RANGER, VET, SEAL and IRON

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Routing and Addressing in Networks with Global Enterprise Recursion (RANGER) – RFC5720

- Recursively-nested connected local network regions joined by Enterprise Border Routers (EBRs) – a network-of-networks
- each distinct local network region is an “enterprise” unto itself
- PI and PA addressing, multihoming, traffic engineering, etc.
- PI prefixes are *portable* - no need for autoconfiguration
- example use cases:
  - Internet interdomain core
  - large academic campus network
  - corporate enterprise network
  - ISP networks
  - SOHO networks
  - civil aviation networks
  - Mobile Ad-hoc Networks
How RANGER Works

- RANGER “concatenates” networks with recursive re-encapsulation
- Example: IPv4 for local routing and addressing; IPv6 for global routing and addressing (other IPvX/IPvY combinations also supported)

Routing scaling through local routing regions (RLOCs) with mapping system for global addresses (EIDs)
- Global communications through recursive re-encapsulation across local routing regions (EIDs)
- VET and SEAL

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Virtual Enterprise Traversal (VET) – RFC5558

- Traversal of a single network within the recursive nesting
- Automatic point-to-multipoint tunneling (NBMA)
- Discover enterprise network exit routers:
  - default routes through border routers on provider networks
  - more-specific routes through border routers on peer networks
  - Secure Redirection
- Router-to-router tunneling
- Only border routers are modified
- Version 2 of ISATAP
How VET Works

Provider Network
Border Routers

IPv4 transit network

Peer Network
Border Router

IPv6 edge network

IPv6 edge network

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IPv6 edge network
- tunnel encapsulation overhead reduces path MTU
- avoid path MTU discovery if possible due to unnecessary packet loss; black-holing due to ICMP filtering
- have the tunnel do transparent link-layer adaptation
- tunnel ingress discovers MRU of tunnel egress
- end result is 1500 and larger gets through

▶ SEAL supports synchronization between tunnel endpoints, so off-path DOS attacks are prevented
▶ SEAL also supports “semi-stateless” mode with no fragmentation/reassembly but robust MTU discovery
How SEAL Works

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Border Routers

IPv4 transit network

Peer Network
Border Routers

IPv6 edge network

IPv6 edge network
How SEAL Works

Provider Network
Border Routers

IPv4 transit network

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IPv4 transit network

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The Internet Routing Overlay Network (IRON)

- RANGER overlay network over the Internet DFZ
- RLOC addresses in underlying network; EID addresses in overlay
- IRON router RIB has EID Virtual Prefix (VP)-to-RLOC mappings
- RIB includes manageable number of coarse-grained EID VPs (e.g., 100k ::/32's)
- More-specific EID prefixes added to router FIBs on-demand
- More-specific EIDs added only on routers that need them

➢ RIB loaded from centrally-managed file; no dynamic routing protocol needed
➢ Excellent scaling properties
IRON Routers

- IRON Routers (IRs) are tunnel endpoint routers
- IRs form the borders of the IRON; encapsulate inner EID-addressed packets in outer RLOC-addressed headers
- Different IR roles:
  - IR(VP) – an IRON router that holds a Virtual Prefix
  - IR(EID) – an IRON router that connects an EID-based enterprise network to the IRON
  - IR(GW) – an IRON router that relays packets between EID-based endpoints and DFZ-based endpoints
- A single IR can serve multiple roles
The IRON – IRON Routers Connected to the DFZ
EID End System to EID End System Example

Host: DFZ (RLOC)

IR(VP): □
IR(EID): ○
IR(DFZ): □
DFZ (RLOC)

IR(VP): 
IR(EID): 
IR(DFZ): 
Host:
EID End System to EID End System Example

IR(VP):

IR(EID):

IR(DFZ):

Host:
EID End System to EID End System Example

IR(VP):  
IR(EID):  
IR(DFZ):  
Host:  

DFZ  
(RLOC)
EID End System to EID End System Example

DFZ (RLOC)

IR(VP): 
IR(EID): 
IR(DFZ): 
Host:
RLOC End System to EID End System Example

IR(VP):
IR(EID):
IR(DFZ):
Host:
RLOC End System to EID End System Example

DFZ (RLOC)

IR(VP):  
IR(EID):  
IR(DFZ):  
Host:  

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RLOC End System to EID End System Example

DFZ (RLOC)

IR(VP):
IR(EID):
IR(DFZ):
Host:
RLOC End System to EID End System Example

DFZ (RLOC)

IR(VP):
IR(EID):
IR(DFZ):
Host:
RLOC End System to EID End System Example

DFZ
(RLOC)

IR(VP):

IR(EID):

IR(DFZ):

Host:
RLOC End System to EID End System Example

DFZ (RLOC)

IR(VP): 
IR(EID): 
IR(DFZ): 
Host:
IRON Scaling

• VPs:
  • Assume $O(100K)$ VPs (e.g., ::/32s)
  • Assume IRON RIB changes only very rarely
  • RIB size is 100K entries – fully populated in each IR

• EIDs:
  • Assume $O(100K)$ EID prefixes per VP
  • Yields $10^{10}$ EID prefixes in the IRON
  • Populated to IR FIBs on-demand

• RIB Size: 100K VPs in each IR
• FIB Size: 100K EID prefixes + 100K VPs = 200K
Civil Aviation Example

Global Internet (IPv6)

Global ATN Backbone Routing and Addressing Domain (IPv4)

Air Traffic Control Functional Domain

ATC Workstation

European-Regional ANSP

Asian-Regional ANSP

US-Regional ANSP

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Civil Aviation Example

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Routing & Addressing in Next Generation Enterprises (RANGER)
- Network-of-networks architecture
- Minimal touch-points (border routers only)
- No changes to most hosts and routers
- Fully-provisioned IP services; balanced blend of tunneling, translation and native
- Gradual integration of IPv6
  - Customer-driven requirements lead policy and strategy
  - IPv6 and IPv4 in peaceful co-existence
  - It’s not an “either-or” decision
- Tangible Benefits
  - Secure Mobile Architecture (SMA)
  - Simplified management
  - Logical partitioning
  - Traffic engineering
  - End-to-end addressing
  - Mobility and multihoming
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Enterprise Network Example

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• Intra-Site Automatic Tunnel Addressing Protocol (ISATAP)  
  [Link](http://www.ietf.org/rfc/rfc5214.txt)
• Routing and Addressing in Networks with Global Enterprise Recursion (RANGER)  
  [Link](http://www.ietf.org/rfc/rfc5720.txt)
• RANGER Scenarios  
  [Link](http://tools.ietf.org/html/draft-russert-rangers)
• Virtual Enterprise Traversal (VET)  
  [Link](http://www.ietf.org/rfc/rfc5558.txt)  
  [Link](http://tools.ietf.org/html/draft-templin-intarea-vet)
• Subnetwork Encapsulation and Adaptation Layer (SEAL)  
  [Link](http://www.ietf.org/rfc/rfc5320.txt)  
  [Link](http://tools.ietf.org/html/draft-templin-intarea-seal)
• The Internet Routing Overlay Network (IRON)  
  [Link](http://tools.ietf.org/html/draft-templin-iron)