Chapter5 Network Layer(8)

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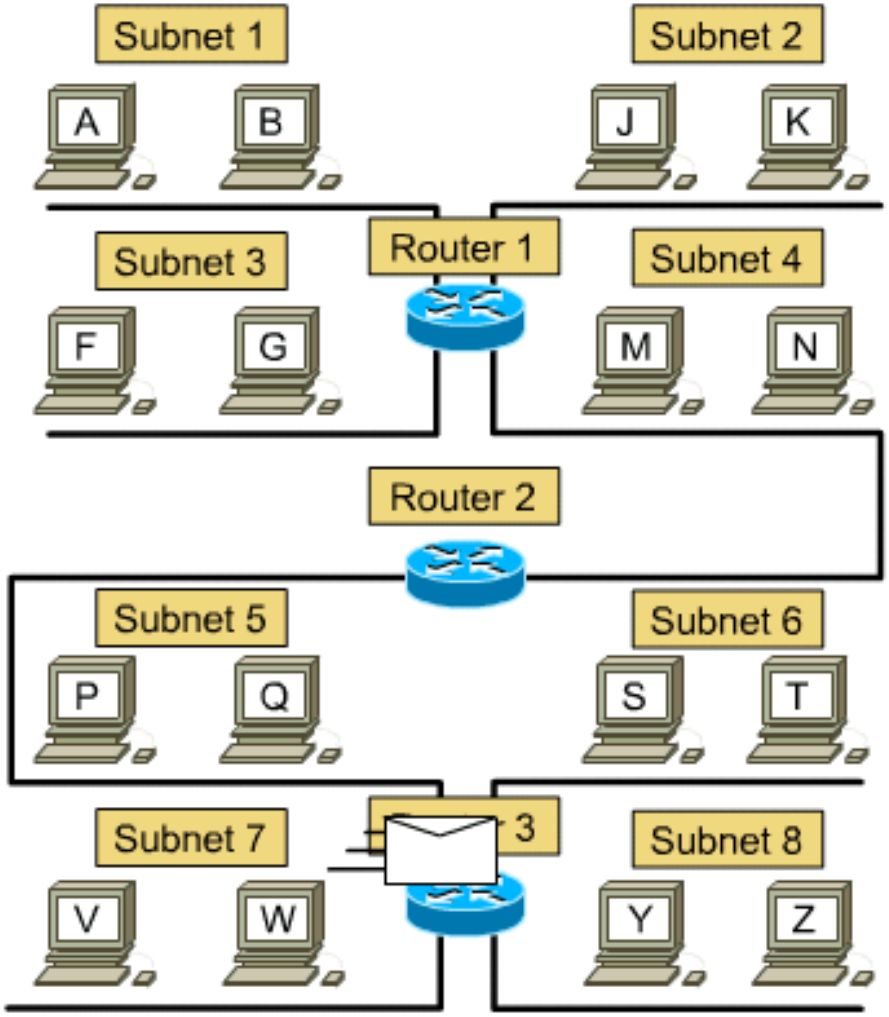
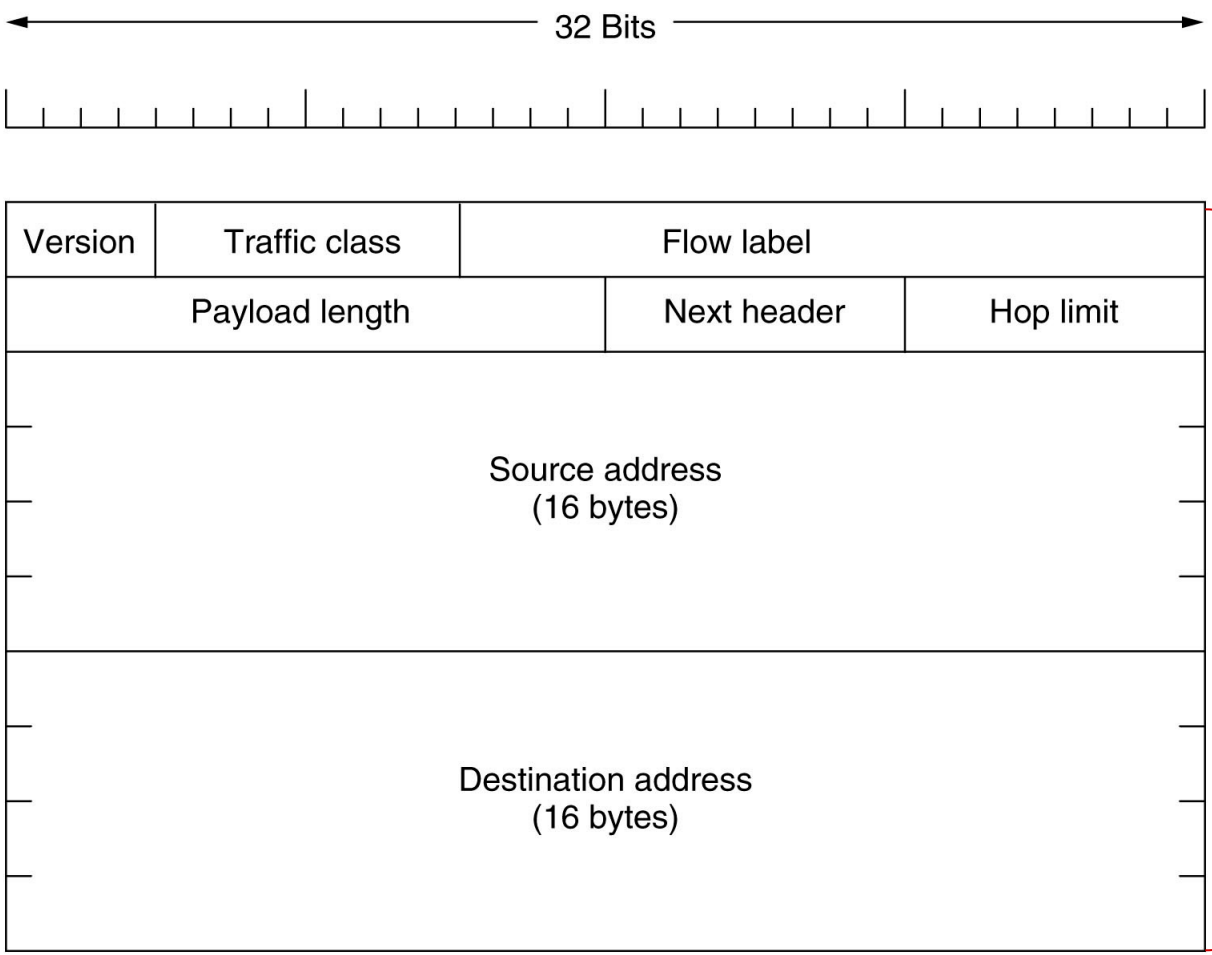
How a packet go from A to Z ?



IPv6

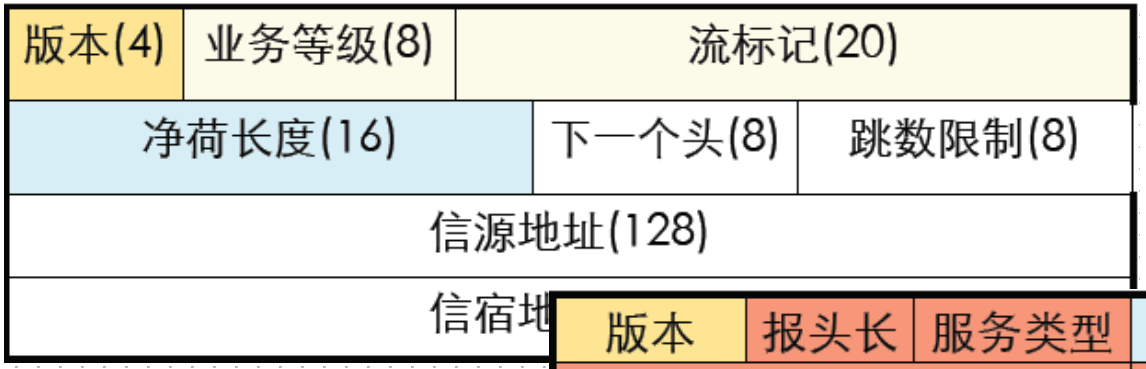
- CIDR and NAT may "buy" a few more years, but the days of IPv4 are numbered (shortage problem).
- In 1990, IETF started work on a new version of IP with the following goals:
  - Support billion of hosts
  - Reduce the size of the routing tables
  - Simplify the protocol, to allow routers to process faster
  - Provide better security (auth and privacy) than IPv4
  - Pay more attention to type of service (for real time data)
  - Aid multicasting (by allowing scopes to be specified)
  - Make roaming possible without change of address
  - Allow protocol expansion
  - Permit the old and new protocols to coexist for years

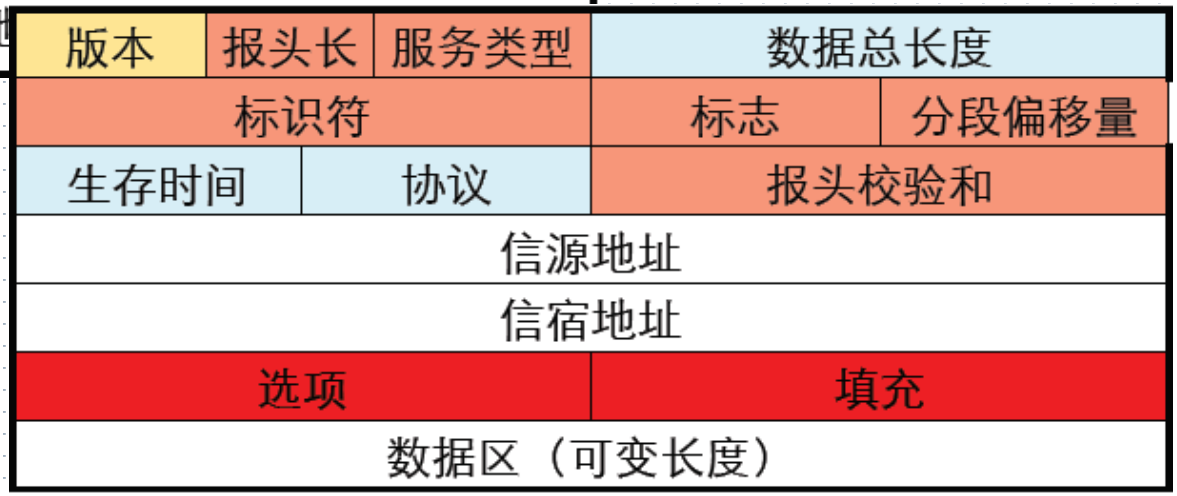
Main IPv6 Header



IPv6分组格式

- IPv6 的报头在起始64比特之后是128比特的源地址和目的地址，全长为40字节。





报头变化小结

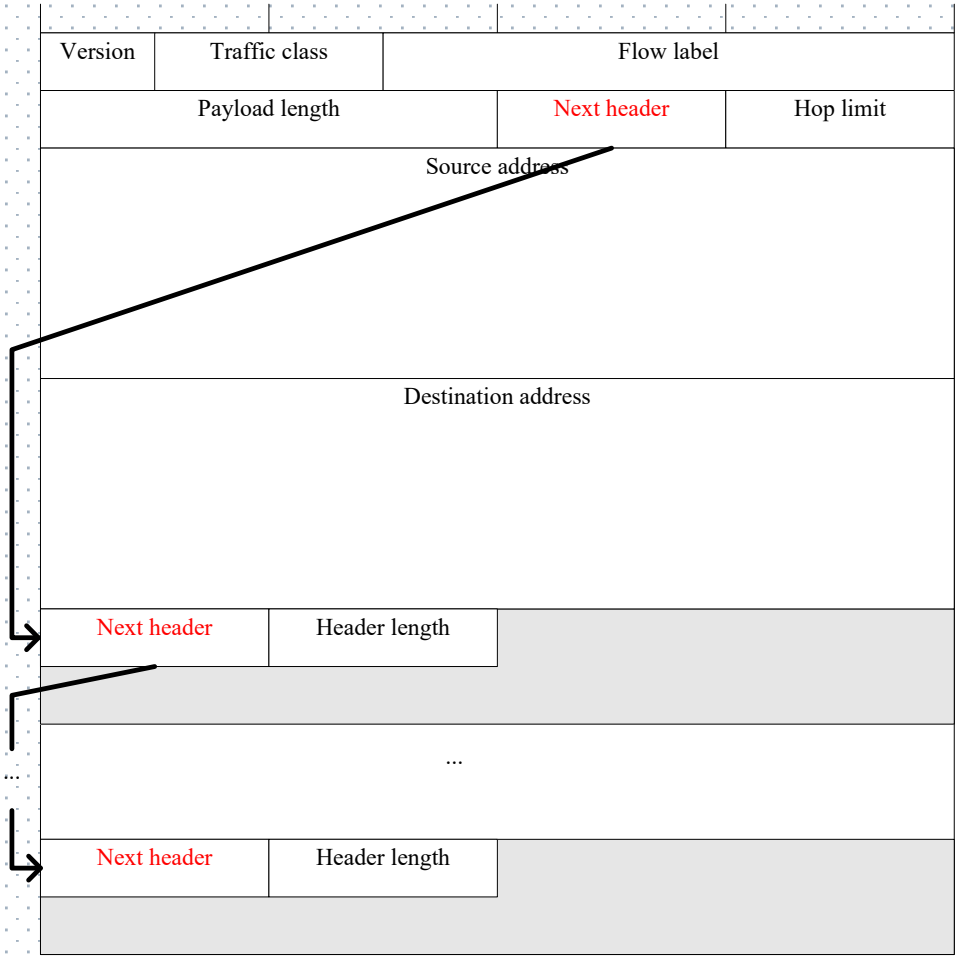
- Revised
  - Addresses increased 32 bits -> 128 bits
  - Time to Live -> Hop Limit（跳数限制）
  - Protocol -> Next Header
  - Type of Service -> Traffic Class（流量类别）
- Streamlined
  - Fragmentation fields moved out of base header(主头部)
  - IP options moved out of base header
  - Header Checksum eliminated
  - Header Length field eliminated
  - Length field excludes IPv6 header
- Extended
  - Flow Label field added

Ipv6 Extension Headers

- Six kinds of extension headers are defined at present.
- Each one is optional, but if more than one is present, they must appear directly after the fixed header, and preferably in the order listed.
- Some extension headers have a fixed format
- Other headers contain a variable number of variable-length fields.
  - Each item is encoded as a (Type, Length, Value) tuple.

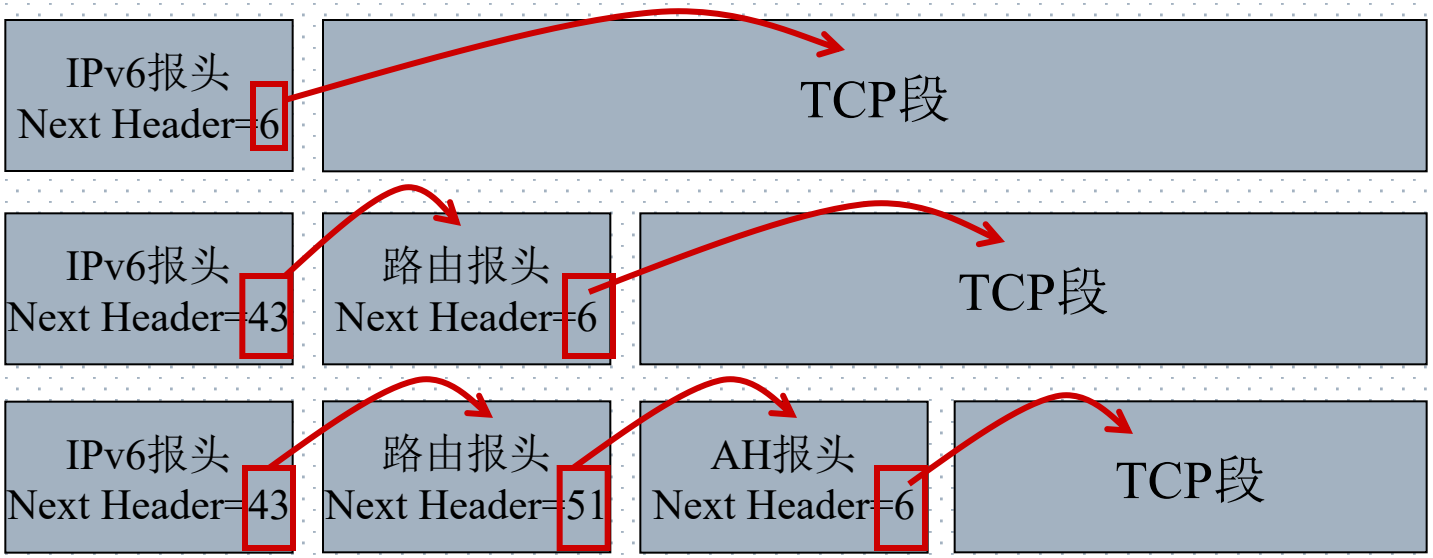
Extension header	Description
Hop-by-hop options	Miscellaneous information for routers
Destination options	Additional information for the destination
Routing	Loose list of routers to visit
Fragmentation	Management of datagram fragments
Authentication	Verification of the sender's identity
Encrypted security payload	Information about the encrypted contents

Ipv6 Extension Headers



基本报头、扩展报头和上层协议的关系

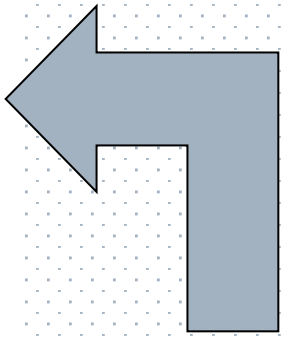
- 每一种扩展报头其实也有自己特定的协议号，例如：路由报头为43，AH报头为51
- 每一个基本报头和扩展报头的protocol字段标识后面紧接的内容



来个真的！

```
⊟ Ethernet II, Src: 00:0d:56:6d:6f:fc, Dst: 00:e0:fc:06:7a:d8
    Destination: 00:e0:fc:06:7a:d8 (HuaweiTe_06:7a:d8)
    Source: 00:0d:56:6d:6f:fc (DellPcba_6d:6f:fc)
    Type: IPv6 (0x86dd)
⊟ Internet Protocol Version 6
    Version: 6
    Traffic class: 0x00
    Flowlabel: 0x00000
    Payload length: 40
    Next header: ICMPv6 (0x3a)
    Hop limit: 128
    Source address: 1::7146:ab89:3e23:e38c
    Destination address: 1::1
⊟ Internet Control Message Protocol v6
    Type: 128 (Echo request)
    Code: 0
    Checksum: 0x9675 (correct)
    ID: 0x0000
    Sequence: 0x0001
    Data (32 bytes)
```

- 一个IP V6数据包



```
00 e0 fc 06 7a d8 00 0d  56 6d 6f fc 86 dd 60 00
00 00 00 28 3a 80 00 01  00 00 00 00 00 00 71 46
ab 89 3e 23 e3 8c 00 01  00 00 00 00 00 00 00 00
00 00 00 00 00 01 80 00  96 75 00 00 00 01 61 62
63 64 65 66 67 68 69 6a  6b 6c 6d 6e 6f 70 71 72
73 74 75 76 77 61 62 63  64 65 66 67 68 69
```

IPv6的最显著变化—地址空间

- IPv4：$2^{32}=4\times10^{9}$（约40亿）
- IPv6地址空间：
  - $2^{128}=3.4\times10^{38}$
  - 340,282,266,920,938,463,463,374,607,431,768,211,456
  - 每平方厘米2.2×1020个地址
  - 夸张地说，世界上每一粒沙子都可以分到一个IP地址

IPv6地址表示（1/3）

00100000000000010000100000100000000000000000000000000000000000001
00000000000000000000000000000000000000000000000100010111111111

0010000000000001 0000010000010000 0000000000000000 0000000000000001
0000000000000000 0000000000000000 0000000000000000 0100010111111111

2001:0410:0000:0001:0000:0000:0000:45ff

2001:410:0:1:0:0:0:45ff

2001:410:0:1::45ff

IPv6地址表示（2/3）

- v6地址与v4地址表示方法有所不同
  - 点分十进制 → 冒分十六进制
  - 用十六进制表示，如： FE08:….
  - 4位一组，中间用“:”隔开，如：2001:12FC:….
  - 若以零开头可以省略，全零的组可用“::”表示，如： 1:2::ACDR:….
  - 地址前缀长度用“/xx”来表示，如： 1::1/64

IPv6地址表示（3/3）

- 以下是同一个地址不同表示法的例子：
  - 0001:0123:0000:0000:0000:ABCD:0000:0001/96
  - 1:123:0:0:0:ABCD::1/96
  - 1:123::ABCD:0:1/96

IPv6地址分类

- 单播地址（Unicast Address）
- 组播地址（Multicast Address）
- 任播地址（Anycast Address）
- 特殊地址

地址类型	二进制前缀	IPv6标识
未指定	00...0 (128 bits)	::/128
环回地址	00...1 (128 bits)	::1/128
组播	11111111	FF00::/8
链路本地地址	1111111010	FE80::/10
网点本地地址	1111111011	FEC0::/10
全局单播	（其他）	

单播地址

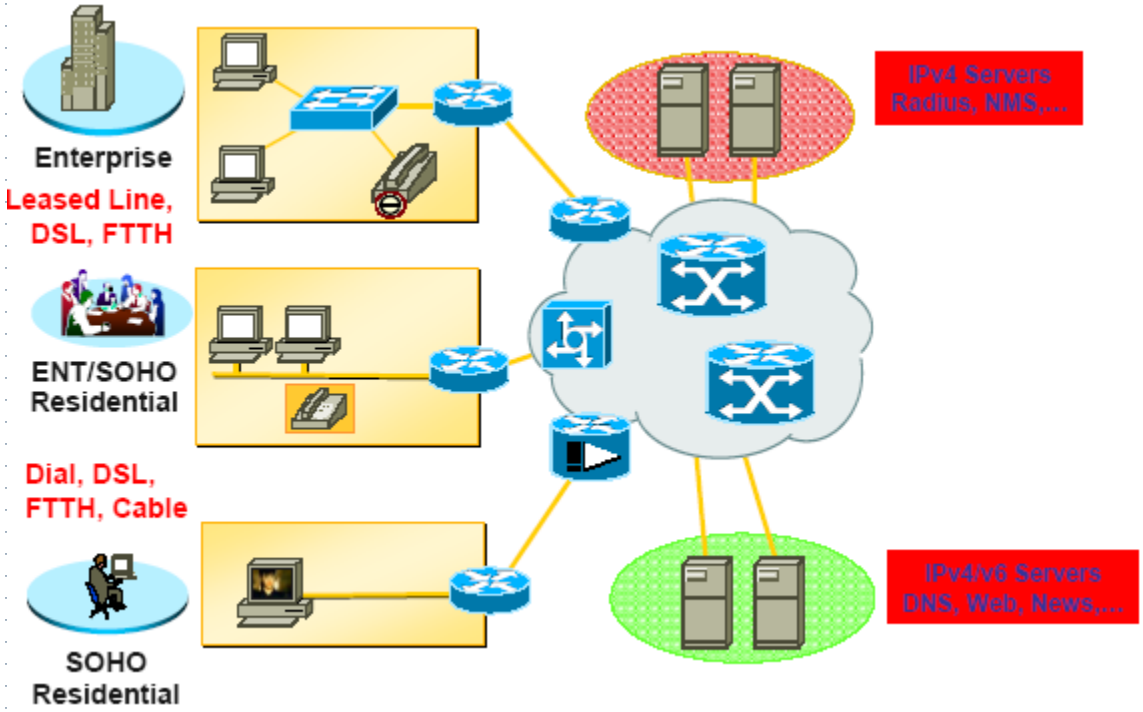
- 链路-本地（Link- Local）
  - 用在单一链路上
  - 带有链路-本地源或目的地址的数据包不转发到其它链路
  - 如：FE80：：20C：76FF：FE0A：9A7C
- 站点-本地（Site- Local）
  - 用于单一站点
  - 带有站点-本地源或目的地址的数据包不转发到其它站点
  - 应用与RFC 1918 类似
  - 如：FEC0：：20C：76FF：FE0A：9A7C
- 全球 （Global）
  - 全球唯一地址
  - 带有全球地址的数据包可被转发到全球网络的任何部分
  - 如：3FFE：321F：0：CE：：1

共存策略、迁移技术

- 共存策略
  - 短时期内从IPv4迁移到IPv6几乎是不可能的
  - IPv6在IPv4的基础上进行改进，在一定的时间内，IPv6将和IPv4共同存在共同运行。
- 问题：
  - 解决IPv6网络的成熟与稳定
  - 解决IPv6网络与IPv4的网络之间通信的问题。
- 两种基本技术（RFC1933）：
  - 双协议栈（Dual Stack）
  - 隧道（Tunnel）

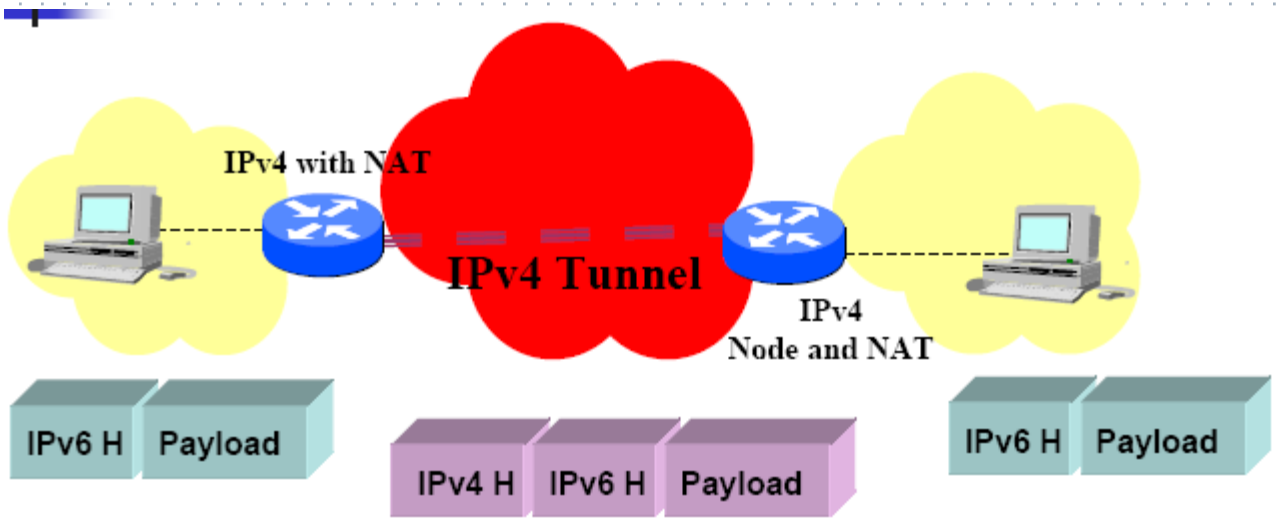
IPv4向IPv6的过渡—双协议栈

- 网络设备、网络系统必须有双协议栈的支持



IPv4向IPv6的过渡—隧道技术

- 通过隧道，IPv6分组被作为无结构无意义的数据，封装在IPv4的数据报中，被IPv4网络传输



本节小结

- IPv6的好处
- IPv6协议
  - IPv6地址
  - IPv6分组
- IPv6现状

thanks !