Control Plane & Data Plane

PANRG - IETF 118
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draft-dekater-scion-controlplane & draft-dekater-scion-dataplane

Background: the SCION Internet Architecture

- Path-aware *inter-domain* Internet architecture, focusing on
  - Availability (even in presence of adversaries)
  - Security (routing)
  - Scalability

- In production use by 7 ISPs, trial deployment by 5 ISPs, serving the Swiss inter-banking network SSFN & an education network, being tested for the Swiss health network.

- For a general overview about SCION, see: draft-dekater-panrg-scion-overview

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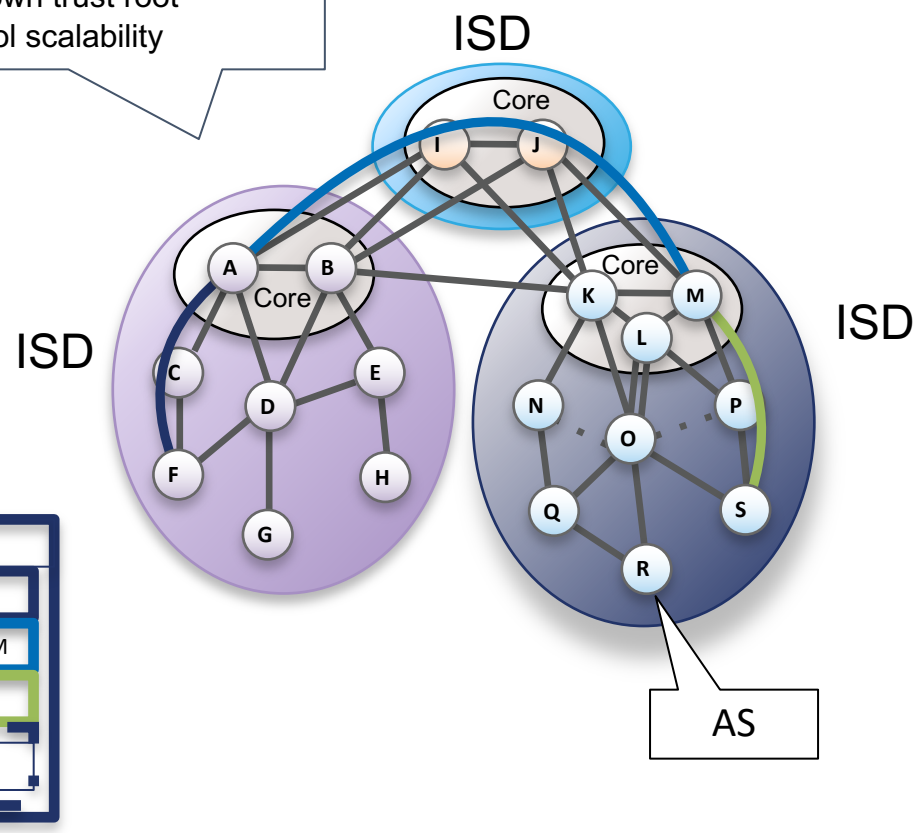
SCION Core Components in a Nutshell

Data Plane - *Packet Forwarding*
- Combine path segments into end-to-end path (ISD-AS level)
- Packets contain end-to-end ISD-AS path
- Forward packet based on e2e path, agnostic of end-host address

Control Plane – *Inter-Domain Routing*
- Discover valid inter-domain paths
- Construct and disseminate path segments
- Routing is based on <ISD>-<AS> tuple as "locator"
- Intra-AS communication reuses existing data plane and routing (e.g., IPv6/IPv4)

Control Plane PKI (CP-PKI) - *Authentication*
- Authenticate path information
- Used by control plane
- Basis for unique ISD trust model

Isolation Domain (ISD):
Grouping of Autonomous Systems (AS)
•Each ISD has its own trust root
•For routing protocol scalability



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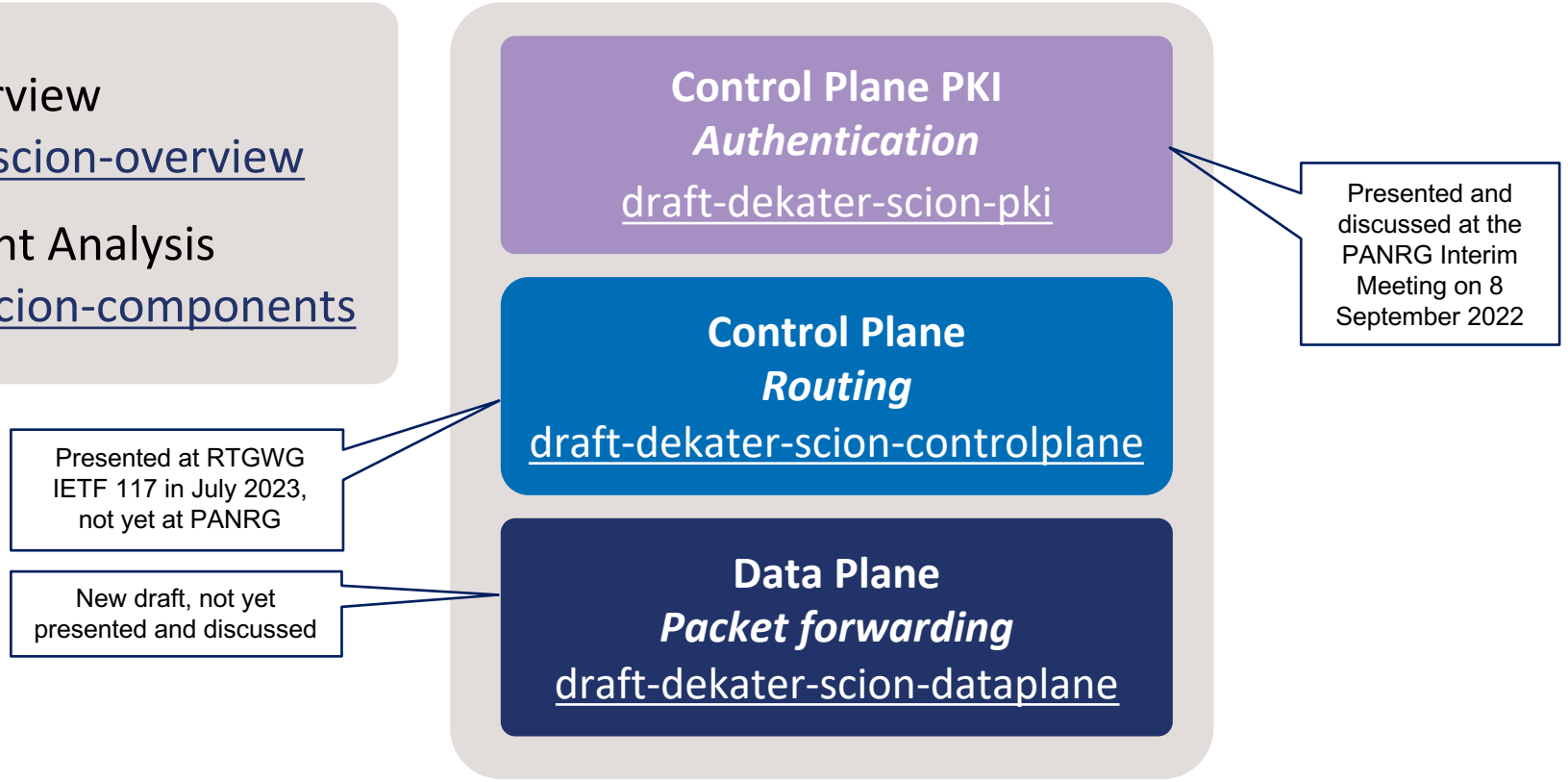
SCION - Work Done Since IETF 116

SCION Overview
draft-dekater-panrg-scion-overview

SCION Component Analysis
draft-rustignoli-panrg-scion-components



IETF 118 Prague:

➔ Joined the Hackathon last weekend
➔ Have a SCION vendor and user here today

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Control Plane

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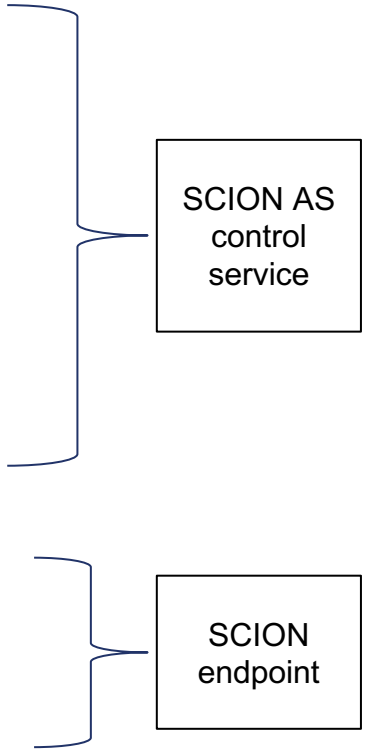
Control Plane – Inter-Domain Routing

- **Exploration (beaconing)**
  SCION control plane discovers valid paths through "beaconing"
- **Registration**
  ASes select path segments and make them available to other ASes
- **Resolution (lookup and combination)**
  Source endpoint creates an e2e path and adds it to the packet header



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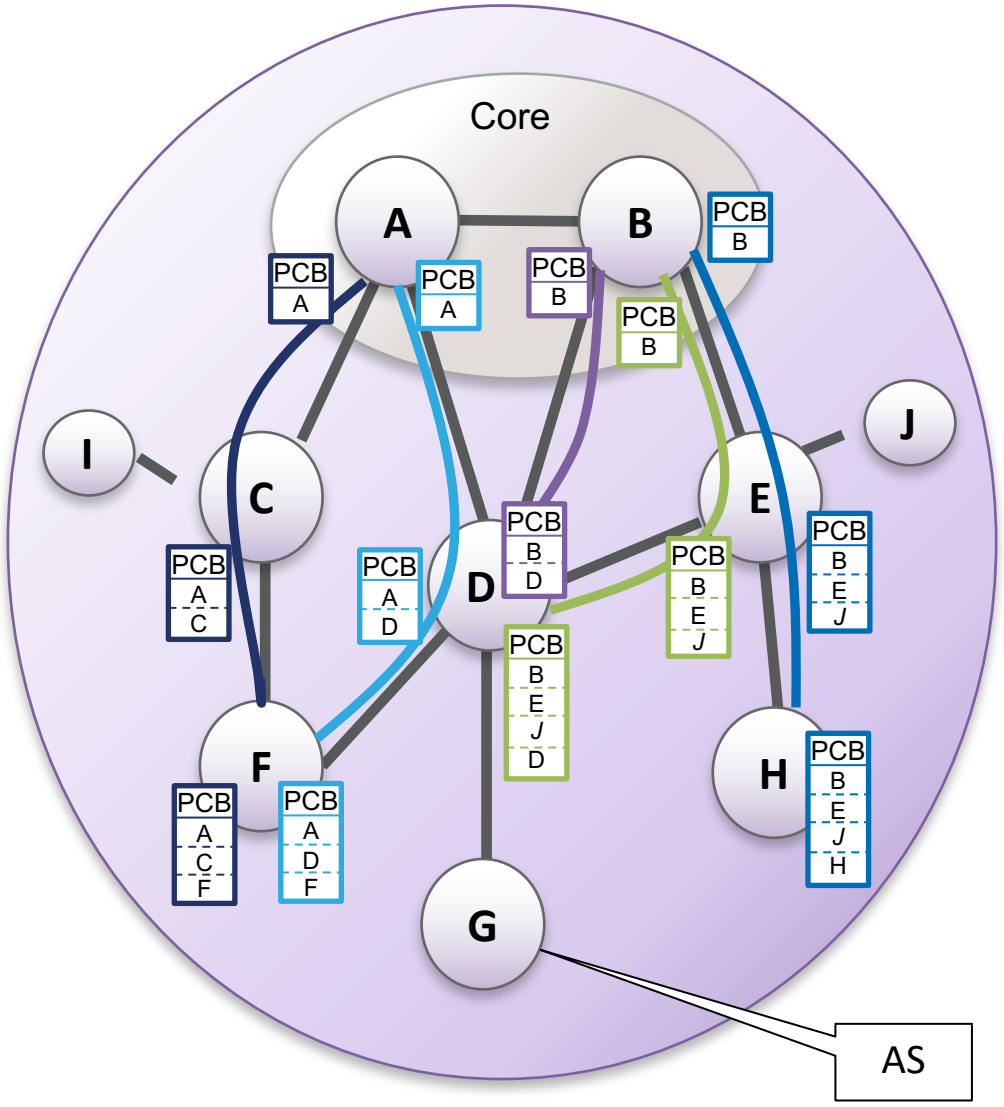
CP - Path Exploration

- Core ASes periodically send Path Construction Beacons (PCBs)
  - **Inter**-ISD “core” beacons are flooded (with loop prevention mechanism)
  - **Intra**-ISD beacons travel top-down (parent to child)
- Per propagation period, each AS
  - further propagates selected PCBs to neighbors
- PCBs accumulate cryptographically protected path- and forwarding information per traversed AS
- Key content of one PCB:
  - Initiation timestamp/Expiration time/ID
  - List of all ASes on the path so far
  - Signed routing information per AS
  - Possibility of peering links



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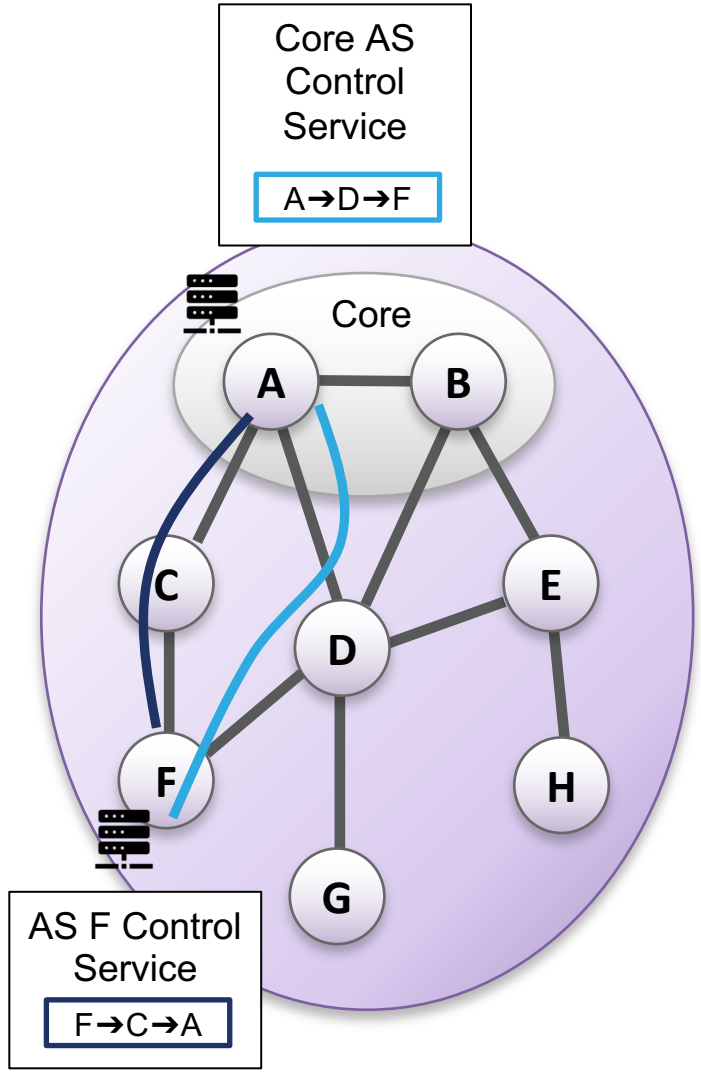
CP - Path Registration

- Each AS periodically stores/registers selected PCBs as **path segments** (**up**-path or **down**-path)
  - Each AS can freely choose selection algorithm and criteria
  - Reversion of path segment direction is possible
- **Up-path** segments
  - How the AS wants to reach its core AS(es)
  - Stored at the AS's local control service
- **Down-path** segments
  - How the AS wants to be reached by other ASes
  - Registered with the control services of the relevant core ASes



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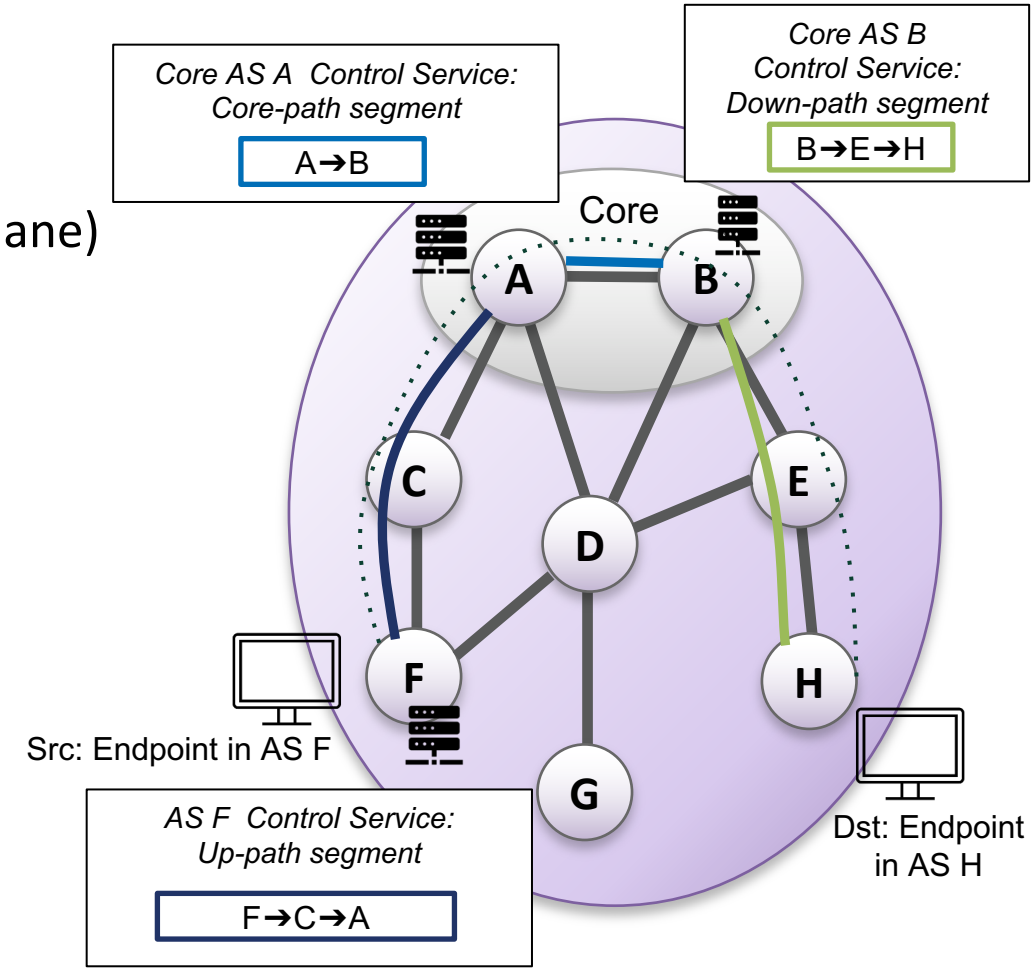
CP/DP - Path Resolution

Source endpoint creates e2e path by
- looking up path-segments to destination AS (control plane)
- combining path-segments into e2e path (data plane)

Requires lookup of max. **3** path segments:
- **Up**-path segment
  - To reach **core AS** in **source ISD**
  - Responsible: control service of **source AS**
- **Core**-path segment
  - To reach **core AS** in **destination ISD**
  - Responsible: control service of **core AS** in **source ISD**
- **Down**-path segment
  - To reach **destination AS**
  - Responsible: control service of **core AS** in **destination ISD**

Reduce latency by:
- Caching returned path segments
- Sending requests for path segments in parallel



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Data Plane

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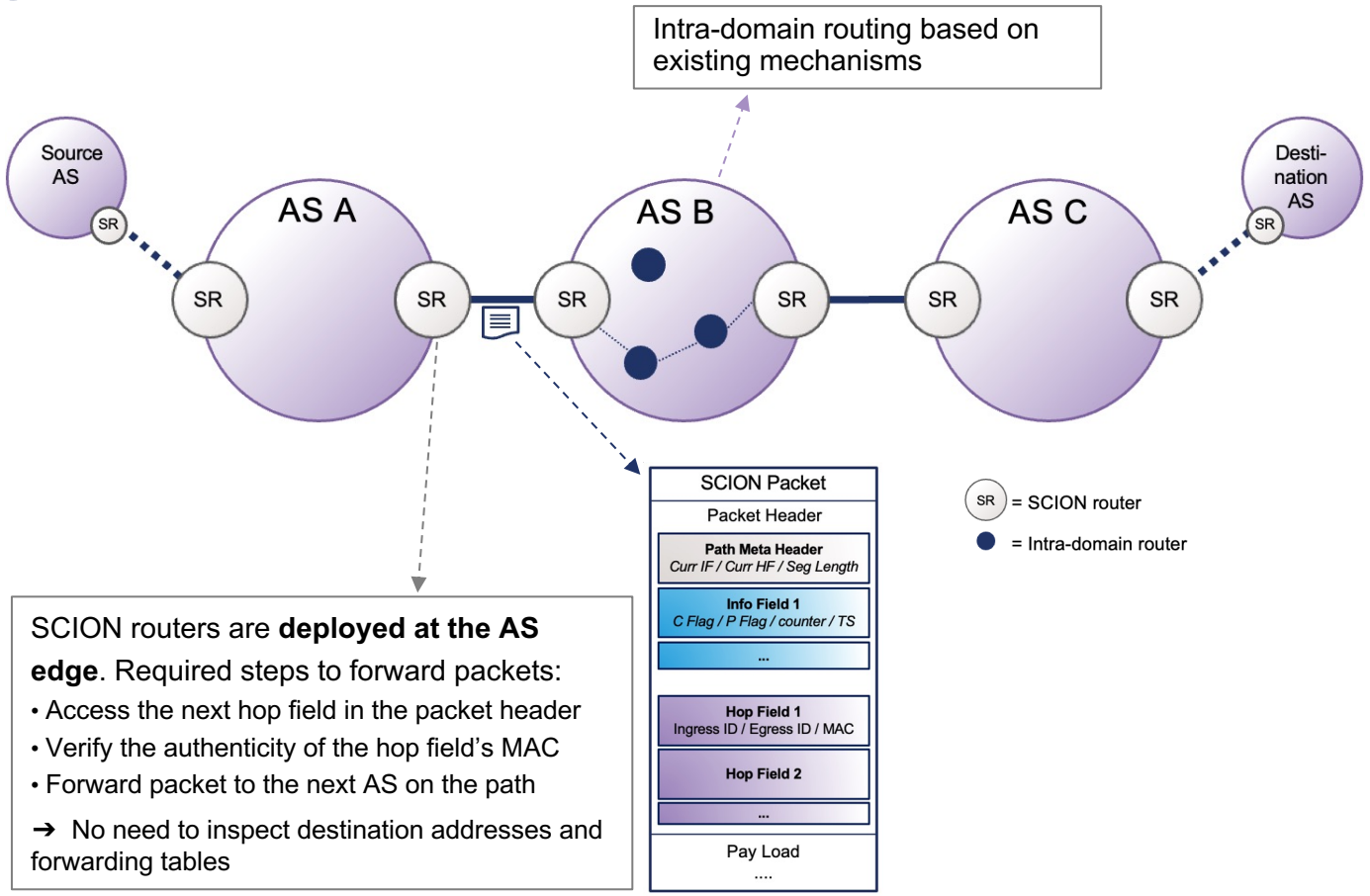
Data Plane - Overview

- SCION data plane forwards inter-domain packets between ASes
- Forwarding is based on **end-to-end path information** contained **in the packet header**
  - Path information consists of a sequence of hop fields – 1 hop field per on-path AS
  - Each hop field includes ingress- and egress interface IDs for the corres-ponding AS
  - Hop fields are authenticated with a Message Authentication Code (MAC) to prevent forgery:
    - ASes use their own secret key to authenticate the hop field
    - The MAC is checked by routers during forwarding
    - ASes only forward authorized traffic



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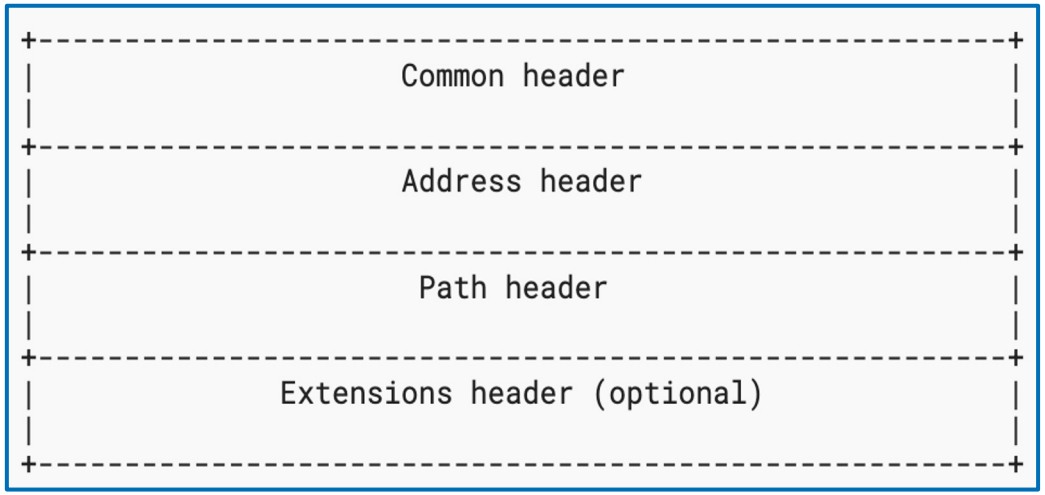
DP – SCION Header Specification

SCION forwarding is based on end-to-end path information contained in the packet header.
The SCION packet header consists of a

- ***Common* header** - defines the
  - length of header & payload
  - type of SCION path
  - type & length of endpoint address of source and destination
- ***Address* header** – defines the
  - ISD-, AS-, and endpoint addresses of source and destination
- ***Path* header** – contains the
  - full AS-level forwarding path
- ***Extensions* header** (optional)
  - Hop-by-Hop and End-to-End options, similar to IPv6 extensions



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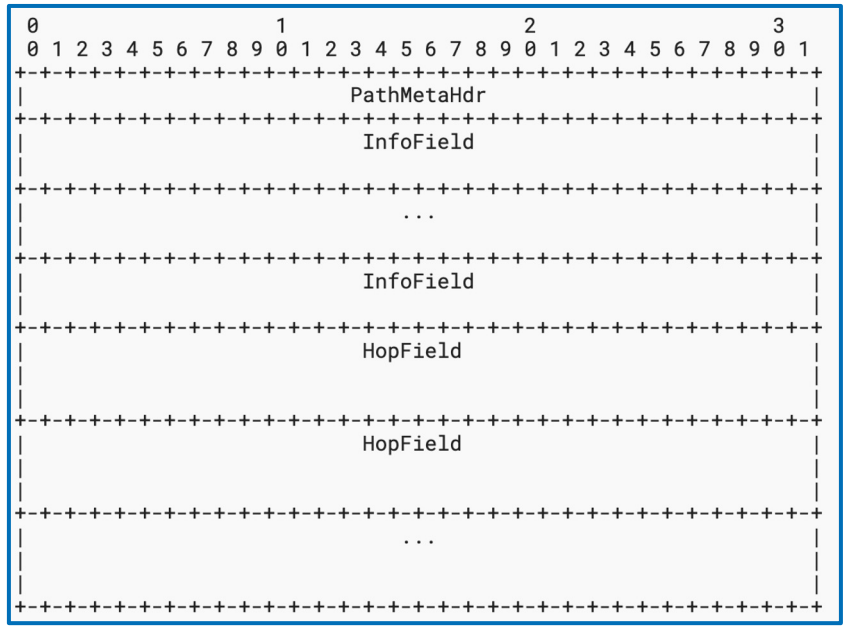
SCION Path - Path Header Overview

The **SCION** path type is the standard path type in SCION.
The path header of the SCION path type consists of:

- *One* **path meta header**
  - Indicates the currently valid segment info field and AS hop field while the packet is traversing the network
  - Defines the number of hop fields per segment
- *Up to 3* **info fields**
  - Each info field contains basic information about corresponding path segment
  - Number of info fields == the number of path segments in the path
- *Up to 64* **hop fields**
  - Each hop field represents a hop through an AS on the path
  - Hop field information is authenticated with Message Authentication Code (MAC) to prevent forgery



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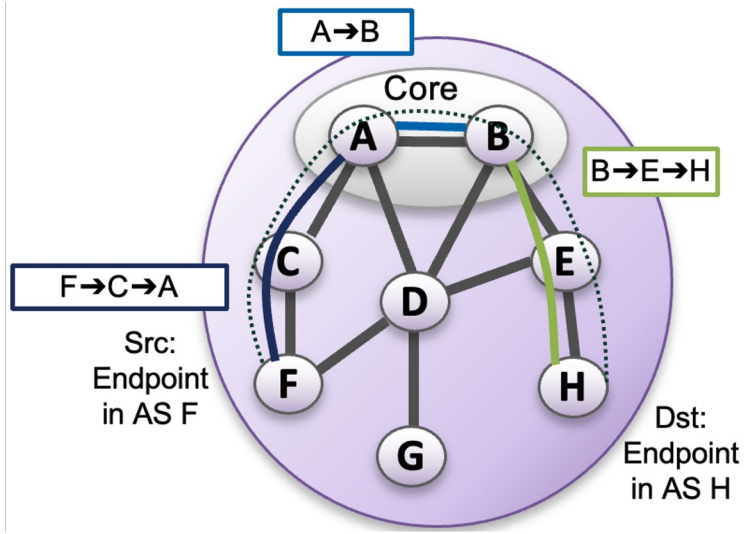
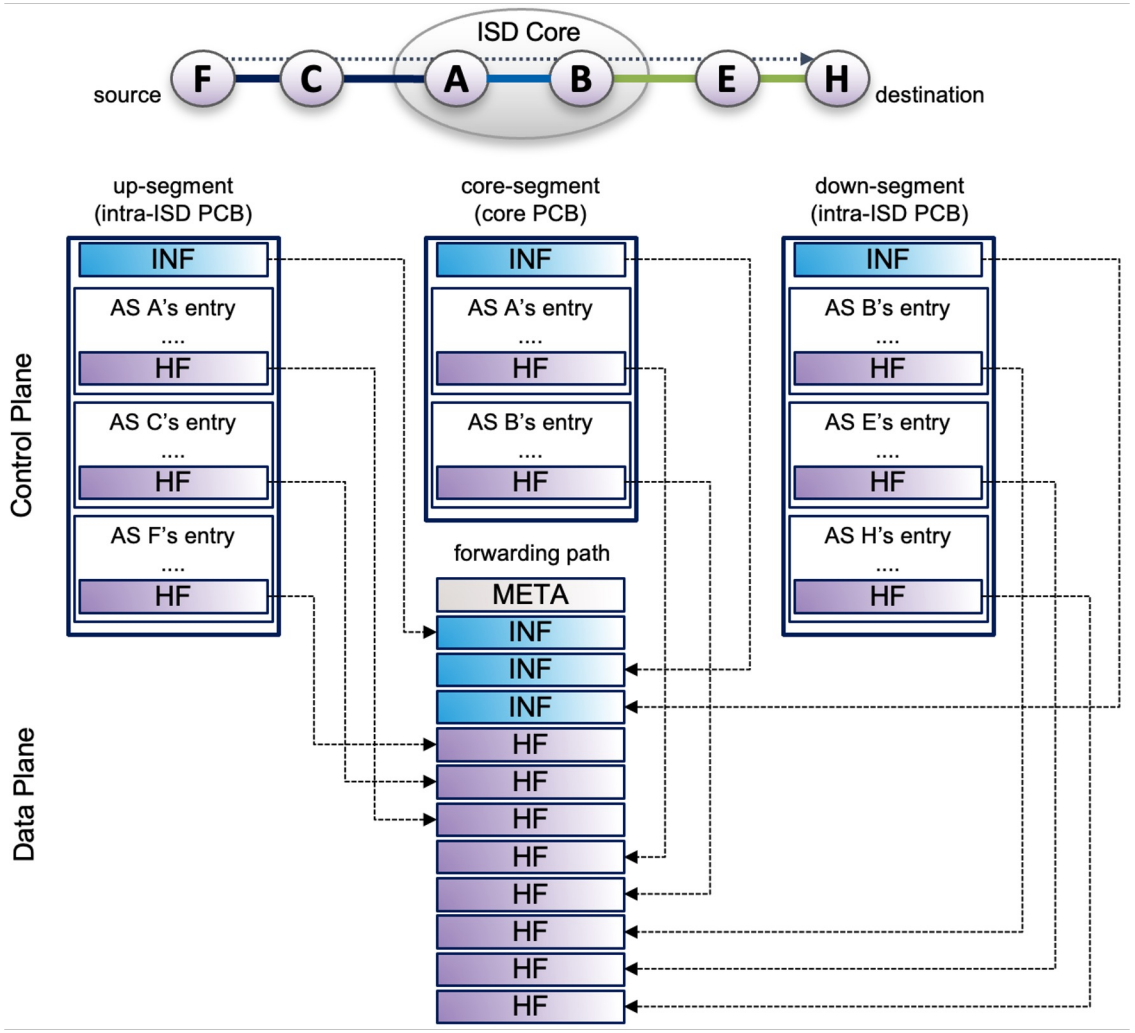
Construction of SCION Path - Path Header

An endpoint creates E2E paths in the data plane, by combining path segments looked up in the control plane

- Each E2E path can contain at most one of each type of segment (up-, core-, and down-segment)
- The SCION path header is created by extracting required info and hop fields from the corresponding path segments





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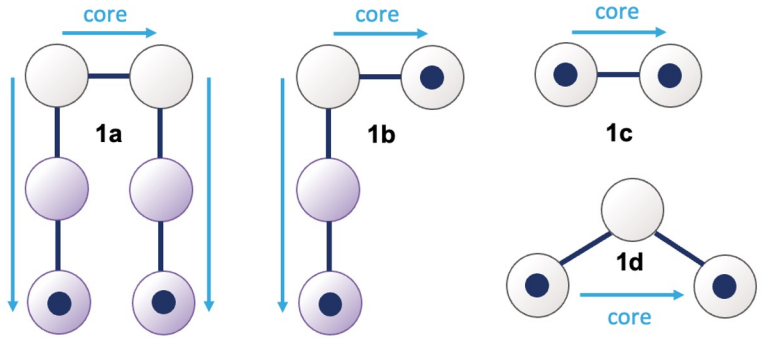
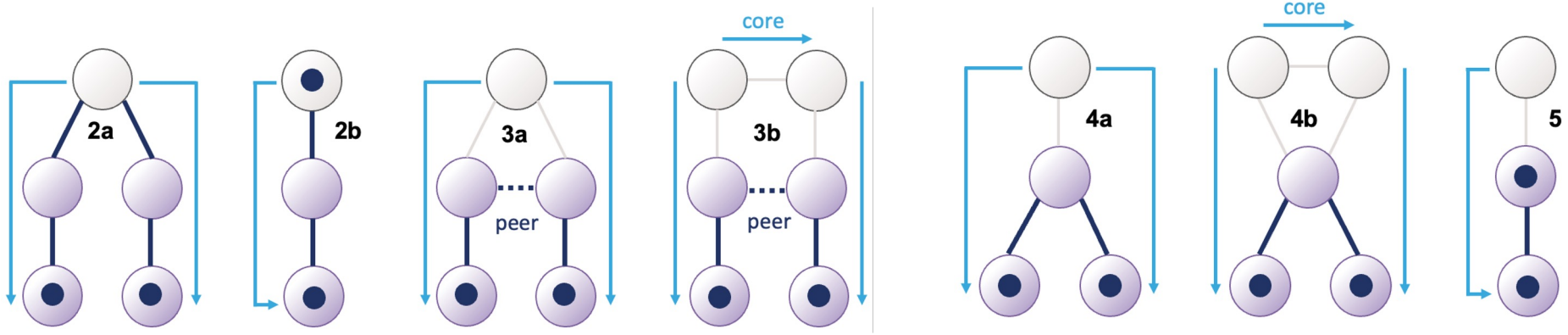
DP - Possible Path-Segment Combinations

Allowed path-segment combinations:

- Communication **through core Ases**
  - Core-segment combination *(1a, 1b, 1c, 1d)*
  - Immediate combination *(2a, 2b)*
- Communication **via a peering shortcut** *(3a and 3b)*
- Communication **via an AS shortcut** *(4a and 4b)*
- **On-path** communication *(5)*





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Data Plane – Advantages SCION Design Choice

- It provides **control & transparency** over forwarding paths **to endpoints**
- It offers **inter-domain multi-path**
- It **enables path authorization**
- It **simplifies the packet-processing** at routers
  - Just access the next hop field in the packet header
  - No longest-prefix matching on IP addresses
- **Intra-domain routing** protocols and infrastructure **is reused**

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Security Considerations*

- **PCBs are signed** in an onion fashion in order to avoid path hijacks/splicing. Every AS can verify all routing messages by following the certificate chain.
- **Hop-by-hop path authorisation**: Information on each hop is authenticated with a MAC, checked by routers at forwarding
  ➔ Each AS only forwards traffic on paths that it has explicitly authorized
- **Lack of global kill-switches**: Roots of trust are ISD-scoped, thanks to the use of own PKI (CP-PKI draft-dekater-scion-pki)

*Section not available in the drafts yet, will come soon

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Summary & Next Steps

Summary:

- SCION is a future Internet architecture with **productive deployment**
  - Its **control plane PKI** builds the basis for a **unique trust model** per ISD
  - Its **control plane** provides **path-aware, inter-domain routing**
  - Its **data plane** forwards data packets based on **end-to-end path information** contained **in the packet header**
- IETF Internet Drafts are available for all three main SCION components (PKI, CP, DP)
  - Feedback is welcome
  - To be done: IANA section, Security considerations

Next Steps (within the IETF):

- To be discussed at the end of today's session

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Thank You For Your Attention!

Questions & Remarks?

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