Network-Wide Policy Enforcement

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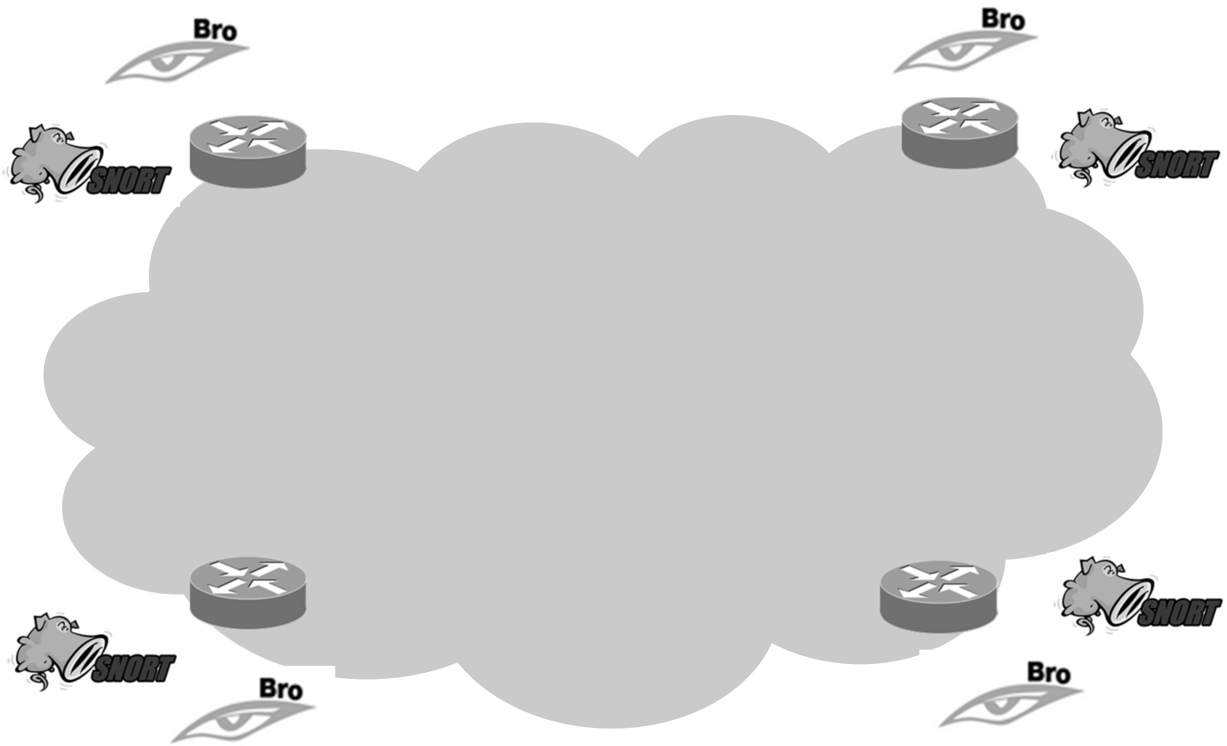
Enforcing Policy in Future Networks

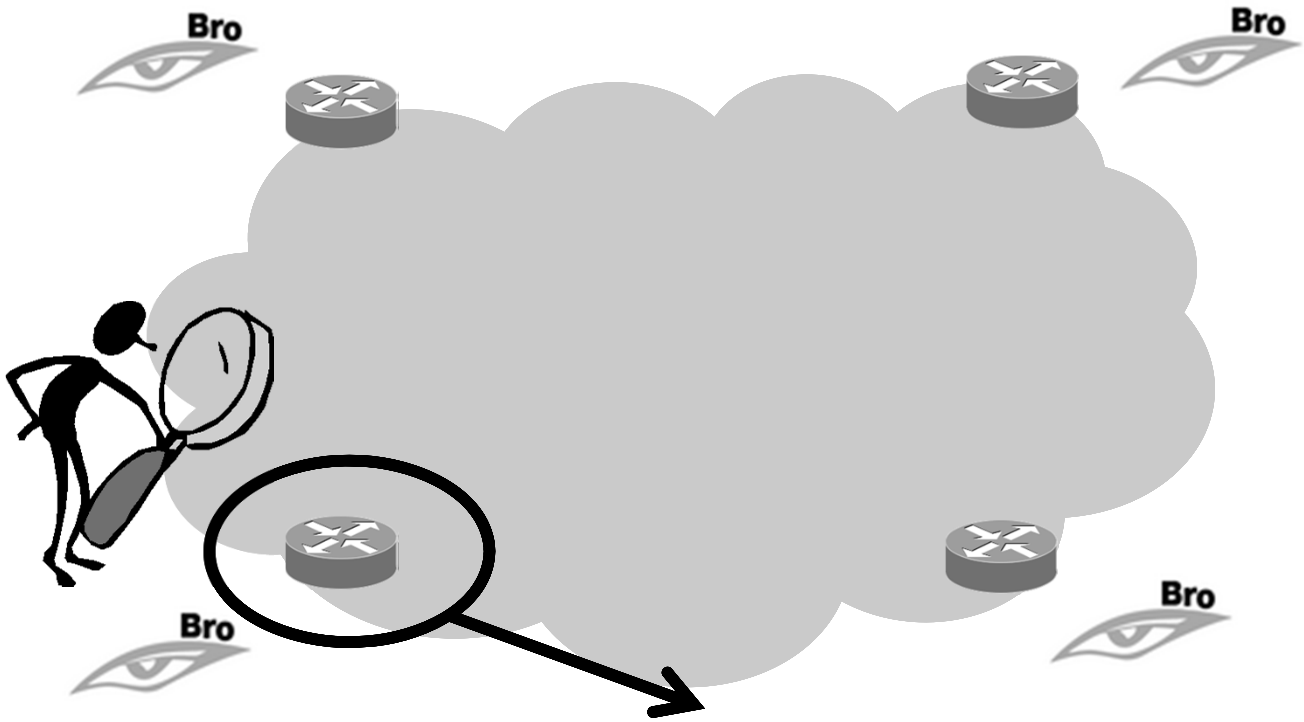
- MF vision includes enforcement of rich policies "in the network"
- E.g., intentional data receipt
  - Only if (or if not) from these addresses
  - Only if a "well-formed" request
  - Only if it's not malicious
  - …
- How can we scale rich policy enforcement?
  - Use modern intrusion detection/prevention policies as examples to drive the research

Scaling intrusion detection & prevention



Traffic increase → More packets to process
User applications changing → More functions/modules
Attacks evolving → Larger set of “rules” to apply

Traditional approaches for scaling NIDS/NIPS

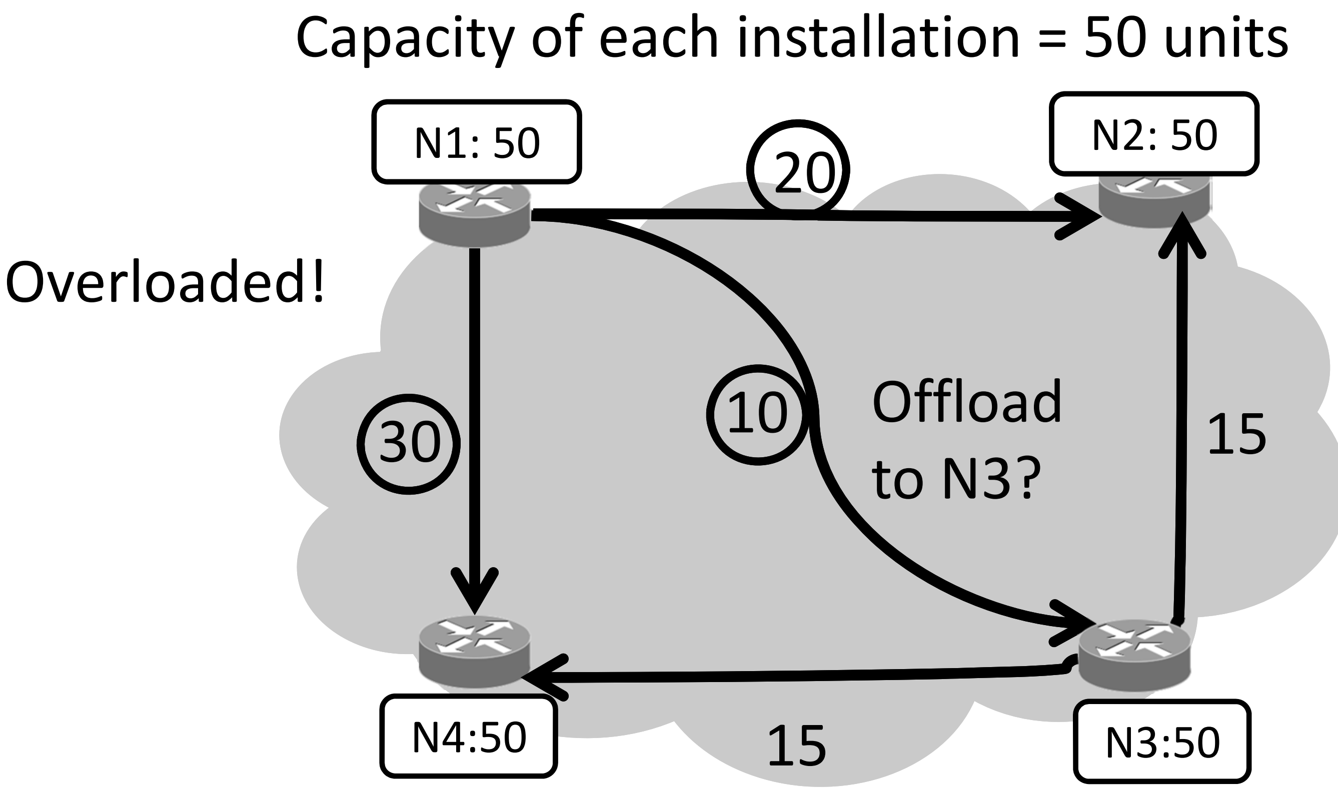


1. Build clusters
2. Better algorithms

....

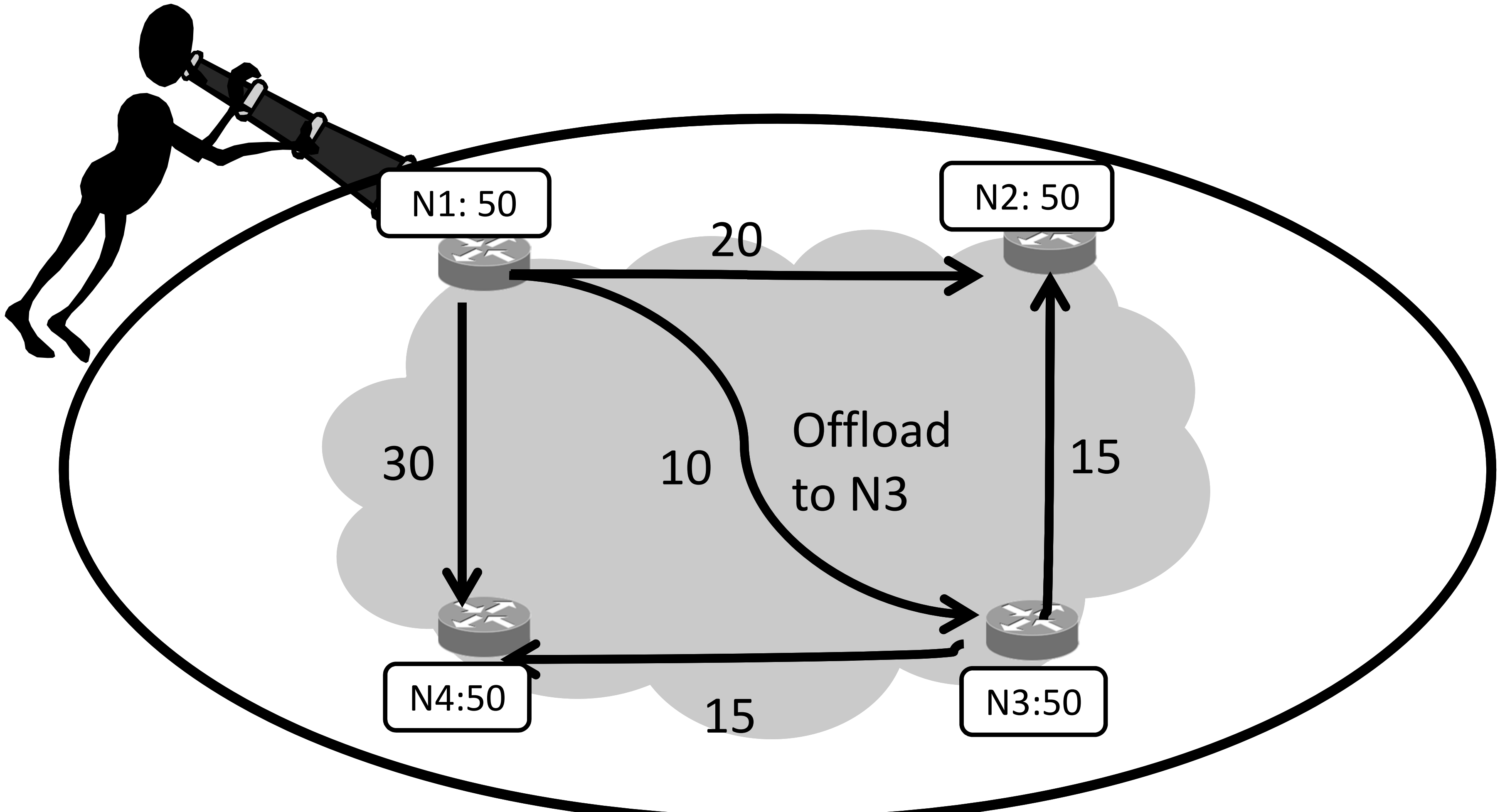
Single-vantage-point solutions designed for ***perimeter*** deployments (gateway between internal/external network)

Single-vantage view is restrictive



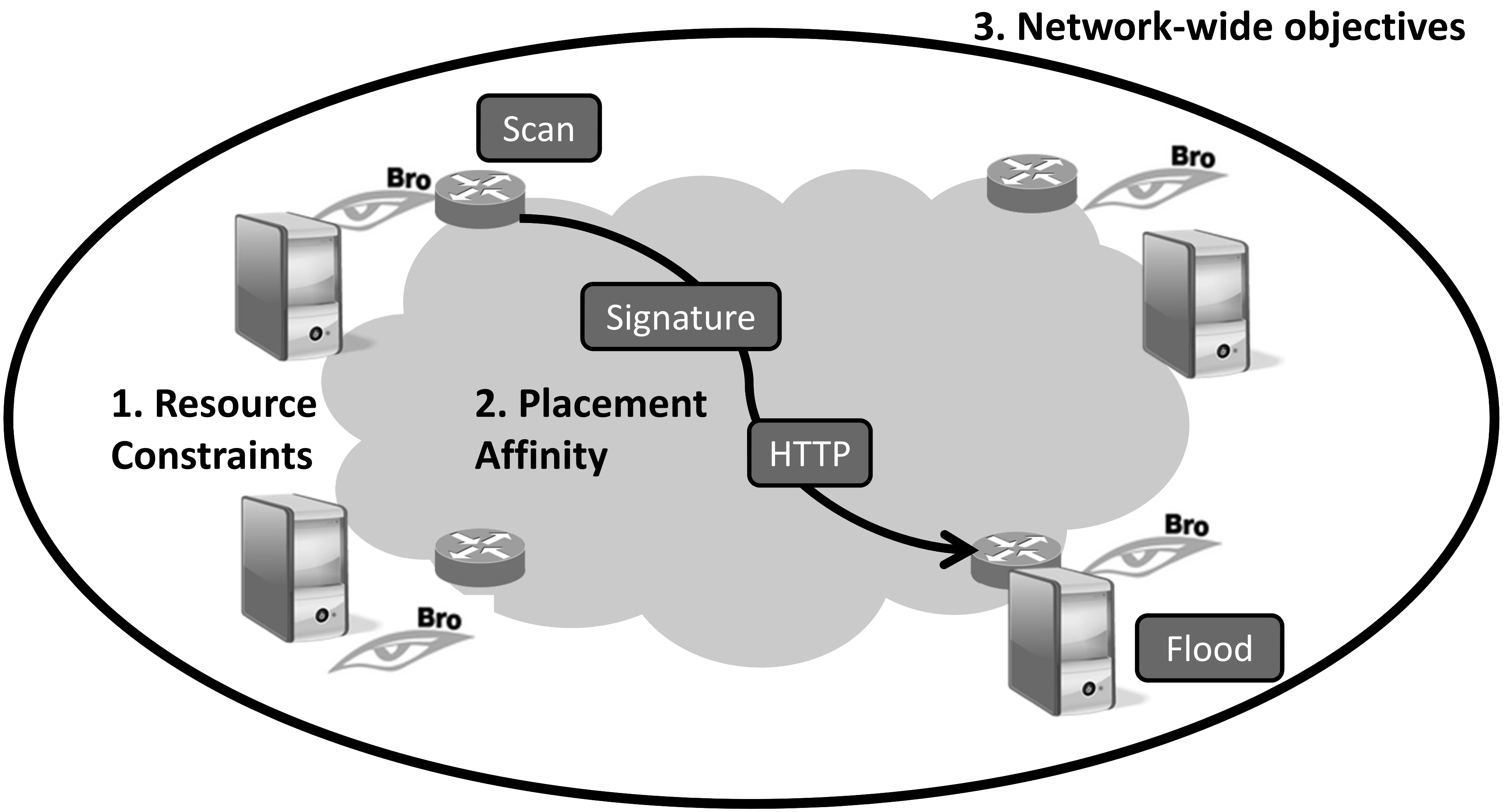
Many NIDS/NIPS infrastructures are multi-node deployments
e.g., ISPs, large enterprises, datacenters

Alternative: Network-wide scaling



Treat NIDS/NIPS infrastructure as one system
→ Leverage on-path opportunities for distributing work
→ Complements single-vantage scaling

Key requirements



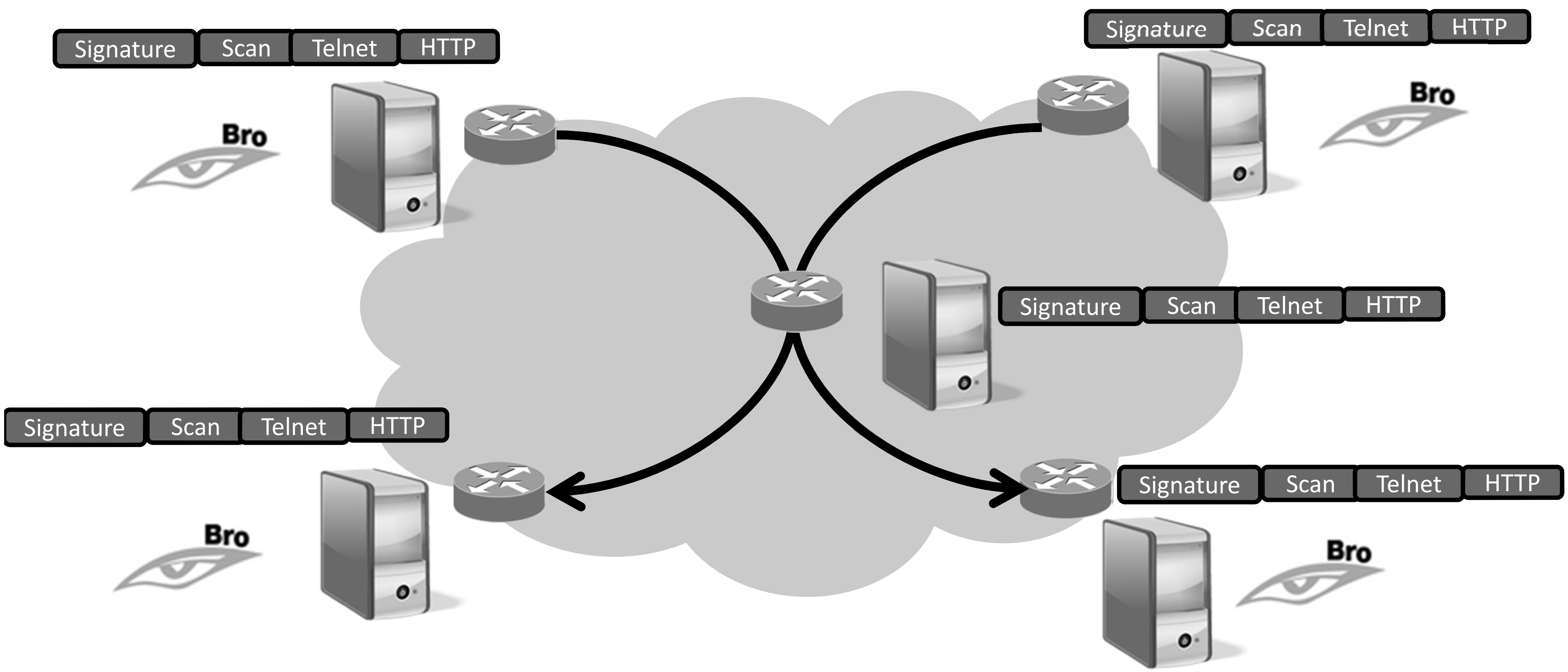
Systematic designs for network-wide NIDS/NIPS deployment

Outline

- Motivation for network-wide approach
- NIDS deployment
- NIPS deployment
- Discussion and summary

System model

Provide functionality equivalent to a single NIDS on all traffic
Minimize the maximum load (CPU/Memory) across the network

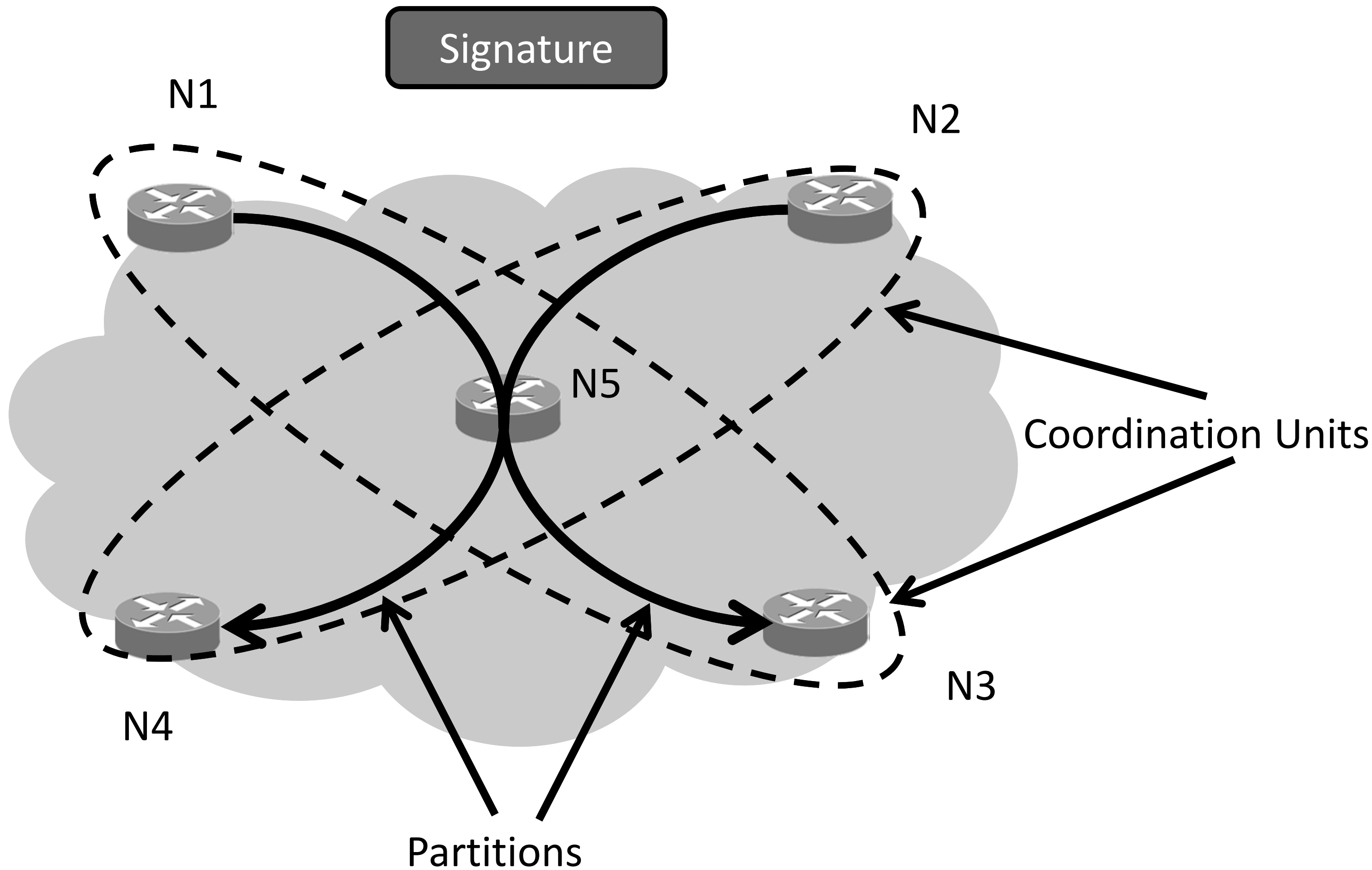


Identifying candidate nodes for offloading

Partition traffic spatially; Identify a set of nodes for each partition
Any node in that set can provide the NIDS function → Coordination Unit

Signature Partition1: {N1,N5,N3}

Signature Partition2: {N2,N5,N4}



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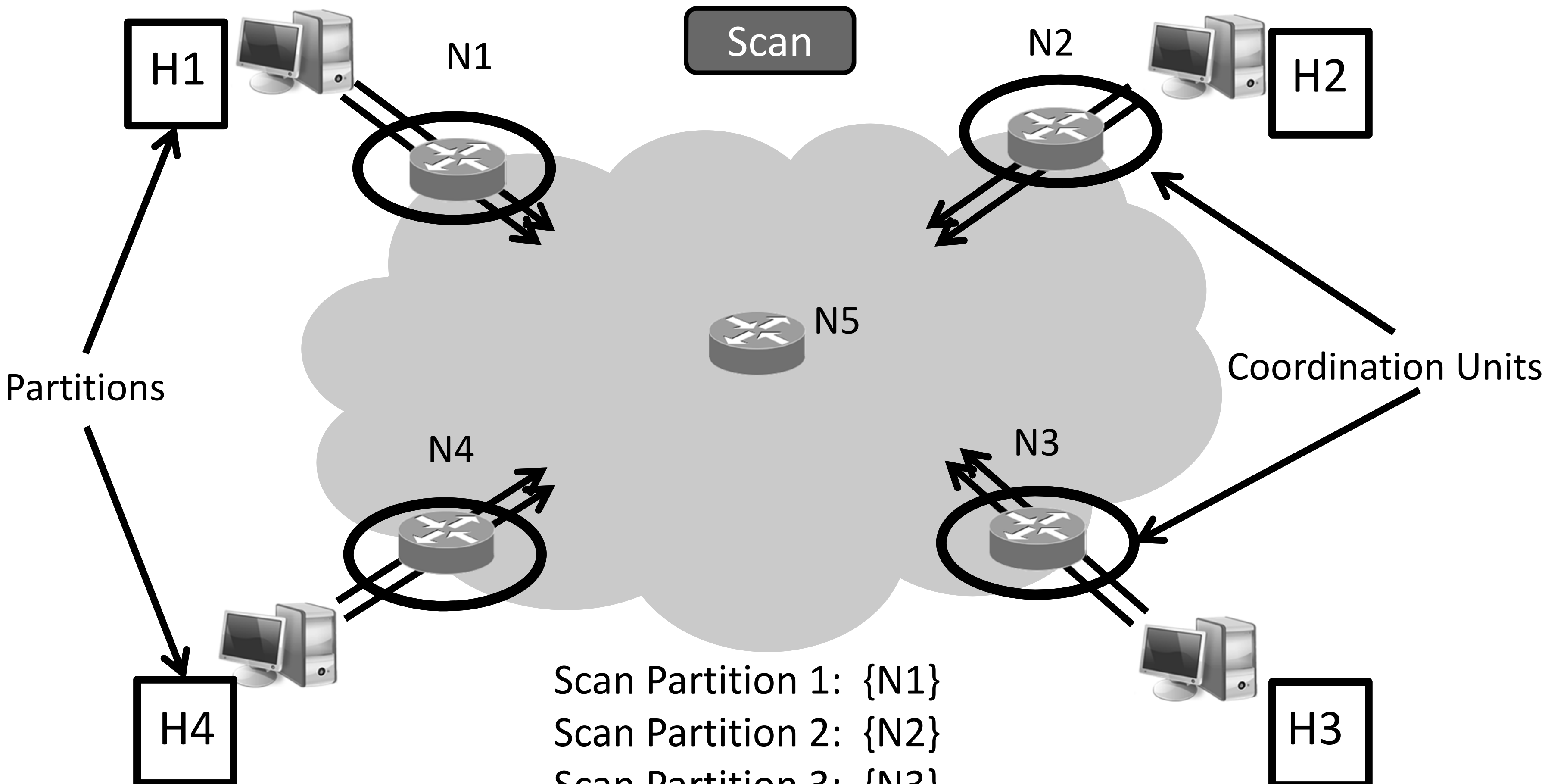

Scan Partition 1: {N1}
Scan Partition 2: {N2}
Scan Partition 3: {N3}
Scan Partition 4: {N4}

System model

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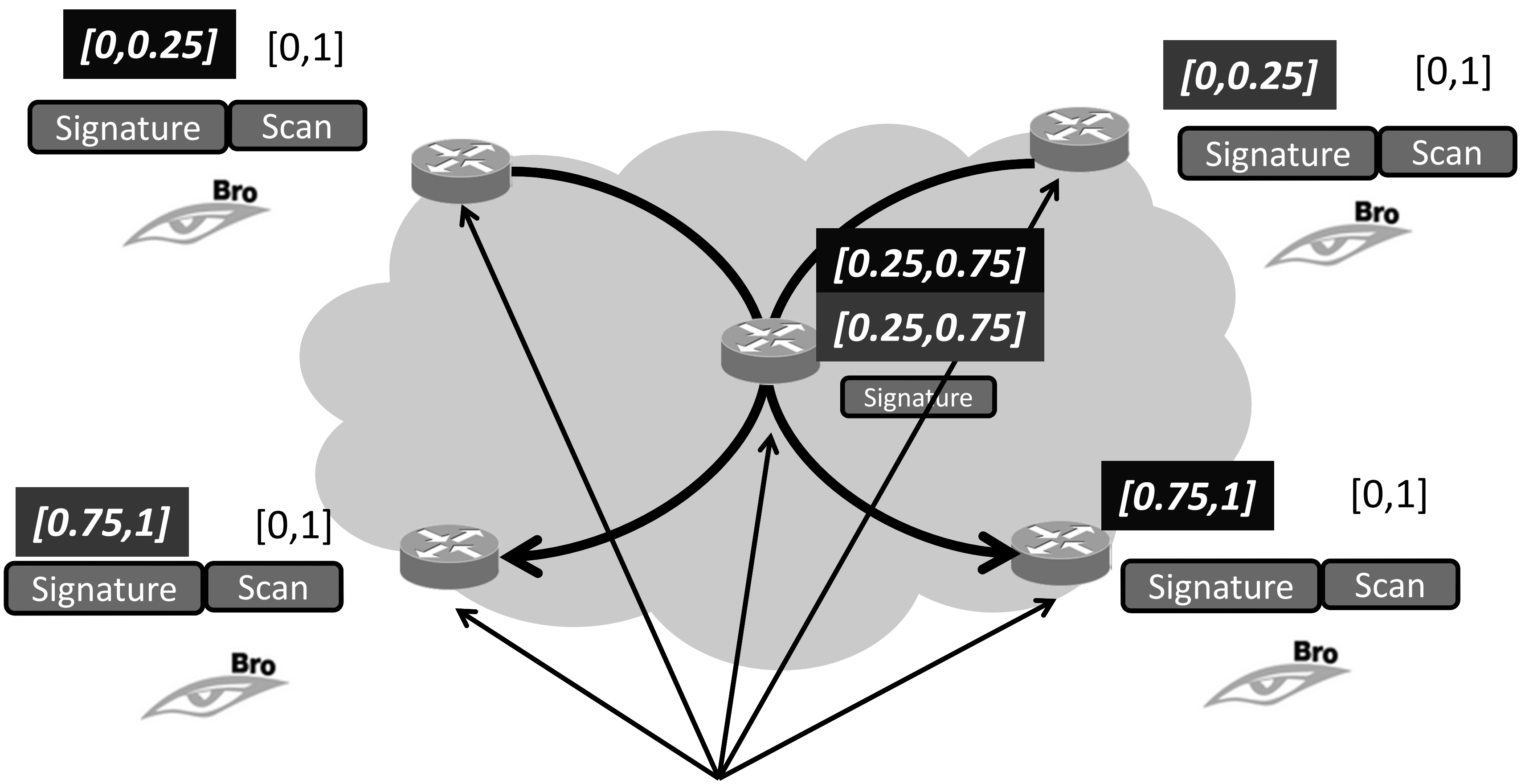


Control fraction of traffic each node processes per module/coordination unit

NIDS optimization framework

Inputs:

Network information

1. Coordination units
2. Traffic specification
3. Routing information

Resource footprints

Mem/CPU profile for
Each NIDS module

Node capacities

Memory/CPU

Objective:

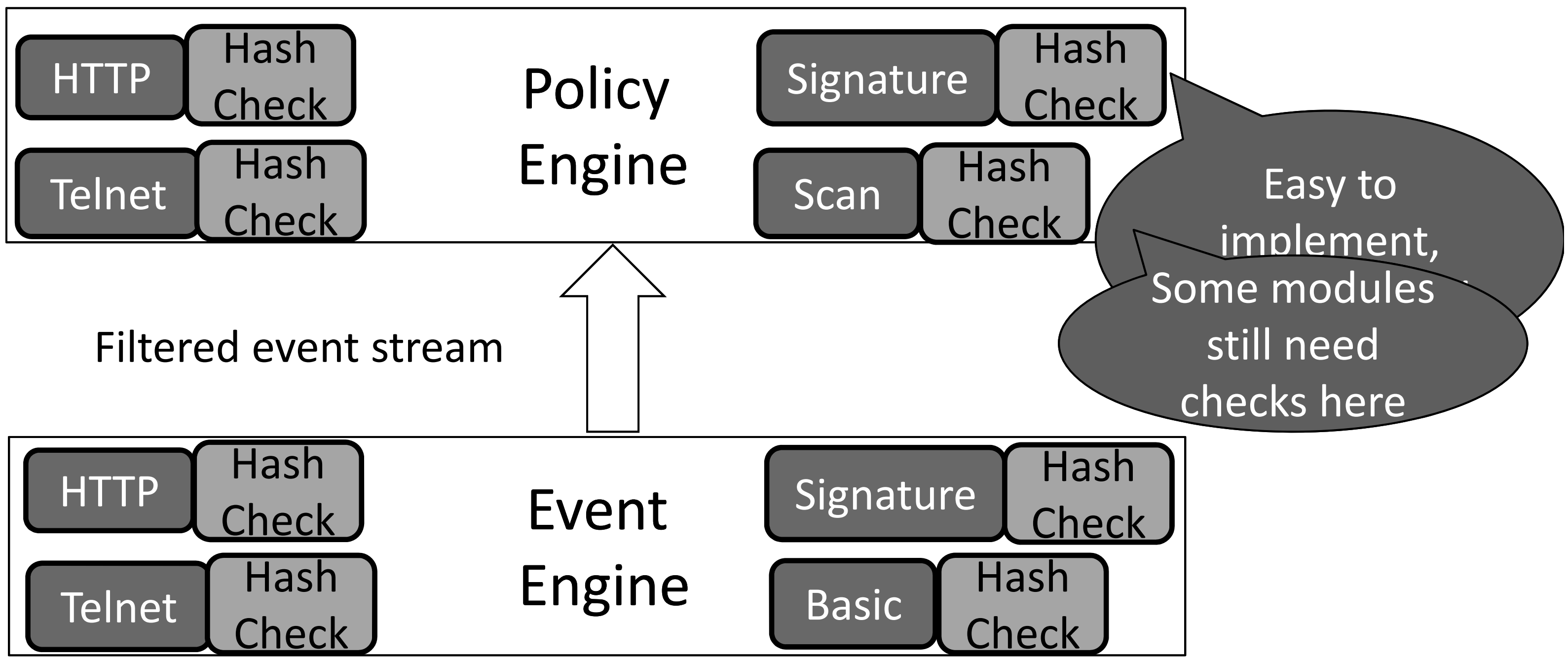
Provide equivalent coverage
Minimize maximum load

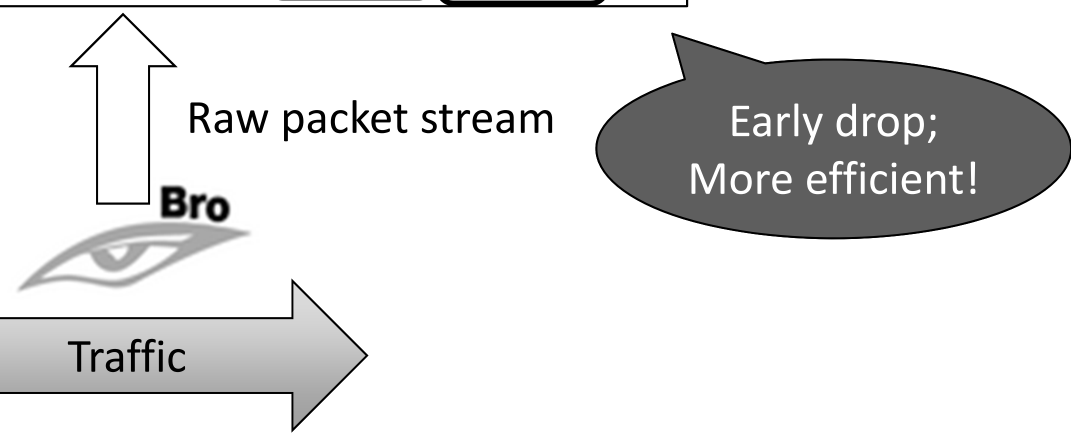
Network-wide optimization using linear programming

Fraction of traffic each node processes per NIDS module

Non-overlapping hash ranges per coordination unit

Prototype implementation in Bro





Hash check:

Compute *hash*(header)

If *hash* in range assigned for module

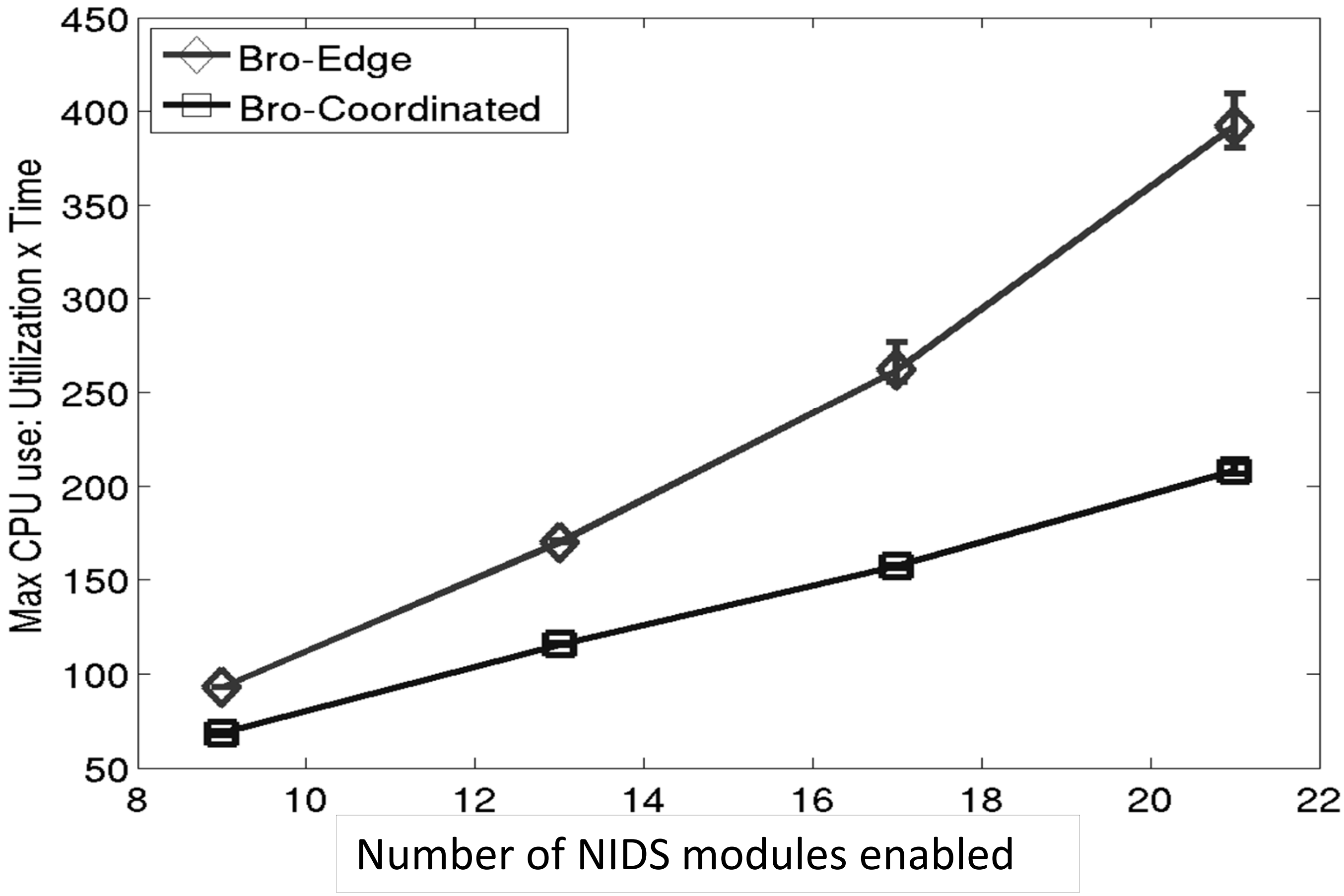
    Process the packet

Else

    Ignore packet

Evaluation: CPU scaling

Emulated Abilene topology: 100,000 sessions; gravity-model matrix
Result shows maximum processing footprint across 11 network nodes



Reduces maximum processing footprint by 50%!

Outline

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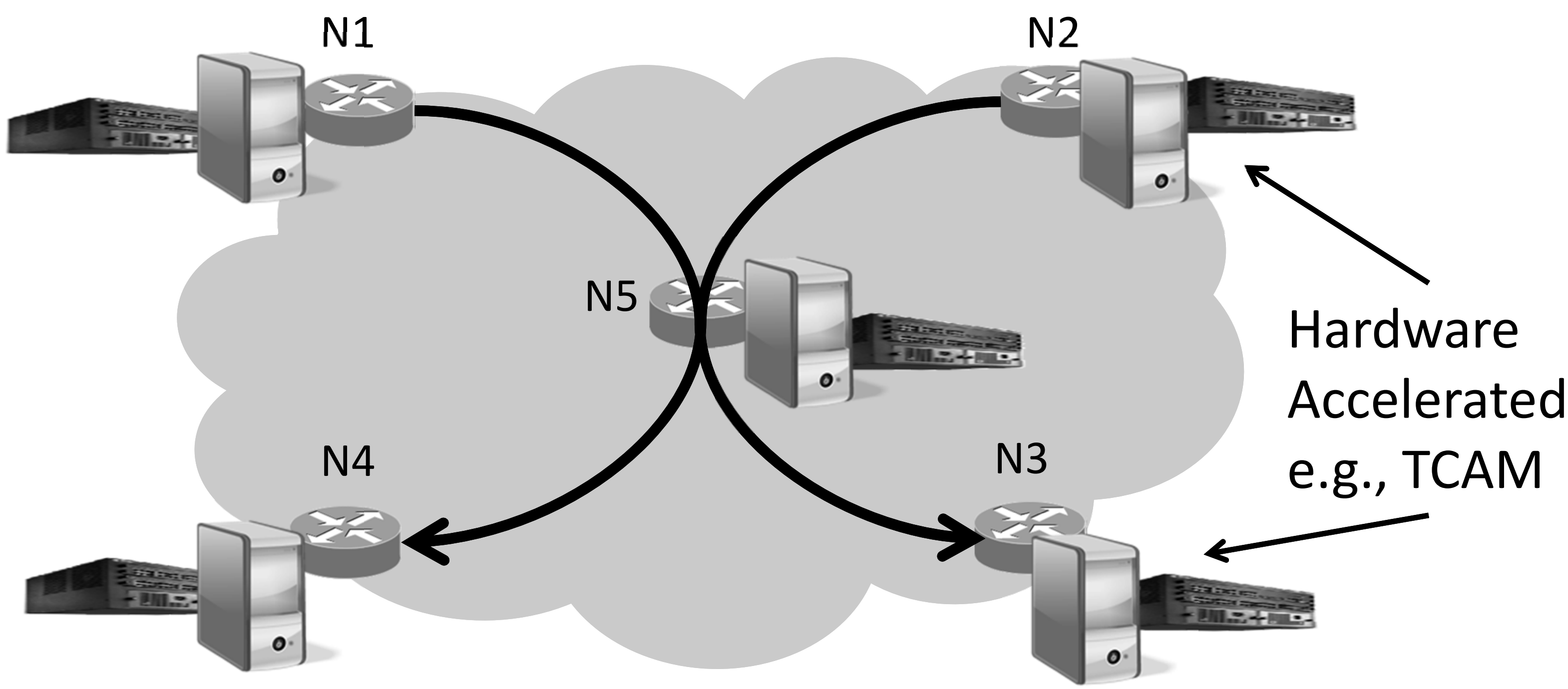
System model

Payload signature,
ACL,
Firewall

Set of ***rules***
Drop traffic that matches the ***rules***
Any node on path can apply the rule



Rule capacity constraints (in addition to CPU, memory)

NIPS optimization framework

Inputs:

<u>Network information</u>
Traffic, Routing

<u>NIPS rules</u>
Rule match rates

<u>Resource footprints</u>
Mem/CPU profile
TCAM per rule

<u>Node capacities</u>
Mem/Processing capacity
TCAM capacity

<u>Objective:</u>
Reduce footprint of unwanted traffic
= (match * volume)

Network-Wide optimization

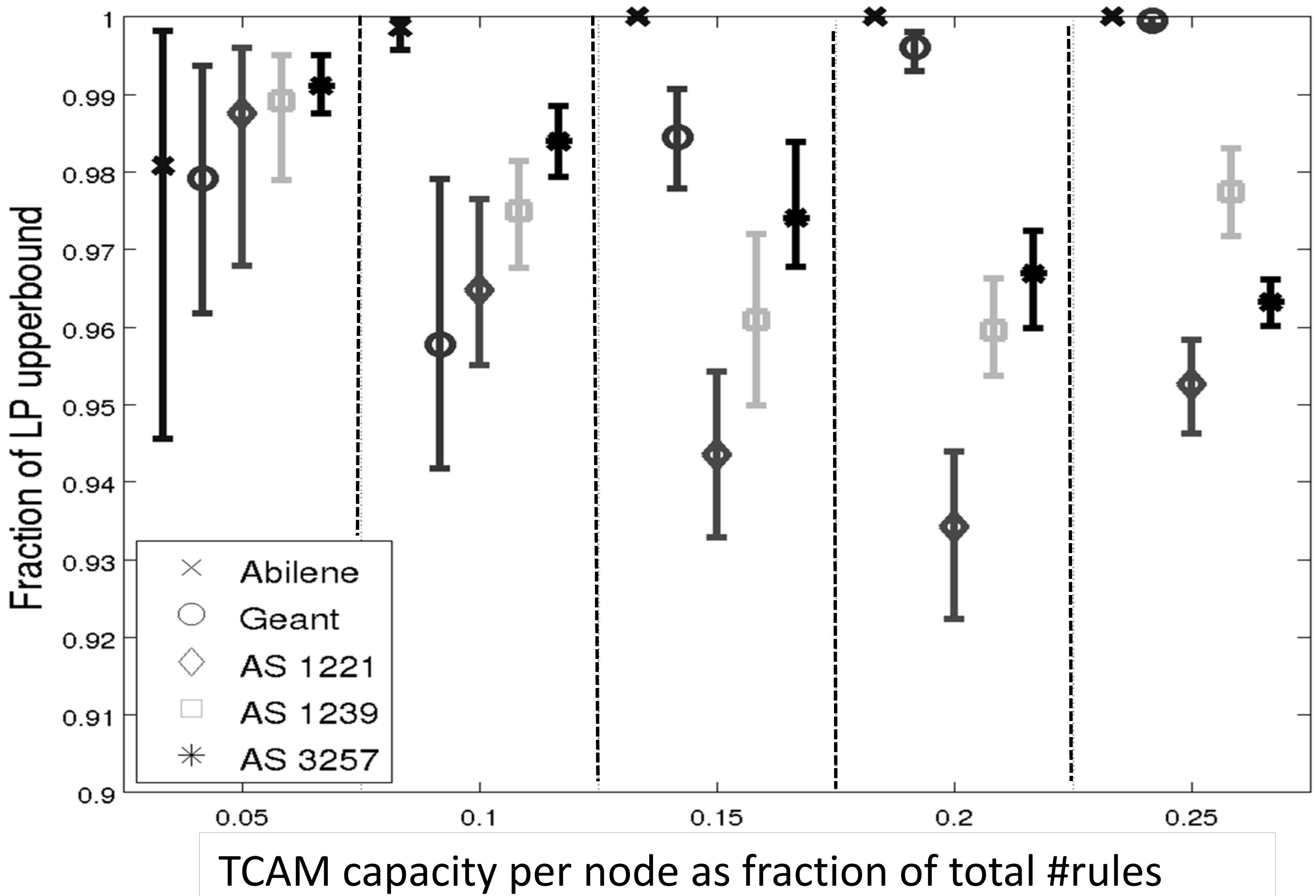
NP-hard!
"Enable" introduces binary variables
Becomes an Integer linear Program

What rules to enable on each node
(TCAM constraint)

Fraction of traffic to apply enabled rules on
(Mem/CPU constraint)

Performance of our approx. algorithm

Different PoP-level topologies from Rocketfuel



Achieves more than 92% of LP-upperbound (and hence OPT)

Other issues

- Providing redundant coverage for NIDS
- Making NIPS robust to adversarial evasion

- Network dynamics
  - Time to recompute optimal solutions
  - Conservative traffic inputs
  - Correctness under routing changes

- Provisioning/upgrades

Conclusions

- Exploit spatial opportunities for load balancing
  - Complements ongoing work in better single-vantage-point solutions
- Key issues:
  Resource constraints, placement affinity, network-wide goals

- Best addressed using network-wide coordinated approach

- NIDS deployment
  - Formulation as a linear program
  - Network-wide NIDS prototype in Bro
- NIPS deployment
  - Formulation as a Integer Linear program
  - Rounding based approximation algorithm