IPv6 Security

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Why is there a problem?

- If you believe that encryption (or firewalls or Intrusion Detection Systems) are the answer to all your security problems, then you probably asked the wrong question.
  - Security is about securing a *system*
  - Security is a *process NOT a product*
  - Over-concentration on technology is deeply naïve
  - However if you do major changes, like IPv4-IPv6, you must ensure you have introduced new holes

What is new with IPv6?

- Security was considered from the start in IPv6
- Some of the key improvements:
  - IPsec useable with the core protocols
  - Cryptographically Generated Addresses (CGA)
  - SEcure Neighbor discovery (SEND)
  - Protocol for Authentication and Network Access
  - Making intrusion harder

Topics in this module

- Threats to be Countered in IPV6
  - Scanning Gateways and Hosts for weakness
  - Scanning for Multicast Addresses
  - Unauthorised Access Control
  - Protocol Weaknesses
  - Distributed Denial of Service
  - Transition Mechanisms
  - Worms/Viruses
    - There are already worms that use IPv6
      - e.g. Rbot.DUD
- Techniques:
  - Firewalls

Scanning Gateways and Hosts

- Subnet Size is much larger
  - About ~28 years to scan a /64 subnet@1M addresses/sec
- But…
  - NMAP does NOT support IPv6 network scanning
  - IPv6 Scanning methods are changing
    - DNS based, parallelised scanning, common numbering
    - Compromising a router at key transit points
      - Can discover addresses in use
      - Scan from router?

Scanning Multicast Addresses

- New Multicast Addresses - IPv6 supports new multicast addresses enabling attacker to identify key resources on a network and attack them
  - E.g. Site-local all DHCP servers (FF05::5), and All Routers (FF05::2)
  - Addresses must be filtered at the border in order to make them unreachable from the outside
    - To prevent smurf type of attacks: IPv6 specs forbids the generation of ICMPv6 packets in response to messages to global multicast addresses that contain requests

Security of IPv6 addresses

- Cryptographically Generated Addresses (CGA) IPv6 addresses [RFC3972]
  - Host-ID part of address is an encoded hash
    - Binds IPv6 address to public key
  - Used for securing Neighbor Discovery [RFC3971]
  - Is being extended for other uses [RFC4581]
- Private addresses as defined [RFC 4941]
  - prevents device/user tracking from
  - makes accountability harder
- Host-ID could be token to access network

Autoconfiguration/Neighbor Discovery

- Neigbor Discovery (cf Address Resolution Protocol)
  - Can suffer similar problems of ARP cache poisoning
- Stronger solution with SEcure Neighbor Discovery (SEND) [RFC3971] uses CGA
  - Available in IOS-12.4(24)T, and JUNOS in 9.4 Linux/BSD (DoCoMo's SEND Project)
- DHCPv6 with authentication is possible
- ND with IPSec also possible

Neighbor Discovery

- DoS - Duplicate Address Detection (DAD)
  - Nodes usually create own address (EUI 64, Privacy Extensions)
  - Optimistic DAD – “sorry, the address is mine, choose another one”
- Neighbor Cache table overload
  - Big address space (64 bits – 1.8e+19 address)
  - Many records in the neighbor cache for non existing clients

Problems with SLAAC

- **Rogue RAs – a documented in [RFC 6104]**
- **Possible solutions:**

1. RA snooping - RA Guard - as defined [RFC 6105]
2. ACL on switches
3. Usage of SEND
4. Using RA router preference – use high
5. Layer 2 admission control – like 802.1X
6. Host based filtering - unwanted RAs
7. Deprecation tools:
    1. **rafixd:** http://www.kame.net/dev/cvsweb2.cgi/kame/kame/kame/rafixd/
    2. **ramond:** http://ramond.sourceforge.net/
8. Using DHCPv6 with prefix and default gateway option

DHCPv6 problems

- Fake DHCPv6 server
  - Define who can act as DHCP server

DHCPv6 problems and solutions

- SAVI (draft-ietf-savi-dhcp-07, November 2010)
  - Complex solution solving: fakeRA,DHCPv4 and DHCPv6

Poor men's RA Guard

- ACL to filter RA and DHCPv6:

```
ipv6 access-list block-ra-dhcp
   10 deny icmp any any 134 0
   20 deny udp any eq 547 fe80::/64 eq 546
   30 permit ipv6 any any
exit
```

- Apply for the interface:

```
interface 1-44
   ipv6 access-group block-ra-dhcp in
```

Unauthorised Access Control

- Policy implementation in IPv6 with Layer 3 and Layer 4 is still done in firewalls
- Some design considerations!
  - Filter site-scoped multicast addresses at site boundaries
  - Filter IPv4 mapped IPv6 addresses on the wire

Unauthorised Access control

- **Non-routable + bogon (unallocated) address filtering slightly different**
  - **in was IPv4 easier deny non-routable + bogons**
  - **in IPv6 simpler to permit legitimate (almost)**

Action	Src	Dst	Src port	Dst port
deny	2001:db8::/32	host/net		
permit	2001::/16	host/net	any	service
permit	2002::/16	host/net	any	service
permit	2003::/16	host/net	any	service
Deny	3ffe::/16	host/net	any	service
deny	any	any		

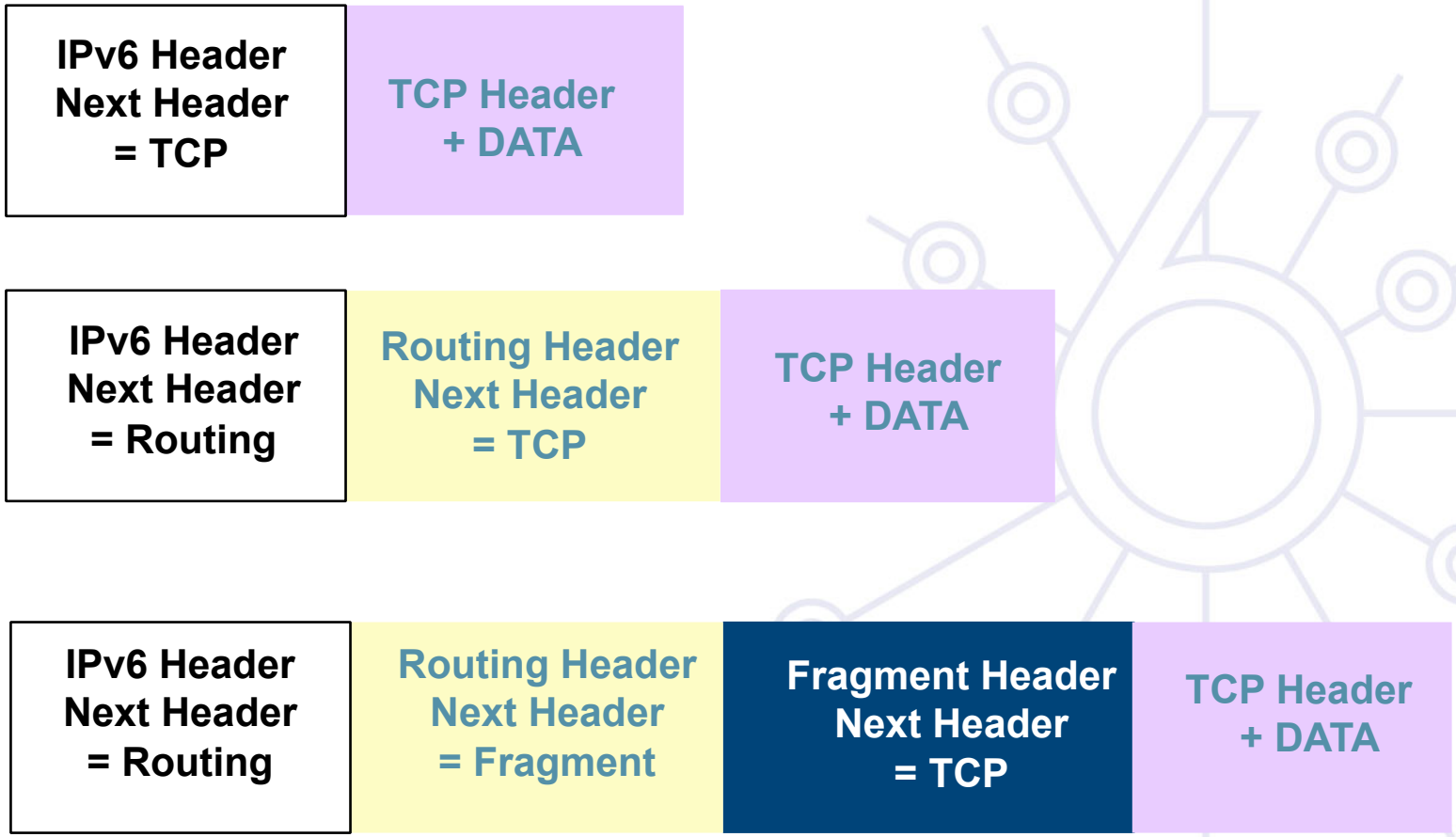
Doc prefix - NO

6to4 - YES

6bone - NO

Consult for non exisiting addresses at:
http://www.space.net/~gert/RIPE/ipv6-filters.html

IPv6: Optional headers



Problems with extension headers

- Routing header (RH0, deprecated by RFC 5095)
- Fragmentation - how can you determine in the fragment the upper layer protocols?
- Extension header tricking (reorder, long chains of headers, overlapping fragments)
- Difficult to filter!

```
deny ipv6 any any log undetermined
  transport
```

L3- L4 Spoofing

- While L4 spoofing remains the same, IPv6 address are globally aggregated making spoof mitigation at aggregation points easy to deploy
- Simpler to protect due to IPv6 address hierarchy
- However host part of the address is not protected
  - You need IPv6 <– >MAC address (user) mapping for accountability!

Amplification (DDoS) Attacks

- There are no broadcast addresses in IPv6
  - This would stop any type of amplification attacks that send ICMP packets to the broadcast address
  - Global multicast addresses for special groups of devices, e.g. link-local addresses, etc.
- IPv6 specifications forbid the generation of ICMPv6 packets in response to messages to global multicast addresses
  - Many popular operating systems follow the specification
  - Still uncertain on the danger of ICMP packets with global multicast source addresses

Mitigation of IPv6 amplification

- Be sure that your host implementations follow the ICMPv6 spec [RFC 4443]
- Implement Ingress Filtering
  - Defeats Denial of Service Attacks which employ IP Source Address Spoofing [RFC 2827]
- Implement ingress filtering of IPv6 packets with IPv6 multicast source address

Mixed IPv4/IPv6 environments

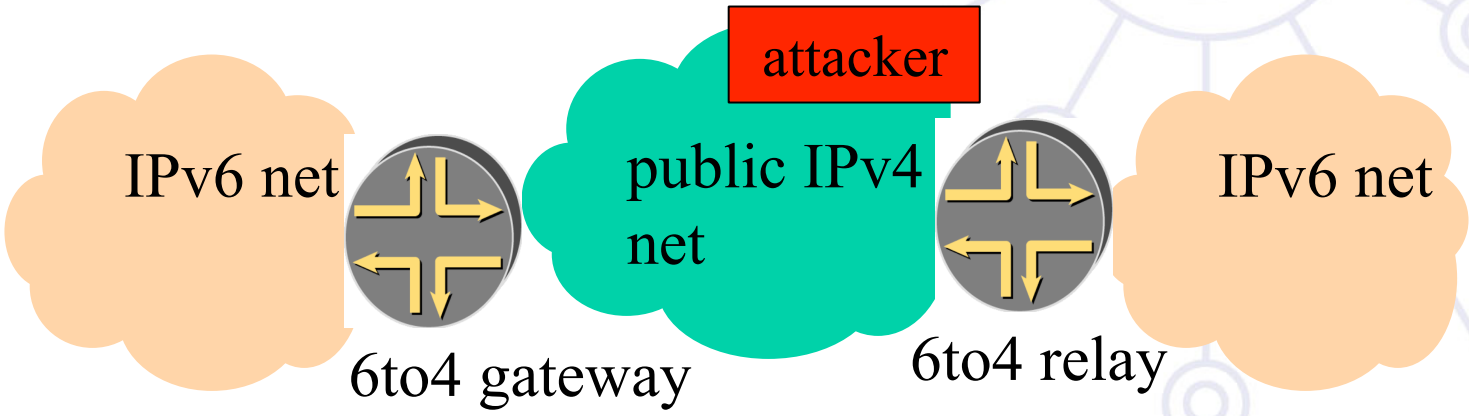
- Some security issues with transition mechanisms
  - Tunnels often interconnect networks over areas supporting the “wrong” version of protocol
  - Tunnel traffic often not anticipated by the security policies. It may pass through firewall systems due to their inability to check two protocols in the same time
- Do not operate completely automated tunnels
  - Avoid “translation” mechanisms between IPv4 and IPv6, use dual stack instead
  - Only authorised systems should be allowed as tunnel end-points

IPv6 transition mechanisms

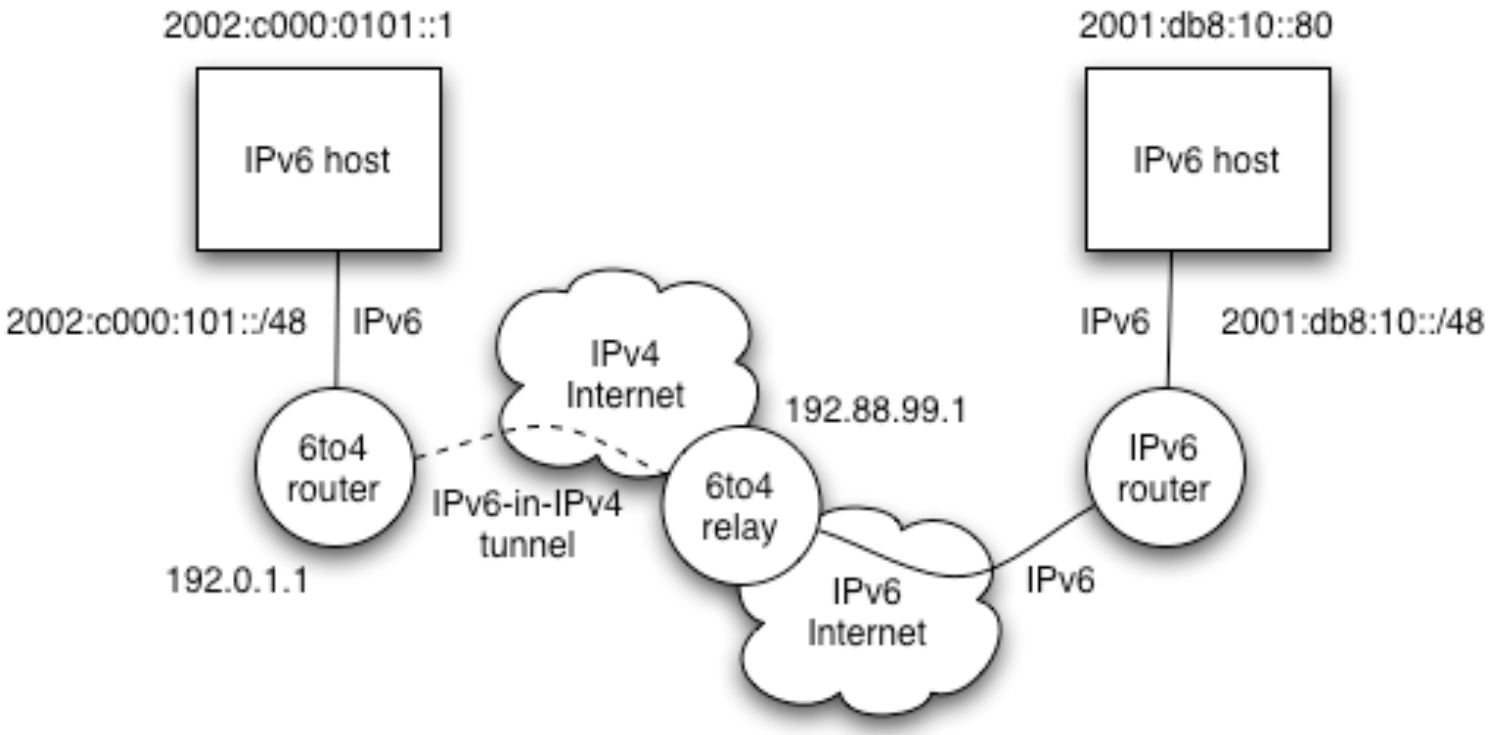
- ~15 methods possible in combination
- Dual stack:
  - enable the same security for both protocol
- Tunnels:
  - ip tunnel – punching the firewall (protocol 41)
  - gre tunnel – probably more acceptable since used several times before IPv6
  - l2tp tunnel – udp therefore better handled by NATs
  - Teredo tunnel – udp - better to avoid – host only solution

L3 – L4 Spoofing in IPv4 with 6to4

- For example, via 6to4 tunnelling spoofed traffic can be injected from IPv4 into IPv6.
  - IPv4 Src: IPv4 Address
  - IPv4 Dst: 6to4 Relay Anycast (192.88.99.1)
  - IPv6 Src: 2002:: Spoofed Source
  - IPv6 Dst: Valid Destination



6to4 with relay



Other threats

- IPv6 Routing Attack
  - Use traditional authentication mechanisms for BGP and IS-IS.
  - Use IPsec to secure protocols such as OSPFv3 and RIPng
- Viruses and Worms
- Sniffing
  - Without IPsec, IPv6 is no more or less likely to fall victim to a sniffing attack than IPv4
- ICMP attacks – slight differences with ICMPv4
  - Recommendations for Filtering ICMPv6 Messages in Firewalls (RFC4890)
  - TCP ICMP attacks – slight differences with ICMPv6
    - http://tools.ietf.org/html/draft-ietf-tcpm-icmp-attacks-06
- Application Layer Attacks
  - Even with IPsec, the majority of vulnerabilities on the Internet today are at the application layer, something that IPsec will do nothing to prevent
- Man-in-the-Middle Attacks (MITM)
  - Without IPsec, any attacks utilizing MITM will have the same likelihood in IPv6 as in IPv4
- Flooding
  - Flooding attacks are identical between IPv4 and IPv6

Vulnerability testing/ assessment

- Testing tools
  - Nmap, Ettercap, Lsof, Snoop, DIG, Etherape, Wireshark, Fping, Ntop, SendIP, TCPDump, WinDump, IP6Sic, NetCat6, Ngrep, THC-IPv6, Amap
- Assessment tools
  - SAINT, nessus, ndpmon, ramond, rafixd
- Solutions - implementations:
  - raguard
  - 802.1x
  - …

Attacker tools

- Scanners: Nmap, halfscan6, Scan6, CHScanner
- Packet forgery: Scapy6, SendIP, Packit, Spak6
- DoS Tools: 6tunneldos, 4to6ddos, Imps6-tools
- THC IPv6 Attack Toolkit: parasite6, alive6, fake_router6, redir6, toobig6, detect-new-ip6, dos- new-ip6, fake_mld6, fake_mipv6, fake_advertiser6, smurf6, rsmurf6

  http://freeworld.thc.org/

Firewalls

- IPv6 architecture and firewall
  - NAT does not make secure – same level of security with IPv6 possible as with IPv4 (security and privacy)
    - Even better: e2e security with IPSec
  - Weaknesses of the packet filtering cannot be hidden by NAT
  - IPv6 does not require end-to-end connectivity, but provides end-to-end addressability
  - Support for IPv4/IPv6 transition and coexistence
  - Not breaking IPv4 security
- Most firewalls are now IPv6-capable
  - Cisco ACL/PIX, Juniper NetScreen, CheckPoint
  - Modern OSes now provide IPv6 capable firewalls

Firewall setup

- No blind ICMPv6 filtering possible:

	Echo request/reply	Debug
	No route to destination	Debug – better error indication
	TTL exceeded	Error report
IPv6 specific	Parameter problem	Error report (e.g. Extension header errors)
IPv6 specific + required	NS/NA	Required for normal operation – except static ND entry
IPv6 specific + required	RS/RA	For Stateless Address Autoconfigration
IPv6 specific + required	Packet too big	Path MTU discovery
IPv6 specific	MLD	Requirements in for multicast

Firewalls L4 issues

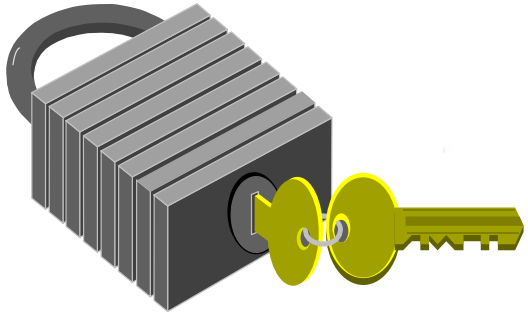
- Problem FTP
  - Complex: PORT, LPRT, EPRT, PSV, EPSV, LPSV (RFC 1639, RFC 2428)
  - No support in IPv6 firewalls for all the variants
- Solution: HTTP seems to be the next generation file transfer protocol with WEBDAV and DELTA
- Other non trivially proxy-able protocol:
  - No support (e.g.: H.323)

Security: VPNs

- Layer 2 solutions
  - MPLS
- IPSecurity
  - IPSec - Suite of protocols
- Other solutions
  - E.g. OpenVPN, Tinc, yavipin, l2tp, pptp, ssl based VPNs

Security: IPSec

- General IP Security mechanisms
  - From the IETF IPsec Working Group
    - http://tools.ietf.org/wg/ipsec/
    - IP Security Architecture: RFC 4301
- Applies to both IPv4 and IPv6:
  - Mandatory for IPv6
  - Optional for IPv4
- Applicable to use over LANs, across public & private WANs, & for the Internet
- IPSec is a security framework
  - Provides suit of security protocols
  - Secures a pair of communicating entities



IPsec protocol overview

- IPsec services
  - Authentication
    - AH (Authentication Header - RFC 4302)
  - Confidentiality
    - ESP (Encapsulating Security Payload - RFC 4303)
  - Replay protection, Integrity
  - Key management
    - IKEv2 (Internet Key Exchange - RFC4306)
  - IPsec modes: Transport Mode & Tunnel Mode
- Implementations
  - Linux-kernel (USAGI), Cisco IOS-12.4(4)T, BSD&OSX(Kame)

Summary

- IPv6 has potential to be a foundation of a more secure Internet
- Elements of the IPv6 security infrastructure
  - Firewalls, IPSec, AAA, etc.

  are mature enough to be deployed in production environment.
- Other elements are in usable prototype state
  - CGA, SEND, VPNs

  But even these are ready for deployment