ETH
Eidgenössische Technische Hochschule Zürich
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New Internet Architectures

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Distributed Computing Seminar

Motivation

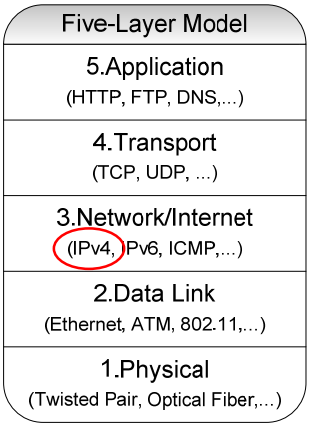
Outline

- **Motivation**
- **Problems with IPv4**
- **Network Address Translation**
- **Improving NAT and IPv4**
  - **NAT extensions**
  - **Content Routing**
- **IPv6**
- **Summary**

IPv4

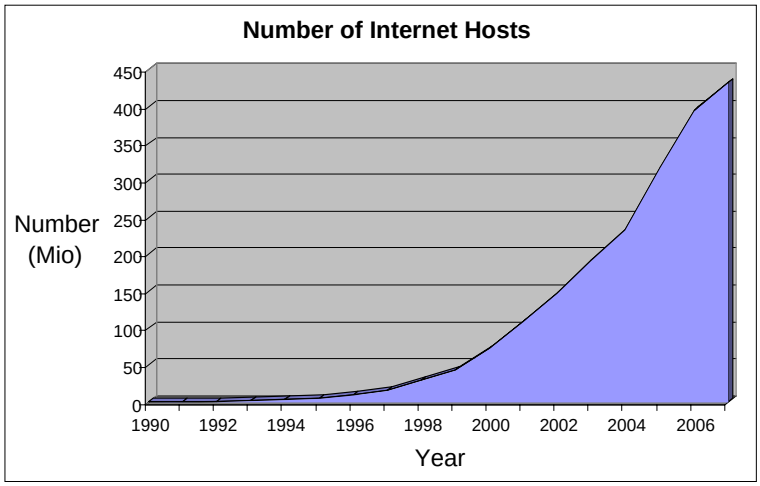
- **Widely deployed**
- **Best effort protocol**
- **Adressing**
  - **32-bit addresses (4 byte)**
  - **~ 4 billion unique addr.**

129.132.46.11



- **First: classful networking**
- **Later: CIDR (e.g. 129.132.0.0 / 16)**

Exhaustion of IPv4 address space (1)



- July 2007: 480.774.269 hosts
- IANA pool exhausted by 2010

Main problem: Address space too small

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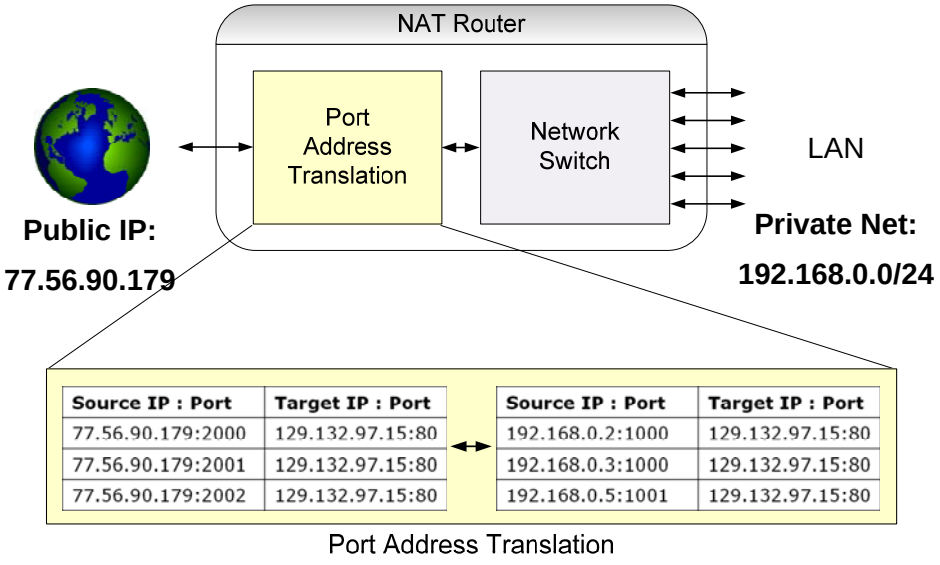
Network Address Translation



Source IP : Port	Target IP : Port	Source IP : Port	Target IP : Port
77.56.90.179:2000	129.132.97.15:80	192.168.0.2:1000	129.132.97.15:80
77.56.90.179:2001	129.132.97.15:80	192.168.0.3:1000	129.132.97.15:80
77.56.90.179:2002	129.132.97.15:80	192.168.0.5:1001	129.132.97.15:80

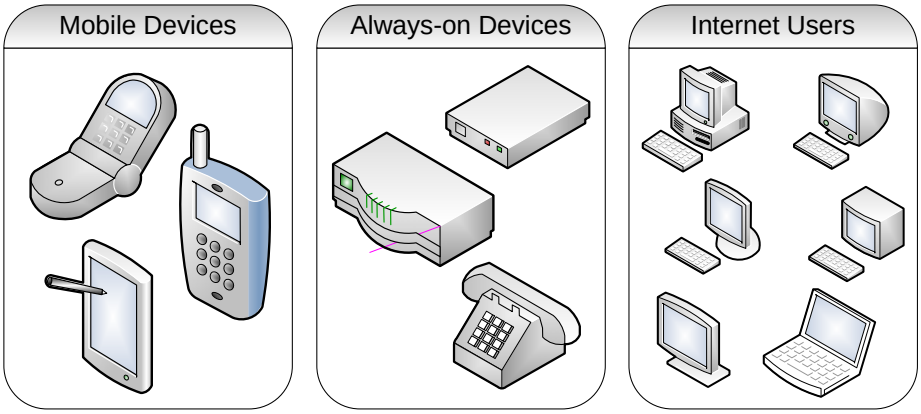
Port Address Translation

Evaluation of NAT

- **Benefits**
  - Way to deal with address shortage
  - Adds security
  - No end-to-end connectivity
  - Isolation of site's space from global space
- **Drawbacks**
  - Violates end-to-end semantics
  - Application gateways required e.g. for FTP
  - Complicates structuring of Internet applications
  - Slowed acceptance of IPv6

Why something new ?

Several driving forces for other solution:



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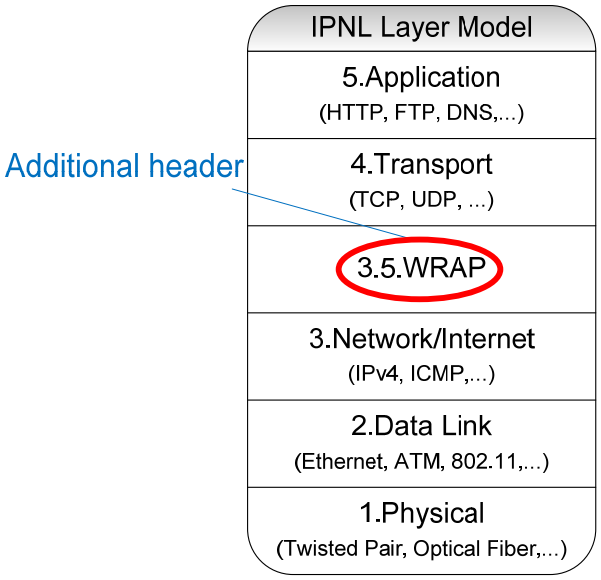
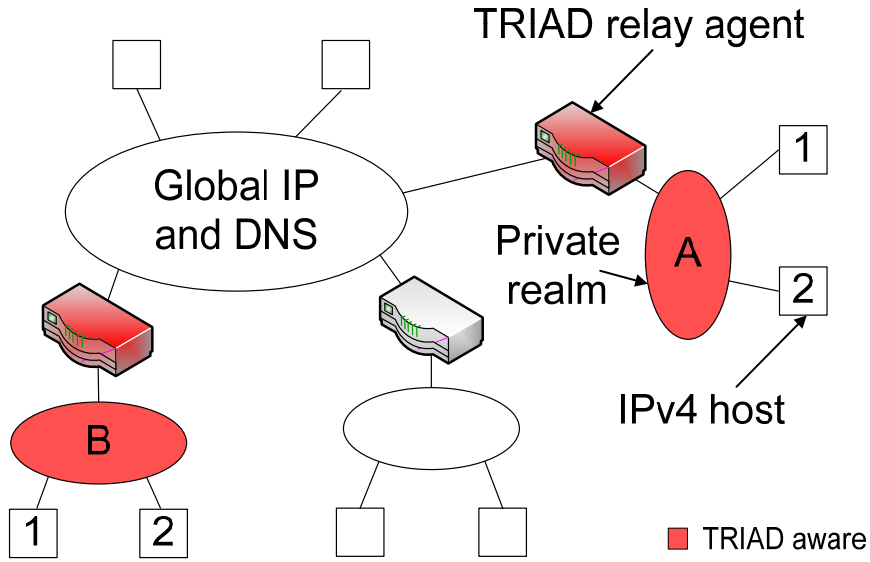
TRIAD: NAT-based Internet Architecture (1)



- **Routing by**
  - **FQDN only**

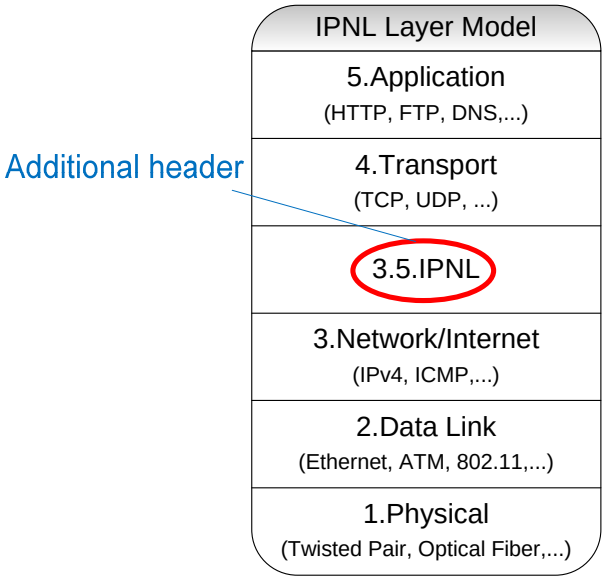
TRIAD: NAT-based Internet Architecture (2)



TRIAD: NAT-based Internet Architecture (3)

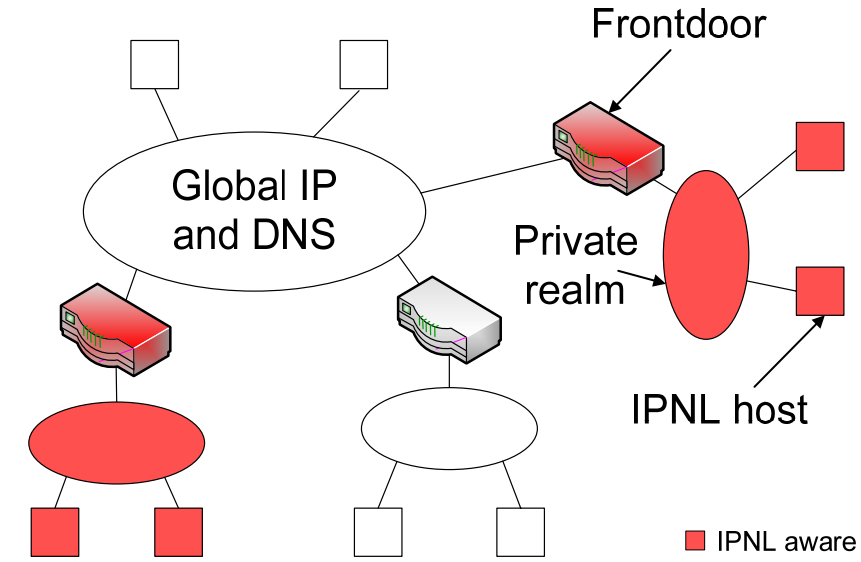
- **General characteristics of TRIAD**
  - Adds named based “shim” protocol over IPv4 called WRAP
  - Depends on DNS
  - No changes to DNS and global addressing
  - Modifies NAT box only
- **Features of TRIAD**
  - Only FQDN utilization for host identification
  - Extended IP address space
  - Isolates site addressing from global connectivity
  - Only NAT box needs a public IP address
  - End-to-end semantics of TRIAD enabled hosts

IPNL: NAT-Extented Internet Architecture (1)



- **Routing by**
  - FQDN
  - IPNL address

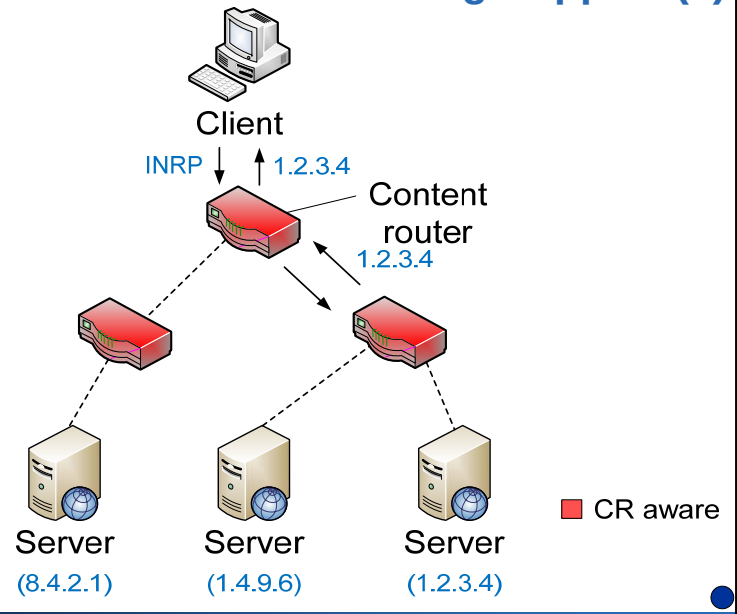
IPNL: NAT-Extented Internet Architecture (2)



IPNL: NAT-Extented Internet Architecture (3)

- **General characteristics of IPNL**
  - **Adds an additional layer**
  - **Depends on DNS**
  - **No changes to DNS and global addressing**
  - **Modifies both hosts and NAT box**
- **Features of IPNL**
  - **Utilizes FQDN and IPNL addresses for host identification**
  - **Extended IP address space**
  - **Isolates site addressing from global connectivity**
  - **Only Frontdoor router needs a public IP address**
  - **End-to-end semantics of IPNL enabled hosts**

Architecture for Content Routing Support (1)



Architecture for Content Routing Support (2)

- **General characteristics**
  - Adds Internet Content Layer
  - Based on name-based routing
  - Faster than basic approach based on plain DNS lookups
  - Network integrated content routing
- **Features**
  - Efficient content location to reduce round-trip latency
  - Avoids congested points in the network
  - Content routers act as IP routers and name servers
  - “anycast” capability
  - Name-based routing (NBRP), similar to BGP

Comparison of alternative architectures (1)

- **Purpose**
  - TRIAD: enhance NAT with end-to-end semantics
  - IPNL: enhance NAT with end-to-end semantics
  - CR: reduce time to access content
- **Estimation of the authors**
  - TRIAD: TRAID eliminates need for painful IPv6
  - IPNL: rather late, not elegant, not to supplant IPv6
  - CR: we would like to replace current DNS by INRP
- **Changes in IPv4 and NAT architecture**
  - TRIAD: NAT boxes only
  - IPNL: hosts and NAT boxes
  - CR: routers in core of the Internet, replace DNS !

Comparison of alternative architectures (2)

- **Technique**
  - TRIAD: adds new layer above IPv4
  - IPNL: adds new layer above IPv4
  - CR: network integrated content routing
- **Addressing**
  - TRIAD: FQDNs as end-to-end host identifier
  - IPNL: FQDNs or IPNL addresses as identifier
  - CR: name-based
- **Possible problems**
  - TRIAD: globally distributes routes, does not scale
  - IPNL: depends on DNS. Security ? Performance ?
  - CR: changes in the core of the Internet and DNS

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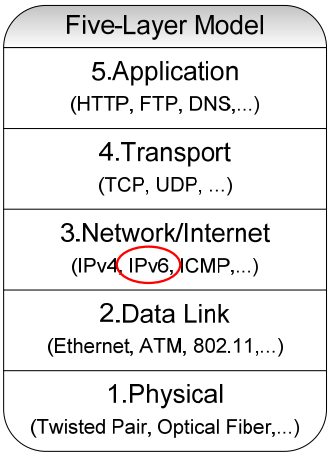
IPv6

- Much larger address space
  - Supports 2^{128} or 3.5×10^{38} addresses (instead 4.3×10^{9})
  - Gives 5×10^{28} addresses for each of the 6.5 billion people
- Some additional features
  - Autoconfiguration of hosts
  - Multicast
  - Jumbograms
  - Network-layer security
  - Mobility



IPv6 addressing

- Different kinds of addresses
  - Unicast addresses
  - Multicast addresses
  - Anycast addresses
- Notation
  - Written as eight groups of four hex digits, e.g.
    2001:0db8:0000:0000:0000:0000:1428:57ab
  - Zeros may be replaced with two colons (::)
    2001:0db8::1428:57ab

Transition from IPv4 to IPv6

- Some special addresses
  - `::1/128` is the loopback address
  - `::ffff:0:0/96` prefix used for IPv4 mapping

IPv4 129.132.46.11

IPv6 ::ffff:8184:610e

0000:0000:0000:0000:0000:ffff:8184:610e

- Literal IPv6 addresses in URLs
  - `http://[0000:0000:0000:0000:0000:ffff:8184:610e]/`
  - `https://[0000:0000:0000:0000:0000:ffff:8184:610e]:443/`

Transition mechanisms

Mechanisms for IPv6 hosts to communicate with IPv4 hosts:

- **Dual stack**
- **Tunneling**
- **Proxying and translation**

Support of IPv6:

1996	IPv6 support in Linux kernel
2002	Windows XP and Server 2003 for commercial usage
2003	Apple OS X has IPv6 support enabled by default
2007	Windows Vista has IPv6 enabled by default

Evaluation of IPv6

- **Benefits**
  - **IPv6 is widely supported by OSes**
  - **Easy to implement dual stack**
  - **Little change necessary to applications**
  - **Suitable long term solution**

- **Drawbacks**
  - **Address size carries bandwidth overhead**
  - **Deployment because of address space only**
  - **Change in network infrastructure necessary**

Long term solution: Much larger address space

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What to do ?

NAT extensions compared to IPv6

- **Benefits of NAT extensions**
  - No change in backbone network necessary
  - Easy, cheap and quick
  - Usage of base technology which is well known
- **Drawbacks of NAT extensions**
  - Address space exhaustion only delayed
  - No “real” end-to-end (only with extended LANs)
  - Same extension in both LANs required

NAT extensions only delay but do not solve the problem

Content routing compared to other technics

- Paper on CR focuses on content delivery
- NAT extensions, IPv6 deal with end-to-end
- CR independend of NAT, IPv6
- CR deals with a common problem
- But: “Painful” change in network core
- Wants to completely replace current DNS

Cost and effort are not in line with resulting benefit

Summary

- IPv4 cannot be a long term solution
- NAT & extensions only delay the inevitable
- End-to-end is often not necessary
- NAT will still be important with IPv6
- IPv6 will not completely supplant IPv4 soon

Transition to IPv6 will take place slowly

Questions? Comments?

Thank you for your attention !