It's 11PM.

DO YOU KNOW WHERE YOUR HEADERS ARE?

Measuring Network Privacy with

Share Count Analysis

David Naylor

Peter Steenkiste

Carnegie Mellon University

GOAL

measure “how private” a network architecture or protocol is

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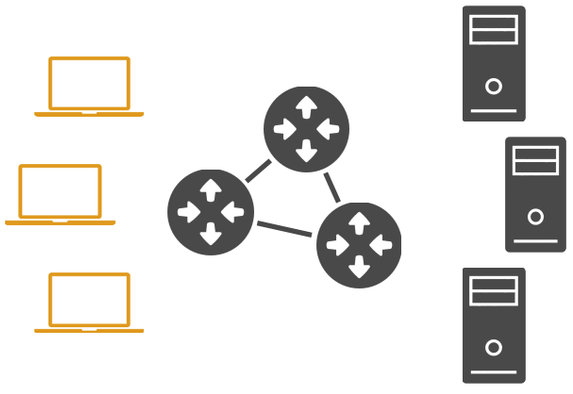
measure "how private" a network architecture or protocol is

1 What is Privacy? | 2 Threat Model | 3 "Indicators"

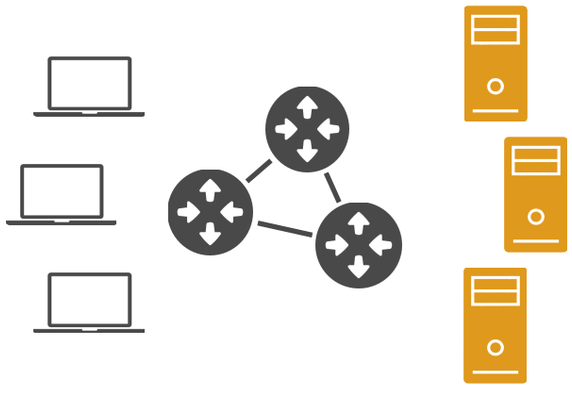
Can the adversary…

…learn sender?



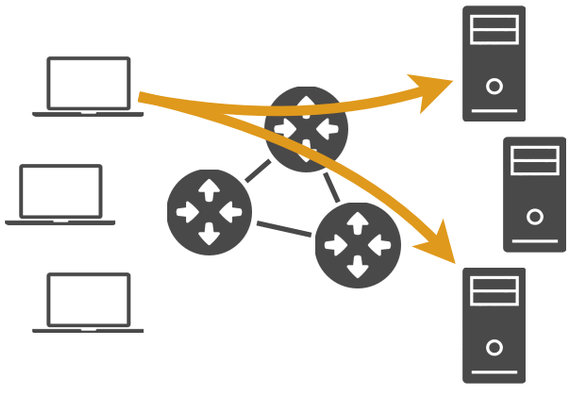
WHO

…learn receiver?



WHAT

…link flows?



HISTORY

GOAL

measure "how private" a network architecture or protocol is

1 What is Privacy?

2 Threat Model

3 "Indicators"

Global, passive adversary.

CAN:

Observe traffic on any link/device.

CANNOT:

Modify, drop, or inject packets.

GOAL

measure "how private" a network architecture or protocol is

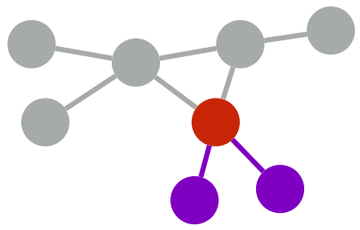
1 What is Privacy?

2 Threat Model

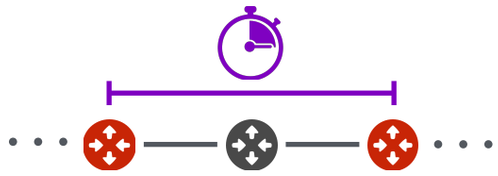
3 "Indicators"

Adversary learns from:

Headers



Topology



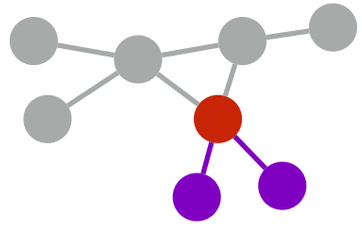
Timing

Choice of indicators has a big impact on measurement tool

Headers

WHAT YOU MEASURE | Properties of an architecture

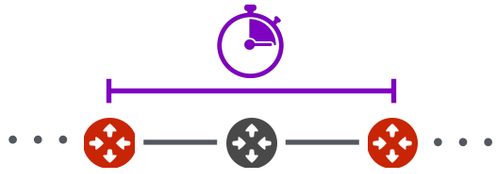
HOW YOU MEASURE | Model headers and devices



Topology

WHAT YOU MEASURE | Properties of a deployed network

HOW YOU MEASURE | Model topology and traffic



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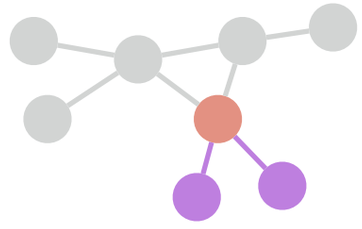
SHARE COUNT ANALYSIS

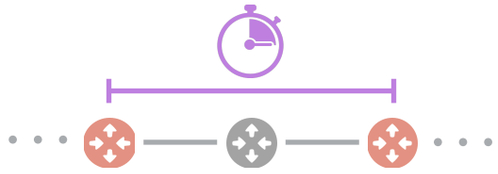


Topology

WHAT YOU MEASURE | Properties of a deployed network

HOW YOU MEASURE | Model topology and traffic

PRIOR WORK



Timing

Share Count Analysis

1

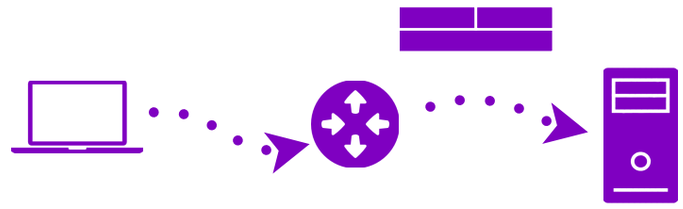
Model header information leakage

2

Model how devices modify headers

3

Measure leakage over test path



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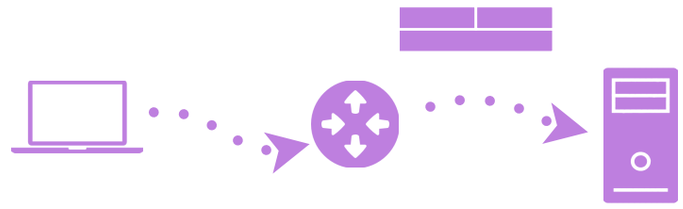
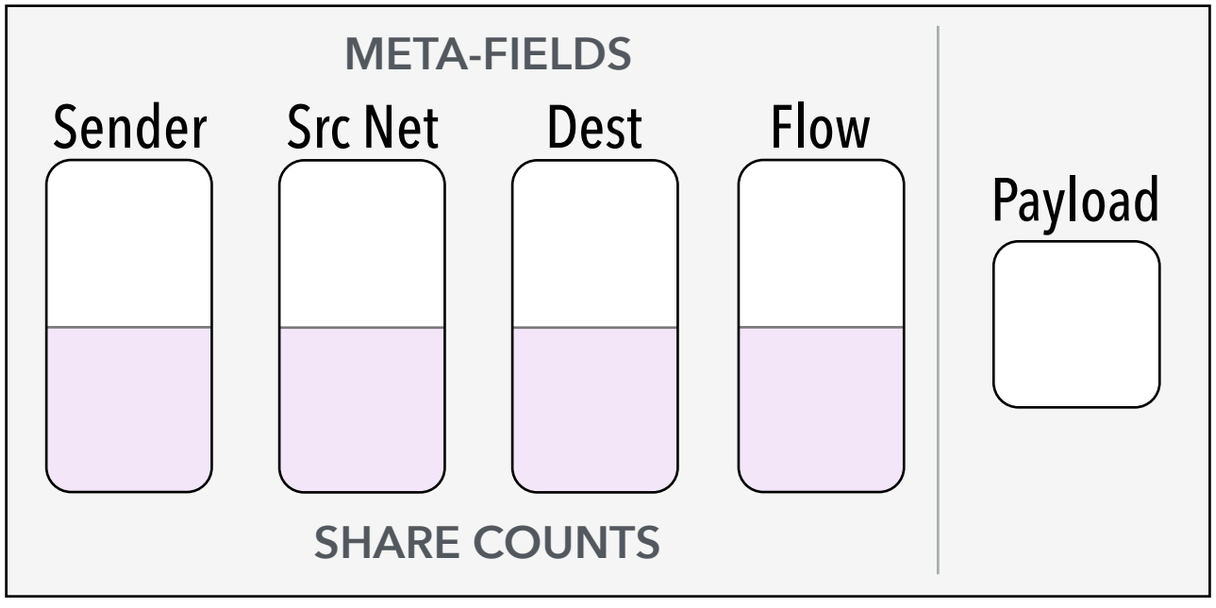
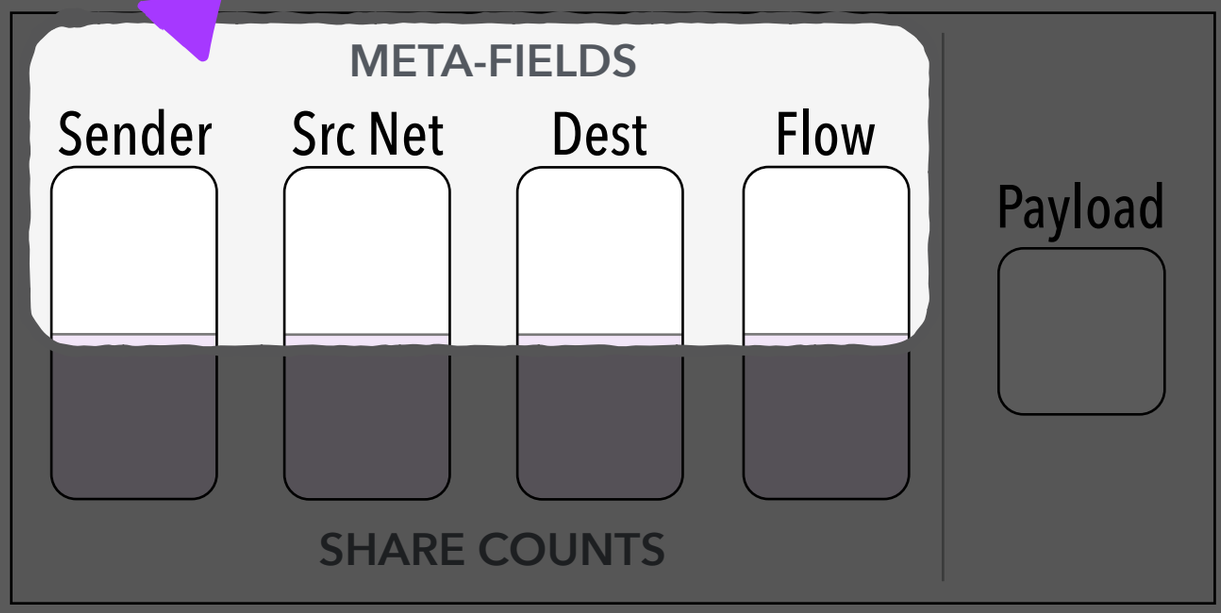


1 Model header information leakage



1 Model header information leakage

replace headers with generic, privacy-related *meta-fields*



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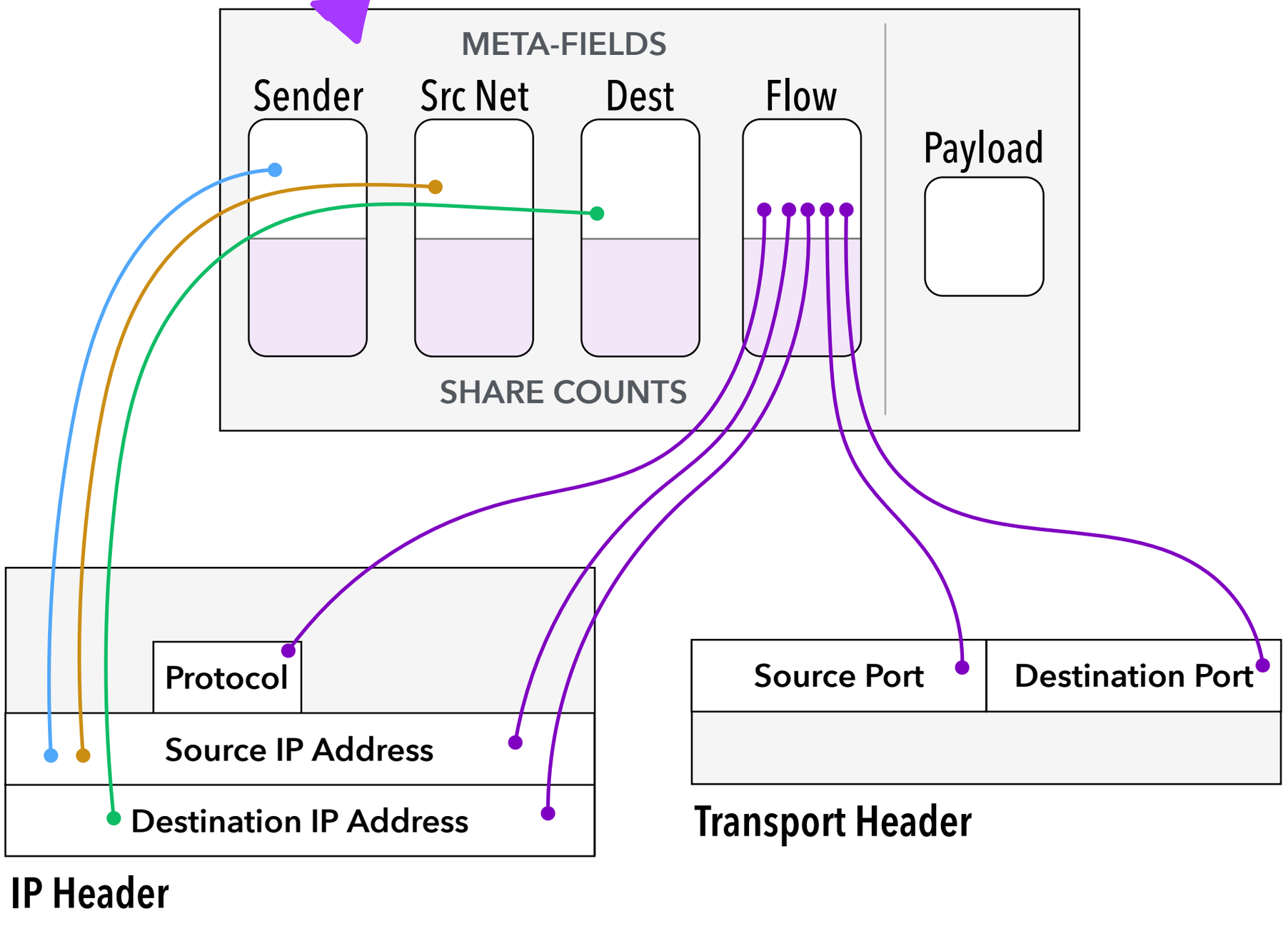

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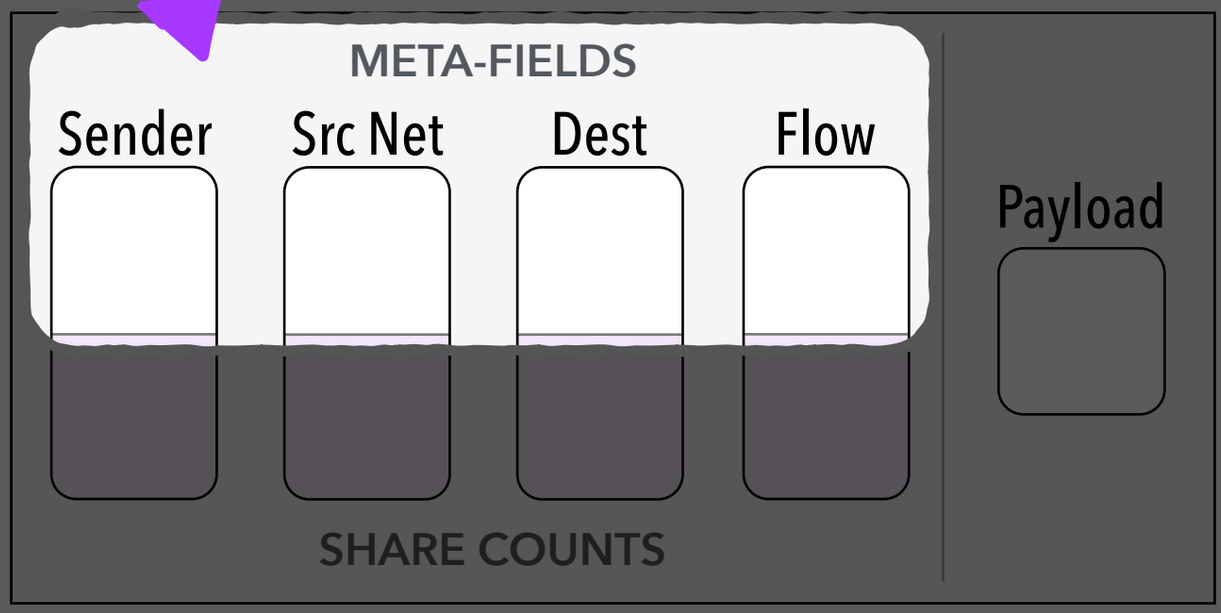

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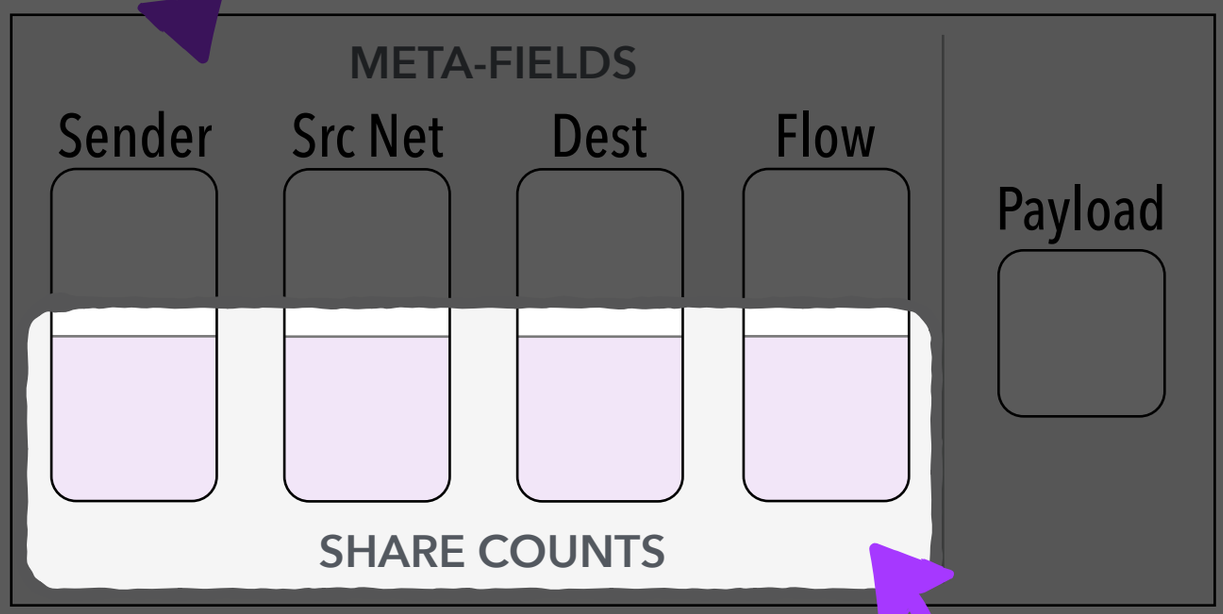

share counts indicate how many entities could share the same value

1

Model header information leakage

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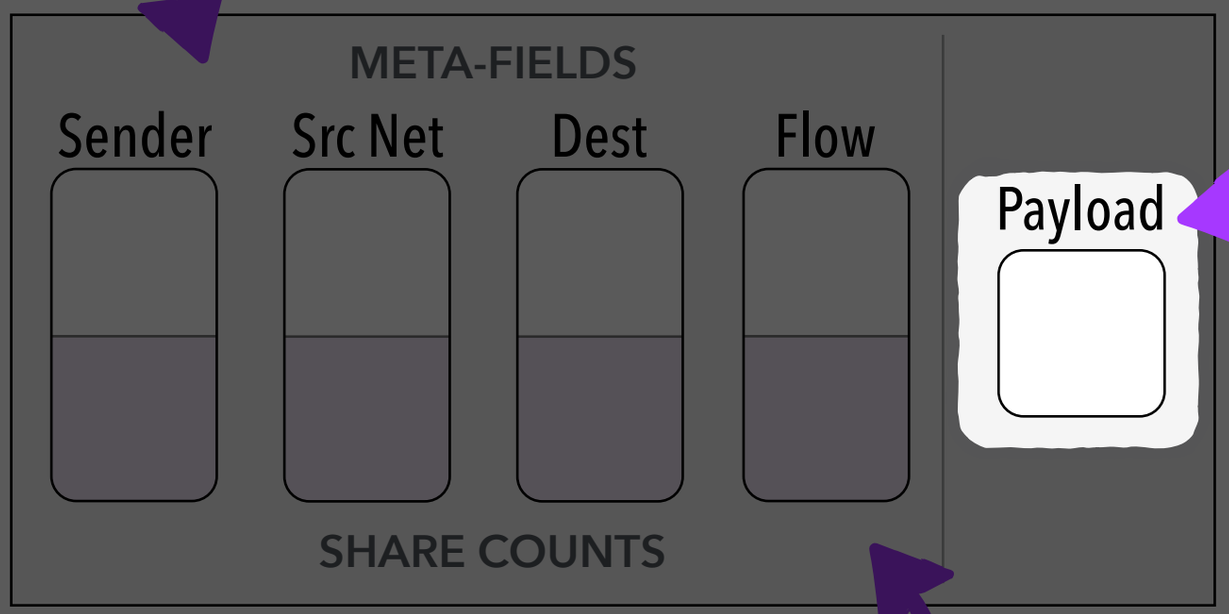

share counts indicate how many entities could share the same value

body is opaque value only used to link multiple sightings of a packet

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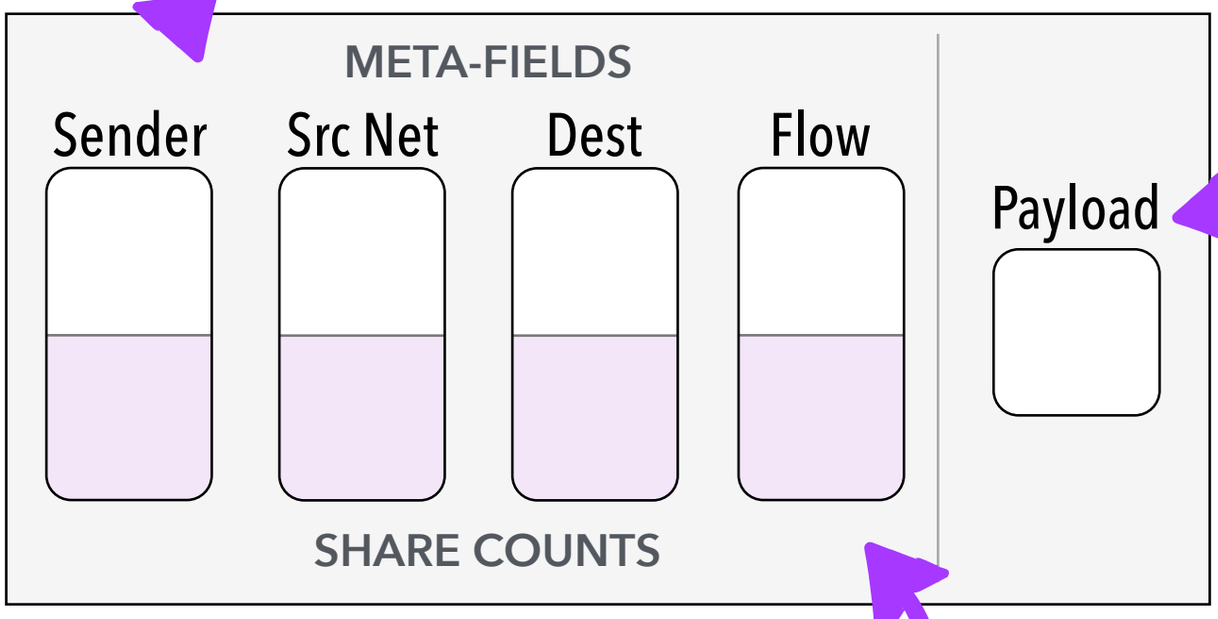

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Share Count Analysis

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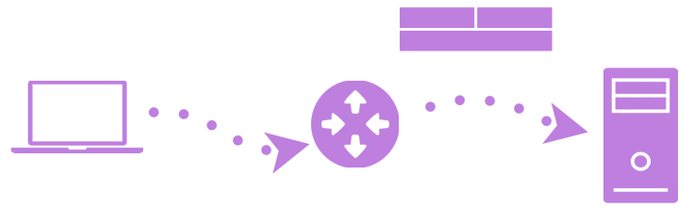
2 Model how devices modify headers

3 Measure leakage over test path



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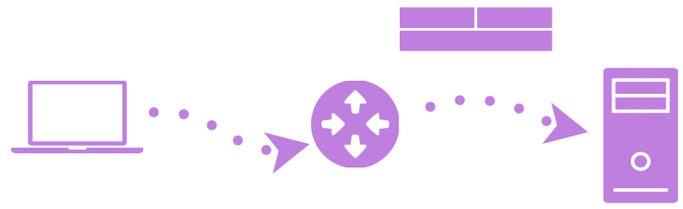
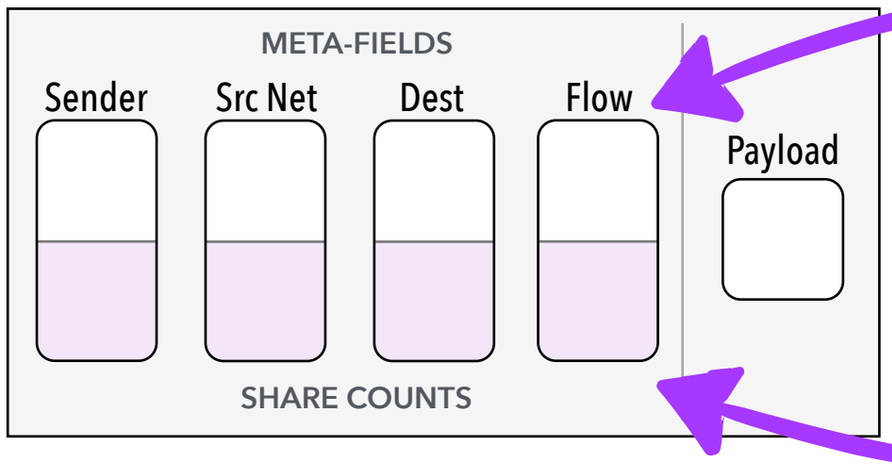


2 Model how devices modify headers

which fields are updated?




```
NAT = {
  update_fields:
    sender,
    flow
  new_share_counts:
    sender: Hn
}
```

what are the new share counts?

H_n = # hosts in source network

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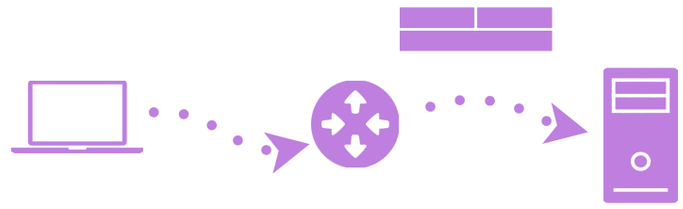

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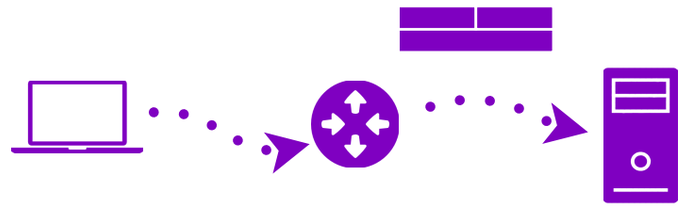
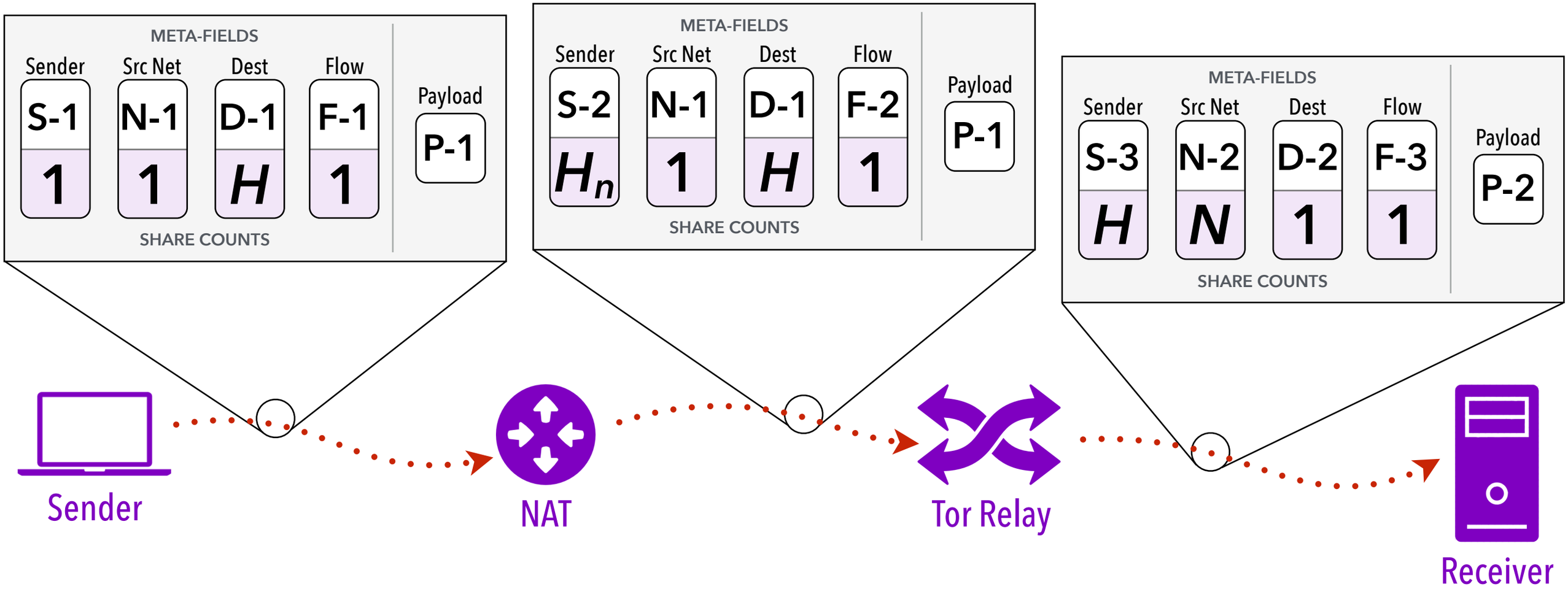
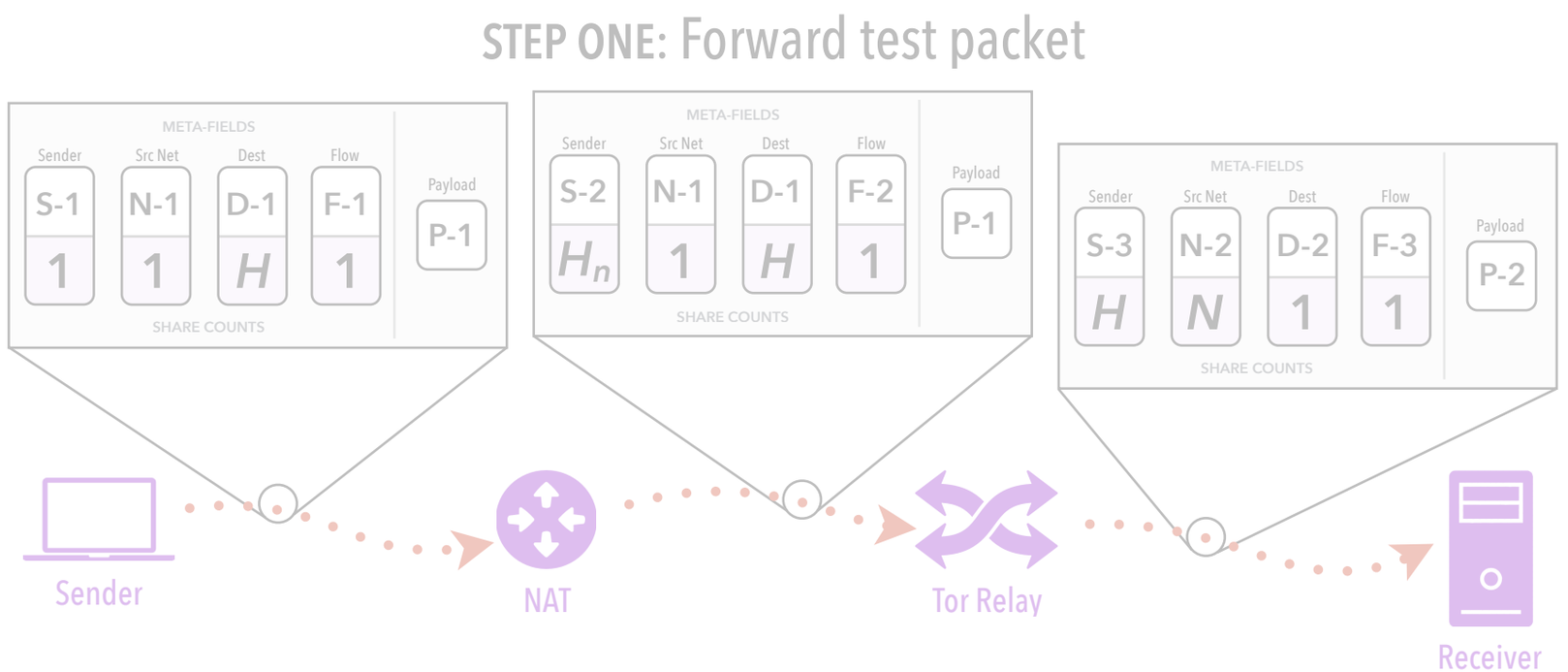


3 Measure leakage over test path

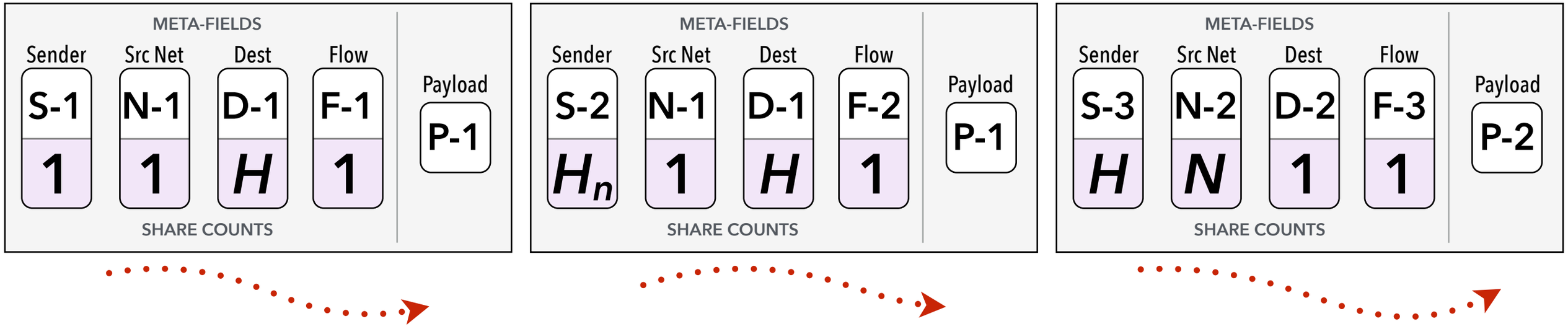
STEP ONE: Forward test packet



H = # hosts *N* = # networks H_n = # hosts in source network



STEP TWO: Save snapshots at vantage points



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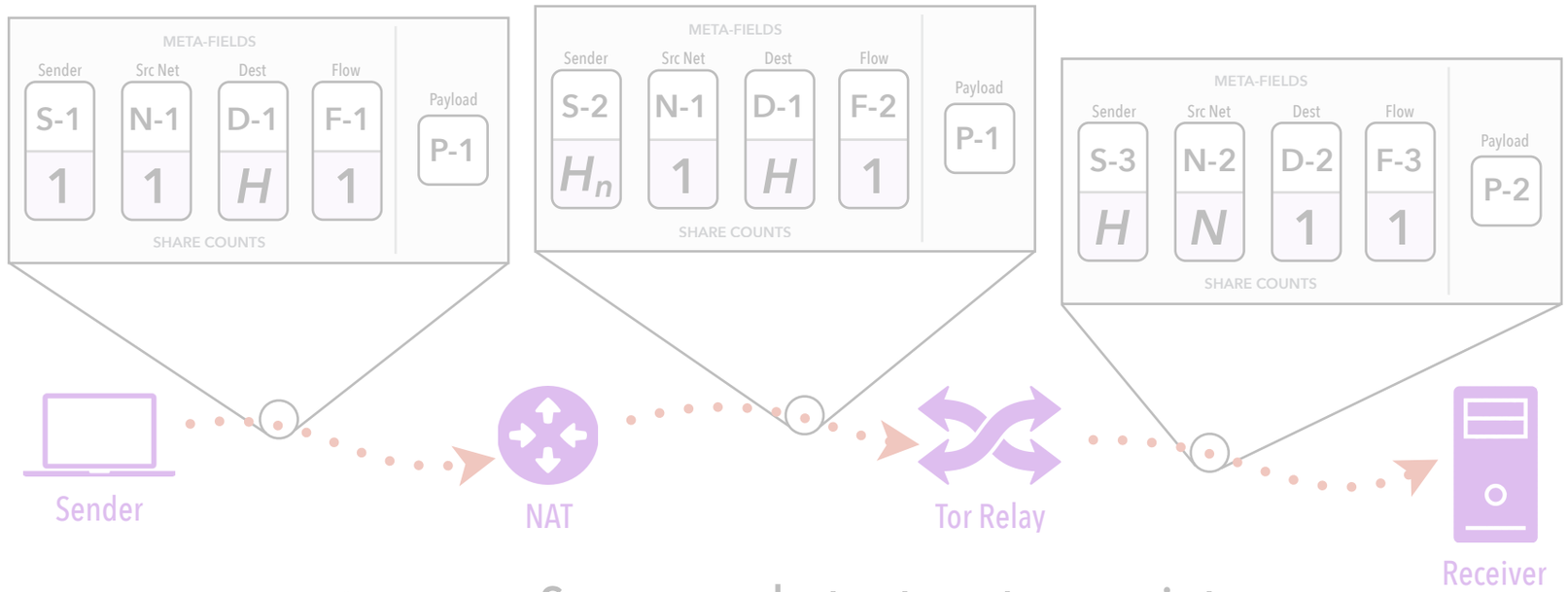
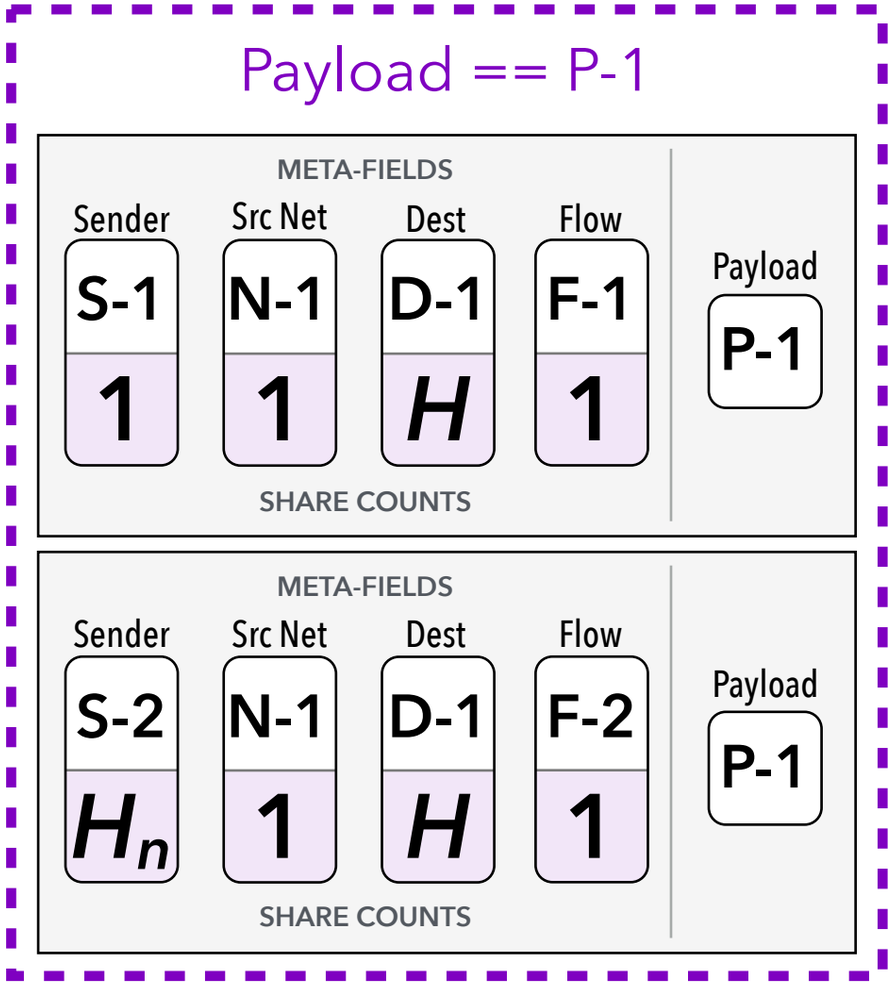
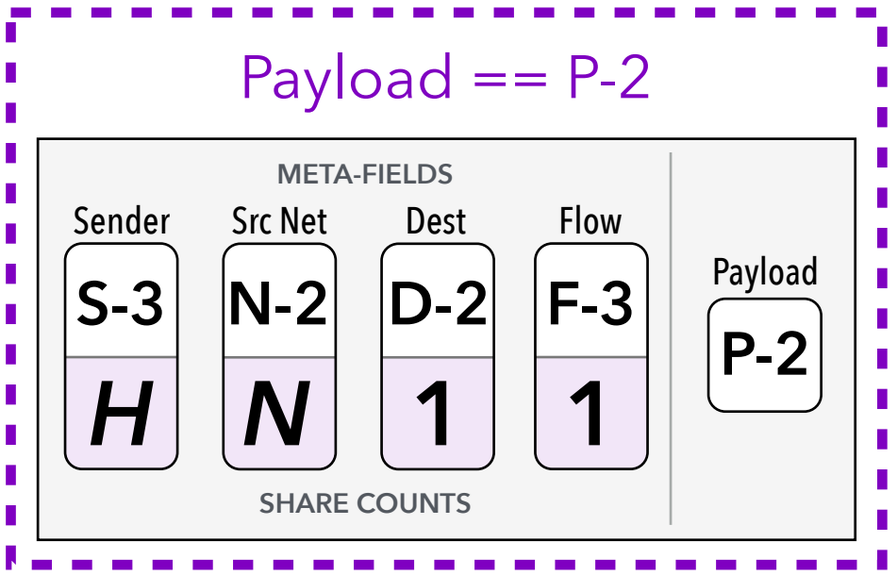


STEP TWO: Save snapshots at vantage points

STEP THREE: Group "linkable" snapshots





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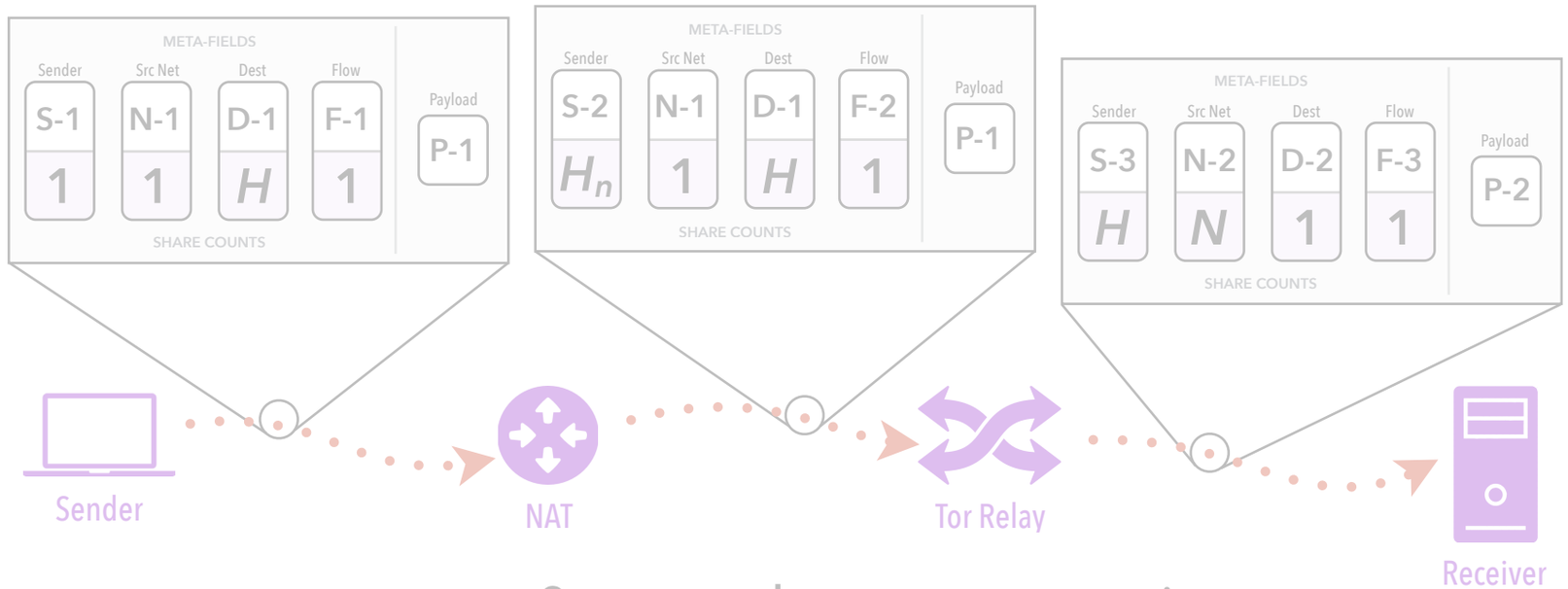

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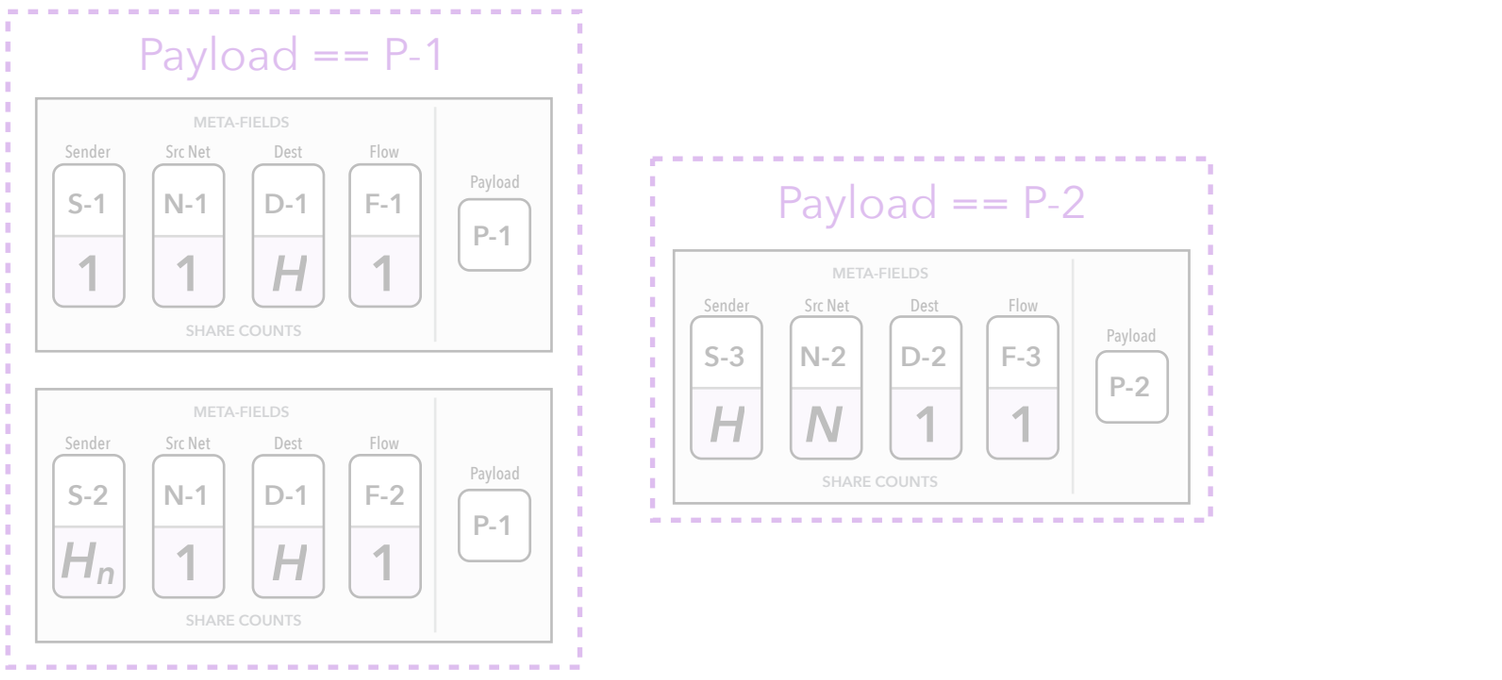
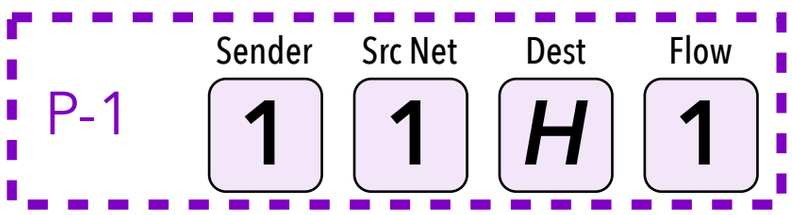
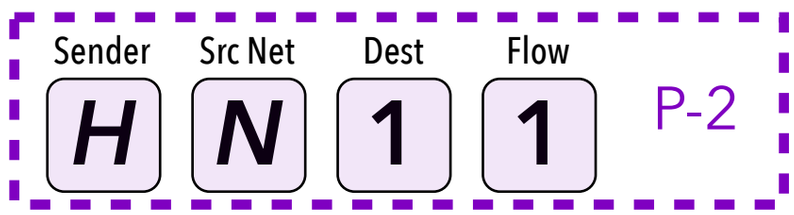


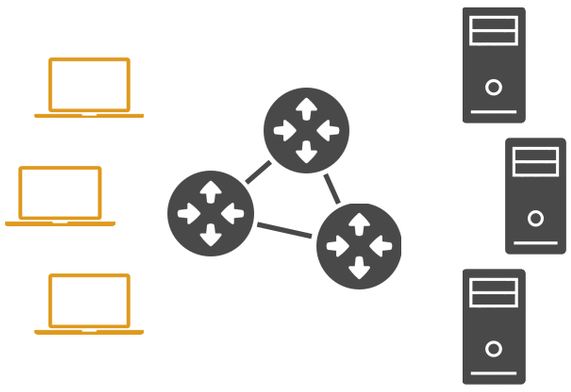
STEP FOUR: Find minimum share counts for each group

Minimum share counts tell us what the adversary learned





…learn sender?



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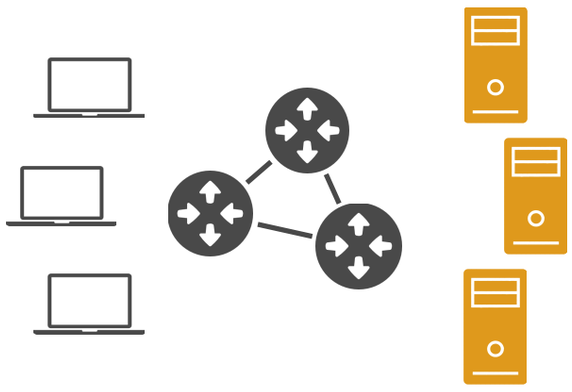

WHAT

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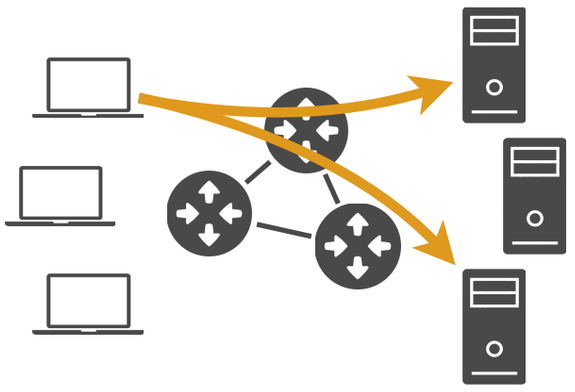


HISTORY

Minimum share counts tell us what the adversary learned

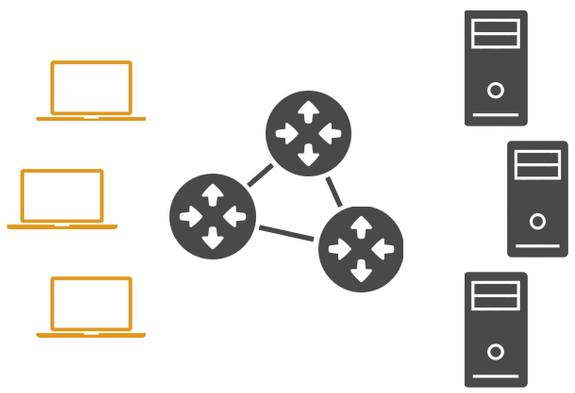
P-1

Sender	Src Net	Dest	Flow
1	1	*H*	1

Sender	Src Net	Dest	Flow
H	*N*	1	1

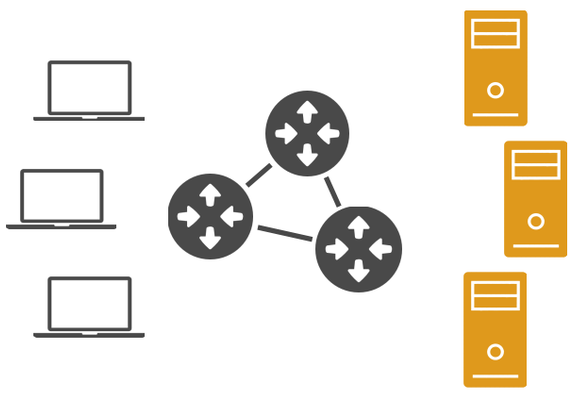
P-2

…learn sender?



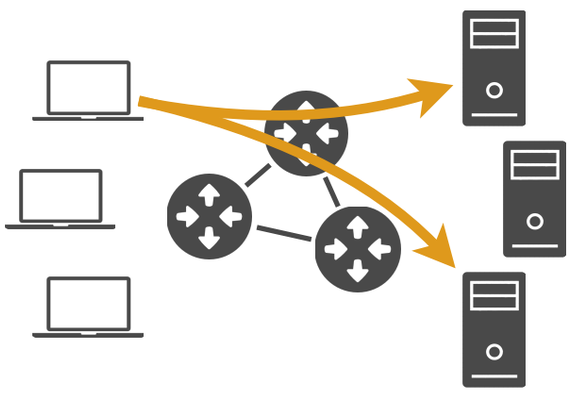
`src net share count == 1`

…learn receiver?



`dest share count == 1`

…link flows?



`sender share count == 1 &&`
`dest share count == 1`

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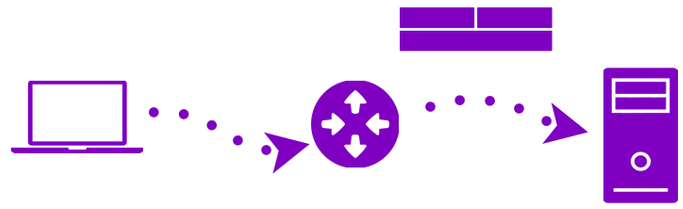

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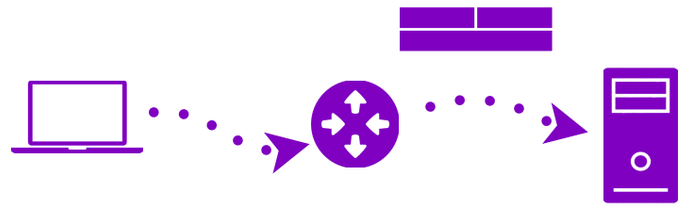

Open Questions

1 Automate meta-field and device specs? **Ease of Use**

From traces? From code? From high-level protocol spec?

2 Does our model capture all architectures? **Generality**

Path-based architectures? In-network state (e.g., MPLS, NDN)?

3 Analyze payloads of common protocols **Completeness**

e.g., DHCP, DNS, & TLS handshake

4 Analyze instances of an architecture **Completeness**

Use topology and timing to limit share counts?

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