IPv6 Security
(Theory vs Practice)

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What Are Security Goals?

- Controlling Data Access
- Controlling Network Access
- Ensuring Network Availability
- Protecting Information In Transit
- Preventing Intrusions
- Responding To Security Breaches

Causes of Security Related Issues

- Protocol error
  - No one gets it right the first time
- Software bugs
  - Is it a bug or feature ?
- Active attack
  - Target control/management plane
  - Target data plane
  - More probable than you think !
- Configuration mistakes
  - Most common form of problem

Security Services

- User Authentication / Authorization
- Device Authentication / Authorization
- Access Control (Packet Filtering)
- Data Integrity
- Data Confidentiality
- Auditing / Logging
- DoS Mitigation

What Is The Same / What Is Different

- Same for IPv4 and IPv6
  - Security Properties
  - Security Services
- Different for IPv6 Architectures
  - Protocol Operation
  - More Automation
  - Scalable Mobile Hosts
  - Potential Application Integration

What Needs To Be Considered

- Where is automation advantageous versus a security risk?
- How will IPv4 content be accessible?
  - Is NAT a security feature or a simple way of getting access to the global Internet (without paying for it)?
  - Where is an address translation capability required?
- Where are network-based security mitigation techniques reliably advantageous versus a hindrance?
- What technologies need to be made easier to deploy to be operationally viable?
- What security services are being used to adhere to security policy requirements but are instantiations of IPv4 architecture limitations?

IPv6 Automation

- Protocol Capabilities
  - Neighbor Discovery allows nodes to easily find one another
  - Router Advertisements enable nodes to automatically create their own globally reachable IPv6 address
- Security Issues
  - Redirect attacks
  - Denial-of-Service attacks
  - Neighbor solicitation spoofing
  - Neighbor advertisement spoofing
  - Neighbor Unreachability Detection failure
  - Duplicate Address Detection DoS attack

Architecture Considerations

- Addressing / Naming
  - What subnet boundaries make sense
    - your own network infrastructure
    - filtering considerations
  - Endpoint Identifier management
    - address automation vs obscurity vs auditability
  - DNS and DHCPv6 Considerations
- Native Routing vs Tunnels
- Management
- Security (Is This A Last Consideration In Practice?)

Addressing Plans

- Need a sound addressing allocation plan
  - Smallest globally routable prefix is a /48
  - Subnets are based on a /64
    - Point-to-Point links should be /127
- Best Practices Today
  - If network has many POPs and can't easily predict growth use sparse algorithm to help per-POP aggregation
    - http://www.ripe.net/docs/ipv6-sparse.html
  - If network is fairly static, distribute your /32 to your POPs but leave some space for future growth
    - For example: a /36 for each of the 10 POPs, keeping 6 in reserve

IPv6 Evolution of Deployment

- Addressing Devices (since mid to late 1990’s)
  - RA vs DHCPv6 debates still ongoing
- Routing (since mid to late 1990’s)
  - ConnexionByBoeing had a /48 PI live in Dec 2005
- DNS
  - Working but seems to require ongoing tweaks mostly due to end host behavior with A vs AAAA records
- Evolving Stuff
  - Layer 2/3 Access Control
  - Monitoring / Provisioning
  - Applications / Content

Choices in Transition Technologies

- In the beginning
  - 6to4
  - Teredo
  - ISATAP
  - NAT64
- Playing catch-up
  - DS-Lite
  - 6rd
  - Carrier Grade NAT
  - NAT444

Dual Stack - Lite

- Trying to help build an IPv6-only native infrastructure
- Assumes you have an IPv6 network and enables you to tunnel your IPv4 over it
  - Upstream, there might be a traditional IPv4/IPv4 NAT
- Premise is that your network is primarily IPv6 within a given domain but the service is primarily IPv4
- Includes a NAPT44 function, which is a carrier grade NAT
  - This is how DS-Lite shares one IPv4 address among several subscribers.
- DS-Lite is both a tunnel (IPv4 over IPv6) and a carrier grade NAT44.

6rd

- Tries to help build a dual-stack infrastructure
- Start with IPv4 infrastructure
  - Free.fr provided an application that only ran on IPv6 and came up with an IPv6/IPv4 tunneled infrastructure that could provide that service
- It is IPv4 plus IPv6/IPv4.
- Premise is that the service is applications
  - at least one application runs IPv6 (which happens to run on IPv4 but can be changed to native service without the user knowing)
  - at least one application runs on IPv4

Transitions

- Framework for IPv4/IPv6 Translation
  - http://datatracker.ietf.org/doc/draft-ietf-behave-v6v4-framework
- IPv6 Addressing of IPv4/IPv6 Translators
  - http://datatracker.ietf.org/doc/draft-ietf-behave-address-format
- DNS64: DNS extensions for Network Address Translation from IPv6 Clients to IPv4 Servers
  - http://datatracker.ietf.org/doc/draft-ietf-behave-dns64
- IP/ICMP Translation Algorithm
  - http://datatracker.ietf.org/doc/draft-ietf-behave-v6v4-xlate
- Stateful NAT64: Network Address and Protocol Translation from IPv6 Clients to IPv4 Servers
  - http://datatracker.ietf.org/doc/draft-ietf-behave-v6v4-xlate-stateful
- Guidelines for Using IPv6 Transition Mechanisms during IPv6 Deployment
  - http://datatracker.ietf.org/doc/draft-arkko-ipv6-transition-guidelines

Summary Thought on Transition

- IPv6-only connectivity does not exclude having a dual stack host that reaches IPv4 via an IPv4-in-IPv6 tunnel.
- An application proxy will work fine for HTTP and email, and the user experience won't change noticeably.
- Service providers need to define products that work with IPv6-only today, build up on what works today, and keep growing the services that work withIPv6-only.
- Any content provider should avoid all transition issues by moving to a dual stack model as soon as possible.

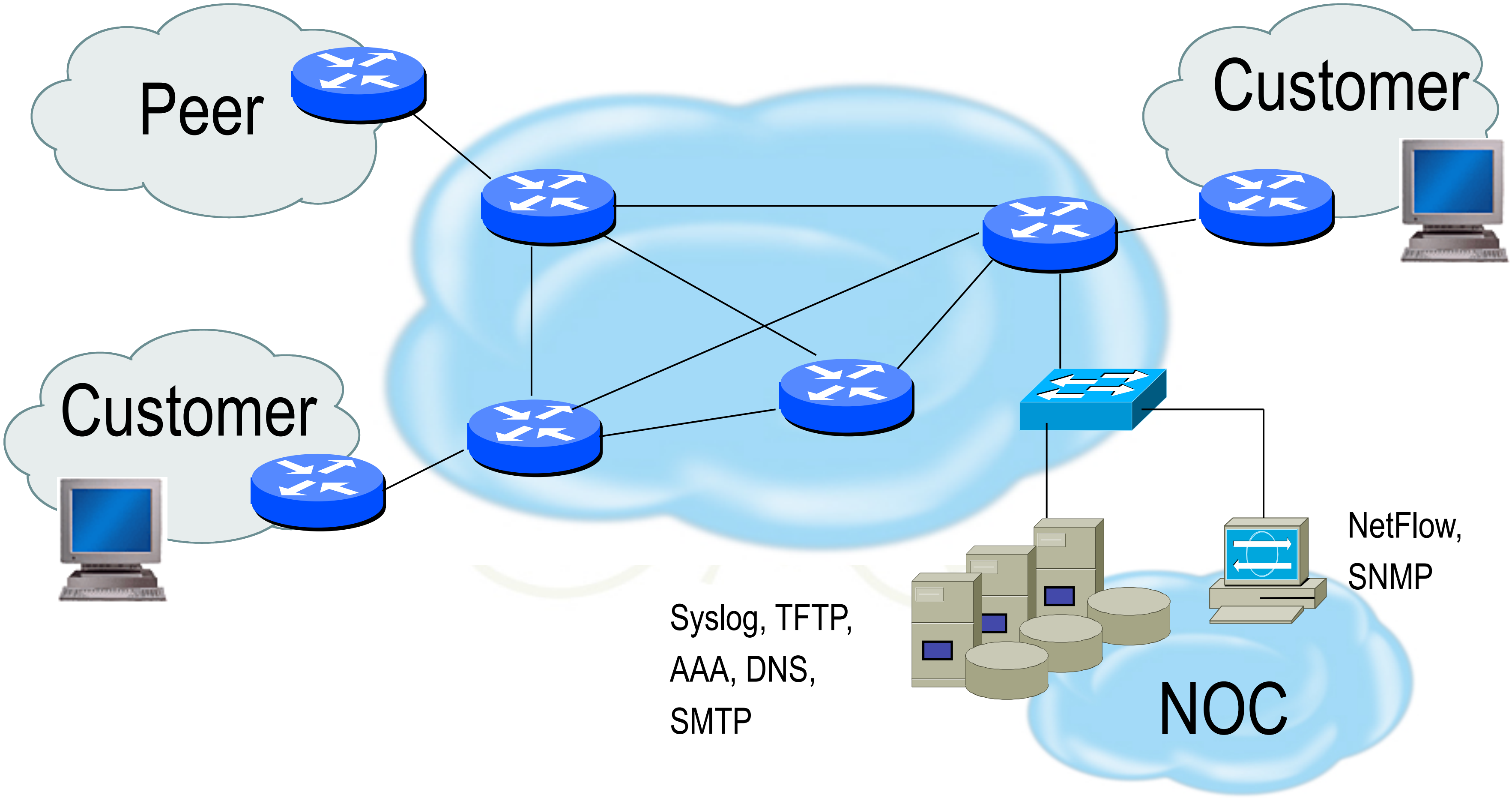
Tunneling Considerations

- Manually configured tunnels are not scalable
- Automated tunnels require more diligence to provide effective security services
- Deployments of 6to4, ISATAP and Teredo all require layered security models
  - Perform ingress firewall sanity checks
  - Log and audit tunneled traffic
  - Provide authentication where possible
  - Use IPsec where appropriate

IPv6 Security Enhancements

- Fragmentation
  - Prohibited by intermediary devices
  - Overlapping fragments are not allowed
  - Devices must drop reassembled packets that are less than 1280 bytes
- Broadcasts
  - Removes concept of dedicated broadcasts
  - Specific language to avoid ICMPv6 broadcast amplification attacks
- IPsec
  - Defined into the base protocol spec

Infrastructure Security



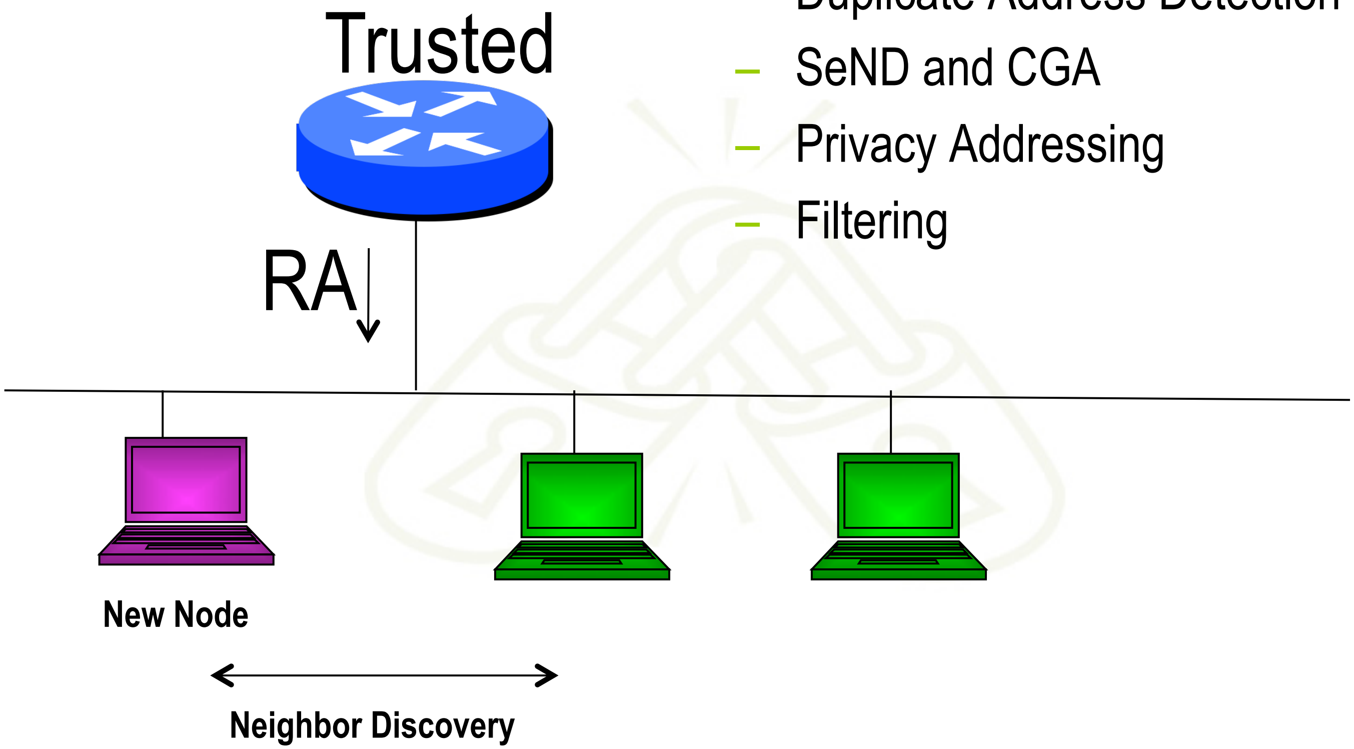
Fundamental Issues

- What is meant by *Securing The Network* ?
- Design security into IPv6 networks that do not blindly mimic the current IPv4 architectures
  - Don't break working v4 infrastructure
  - Don't re-architect current problems and place limitations on IPv6 capabilities
- Requires some thought to policy
  - Where are you vulnerable today ?
  - What new application capabilities are possible with IPv6?
  - New risk assessment will help (re)define appropriate security policy
- Security policy will dictate which security measures to implement

IPv6 Security Theory vs Reality

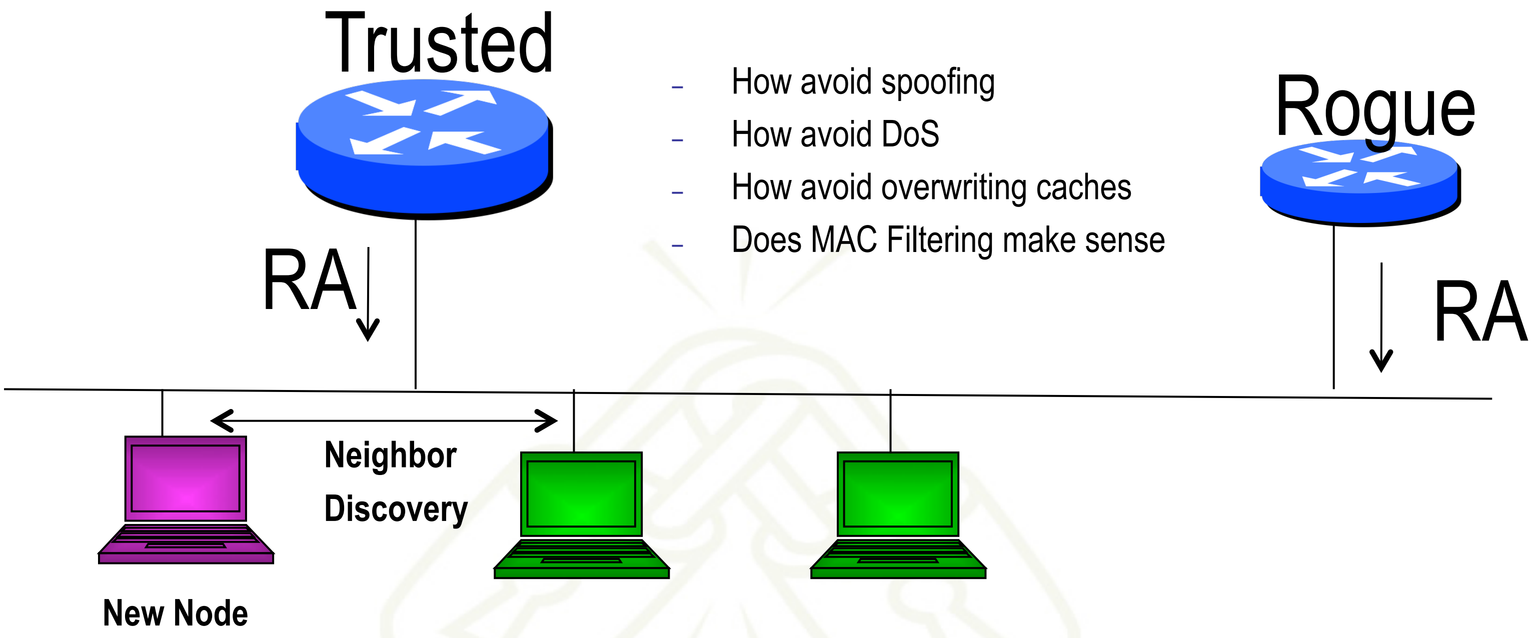
- IPv6 has security built-in
  - Mostly based on mandate to implement IPsec
  - IPsec use was never fully defined in IPsec specs
    - Early implementations made it up
    - Configuration is still difficult and often operationally not optimal
    - IPv6 conformance testing doesn’t necessarily require it
- IPv6 needs IPv4 security feature parity
  - Yes and No ☺

Node Initialization Security (Theory)



- Duplicate Address Detection
- SeND and CGA
- Privacy Addressing
- Filtering

Node Initialization Security (Practice)



- How avoid spoofing
- How avoid DoS
- How avoid overwriting caches
- Does MAC Filtering make sense

- Host behaviors vary and need to be understood
- SeND and CGA not widely used (yet?)
- Layer 2 mitigation techniques wip for vendors
- http://www.kb.cert.org/vuls/id/472363

SeND Capabilities

- SeND protects against:
  - Spoofed Messages To Create False Entries In Neighbor Cache
  - Neighbor Unreachability Detection Failure
  - Duplicate Address Detection DoS Attack
  - Router Solicitation and Advertisement Attacks
  - Replay Attacks
  - Neighbor Discovery DoS Attacks
- SeND does NOT:
  - Protect statically configured addresses
  - Protect addresses configured using fixed identifiers (I.e.EUI-64)
  - Provide confidentiality
  - Compensate for unsecured link-layer
    - No guarantee that payload packets came from node that used SEND

Node Global Addressing Security (Theory)

- Static addressing can be used
- Stateful Autoconfiguration
  - Requires use of a server to give hosts information
- Stateless Autoconfiguration
  - Requires no manual configuration of hosts
  - Minimal (if any) configuration on routers
- Privacy Addresses (rfc4941)
- Router Advertisements vs DHCPv6

Node Global Addressing Security (Practice)

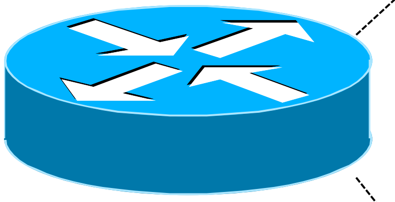
- Statically defined addresses used for critical devices
- Privacy addresses are used by default by Vista
  - How do you correlate IPv6 address to log info?
- Router Advertisement
  - Relying on unauthenticated broadcast packet to determine where host should send traffic to
- DHCPv6
  - Can send requests to local LAN before get an RA message telling you to do so. This requires manual configuration on host

Better RA/DHCPv6 Filtering Needed

- Networks with visitors have shown a serious problem with rogue RA and DHCP servers
  - Networks with visitors that use either RA or DHCPv6 for address assignment will have the exact same problem if someone comes along with a rogue server
- Features needed to limit where RA messages and DHCPv6 messages can be sent from
  - Allow RA messages only from routers, and DHCPv6 responses only from DHCPv6 servers
- Some Ethernet equipment has the ability to filter on Ethernet source/destination
  - Only allow messages to the all routers multicast address to go to the switch interfaces that have routers on them
  - Only allow messages to the all DHCPv6 servers multicast address to go to the switch interfaces that have DHCPv6 servers or relays on them

Packet and/or Route Filtering in IPv6

- In theory, certain addresses should not be seen on the global Internet
- In practice, they are and filters aren’t being deployed (even when capability available)



```
ipv6 access-list extended DSL-ipv6-Outbound
 permit ipv6 2001:DB8:AA65::/48  any
 deny   ipv6 any any log

interface atm 0/0
  ipv6 traffic-filter DSL-ipv6_Outbound out
```

General Firewall BCP (same for IPv6 and IPv4 networks)

- Explicitly deny all traffic and only allow what you need
- The default policy should be that if the firewall doesn't know what to do with the packet, deny/drop it
- Don't rely only on your firewall for all protection of your network
- Implement multiple layers of network protection
- Make sure all of the network traffic passes through the firewall
- Log all firewall exceptions (if possible)

Ingress IPv6 Packet Filters To Consider

- Accept all ICMPv6 packets for Neighbor Discovery and Path MTU Discovery that is a function necessary for the communication with IPv6
- Reject the packets which contain relevant special-use prefix in the ***source*** address field
  - ::1/128 : loop back address
  - ::/128 : unspecified address
  - ::/96 : IETF reserved address;IPv4-compatible IPv6 address
  - ::ffff:0:0/96 : IPv4-mapped IPv6 address
  - ::/8 : reserved
  - fc00::/7 : unique-local address
  - ff00::/8 : multicast address
  - 2001:db8::/3 : documentation addresses

Ingress IPv6 Packet Filters To Consider (2)

- Reject the packets which contain relevant special-use prefix in the ***destination*** address field

::1/128	: loop back address
::/128	: unspecified address
::/96	: IETF reserved address;IPv4-compatible IPv6 address
::ffff:0:0/96	: IPv4-mapped IPv6 address
::/8	: reserved
fc00::/7	: unique-local [fc00::/16] and site-local [fc00::/10] address
2001:db8::/32	: documentation address

- Reject the packets which have your own prefix in the source address field
- Reject packets that use the routing header Care must be taken not to reject ICMPv6 packets whose source address used with Duplicate Address Detection is the unspecified address (::/128). If all of ICMPv6 is accepted, then there is no problem although ordering of the filters needs to be carefully thought through.

Egress IPv6 Packet Filters To Consider

- Permit sending all ICMPv6 packets for Neighbor Discovery and Path MTU Discovery that is a function necessary for the communication with IPv6
- Deny sending the packets which contain special-use prefix in the source address field

::1/128	: loop back address
::/128	: unspecified address
::/96	: IETF reserved address;IPv4-compatible IPv6 address
::ffff:0:0/96	: IPv4-mapped IPv6 address
::/8	: reserved
fc00::/7	: unique-local address
ff00::/8	: multicast address
2001:db8::/32	: documentation address

- Deny sending packets that use the routing header [unless using mobility features]
- Deny sending packets with destination address in the 6to4 reserved address range (2202::/16) if not supporting 6to4 services (i.e. relays) and not providing transit services
- Deny sending packets with destination address in the Teredo address range (2001::/32) if not running a Teredo relay or offering a Teredo transit service
- Multicast address should only be in source address field.

Allow Following ICMPv6 Through Firewall

- ICMPv6 type 1 code 0: no route to destination
- ICMPv6 type 2: packet too big (required for PMTUD)
- ICMPv6 type 3: time exceeded
- ICMPv6 type 4: parameter problem (informational when IPv6 node has problem identifying a field in the IPv6 header or in an extension header)
- ICMPv6 type 128: echo request
- ICMPv6 type 129: echo reply

Allow Following ICMPv6 To/From A Firewall

- ICMPv6 type 2: packet too big – firewall device is not allowed to fragment IPv6 packets going through it and must be able to generate this message for correct PMTUD behavior
- ICMPv6 type 4: parameter problem
- ICMPv6 type 130-132: multicast listener messages – in IPv6 a routing device must accept these messages to participate in multicast routing
- ICMPv6 type 133-134: router solicitation and advertisement – needed for IPv6 autoconfiguration
- ICMPv6 type 135-136: neighbor solicitation and advertisement – used for duplicate address detection and layer2-to-IPv6 address resolution

Need Better IPv6 Extension Header Filtering

- Carry the additional options and padding features that are part of the base IPv4 header
- Extension headers are optional and placed after the base header
- There can be zero, one, or more Extension Headers between the IPv6 header and the upper-layer protocol header
- Ordering is important

Currently Defined IPv6 Extension Headers:

Hop-by-Hop Options	(0)
Routing Header	(43)
Fragment Header	(44)
ESP Header	(50)
Authentication Header	(51)
Destination Options	(60)

Other Extension Header Values:

TCP upper-layer	(6)
UDP upper-layer	(17)
ICMPv6	(58)
No Next Header Present	(59)

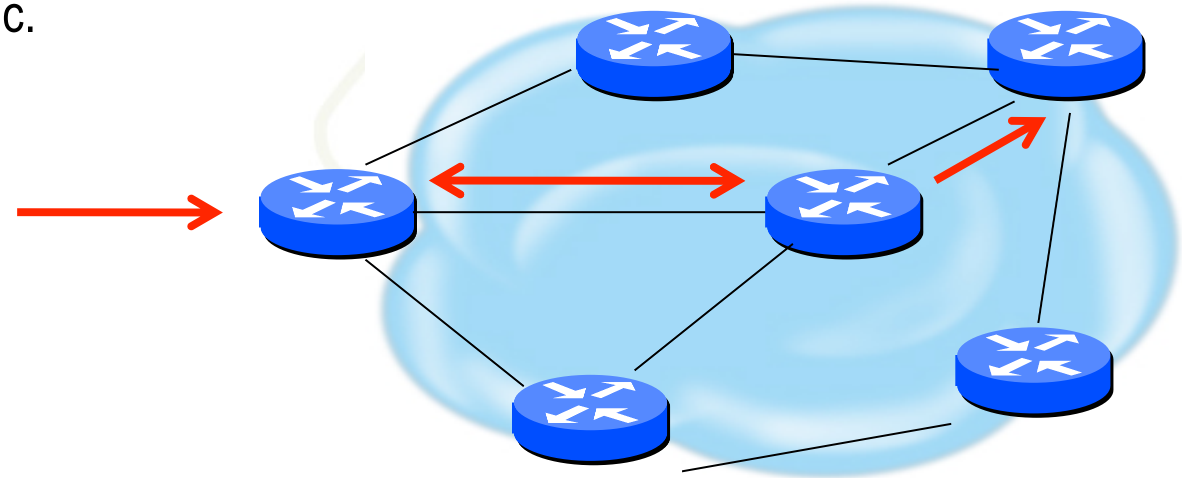
Routing Header: RFC 2460 Text

- The routing header is used by an IPv6 source to list one or more intermediate ***nodes*** to be "visited" on the way to packet's destination.
- Each extension header should occur at most once, except for the destination options header which should occur at most twice.
- IPv6 nodes must accept and attempt to process extension headers ***in any order*** and ***occurring any number of times*** in the same packet.

Routing Header Issue

A single RH of Type 0 may contain multiple intermediate node addresses, and the same address may be included more than once in the same RH0.

If the routing header contains a repetition of a pair of addresses of the form A B A B A B … If this A B pair were repeated 3 times then a single packet directed at A would traverse the path A B 3 times, and B A twice. If such packets were generated at a total rate of 1 Mbps then the path between A and B would experience a total of 5Mbps of traffic.



Routing Header Processing

- Disabling processing still allows all other hosts to be used for attack
- Dropping is required for ISP's
- RFC 5095 – Deprecation of RH0
- Until rfc5095 implemented:
  - Use ingress filtering for RH0 traffic
  - RH Type 2 is required for mobility so have to ensure that only RH0 traffic is blocked

Cisco and RH0 Filtering

- To disable processing of all types routing headers on 12.2(15)T and up one can use:

```
no ipv6 source-route
```

Note that this will still forward these packets on to other hosts which can be vulnerable. This statement also affects perfectly valid Routing Headers of Type 2 which are used by Mobile IPv6.

- If possible upgrade to 12.4(2)T or higher and block only the Type 0 Routing Header (note interface specific config):

```
Router(config)#ipv6 access-list deny-sourcerouted
Router(config-ipv6-acl)#deny ipv6 any any routing-type 0
Router(config-ipv6-acl)#permit ipv6 any any
Router(config)#interface Ethernet0
Router(config-if)#ipv6 source-route
Router(config-if)#ipv6 traffic-filter deny-sourcerouted in
```

Cisco IPv6 NetFlow

- Netflow IPv6 support from 12.4 IOS releases
- Uses Netflow v9
- Activate per interface

```
ipv6 flow ingress
ipv6 flow egress
```

- Show status

```
show ipv6 flow cache
```

IPv6 Filtering References

- RFC 4890 ‘Recommendations for Filtering ICMPv6 Messages in Firewalls’
- RFC 5156 ‘Special-Use IPv6 Addresses’
- http://www.space.net/~gert/RIPE/ipv6-filters.html
- http://www.cymru.com/Bogons/v6top.html
- NSA Router Security Configuration Guide Supplement – Security for IPv6 Routers

Many filtering recommendations are not uniform and that while similarities exist, a definitive list of what to deny and what to permit does not exist. Any environment will need to determine what is most suitable for them by using these references as guidelines.

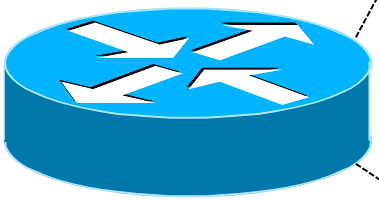
BGP Prefix Filtering (same for IPv6 and IPv4 networks)

- All BGP Prefixes coming into your network and leaving your network need to be filtered to enforce a policy.
- The problem is most ISPs are not:
  - Filtering Comprehensively
  - Filtering their customer's prefixes
  - Filtering prefixes going out of their network.

BGP IPv6 Prefix Filters To Consider

- Special-use prefixes
  - ::/0 exact : default route
  - ::1/128 : loop back address
  - ::/128 : unspecified address
  - ::/96 : IPv4-compatible IPv6 address
  - ::ffff:0:0/96 : IPv4-mapped IPv6 address
  - ::/8 or longer : reserved
  - fe80::/10 or longer : link-local address
  - fc00::/7 or longer : unique-local address
  - ff00::/8 or longer : multicast range (RFC3513)
  - fe00::/9 or longer : multicast range (RFC3513)
  - 2001:db8::/32or longer : documentation address
- Your own prefix
- The 6bone prefix (3ffe::/16)
- The 6to4 reserved address range (2002::/16) if not supporting 6to4 services (i.e. relays) and not providing transit services
- The Teredo address range (2001::/32) if not running a Teredo relay or offering a Teredo transit service

Simple IPv6 Bogon Prefix Filter Example

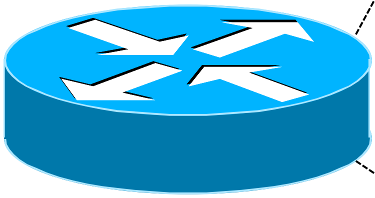


```
ipv6 prefix-list ipv6-special-use-pfx deny 0::/0 le 128
ipv6 prefix-list ipv6-special-use-pfx deny 0::1/128 le 128
ipv6 prefix-list ipv6-special-use-pfx deny 0::/128
ipv6 prefix-list ipv6-special-use-pfx deny 0::/96
ipv6 prefix-list ipv6-special-use-pfx deny 0::ffff:0:0/96
ipv6 prefix-list ipv6-special-use-pfx deny 0::/8 le 128
ipv6 prefix-list ipv6-special-use-pfx deny fe80::/10 le 128
ipv6 prefix-list ipv6-special-use-pfx deny fc00::/7 le 128
ipv6 prefix-list ipv6-special-use-pfx deny fe00::/9 le 128
ipv6 prefix-list ipv6-special-use-pfx deny ff00::/8 le 128
ipv6 prefix-list ipv6-special-use-pfx deny 2001:db8::/32 le 128
ipv6 prefix-list ipv6-special-use-pfx deny 3ffe::/16 le 128
```

BGP Prefix Filters (RIR Allocations)

- APNIC
  - ftp://ftp.apnic.net/stats/apnic/delegated-apnic-latest
- RIPE NCC
  - ftp://ftp.ripe.net/pub/stats/ripencc/delegated-ripencc-latest
- ARIN
  - ftp://ftp.arin.net/pub/stats/arin/delegated-arin-latest
- LACNIC
  - ftp://ftp.lacnic.net/pub/stats/lacnic/delegated-lacnic-latest
- AfriNIC
  - ftp://ftp.afrinic.net/pub/stats/afrinic/delegated-afrinic-latest

IPv6 RIR Allocation Prefix Filter Example (Needs Constant Updating)



```
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2001:0500::/30  ge 48 le 48
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2001:0678::/29  ge 48 le 48
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2001::/16 ge 35 le 35
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2001::/16 ge 19 le 32
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2003::/18 ge 19 le 32
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2400::/12 ge 13 le 32
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2600::/12 ge 13 le 32
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2610::/23 ge 24 le 32
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2620::/23 ge 40 le 48
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2800::/12 ge 13 le 32
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2A00::/12 ge 13 le 32
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2C00::/12 ge 13 le 32
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2001:0DF0::/29 ge 40 le 48
ipv6 prefix-list ipv6-RIR-allocations-pfx permit 2001:43F8::/29 ge 40 le 48
```

Prefix Filter Bogons and RIR Blocks

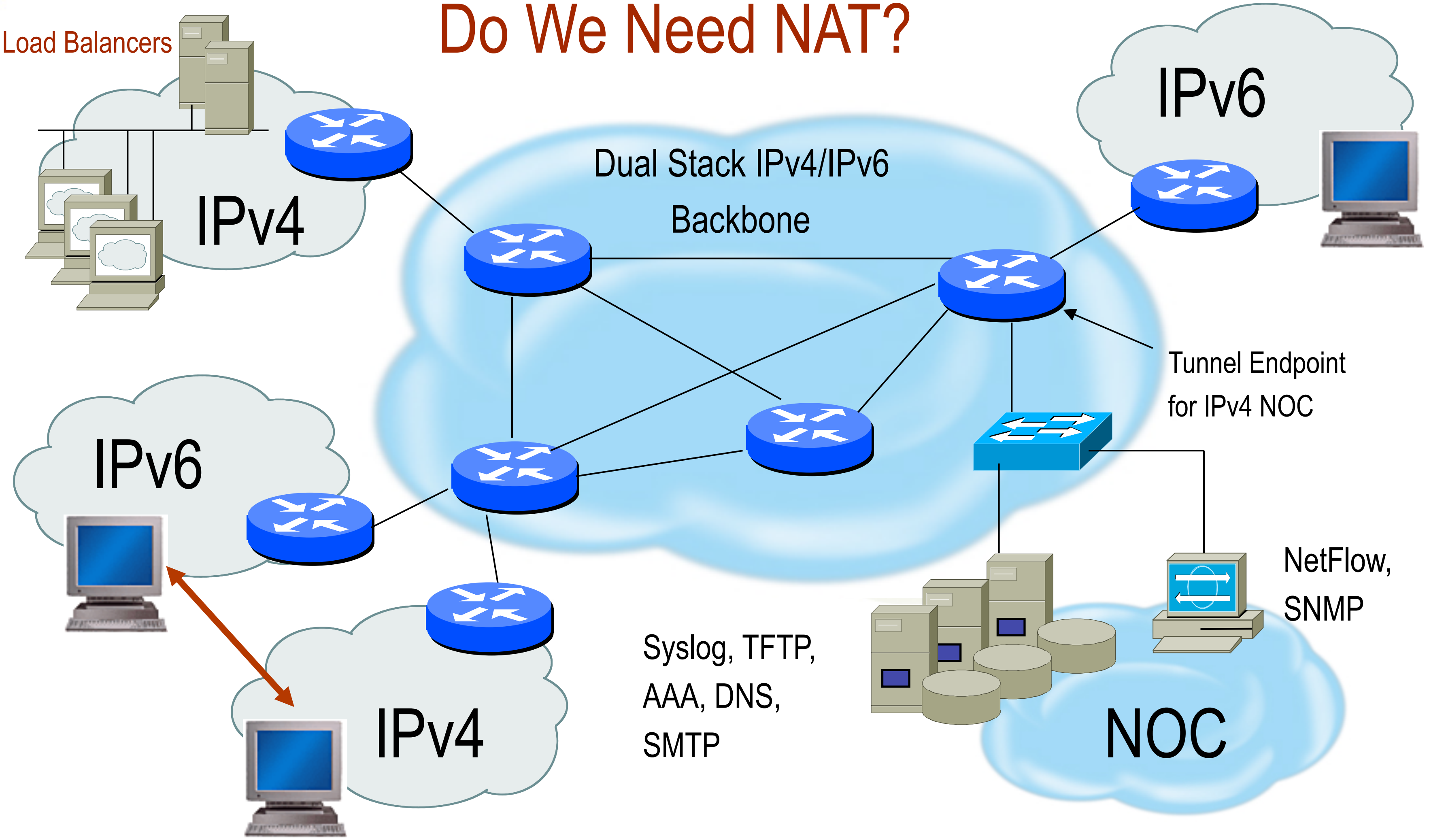
- Templates available from the Bogon Project:
  - http://www.cymru.com/Bogons/index.html
- Cisco Template
  - ftp://ftp-eng.cisco.com/cons/isp/security/Ingress-Prefix-Filter-Templates/
- Juniper Template
  - http://www.qorbit.net/documents.html

IPv6 Tunneling Considerations

- Manually configured tunnels are not scalable
- Automated tunnels require more diligence to provide effective security services
- Look at IETF Softwire Working Group
  - http://www.ietf.org/html.charters/softwire-charter.html
  - RFC 5619 (softwire-security-requirements)
- Deployments of 6to4, ISATAP and Teredo all require layered security models
  - Perform ingress firewall sanity checks
  - Log and audit tunneled traffic
  - Provide authentication where possible
  - Use IPsec where appropriate

Network Address Translation

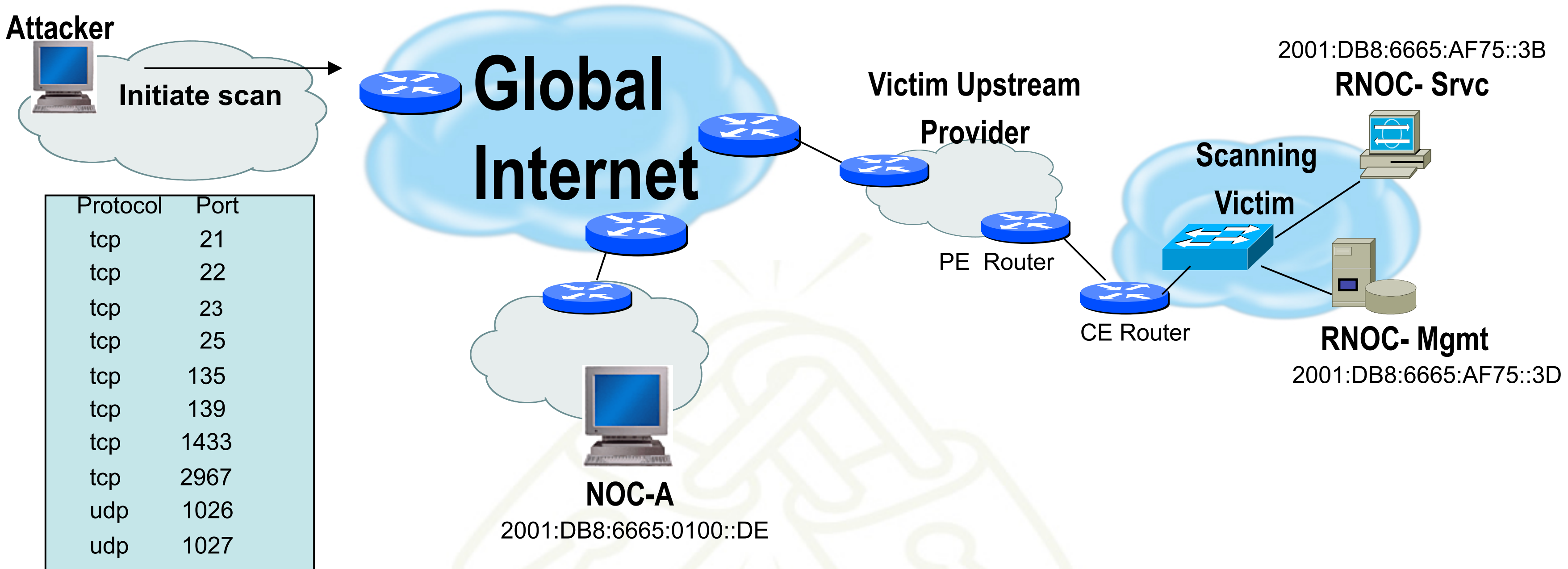
Do We Need NAT?



IPsec in IPv6 Environments

- Bootstrapping credentials
  - Ship all devices with some embedded certificates and trusted roots
- Where useful
  - BGP/OSPFv3/ISIS Authentication
  - Syslogv6 / Radius (server-to-router)
  - TFTP / SNMP / Netflow
- Interoperable defaults
  - Have until widespread deployment of IPv6
  - Window of opportunity closing

Protecting Against Scanning Attacks



Protocol	Port
tcp	21
tcp	22
tcp	23
tcp	25
tcp	135
tcp	139
tcp	1433
tcp	2967
udp	1026
udp	1027
udp	1434

IPsec Security Policy Database

From	To	Protocol	Dst Port	Policy
2001:DB8:6665:0100::DE	2001:DB8:6665:01C8::3B	TCP / UDP	53 (DNS)	ESP: SHA1, AES-256
2001:DB8:6665:0100::DE	2001:DB8:6665:AF75::3B	TCP	25 (SNMP)	ESP: SHA1, AES-256
2001:DB8:6665:0100::DE	2001:DB8:6665:AF75::3D	UDP	1812/1813 (RADIUS)	ESP: SHA1, AES-128
2001:DB8:6665:0100::DE	2001:DB8:6665:AF75::3D	UDP	514 (Syslog)	ESP: SHA1, 3DES
2001:DB8:6665:0100::DE	2001:DB8:6665:AF75::/48	TCP / UDP	ANY	ESP: SHA1

Vendor Specific Deployment Issues

- Lack of interoperable defaults
  - A default does NOT mandate a specific security policy
  - Defaults can be modified by end users
- Configuration complexity
  - Too many knobs
  - Vendor-specific terminology
- Good News: IPv6 support in most current implementations

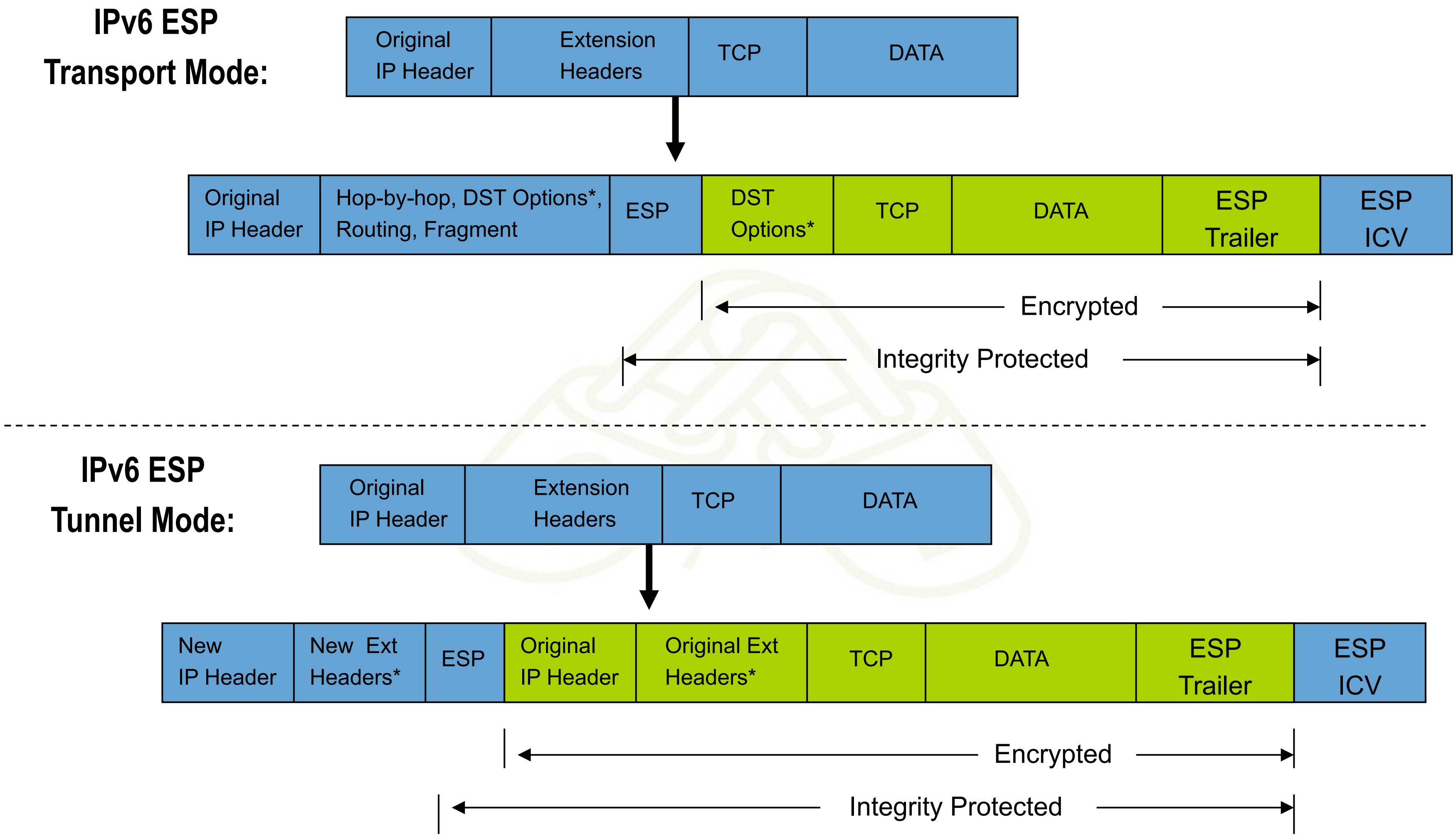
IPv6 IPsec Concerns

- Are enough people aware that IKEv2 is not backwards compatible with IKEv1?
  - IKEv1 is used in most IPv6 IPsec implementations
  - Will IKEv2 implementations first try IKEv2 and then revert to IKEv1?
- Is IPsec implemented for IPv6?
  - Some implementations ship IPv6 capable devices without IPsec capability….this needs to change
- OSPFv3
  - All vendors 'IF' they implement IPsec used AH
  - Latest standard to describe how to use IPsec says MUST use ESP w/Null encryption and MAY use AH

IPv6 IPsec Concerns (cont)

- What is transport mode interoperability status?
  - Will end user authentication be interoperable?
- PKI Issues
  - Which certificates do you trust?
  - How does IKEv1 and/or IKEv2 handle proposals with certificates?
  - Should common trusted roots be shipped by default?
  - Who is following and implementing pki4ipsec-ikecert-profile (rfc4945)
- Have mobility scenarios been tested?
  - Mobility standards rely heavily on IKEv2
- ESP – how determine if ESP-Null vs Encrypted

IPv6 IPsec ESP



IPv6 ESP Transport Mode:

Original IP Header	Extension Headers	TCP	DATA

Original IP Header	Hop-by-hop, DST Options*, Routing, Fragment	ESP	DST Options*	TCP	DATA	ESP Trailer	ESP ICV

Encrypted

Integrity Protected

IPv6 ESP Tunnel Mode:

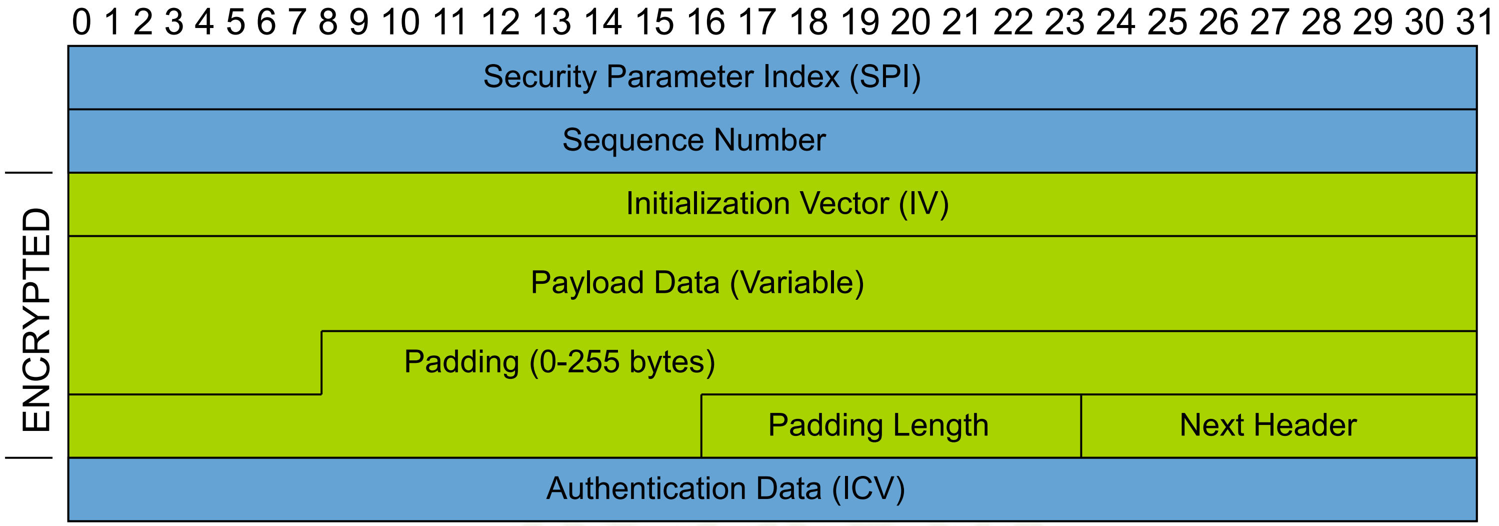
Original IP Header	Extension Headers	TCP	DATA

New IP Header	New Ext Headers*	ESP	Original IP Header	Original Ext Headers*	TCP	DATA	ESP Trailer	ESP ICV

Encrypted

Integrity Protected

ESP Header Format



0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Security Parameter Index (SPI)

Sequence Number

Initialization Vector (IV)

Payload Data (Variable)

Padding (0-255 bytes)

Padding Length

Next Header

Authentication Data (ICV)

ENCRYPTED

SPI: Arbitrary 32-bit number that specifies SA to the receiving device

Seq #: Start at 1 and must never repeat; receiver may choose to ignore

IV: Used to initialize CBC mode of an encryption algorithm

Payload Data: Encrypted IP header, TCP or UDP header and data

Padding: Used for encryption algorithms which operate in CBC mode

Padding Length: Number of bytes added to the data stream (may be 0)

Next Header: The type of protocol from the original header which appears in the encrypted part of the packet

Auth Data: ICV is a digital signature over the packet and it varies in length depending on the algorithm used (SHA-1, MD5)

Default Issues

Vendor A	Vendor B	Vendor C
IKE Phase 1	IKE Phase 1	IKE Phase 1
SHA1	MD5	SHA1
RSA-SIG	Pre-Share Key	Pre-Share Key
Group 1	Group 5	Group 2
Lifetime 86400 Sec	Lifetime 86400 Sec	Lifetime 86400 Sec
Main Mode	Main Mode	Aggressive Mode
IKE Phase 2	IKE Phase 2	IKE Phase 2
PFS	PFS	PFS
Group 1	Group 5	Group 2

Terminology Issues

IKE Phase 1

IKE Phase 1 SA

IKE SA

ISAKMP SA

Main Mode

DH Key Length

DH Group

Modp #

Group #

IKE Phase 2

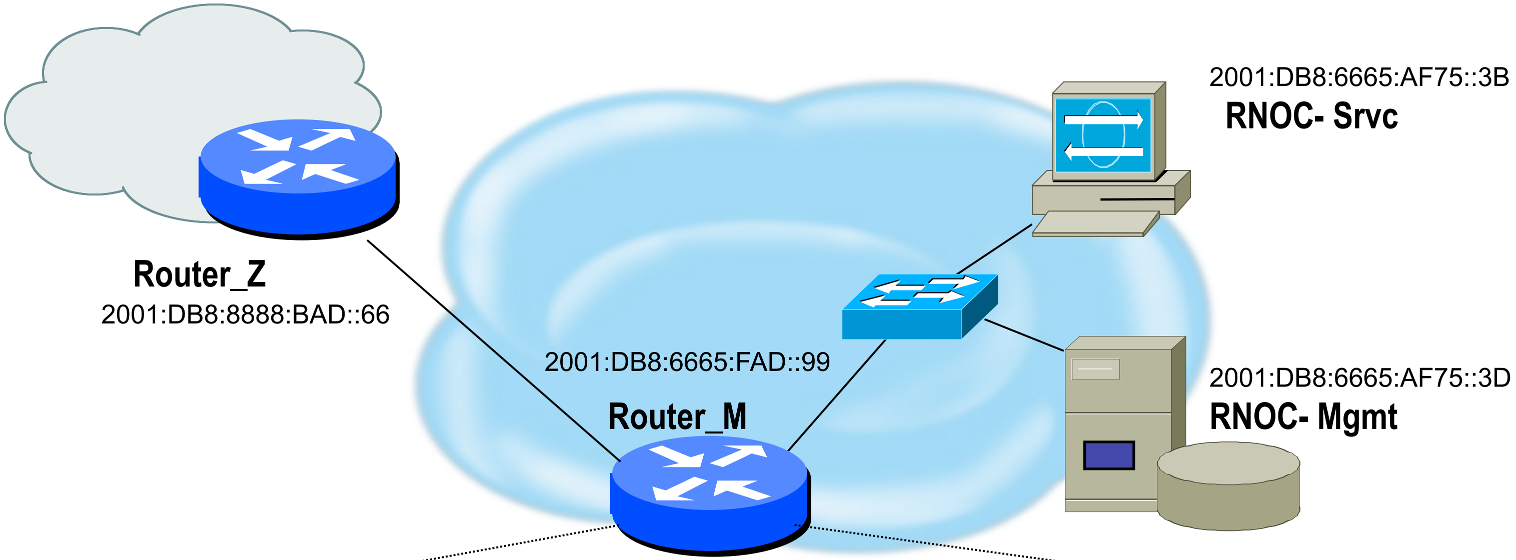
IKE Phase 2 SA

IPsec SA

Quick Mode

Configuration complexity increased with vendor specific configuration terms

Potentially Easy Configuration



Syslog server 2001:DB8:6665:AF75::3D authenticate esp-null sha1 pre-share ‘secret4syslog’

TFTP server 2001:DB8:6665:AF75::3D authenticate esp-null aes128 pre-share ‘secret4tftp’

BGP peer 2001:DB8:8888:BAD::66 authenticate esp-null aes128 pre-share ‘secret4AS#XXX’

Latest IETF Work related IPv6 Security

- CPE Device Issues / Concerns
  - RFC 6092 (recommended simple security requirements)
  - RFC 6204 (basic requirements for IPv6 customer edge router)
- Router Advertisements / Neighbor Discovery
  - RFC 6104 (rogue IPv6 RA problem statement)
  - RFC 6105 (IPv6 RA guard)
  - draft-ietf-v6ops-v6nd-problems-03
- SeND / CGI
  - draft-ietf-savi-send-06.txt
  - RFC 5909 (security ND proxy problem statement)
  - RFC 6273 (SeND hash threat analysis)
  - Draft-ietf-csi-proxy-send-05.txt
  - Draft-ietf-csi-send-cert-010.txt
  - Draft-ietf-csi-dhcpv6-cgs-ps-07.txt

Latest IETF Work Related IPv6 Security

- Tunneling Protocols
  - RFC 6324 (routing loop attacks using automatic tunnels)
  - RFC 6169 (security concerns with IPv6 tunneling)
- General
  - RFC 6434 (updated IPv6 node requirements)
    - IPsec from ‘MUST’ to ‘SHOULD’
- IPsec
  - RFC 5739 (IPv6 Configuration in IKEv2)

Summary: Use Hybrid Security Model

- Defense in Depth
  - Security services in network infrastructure
  - Security services on end host
- Provides gradual move to native v6
  - Add IPv6 capability in places that require dual-stack
  - If services can support native IPv6, deploy native
- Maintains existing policy controls
- Performance vs management tradeoff

End Host IPv6 Security Guidelines

- Basic Principles
  - Address assignment is performed in a reliable manner and cannot be spoofed
  - Traffic sourced from or destined to an end-host can be protected from modification, deletion or spoofing
  - Malicious behavior can be detected and mitigated
- Addressing recommendations
  - Use stateless auto-configuration when low probability that spoofing can occur
  - Use DHCPv6 if need to have control over addresses
  - Use standard but non-obvious static addresses for critical systems
- Hardening the host
  - Restrict access to the client or server to authenticated and authorized individuals
  - Monitor and audit access to the client and server
  - Turn off any unused services on the end node
  - Use host firewall capabilities to control traffic that gets processed by upper layer protocols
  - Use virus scanners to detect malicious programs
- Protecting traffic between hosts
  - Use IPsec

Conclusions

- Many similar issues for security regardless of IPv4/IPv6
- Security policies may need to be modified to enable end-to-end encryption
- Greater security efficiencies if IPv4 security architectures are NOT blindly mimicked
  - Can we reduce use of NAT?!?
- Distributed security management is essential
- Layered defense enhanced with more effective end-host security services
- Identify actual versus perceived risks when deploying IPsec security services….i.e. use IPsec effectively!