Segment Routing with IPv6

Segment Routing Header (SRH)

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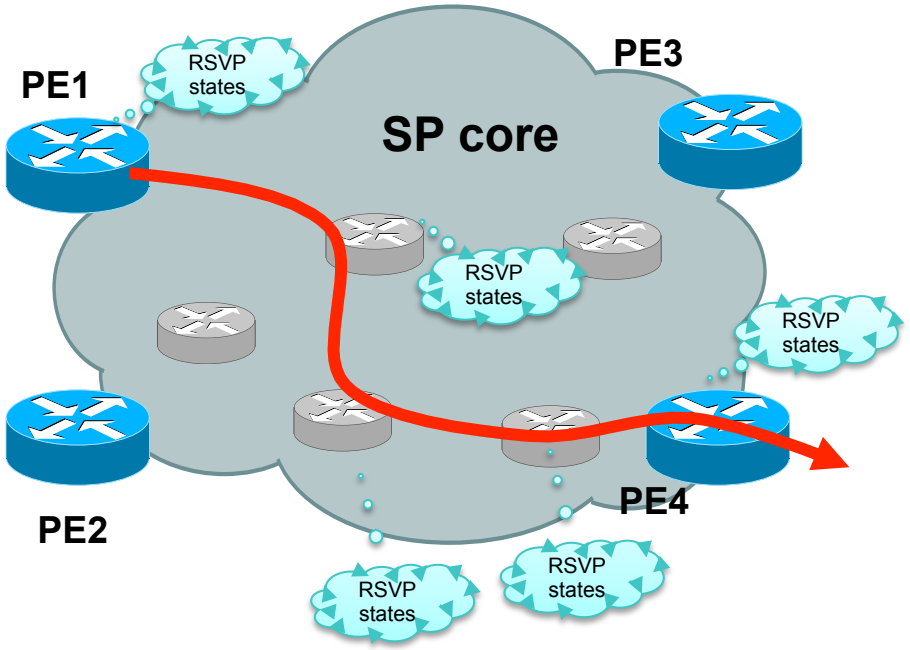
June, 2014

Where is the Internet ?

http://www.google.com/intl/en/ipv6/statistics.html

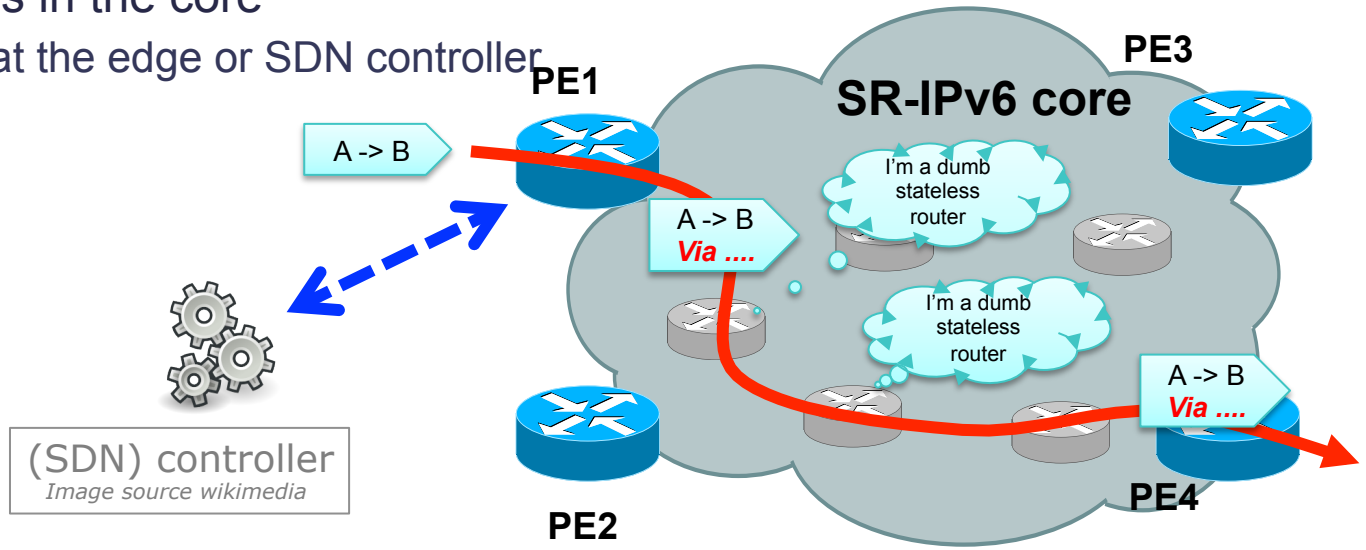
Where is Traffic Engineering (TE) ?

- TE requires RSVP to install states in every the core routers
  - => ‘low’ convergence
  - => TE not widely deployed



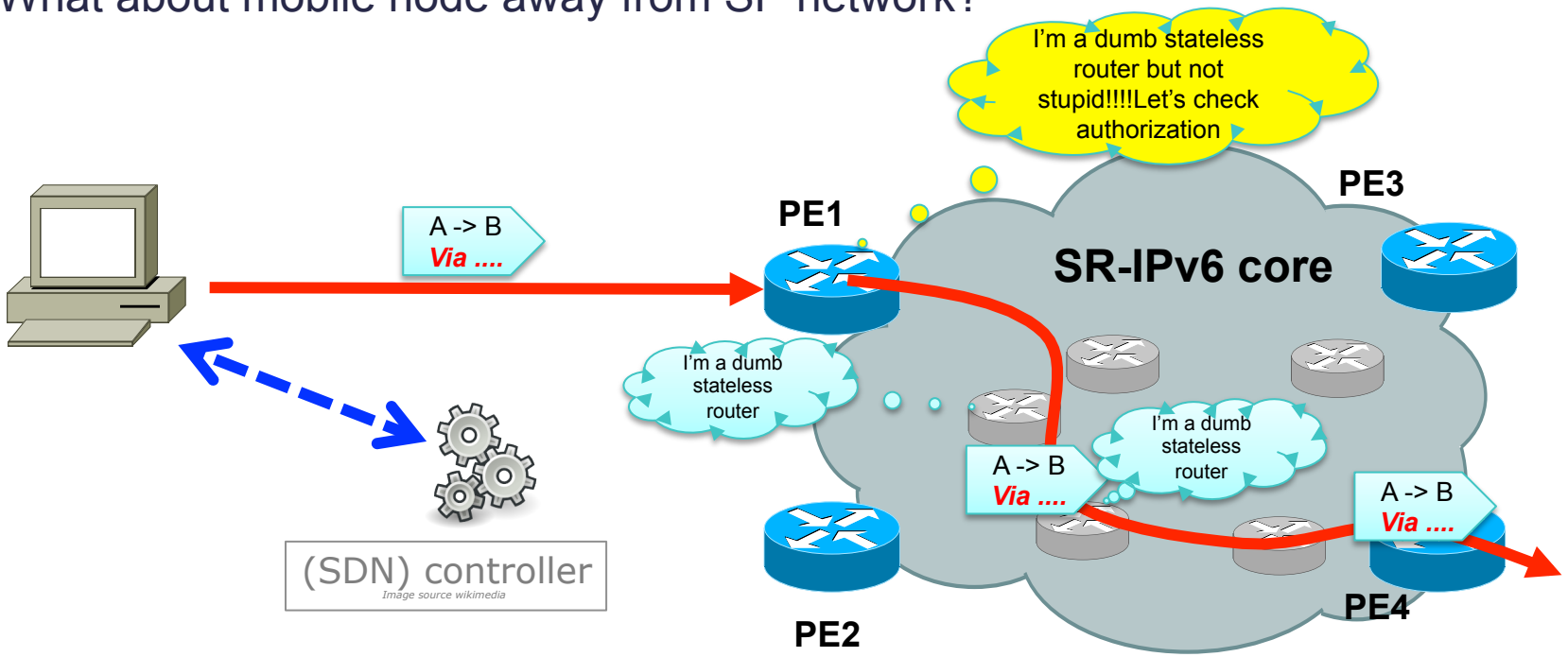
What Can We Do for Efficient/Flexible TE?

- Leverage IPv6 flexibility
  - Overload routing header, i.e. install states in the data packet
- Remove states in the core
  - Push states at the edge or SDN controller



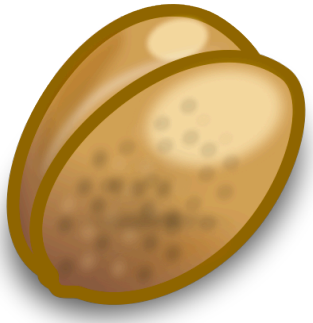
“Extreme Traffic Engineering” from CPE/Set-up Box?

- What about mobile node away from SP network?



Segment Routing in a Nutshell

- Segment Routing:
  - **Source based routing model** where the source chooses a path and encodes it in the packet header as an ordered list of segments
    > Removes routing states from any node other than the source
  - A segment is an instruction applied to the packet.
  - Segment Routing leverages the source routing architecture defined in RFC2460 for IPv6



Source: wikimedia

Segment Routing and the Source Based Routing Model

- Segment Routing technology is extensively explained in
  - http://www.segment-routing.net (includes all published IETF drafts)
- Segment Routing data-planes
  - SR-MPLS: segment routing applied to MPLS data-plane
  - **SR-IPv6: segment routing applied to IPv6**
- SR-IPv6 allows Segment Routing do be deployed over non-MPLS networks and/or in areas of the network where MPLS is not present (e.g.: datacenters)
- Segment Routing backward compatibility
  - SR nodes fully interoperate with non-SR nodes
  - No need to have a full network upgrade

Segment Routing Header

- Segment Routing introduces a new Routing Header Type:
  - The Segment Routing Header (SRH)
  - Contains the list of segments the packet should traverse
  - VERY close to what already specified in RFC2460
  - Changes are introduced for:
    - > Better flexibility
    - > Addressing security concerns raised by RFC5095
- Two SR-IPv6 drafts:
  - draft-previdi-6man-segment-routing-header
  - draft-ietf-spring-ipv6-use-cases

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June 9, 2014

IPv6 Segment Routing Header (SRH)
draft-previdi-6man-segment-routing-header-01

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Source Packet Routing in Networking

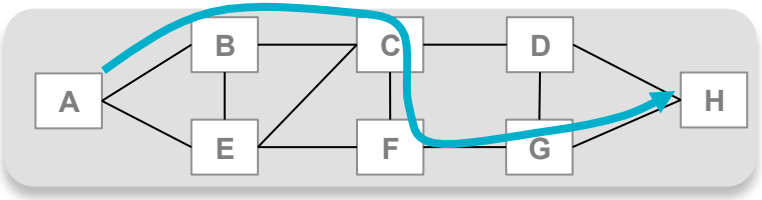
IPv6 SPRING Use Cases
draft-ietf-spring-ipv6-use-cases-00

Segment Routing Model

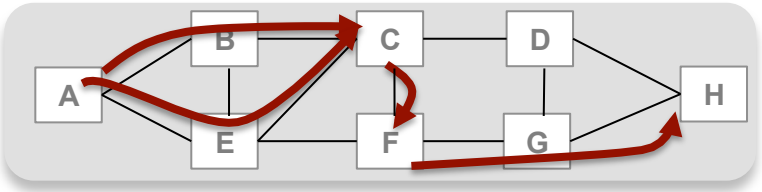
- How to express an explicit (source routed) path knowing that:
  - Nodes may represent routers, hosts, servers, application instances, services, chains of services, etc.
  - A path is encoded into the packet by the originator (or ingress) node
  - A path may be modified by a node within the path
  - The network may have plurality of nodes not all supporting Segment Routing

Segment Routing Model

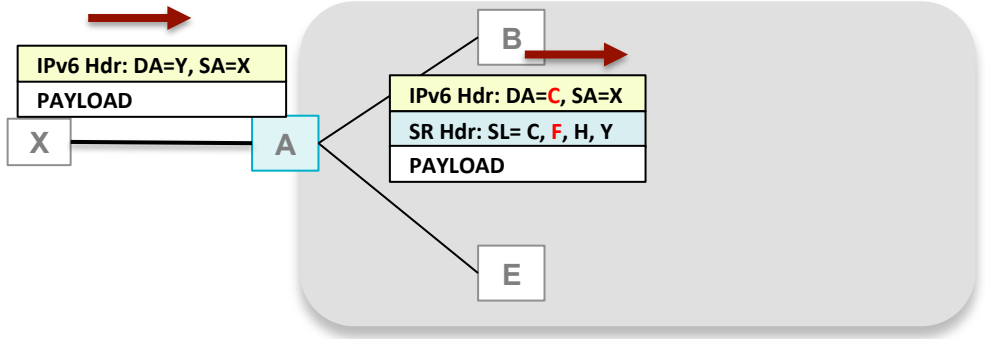
- Assuming following topology:
  - Node A has two shortest paths to C



- How to best express path: [A, B, C, F, G, H]
- Source rooted path with segments: [C,F,H]
  - First segment: set of shortest paths from A to C (ECMP aware)
  - Second segment: adjacency/link from C to F
  - Third segment: shortest path from F to H



Segment Routing Header

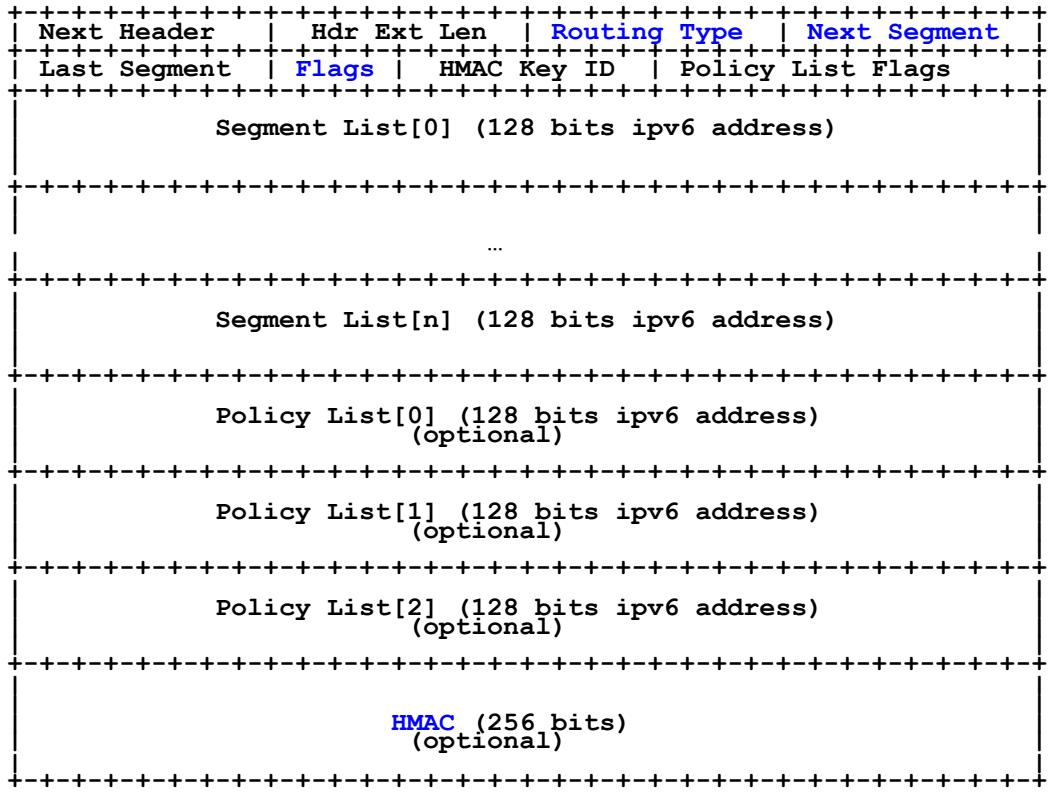


- At ingress:
  - Path is computed or received by a controller (e.g.: SDN Controller)
  - Path is instantiated through a list of segments
  - A SRH is created with the segment list representing the path

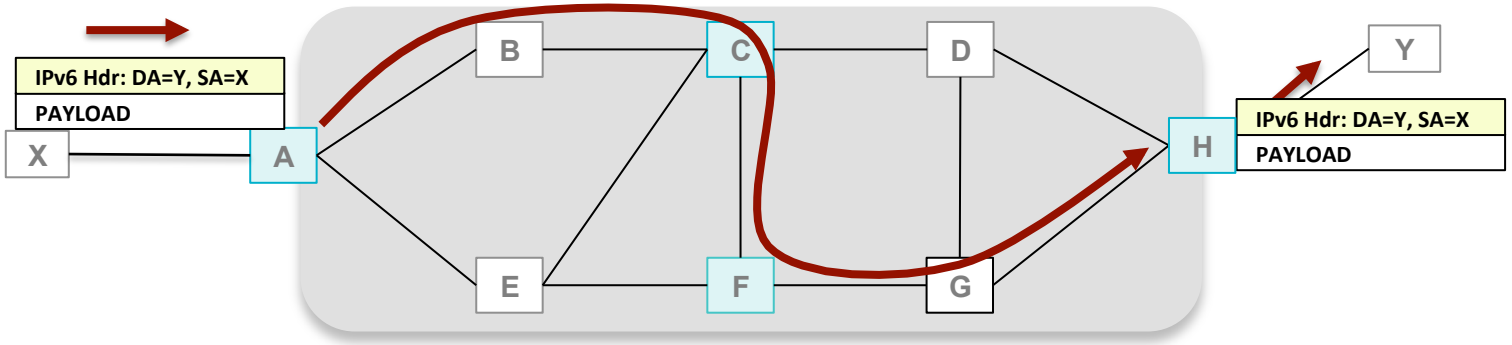
Segment Routing Header

- Segment Routing Header:
  - **Segment List** describes the path of the packet: list of segments (IPv6 addresses)
  - **Next Segment**: a pointer to the segment list element identifying the next segment
  - **HMAC**
  - **Flags** and optional policy information
- The Active Segment is set as the Destination Address (DA) of the packet
  - At each segment endpoint, the DA is updated with the “Next Segment”
  - Compliant with RFC2460 rules for the Routing Header
    > Request to IANA to allocate a new type (probably 4)

Segment Routing Header

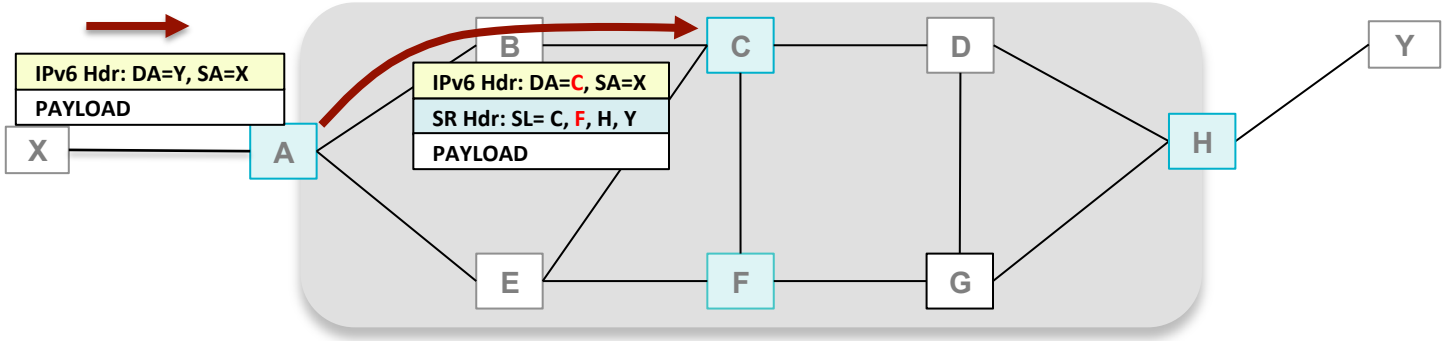


SR-IPv6 Example



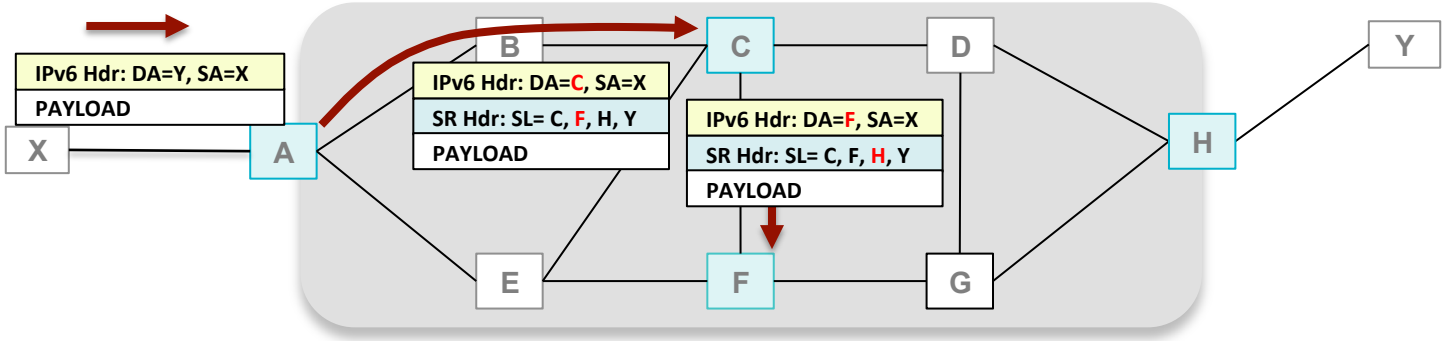
- Example:
  - Classify packets coming from X and destined to Y and forward them across A,B,C,F,G,H path
  - Nodes A, C, F and H are SR capable

SR-IPv6 Example



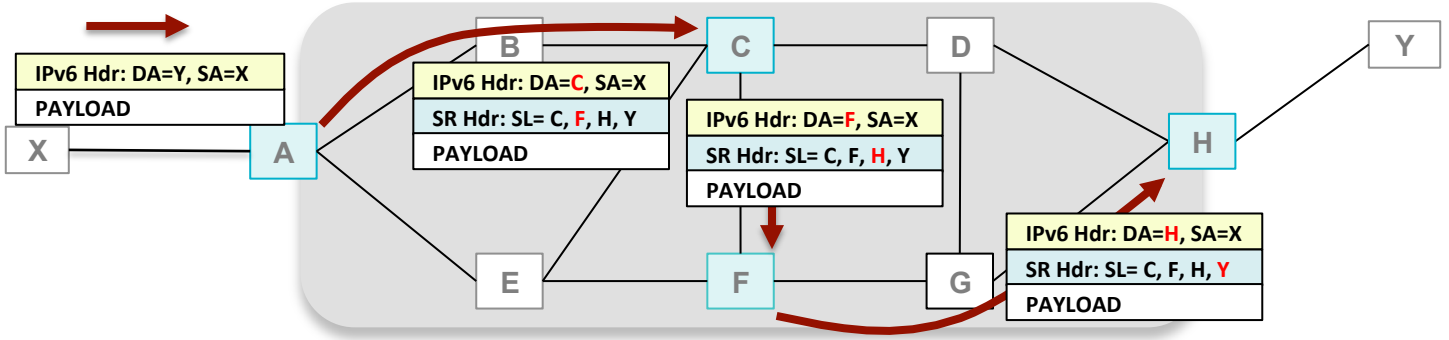
- At ingress, the Segment Routing Header (SRH) contains
  - **Segment List**: C,F,H,Y (original destination address is encoded as last segment of the path)
  - **Next Segment**: points to the next segment of the path (F)
  - **DA** is set as the address of the first segment: C
- Packet is sent towards its DA (C, representing the first segment)
  - Packet can travel across non SR nodes who will just ignore the SRH
  - RFC2460 mandates only the node in the DA must examine the SRH

SR-IPv6 Example



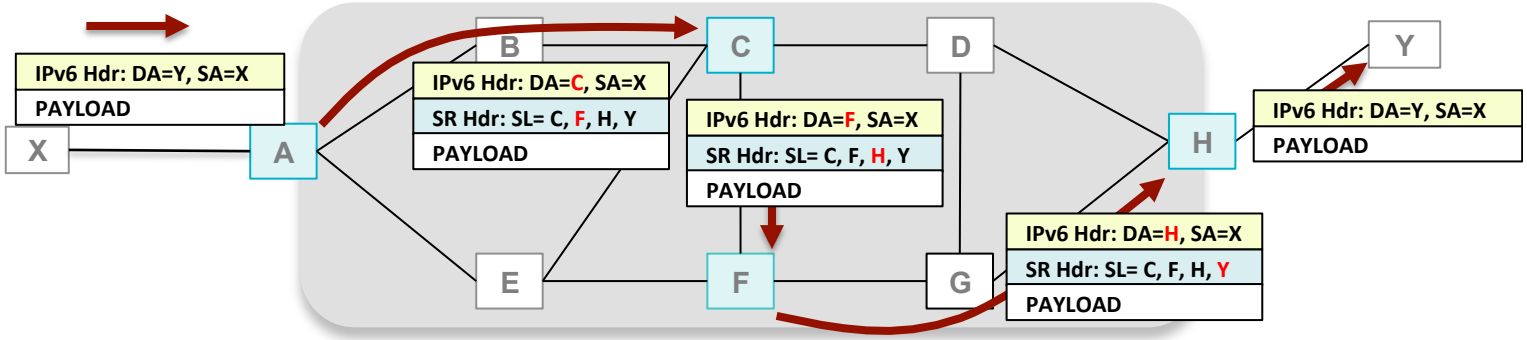
- When packet reaches the segment endpoint C
  - Next Segment is inspected and used in order to update the DA with the next segment address: F
  - Next Segment pointer is incremented: now points to H
  - Packet is sent towards its DA

SR-IPv6 Example



- When packet reaches the segment endpoint F the same process is executed:
  - Next Segment is inspected and used in order to update the DA with the next segment address: H
  - Next Segment pointer is incremented: now points to Y (the original DA)
  - Packet is sent towards its DA

SR-IPv6 Example

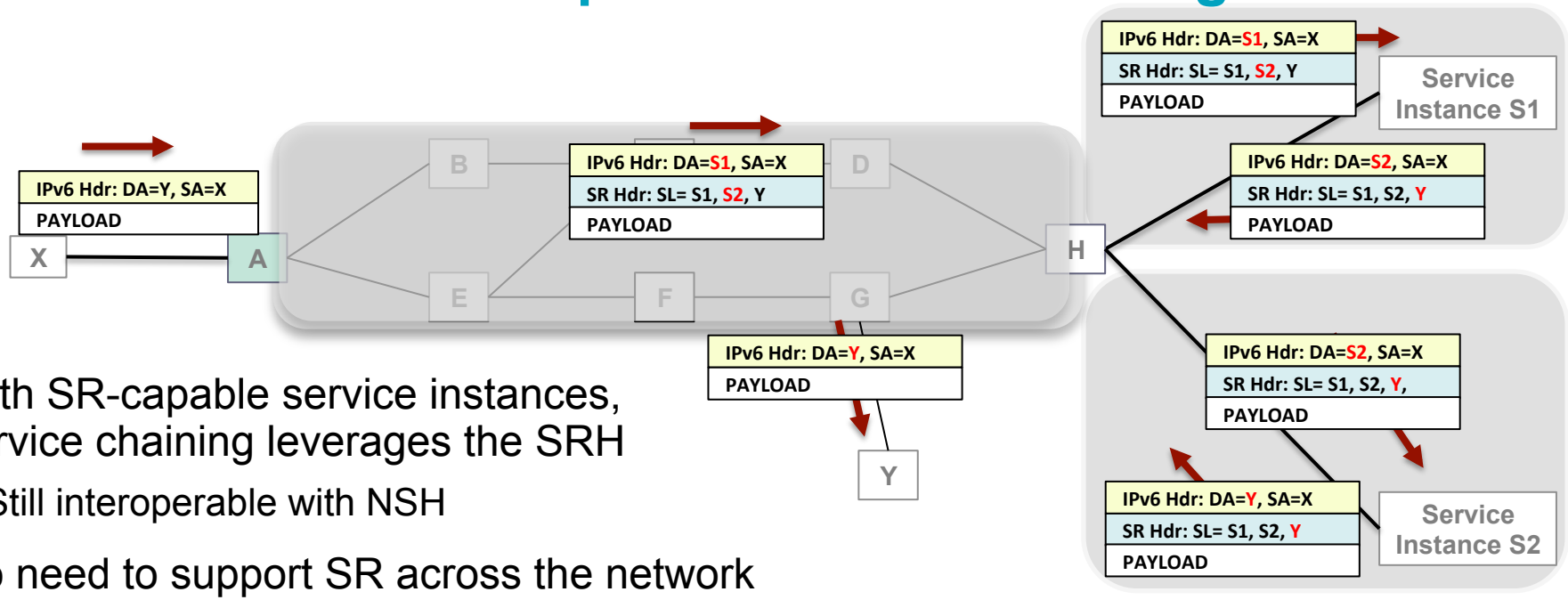


- When packet reaches the segment endpoint H:
  - Next Segment is inspected and used in order to update the DA with the next segment address: Y
  - A flag (cleanup-flag) in SRH tells H to cleanup the packet and remove the SRH
  - Packet is sent towards its DA

Segment Routing Use Cases: Fast Reroute

- Fast Reroute (FRR)
  - Upon failure, the protecting node reroute traffic according to new Segment List
  - Backup path Segment List is pre-computed and pre-instantiated
  - Upon failure, the backup Segment List is inserted

Use Cases: SR-IPv6 Capable Service Chaining



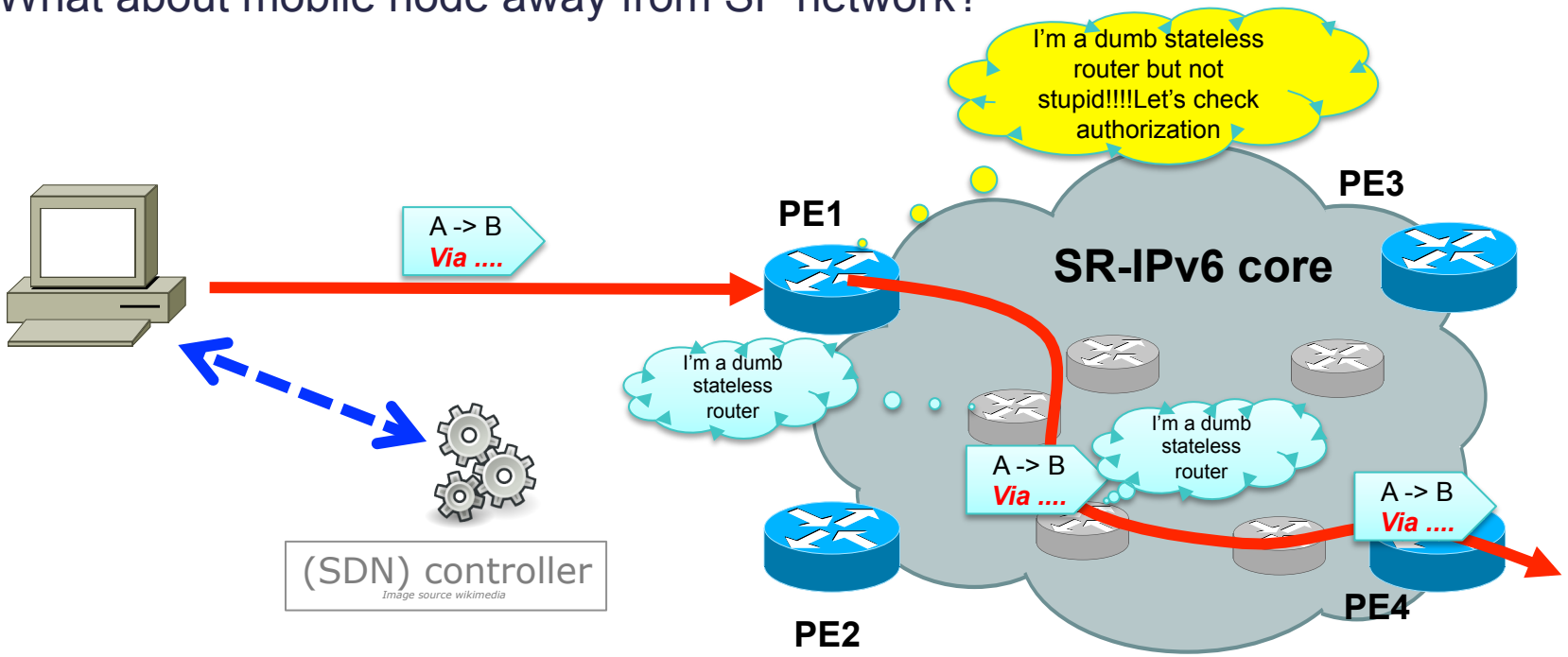
- With SR-capable service instances, service chaining leverages the SRH
  - Still interoperable with NSH
- No need to support SR across the network
  - Transparent to network infrastructure
- Next Step: allow SR service chaining with non-SR applications…
  - Work in progress

Segment Routing Use Cases: Application driven traffic steering

- Impose source-routing semantics within an application or at the edge of a network (for example, a CPE or home gateway)
- CPE gets the SRH from a controller and impose it to outgoing traffic
- SRH includes HMAC that is going to be validated at ingress **only**

“Extreme Traffic Engineering” from CPE/Set-up Box?

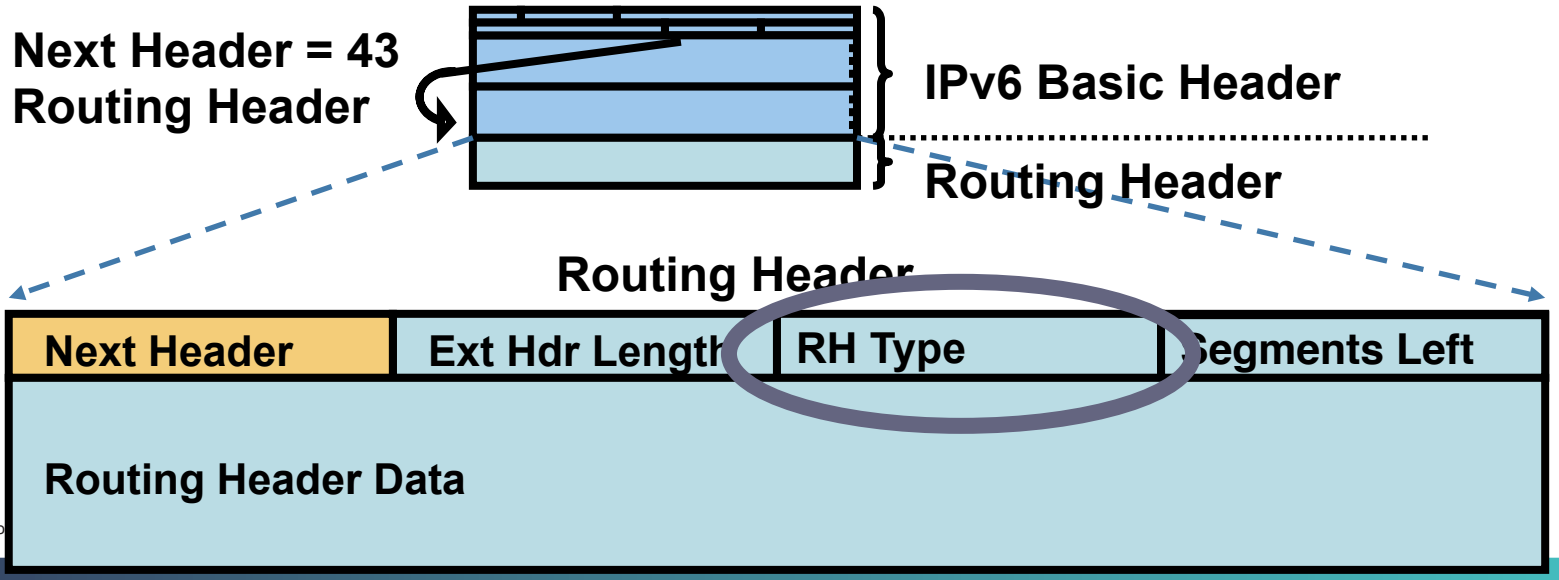
- What about mobile node away from SP network?



Huh??? Source Routing Security? What about RFC 5095?

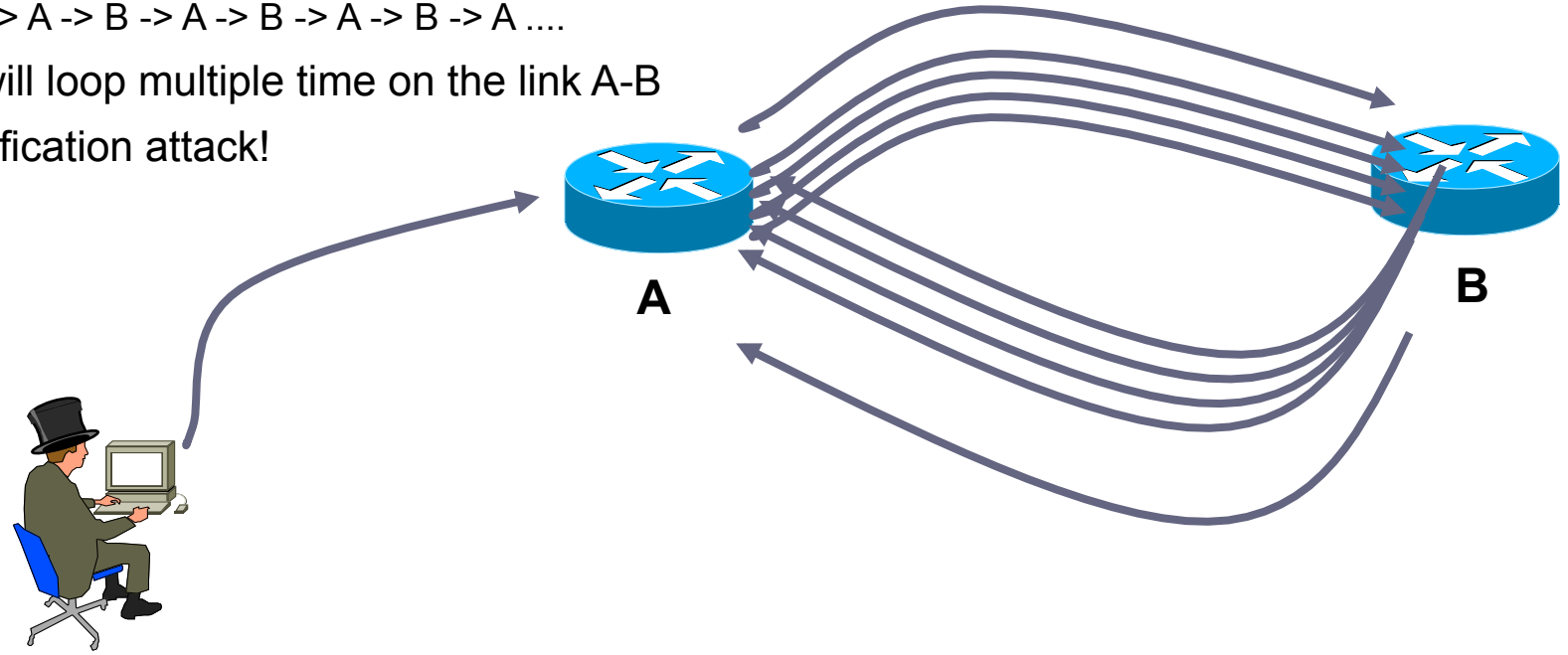
IPv6 Routing Header

- An extension header, processed by **intermediate** routers
- Three types
  - Type 0: similar to IPv4 source routing (multiple intermediate routers)
  - Type 2: used for mobile IPv6
  - Type 3: RPL (Routing Protocol for Low-Power and Lossy Networks)



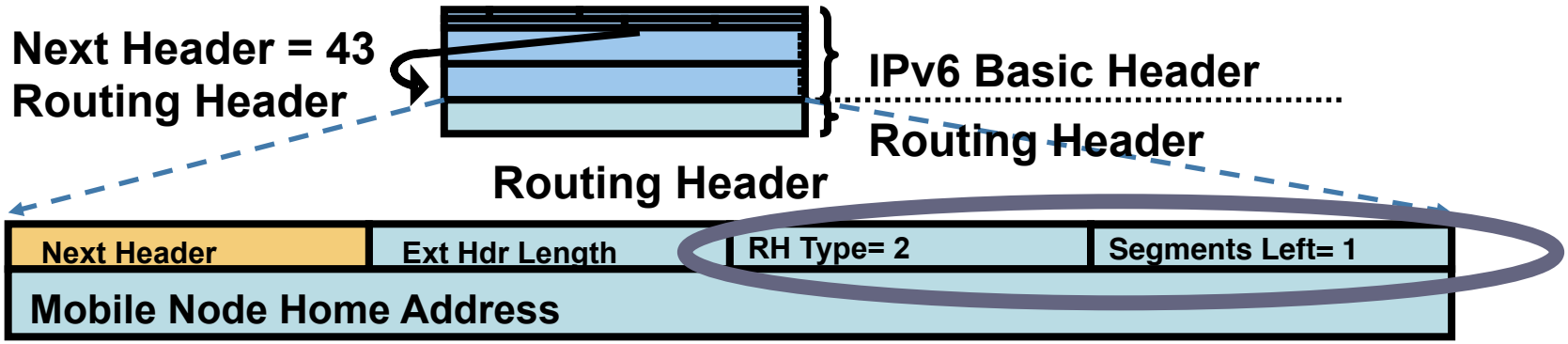
Type 0 Routing Header: Amplification Attack

- What if attacker sends a packet with RH containing
  - A -> B -> A -> B -> A -> B -> A -> B -> A ....
- Packet will loop multiple time on the link A-B
- An amplification attack!



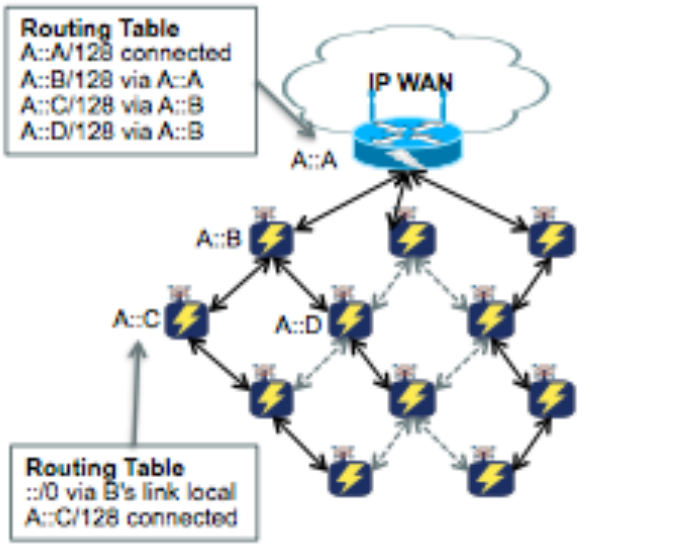
IPv6 Type 2 Routing Header: no problem

- Rebound/amplification attacks impossible
  - Only one intermediate router: the mobile node home address



RH-3 for RPL: no problem

- Used by Routing Protocol for Low-Power and Lossy Networks
- But only **within a single trusted network** (strong authentication of node), never over a public untrusted network
  - Damage is limited to this RPL network
  - If attacker was inside the RPL network, then he/she could do more damage anyway



Segment Routing Security

- Addresses concerns of RFC5095
  - HMAC field to be used at ingress of a SR domain in order to validate/authorize the SRH
  - Inside SR domain, each node trust its brothers (RPL model)

- HMAC requires a shared secret (SDN & SR ingress routers)
  - Outside of current discussions
  - Pretty much similar to BGP session security or OSPFv3 security

SRv6 packets dropped on the Internet

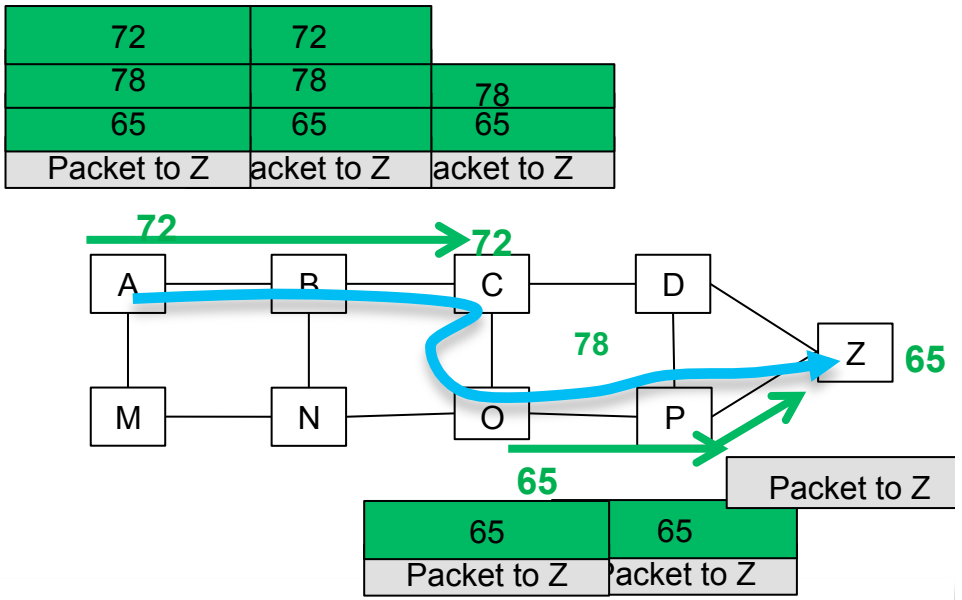
- RFC 5095 deprecates source routing
  - RH-0 only
  - Forwarding based on DA is not prevented even in presence of RH
- Some tests with scapy shows RH-4 (assuming IANA value of 4) => packets are not dropped
- Test on your own: http://www.vyncke.org/sr.php
  - And let us know !

Segment Routing for MPLS

draft-filsfils-spring-segment-routing-mpls

Combining Segments

- ECMP
  - Node segment
- Per-flow state only at head-end
  - not at midpoints
- Source Routing
  - the path state is in the packet header



Wrapping Up

Source: wikimedia

Summary

- Segment Routing implements the source routing model for both MPLS and IPv6
- IPv6 source routing model is already integrated in RC2460 and Segment Routing introduces minor changes through a new routing type header
  - Segment Routing Header
- Segment Routing is very flexible and interoperable with non-SR nodes
  - A SR node can be a router, a server, any appliance, application, …
- Segments are identified by IPv6 addresses, no specific signaling is needed

Conclusion

- Standardization of Segment Routing is in progress at IETF
  - More than 17 drafts
- Running code exists
- Next Step: Segment Routing for Service Chaining
  - More flexible, interoperable with existing applications
- Collaboration with operator on going and very fruitful
  - Join the team !
- Pointers:

  http://www.segment-routing.net

  mailto:ask-segment-routing@cisco.com

Thank you.