aggregate
TLA	Top Level Aggregate	SLA	Site Level Aggregate

More scalable routeing

- There are more network bits
- But any router has only to look at a few
  - Usually only one of TLA or NLA or SLA
- Compare JANET again
  - One TLA for JANET
  - One NLA per institution
  - Institution uses SLA like current "subnets"

Packet Differences

- Designed to be easier on routers
  - Header is fixed size
  - No fragmentation at routers
- Extension headers
  - Either fixed size or have own length

Base Header	Extension Header 1	…	Extension Header N	Data

Base Header

<table>
<tr><td>vers</td><td>class</td><td colspan="3">flow label</td></tr>
<tr><td colspan="3">length</td><td>next</td><td>hop lim</td></tr>
<tr><td colspan="5">Source Address</td></tr>
<tr><td colspan="5">Destination Address</td></tr>
</table>

- Compare with IPv4 (page 3)
  - Bigger
  - Simpler
- Extension for anything else

Extension Headers

- Included in specific order
  - Hop by Hop
  - Destination (for intermediates)
  - Routing
  - Fragment
  - Authentication
  - Encapsulating Security Payload
  - Destination (for final destination)

Path MTU discovery

- Recommended in IPv4
- Necessary in IPv6
- Relies on “too big” ICMP
- Another example of “soft state”

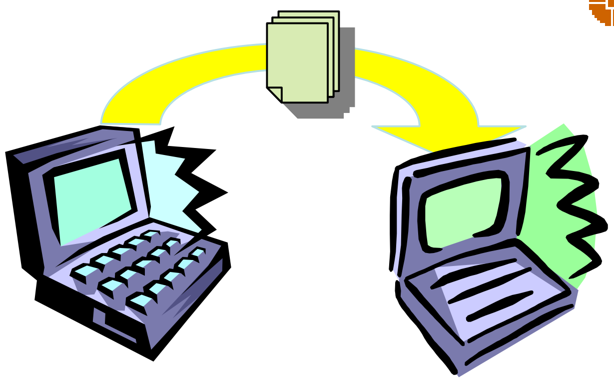
IPv6 Neighbour Discovery

- Replaces ARP, ICMP redirect etc.
- Used for:
  - Router discovery
  - Parameter and prefix discovery
  - Address resolution
  - Address auto-configuration
- Send Neighbour solicitation for ……:…x:yz to ff02::1:ff x:yz

Address auto-configuration

- Router advertises prefix (/64)
- Machines chose an address using MAC
- Look for duplicate before using
  - Send Neighbour solicitation for intended addr
- Also have link local addresses (fe80::)
- Possible privacy concerns
  - An advantage to NAT after all?
  - Work on anonymous addresses

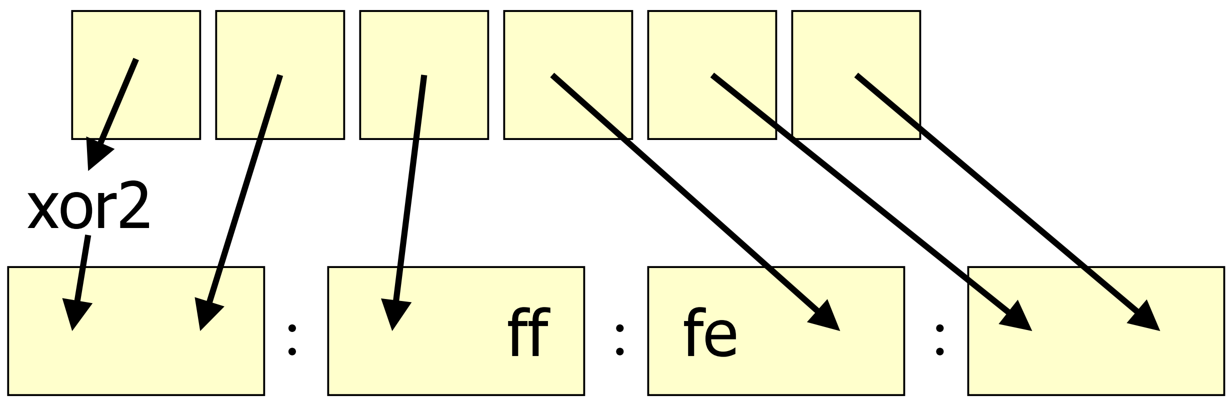
Problem 3: Ad-hoc networking



- IPv4: media lock + 63 sec.
  - Try DHCP
  - Wait for timeout
  - Select Link Local address
    - From 169.254/16
    - See draft-ietf-zeroconf-ipv4-linklocal
  - Conflict detect
- IPv6: media lock + 1 sec.
  - Configure using MAC
  - Conflict detect

IPv6 on Ethernet (802.2)

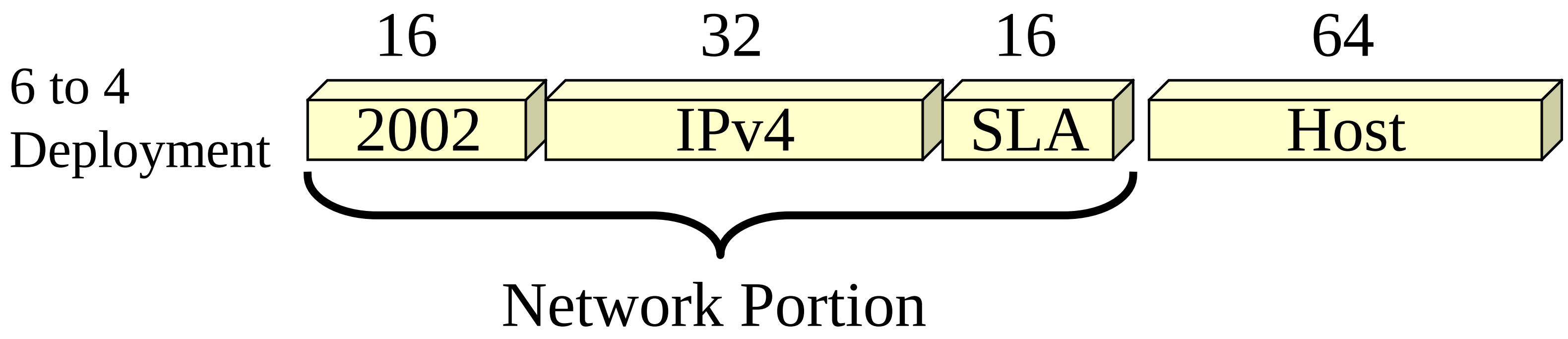
- New Ethernet type (0x86dd)
- IPv6 multicast packets FF……::wx:yz sent to Ethernet 33-33-w-x-y-z
- Auto-configuration from Ethernet address



Transition Mechanisms

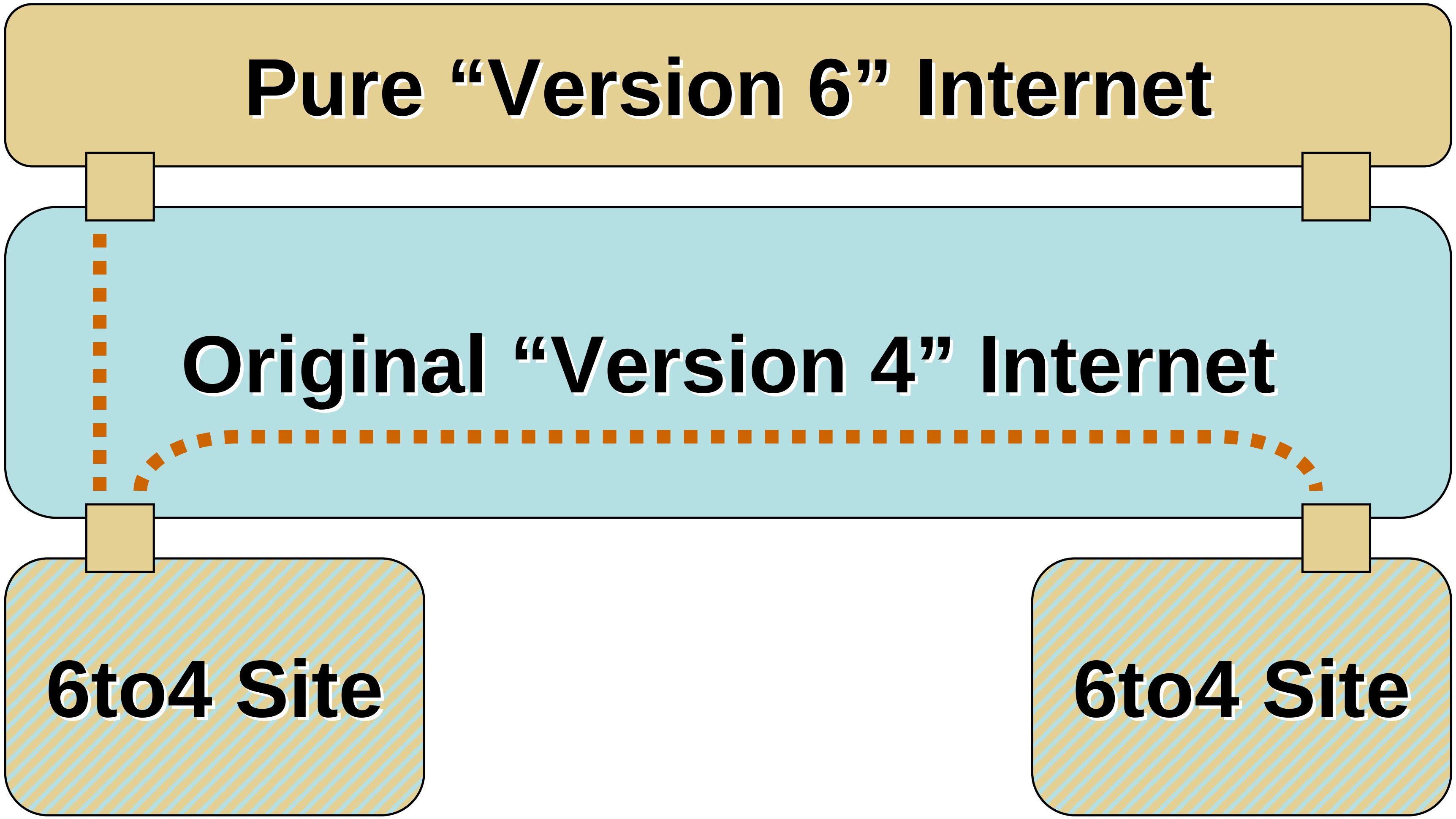
- Tunnel IPv6 over IPv4 (see p78)
- Static/Configured tunnels
  - Especially by ISPs and 6bone
  - Tunnel broker service
- 6over4
  - Use an IPv4 multicast enabled cloud as a single IPv6 link
- 6to4

6to4 Address allocation



- Stateless tunnel over the IPv4 network
  - Assume IPv4 address of "lower layer"
  - Entire campus fits behind one IPv4 address
  - No dependence on IPv6 core

A picture of 6to4



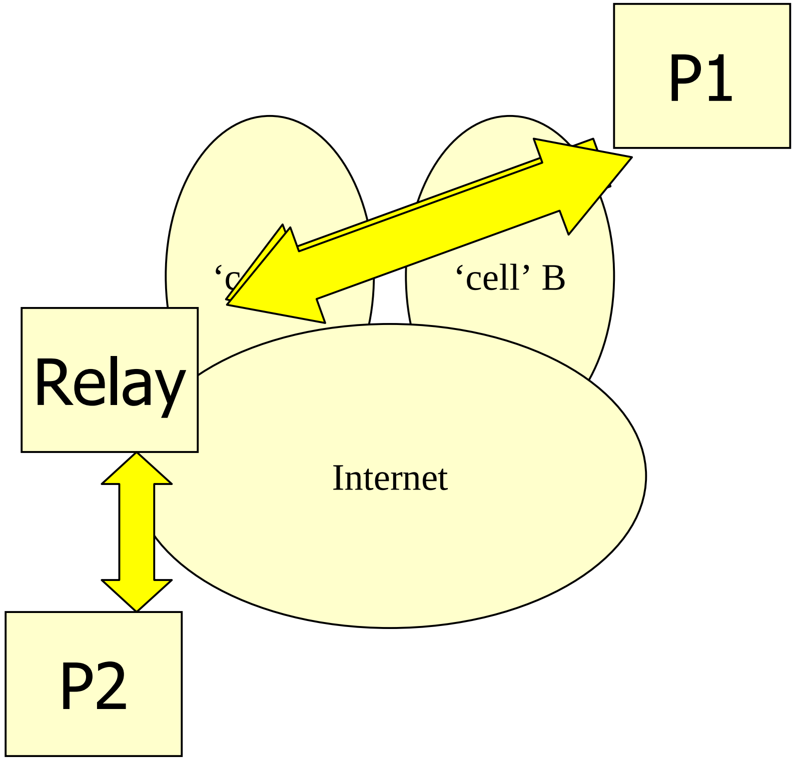
Mobile IP

- Each mobile host:
  - Has a unique permanent address
  - Adopts a "home agent" on home network
  - Sends location updates to agent.
  - Acquires "care-of address" on foreign networks
- Home agent:
  - Intercepts packets intended for mobile host
  - Forwards to mobile host's care-of-address

Mobile IPv6

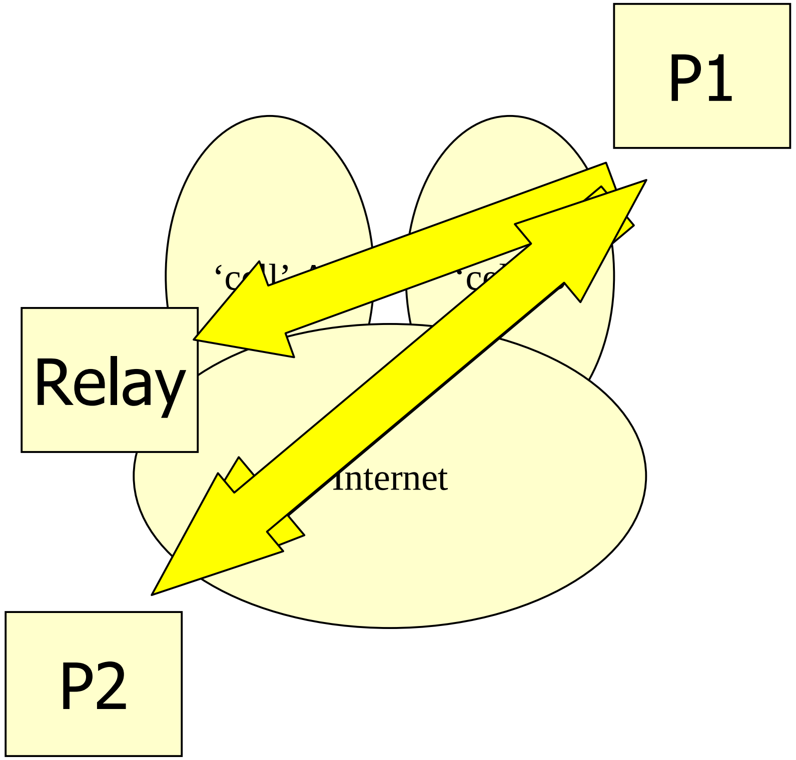
- Less complex than Mobile IPv4
  - Requires ***NO EXTRA FUNCTIONALITY*** in off site routers
- Reuses many standard IPv6 services
- Improved support for low latency handoff
  - Stateless Address Configuration
- Fast convergence to optimal route
- Improved security/authentication mechanisms

Problem 4: Move from "cell" to "cell"



- IPv4:
  - Tell server,
  - Packets are relayed through the server

Solution 4: Move from "cell" to "cell" with IPv6



- IPv6:
  - Tell server + peer
  - Packets take direct path

Where to Get More Information

- http://www.microsoft.com/windows2000/library/technologies/communications/
- http://msdn.microsoft.com/downloads/sdks/platform/tpipv6.asp

The End

Overview

- Give the big picture of the subject
- Explain how all the individual topics fit together