SENSS Against Volumetric DDoS Attacks

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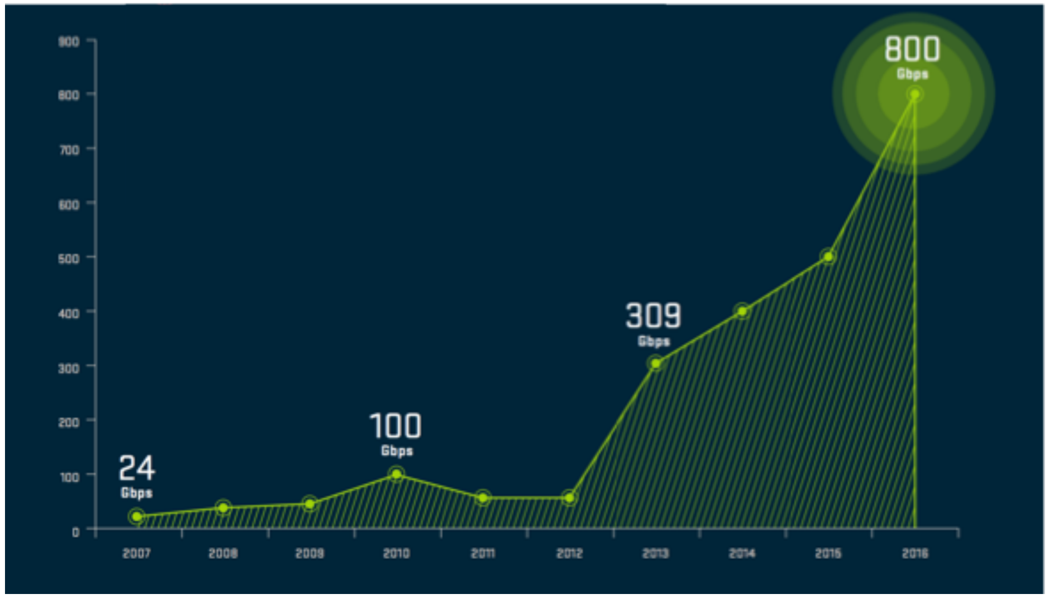
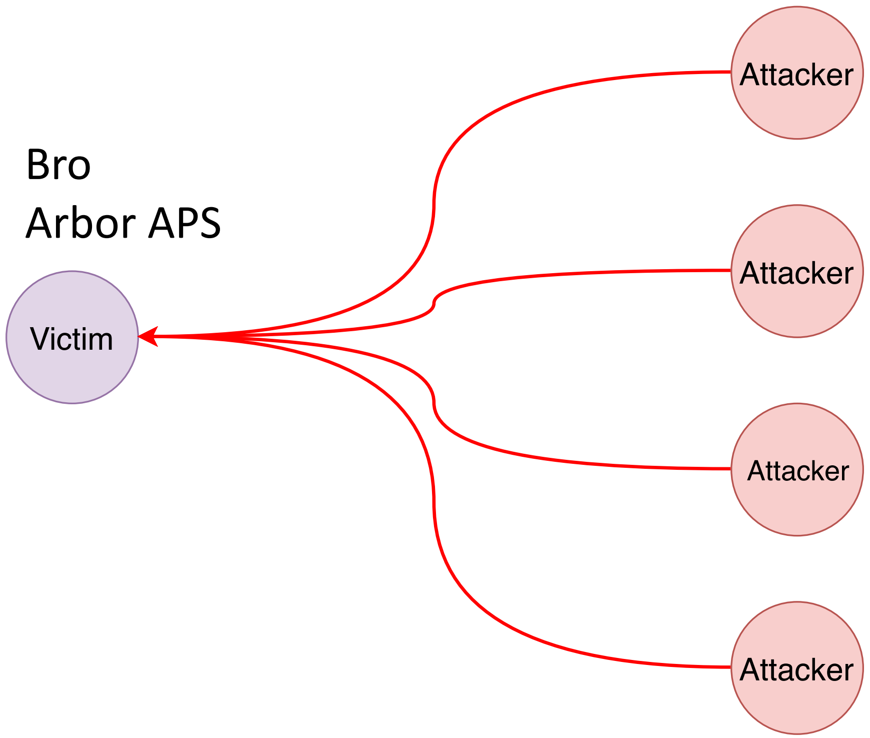
DDoS attacks



- Volumetric DDoS can overwhelm networks
- Such attacks are hard to mitigate by victim
  - Volume is too high for victim to handle – need help of upstream ISPs
  - Legit traffic mixed with attack traffic – need help to place imperfect filters near attack sources to minimize collateral damage
- Need collaborative, distributed response
- But today's internet lacks the infrastructure for victim to ask peers or remote networks for help

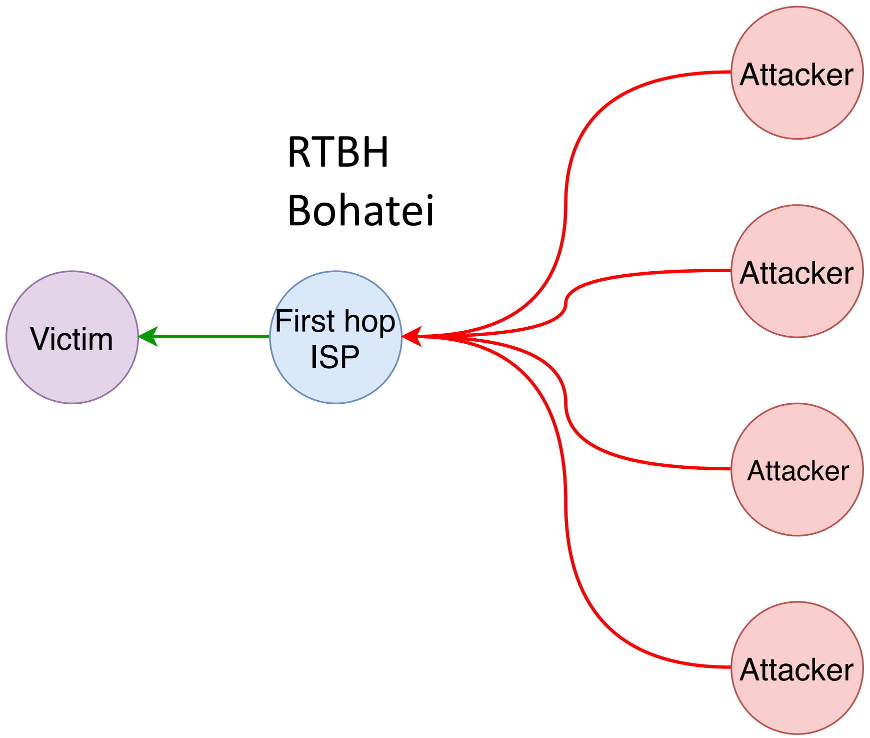
**Figure taken from Arbor Networks worldwide infrastructure security report, 2016*

Existing solutions at victim



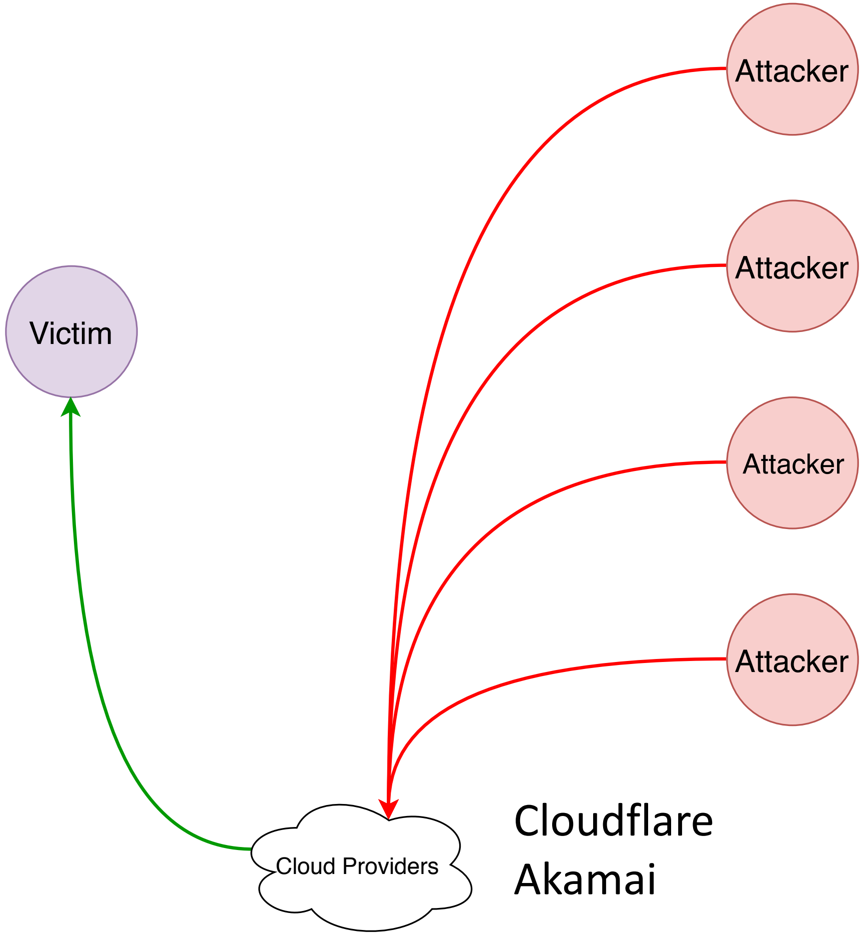
- Solutions such as Bro and Arbor APS deployed at victim
- Filters traffic based on inspection and rules
- Large attacks cannot be filtered as the origin of attack is upstream from victim

Existing solutions at first hop ISP



- Collaboration with ISP via human channels which are error prone and slow
- Crude filtering such as remotely-triggered blackhole saves ISP from attack but cuts victim from internet
- Bohatei uses SDN + NFV to scale defense on demand
- Provides a fine grained traffic control but is resource intensive

Existing solutions at cloud



Cloudflare
Akamai

- Cloud solutions are effective by diverting all victim's traffic towards themselves during an attack
- Apply scrubbing algorithms to remove attack traffic, send the rest to victim
- Ability to handle heavy attacks depends on extent of geo-replication, which is costly

What do we provide?

- SENSS is a collaborative framework which allows victim under attack to communicate with peers or remote networks
- Design is simple
  - SENSS keeps the intelligence at the victim and has simple functionalities at ISP which can be easily implemented in current ISP infrastructure
  - Victim drives decisions to monitor and taking necessary actions to mitigate attacks
  - Victims can create versatile, evolvable and customizable defense for different types of DDoS flavors

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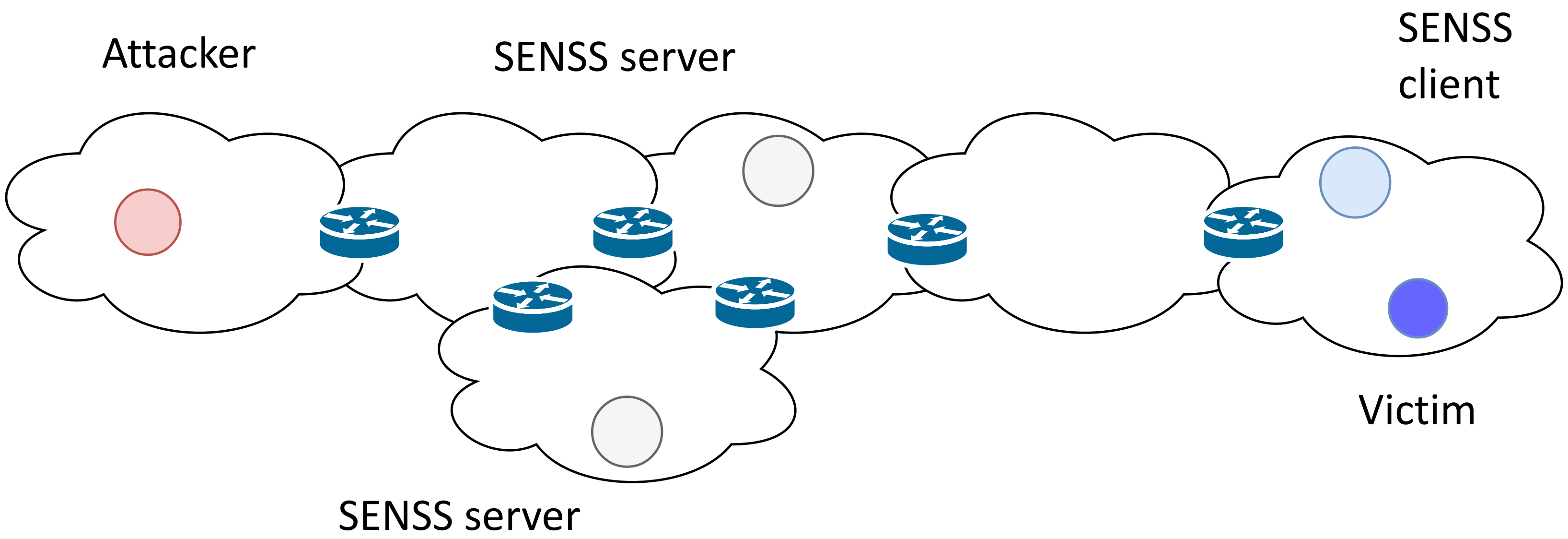
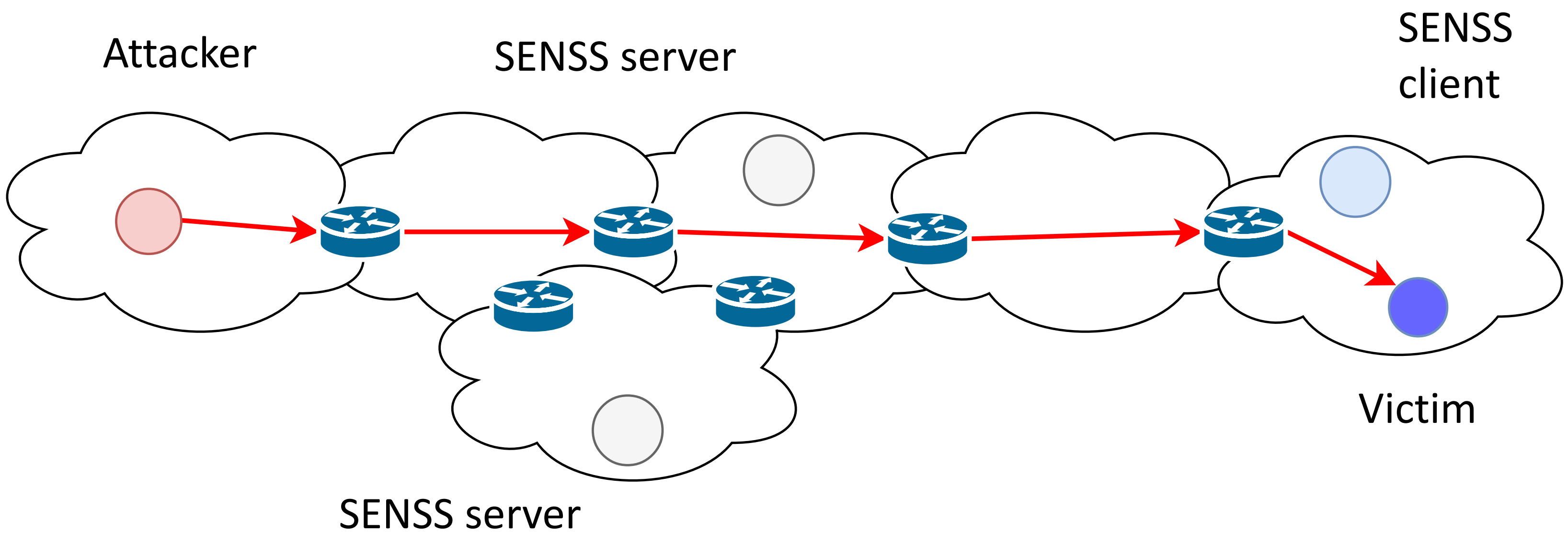
SENSS: Components



SENSS: Attack scenario



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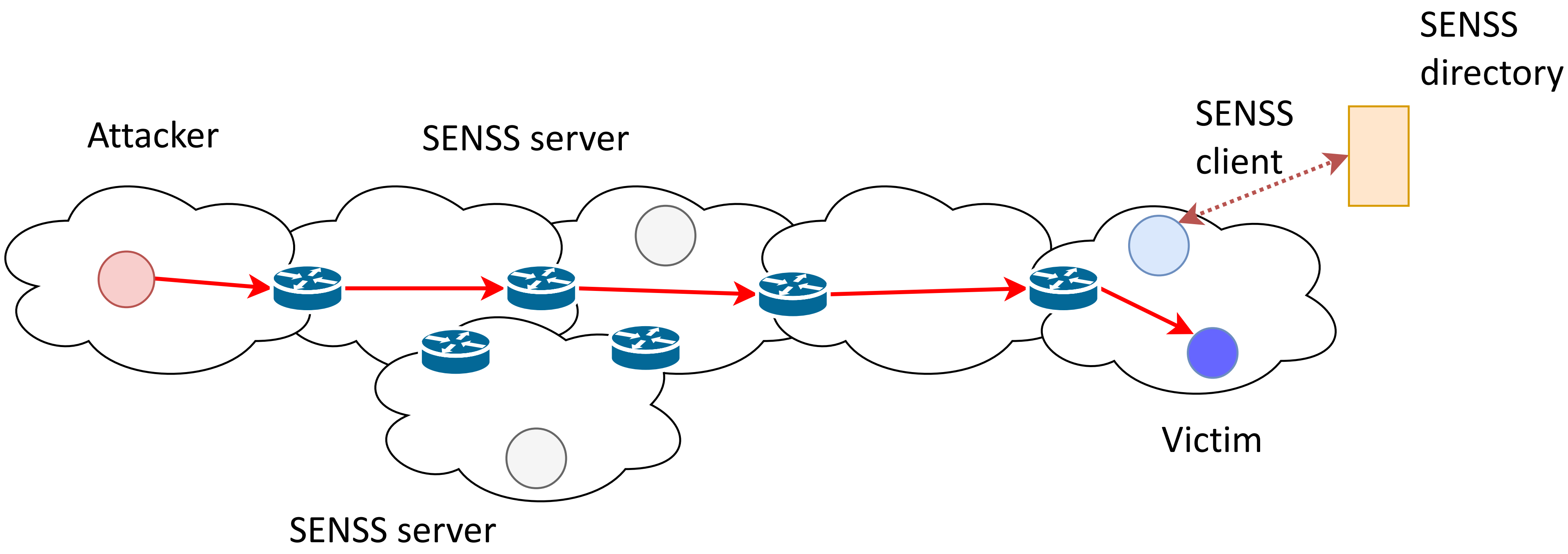

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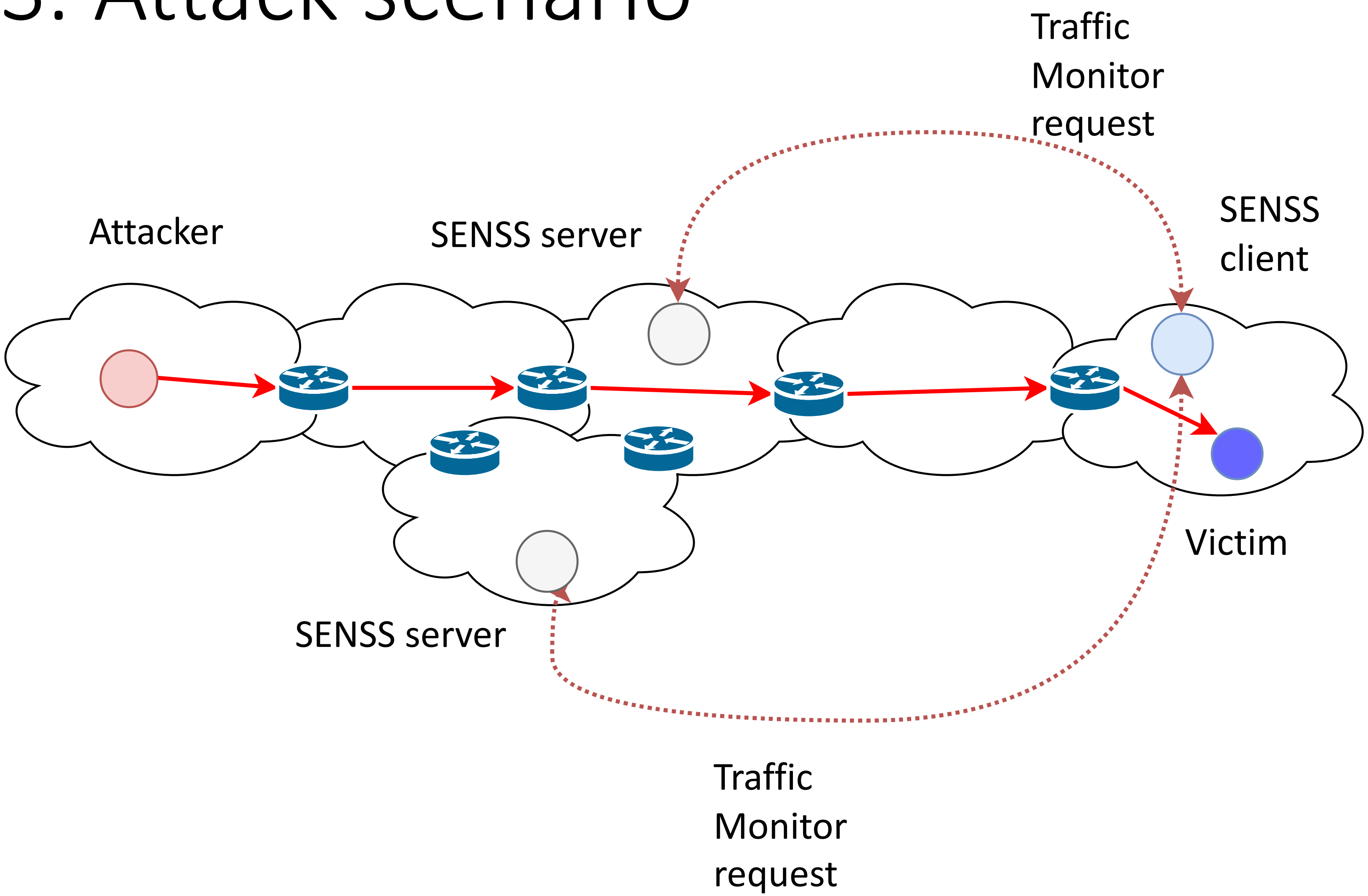

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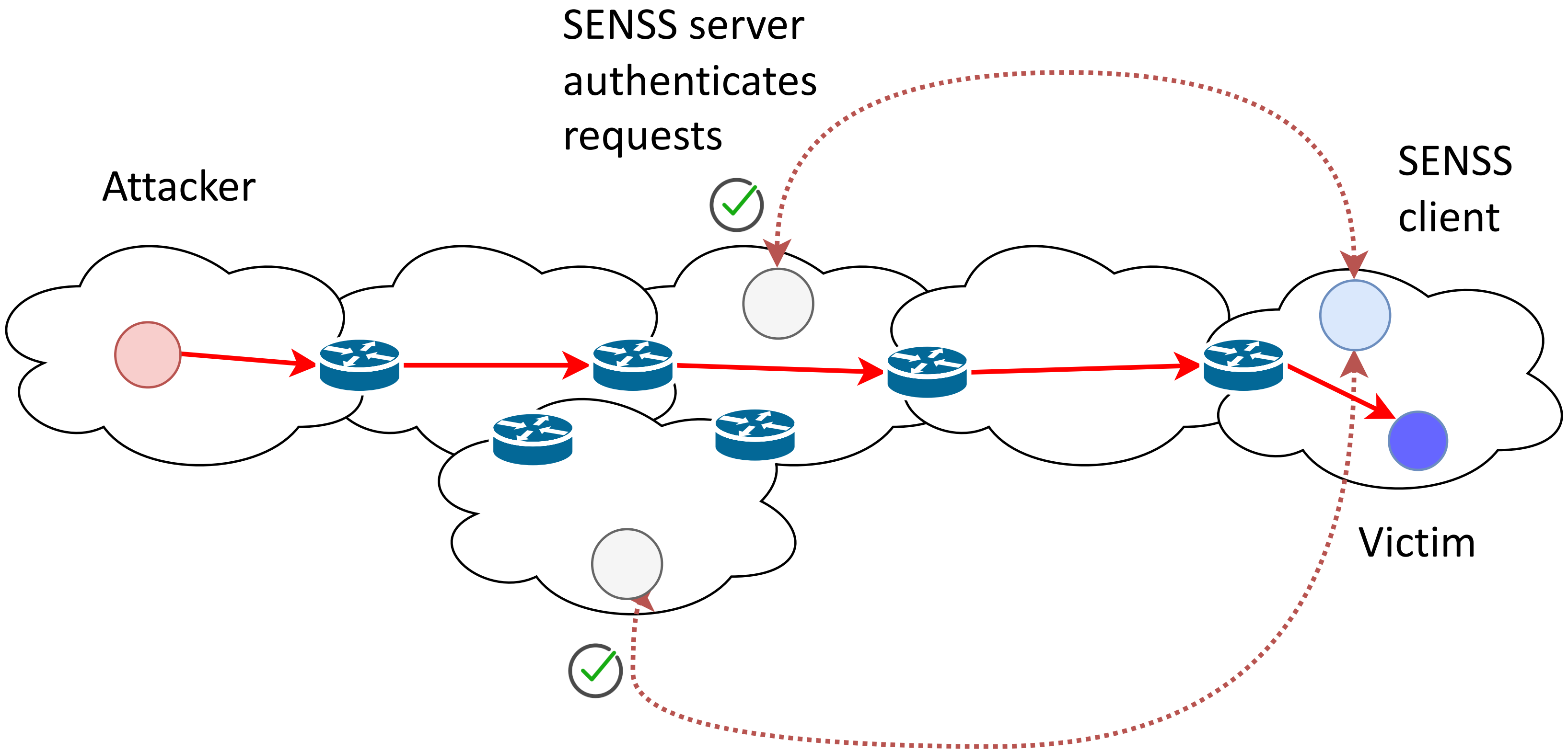

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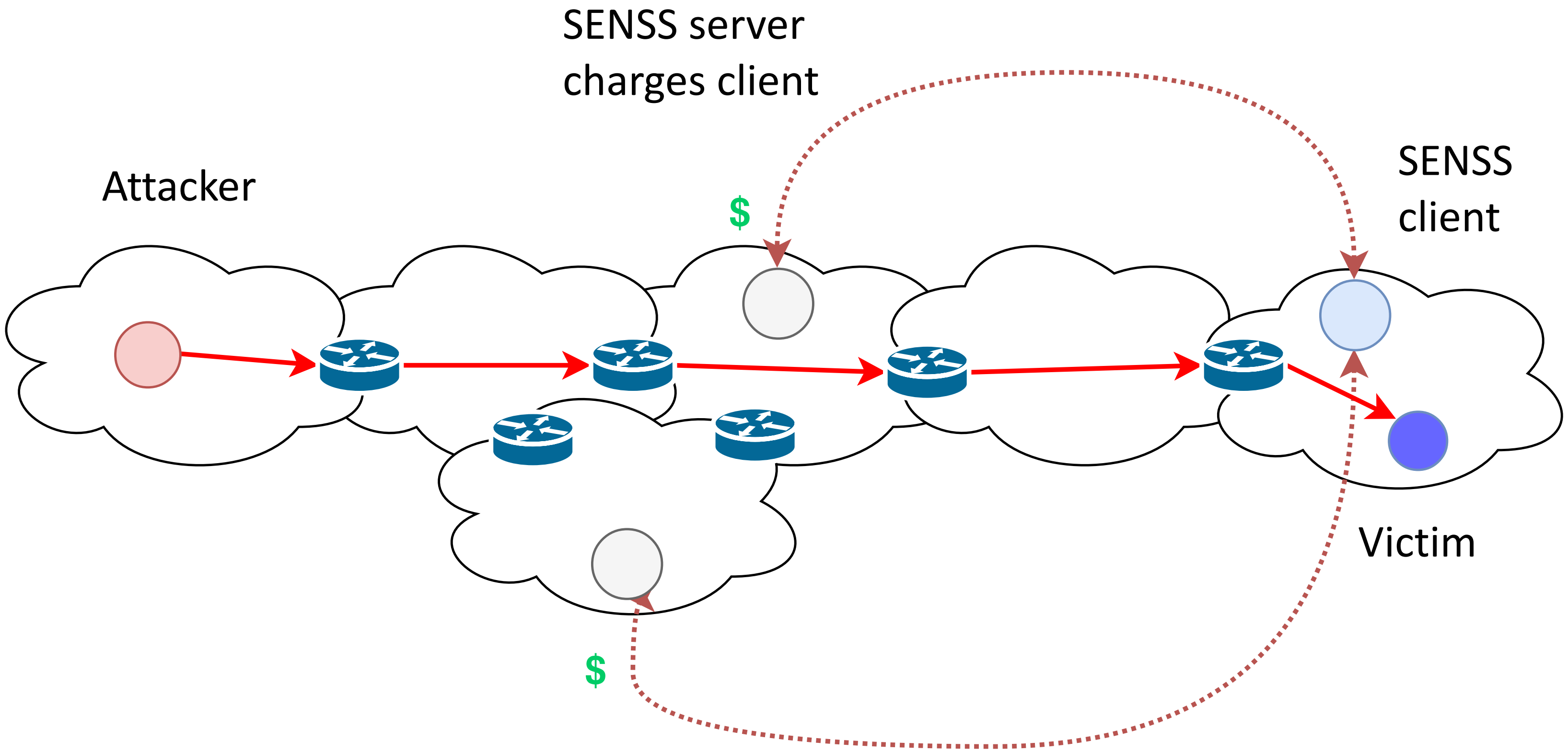

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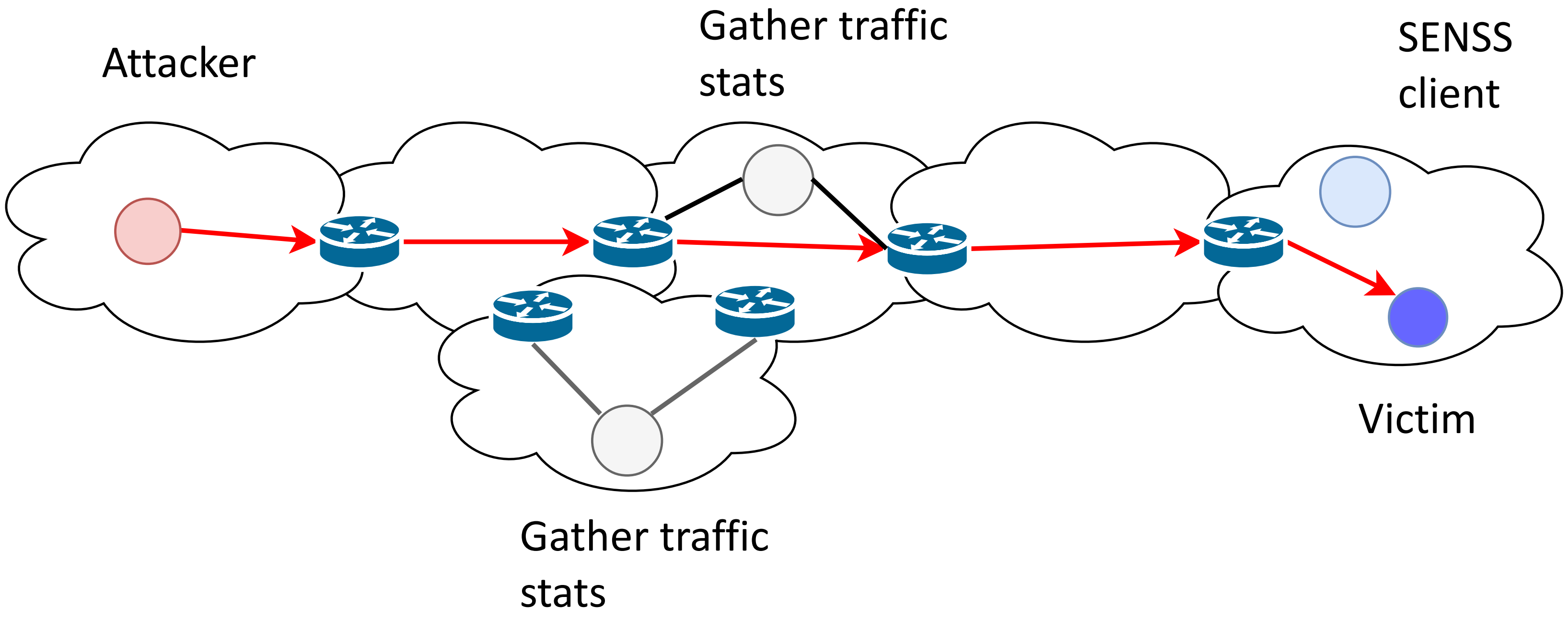

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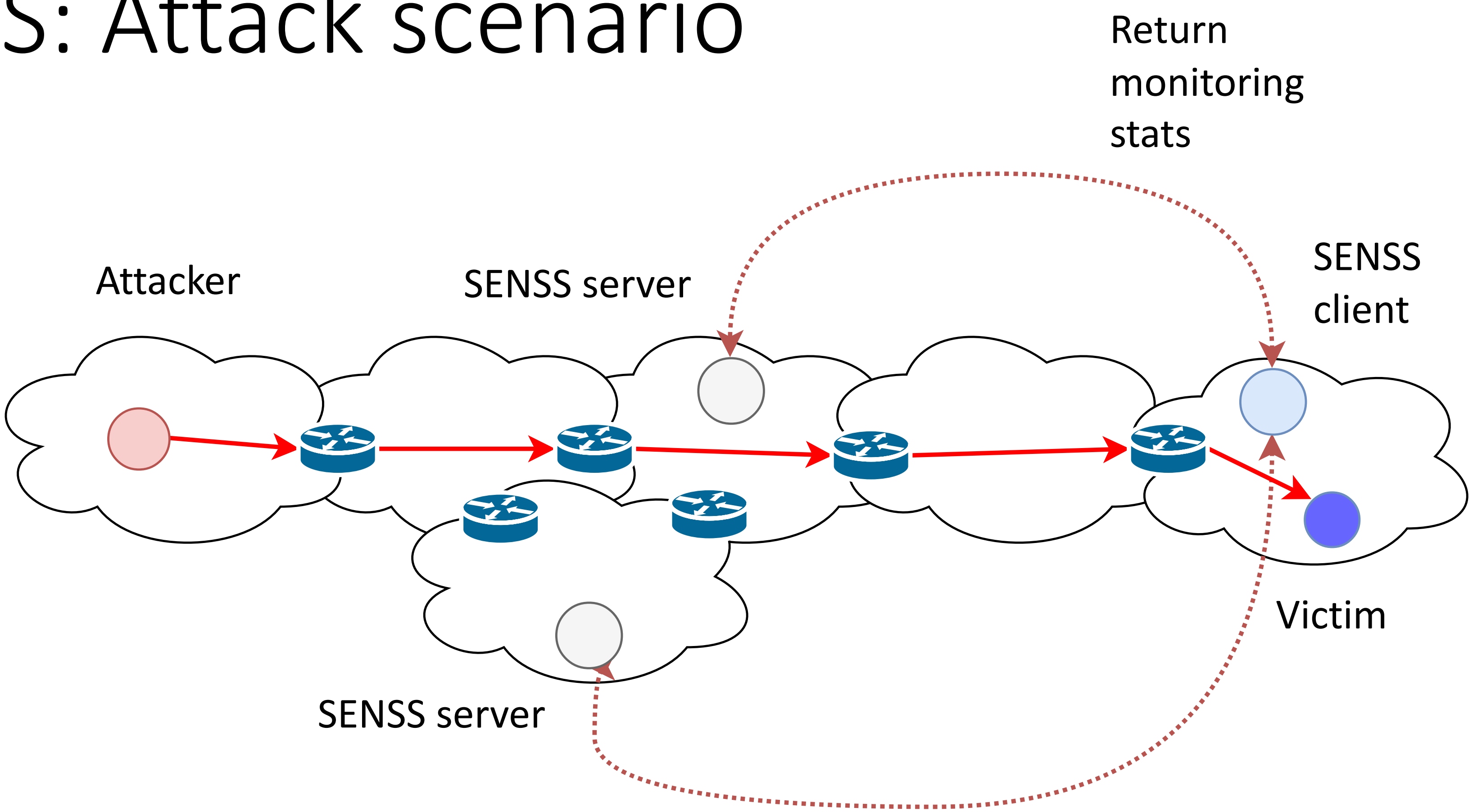

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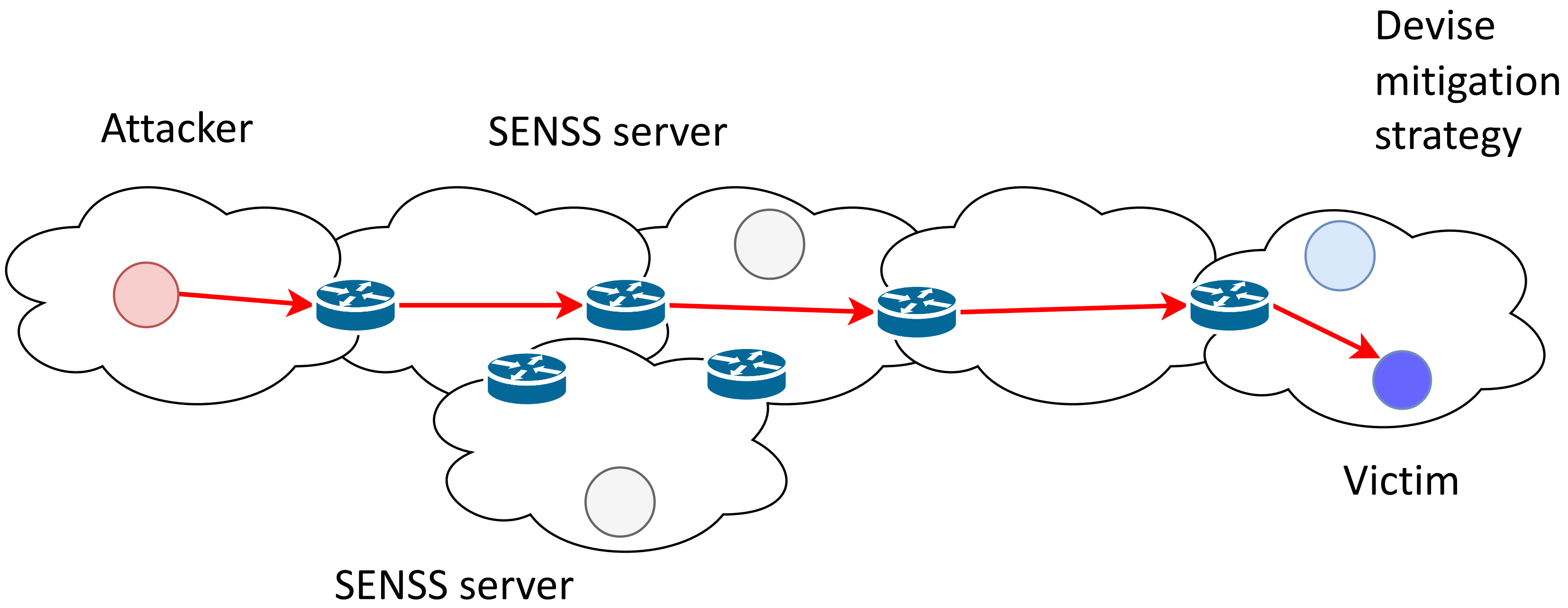

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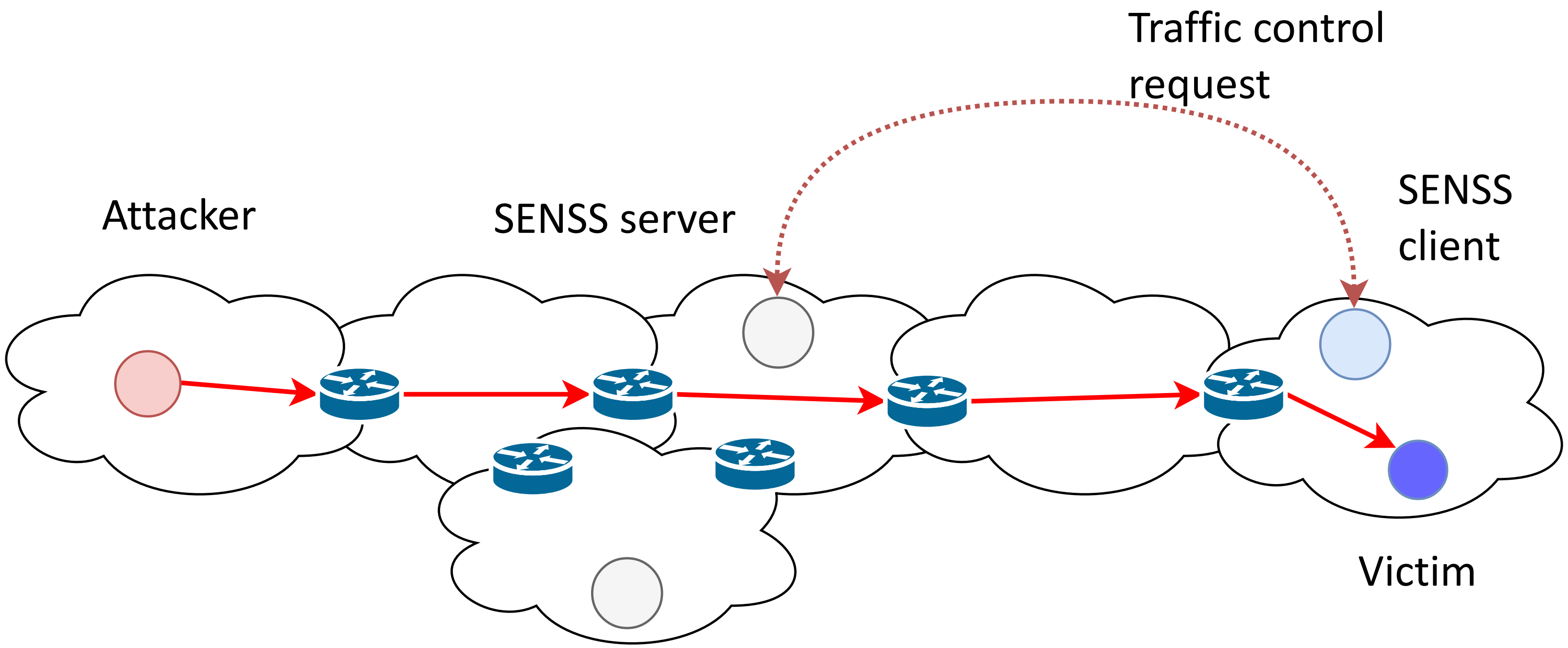

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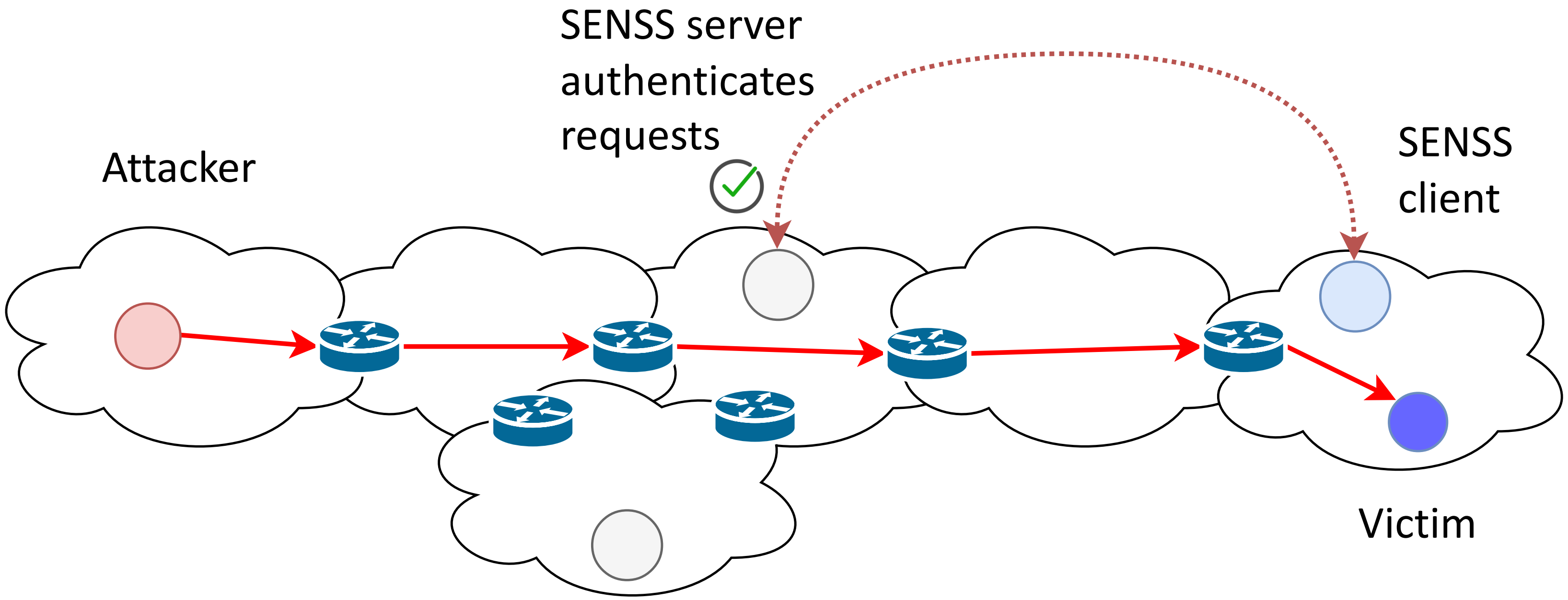

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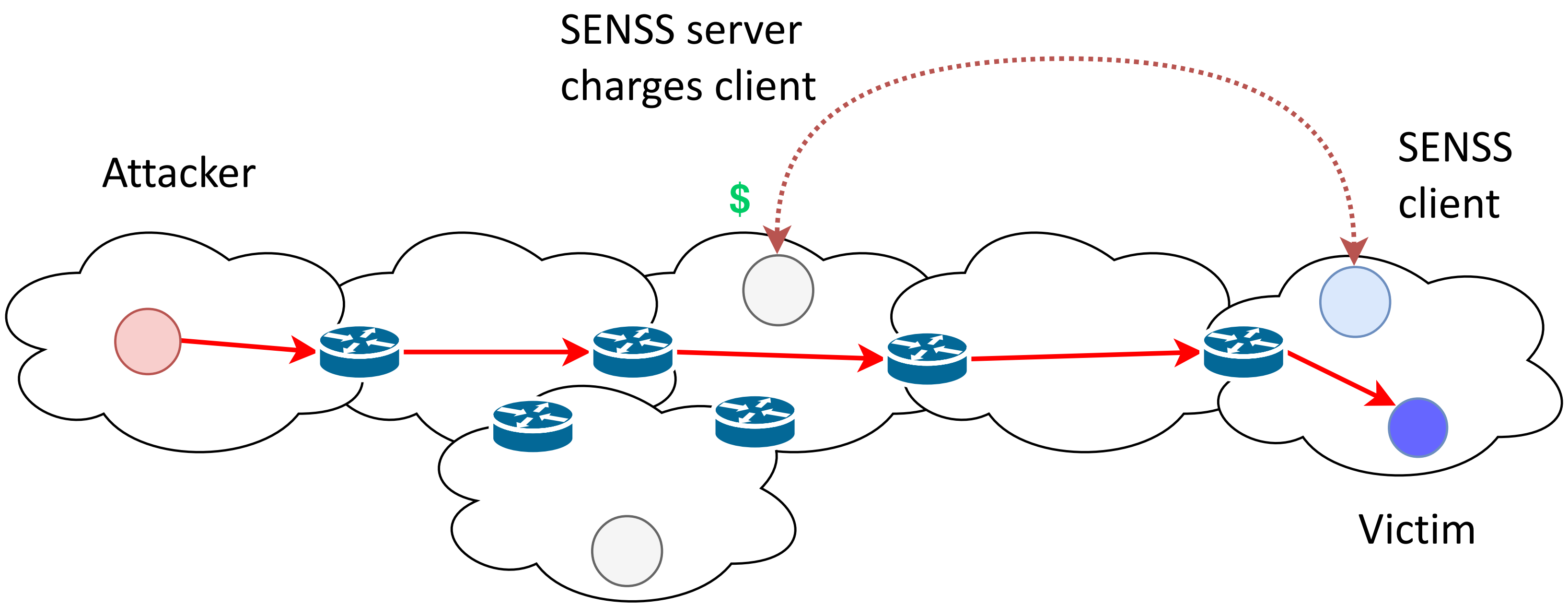

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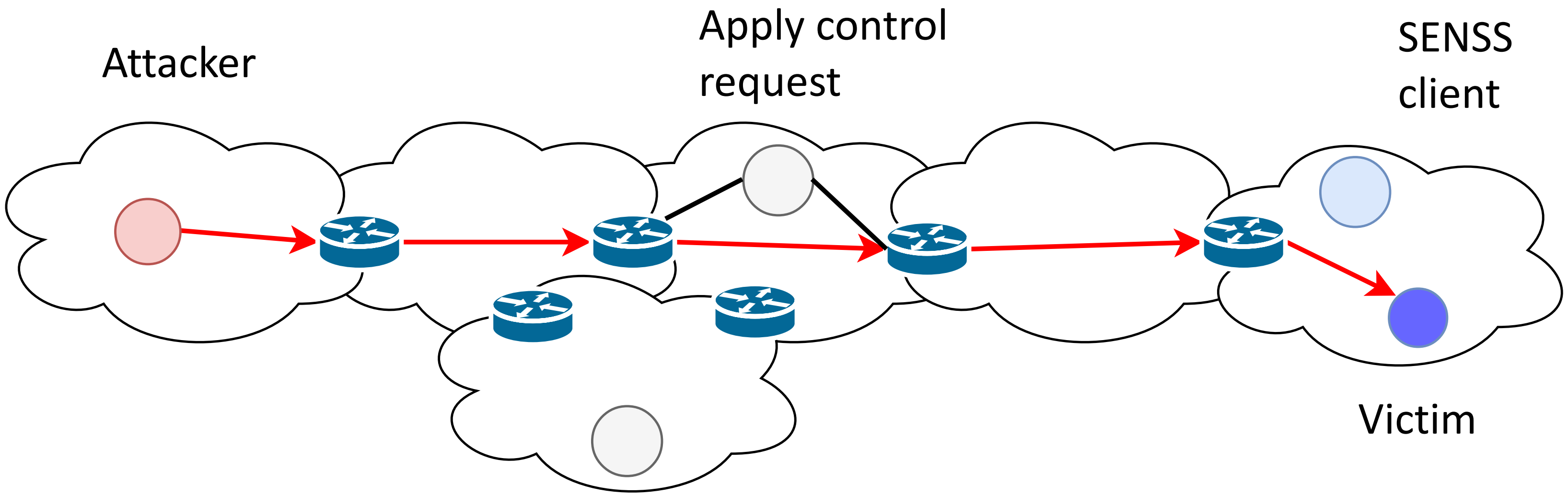
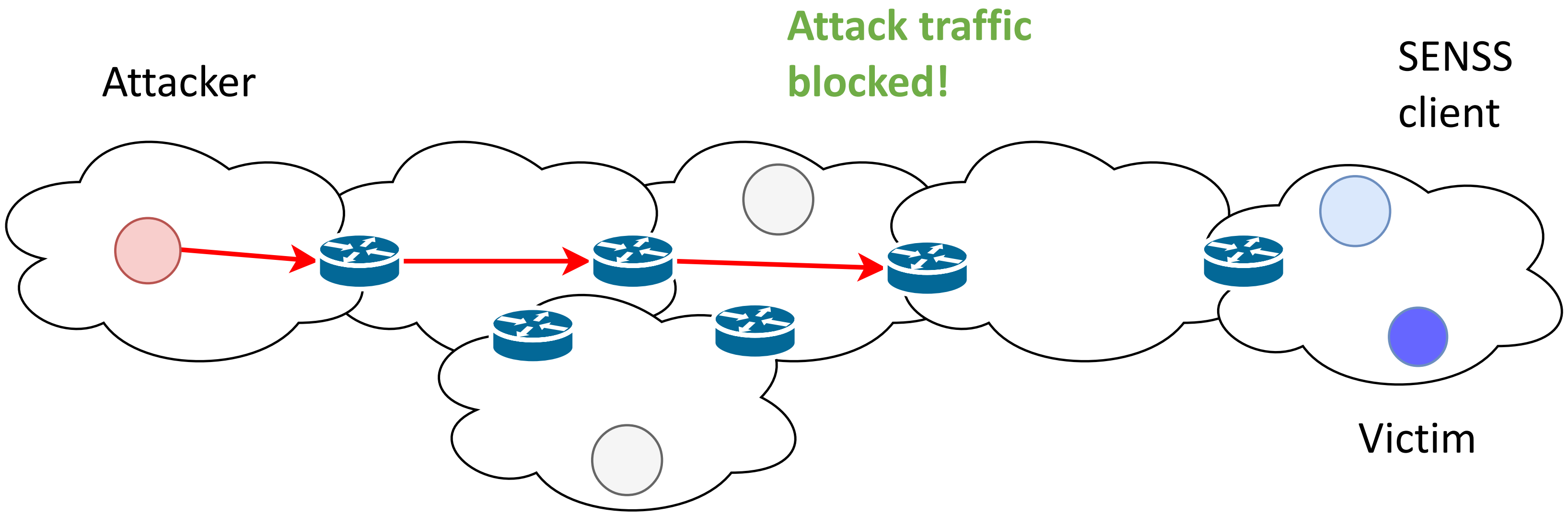
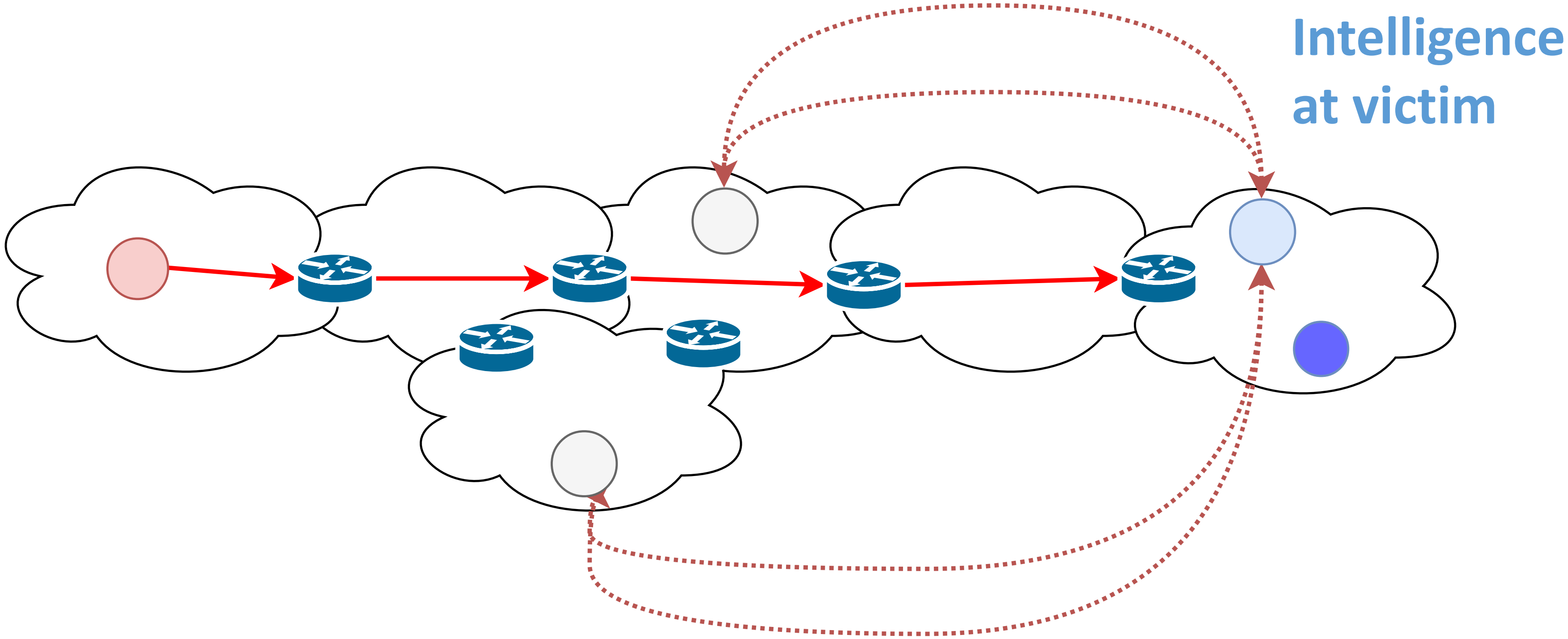


SENSS: Attack blocked

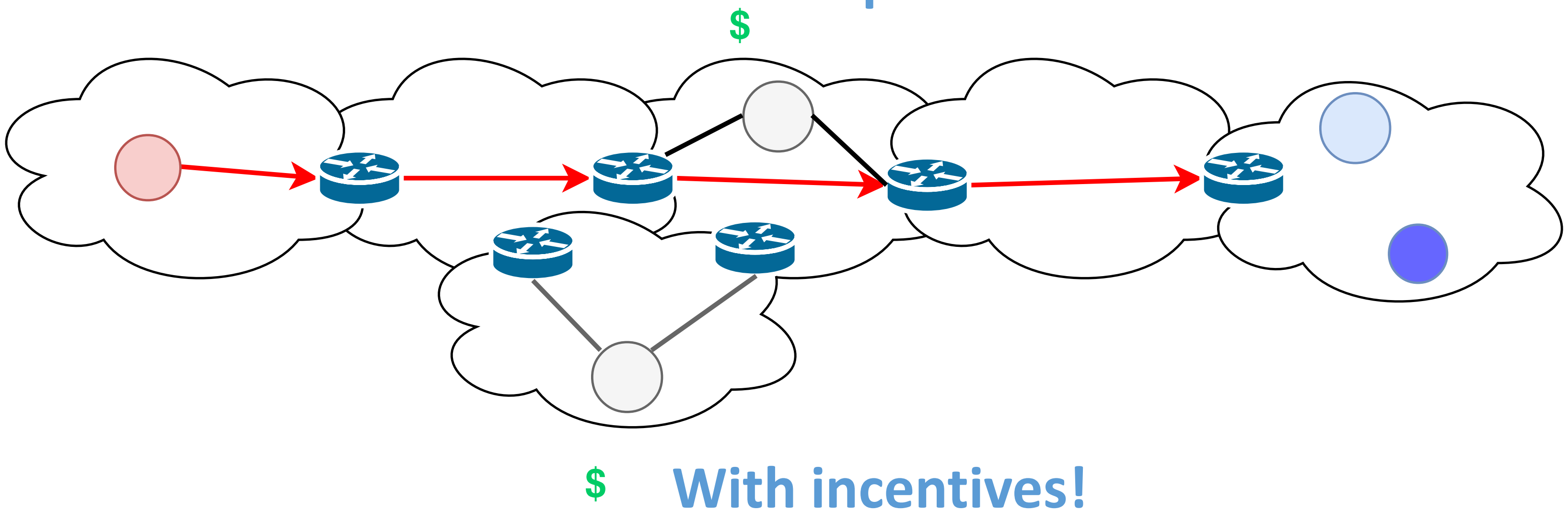


SENSS: Labor division



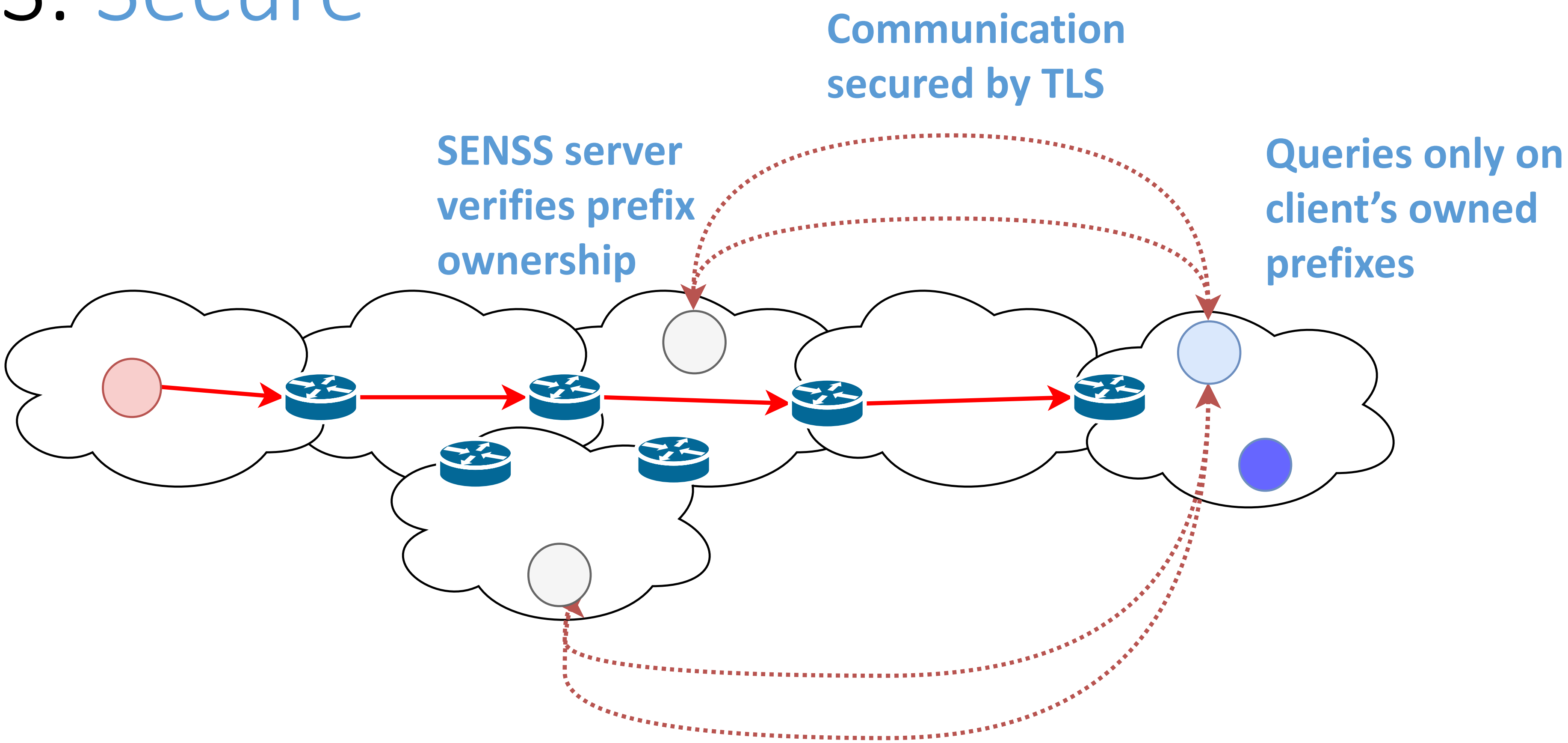
SENSS: Incentives for ISPs

Simple implementation at ISP



With incentives!

SENSS: Secure



SENSS API

Type	**Response from SENSS server**
Traffic Query	Traffic stats matching predicates

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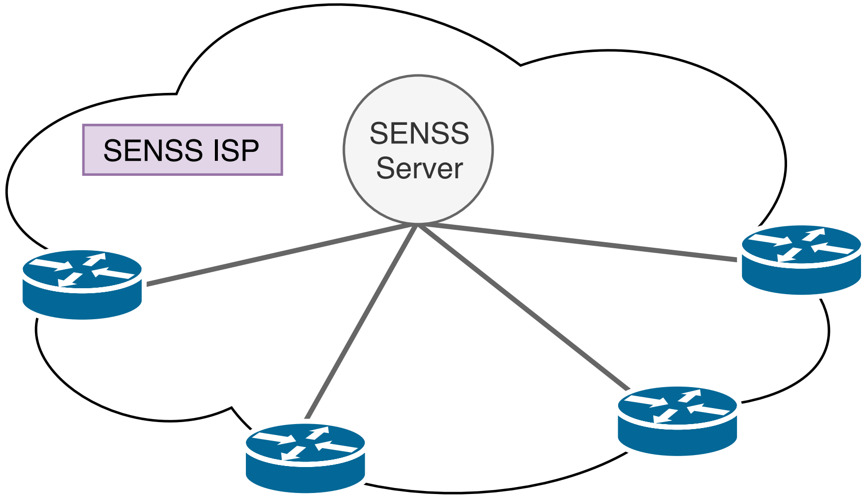
Each traffic query/control consists of a predicate matching flow(s)

- Supports various packet header fields
- Different packet header fields can be combined using negation, conjunction, disjunction and wildcard

SENSS Server Implementation

- Queries to SENSS server can be implemented using Openflow or Netflow+ACL
- SENSS server receives requests from clients, authenticates and sends appropriate replies
- SENSS server also co-ordinates with various border routers within the same ISP and gathers statistics



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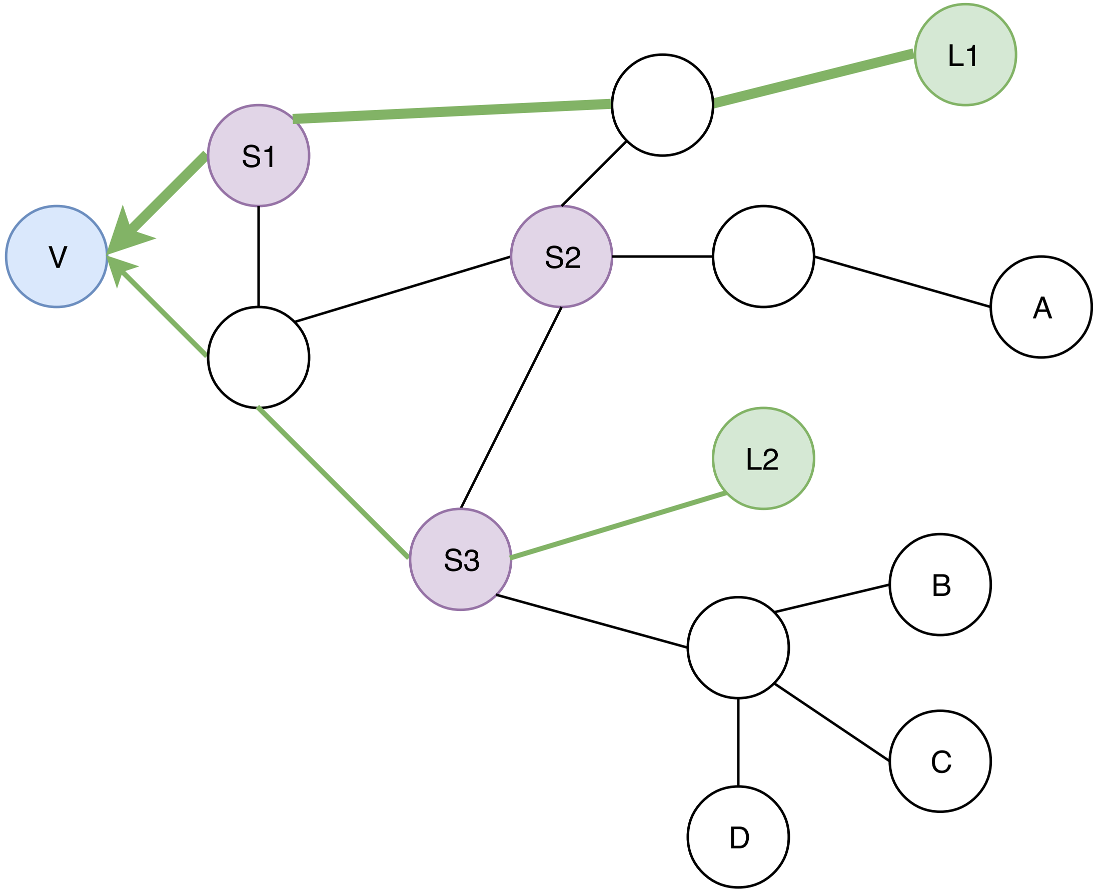
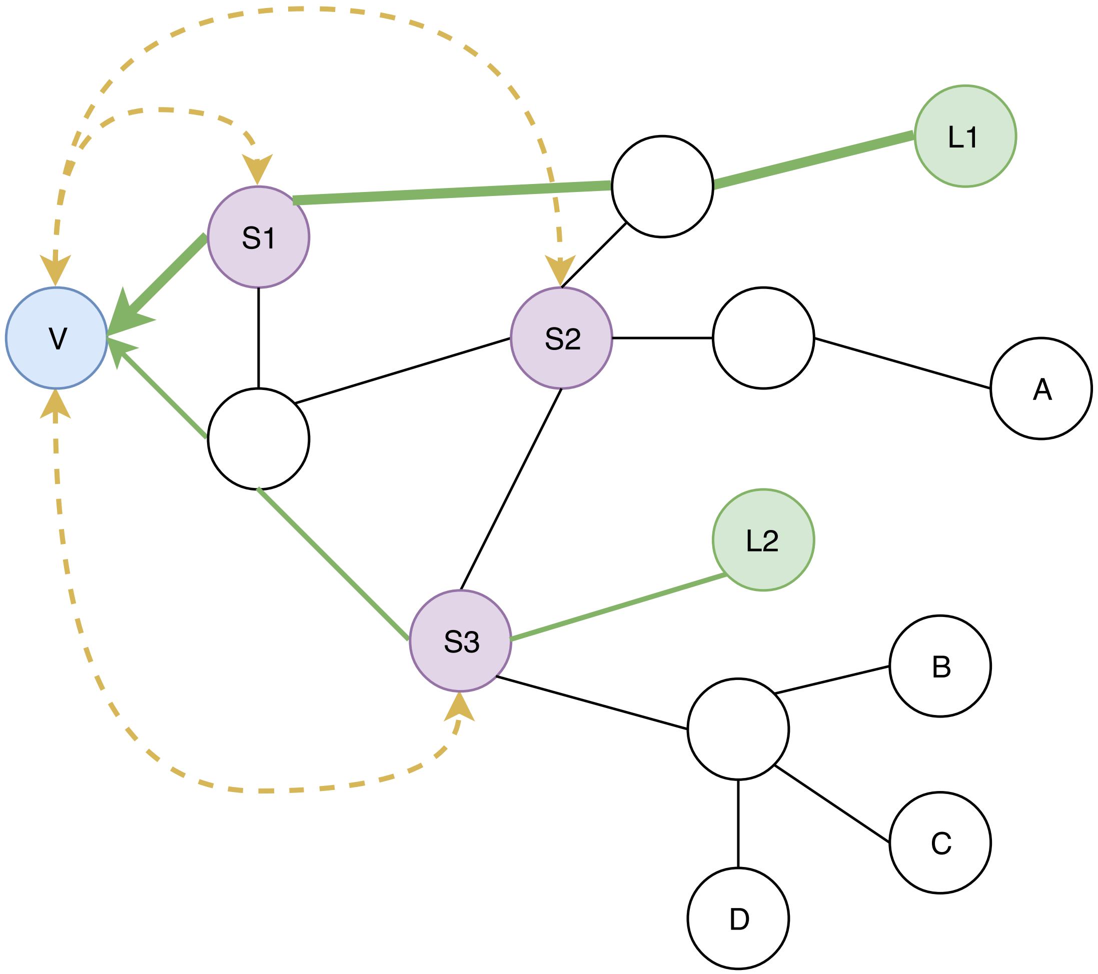
DDoS without signature attack

Legit traffic from L1
and L2



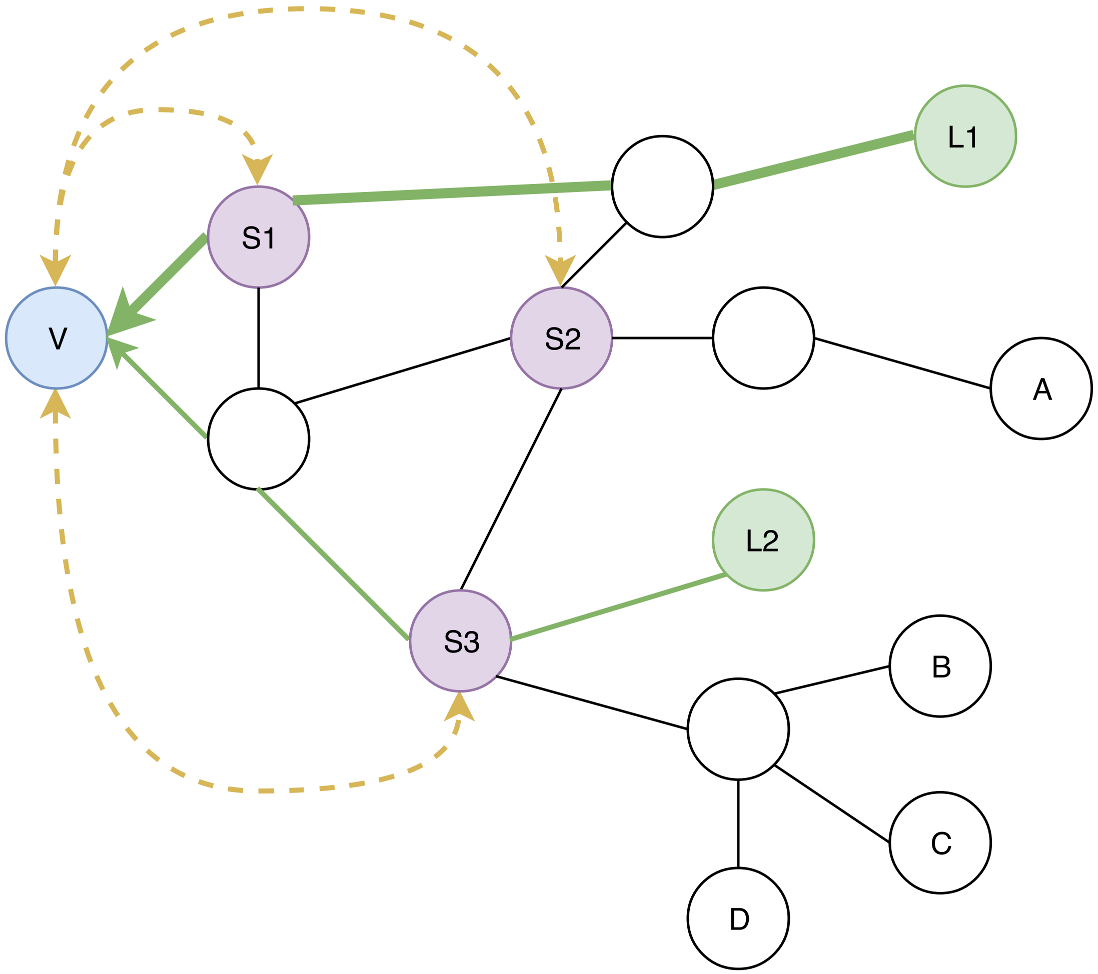
DDoS without signature attack

Periodic traffic query to S1, S2 and S3



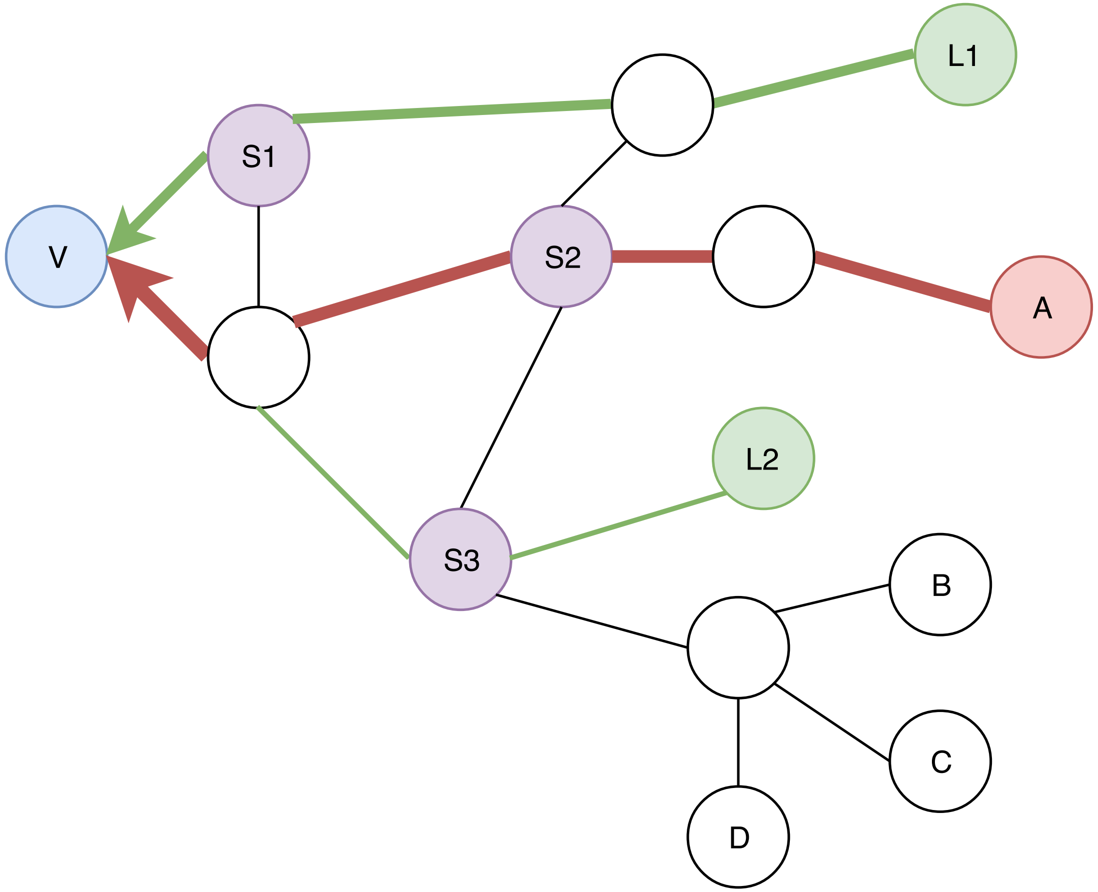
DDoS without signature attack

Replies
S1: 1000 Mbps
S2: 0 Mbps
S3: 400 Mbps



DDoS without signature attack

Attack from A



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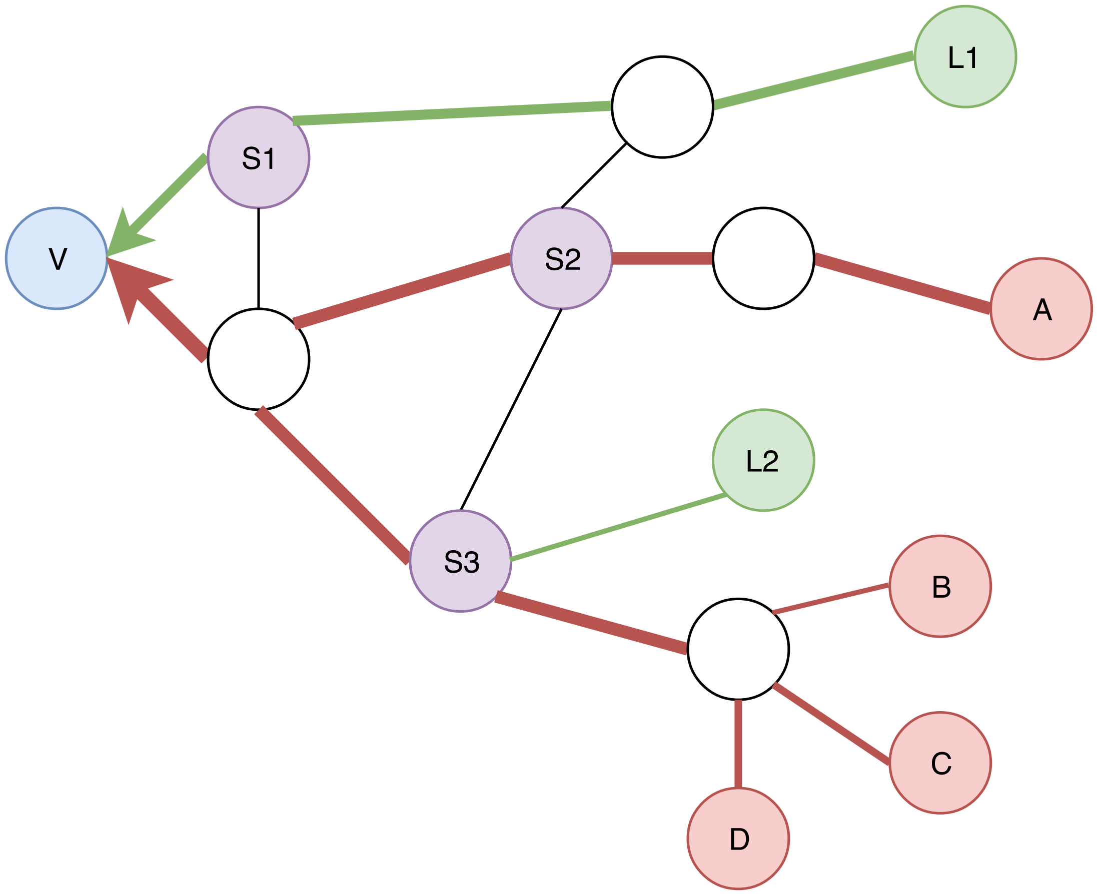
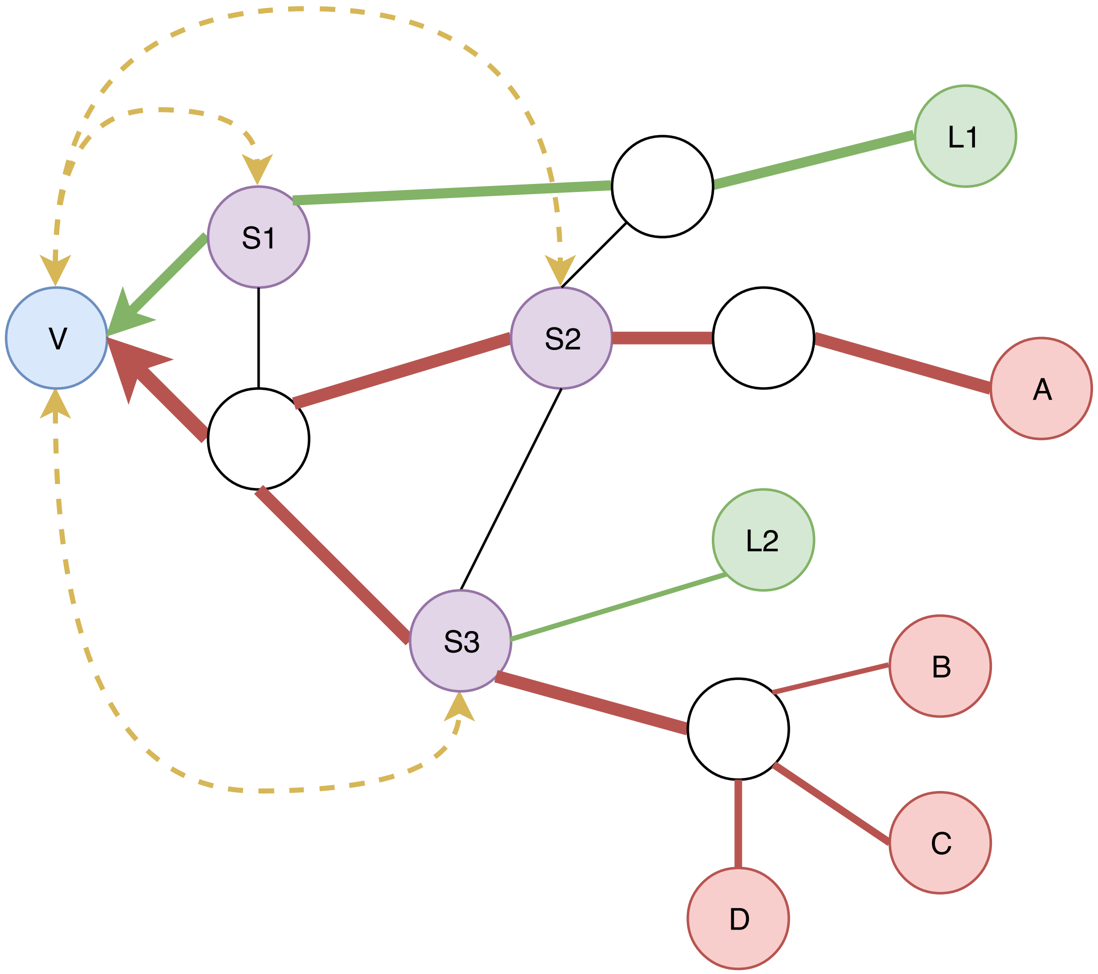


More attack from B, C and D

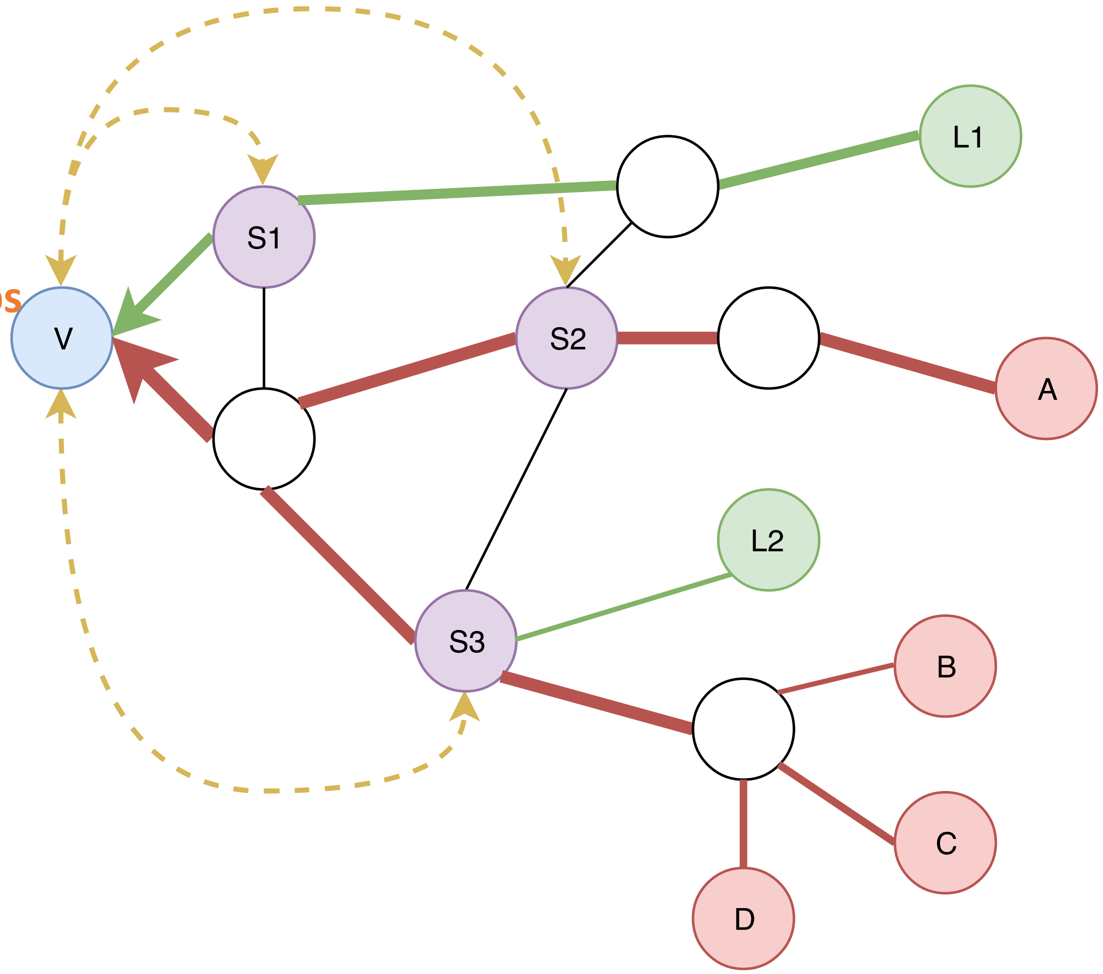
DDoS without signature attack

Periodic traffic query to S1, S2 and S3



DDoS without signature attack

Replies
S1: 1000 Mbps
S2: 500 Mbps
S3: 750 Mbps



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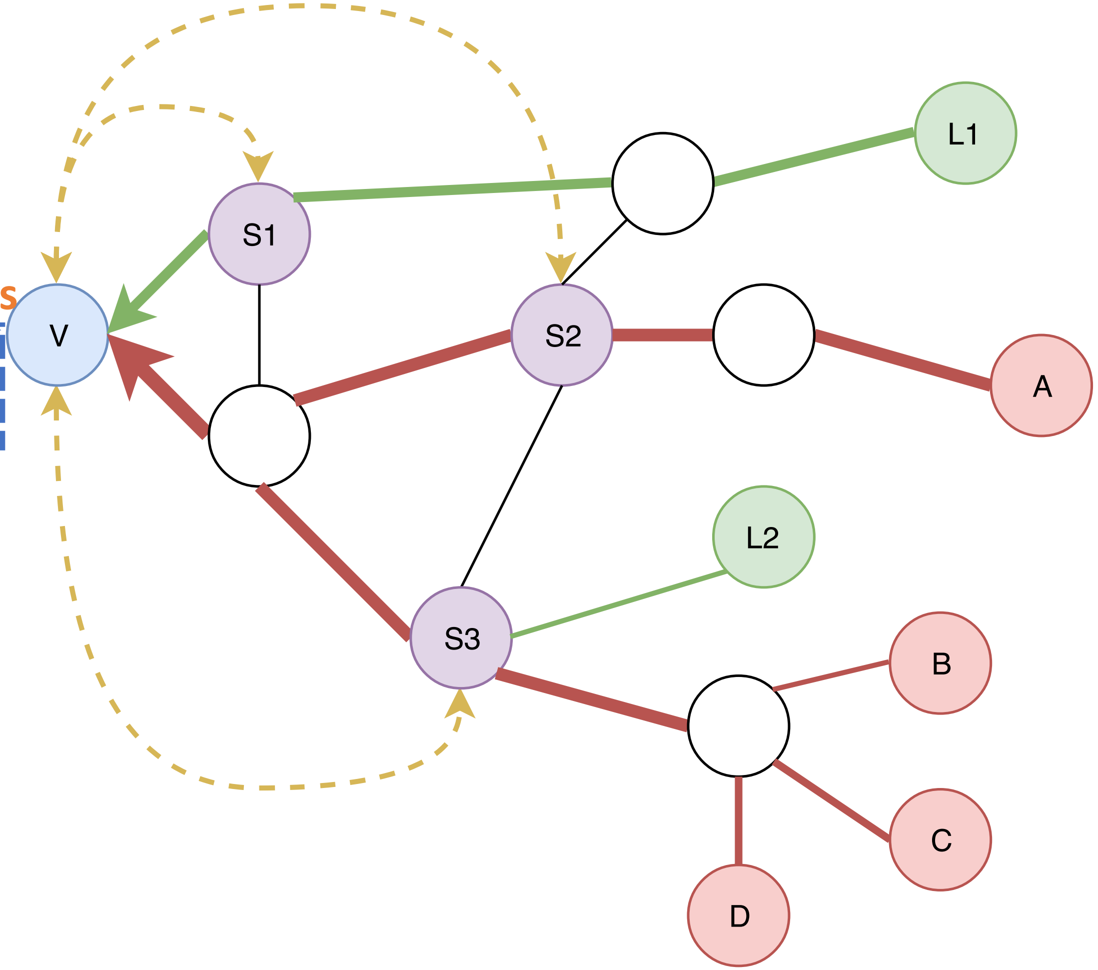

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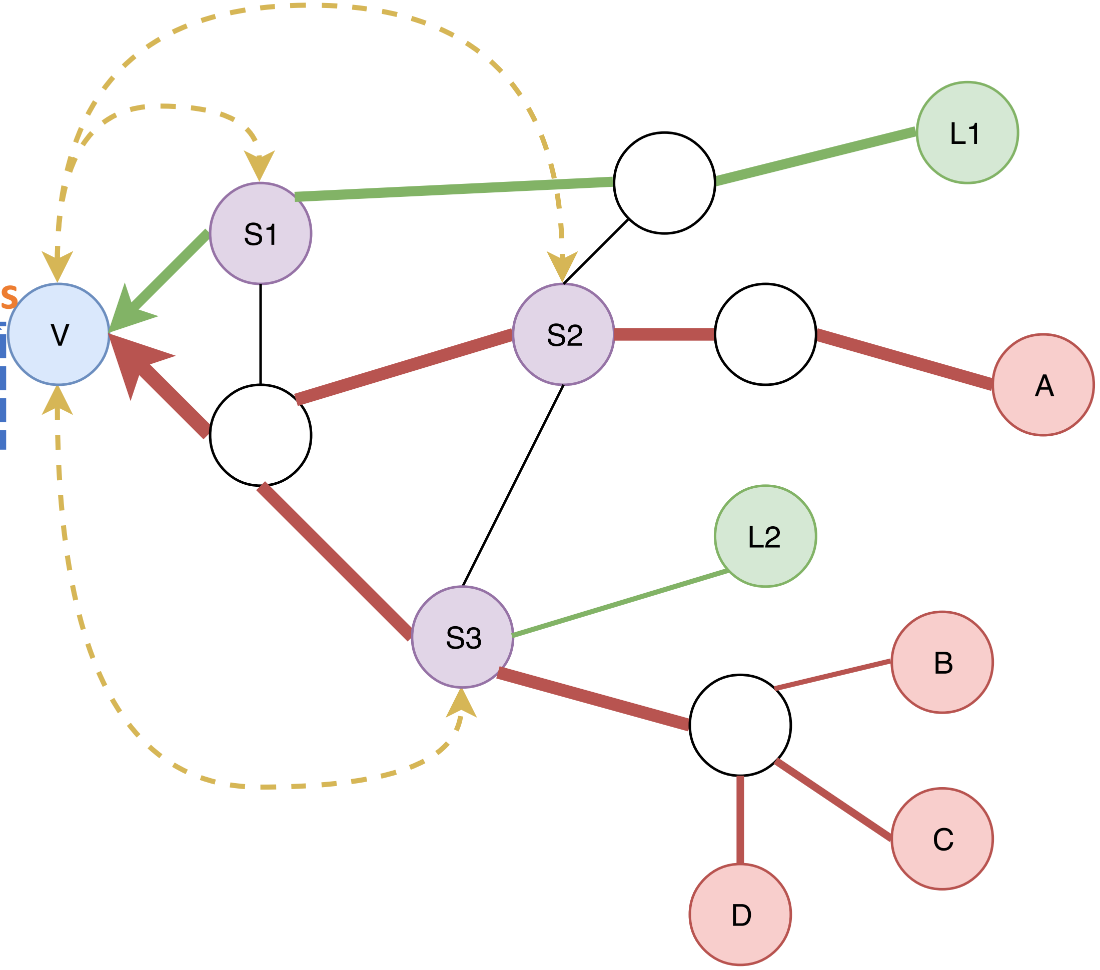
Unusual traffic
from S2 and S3



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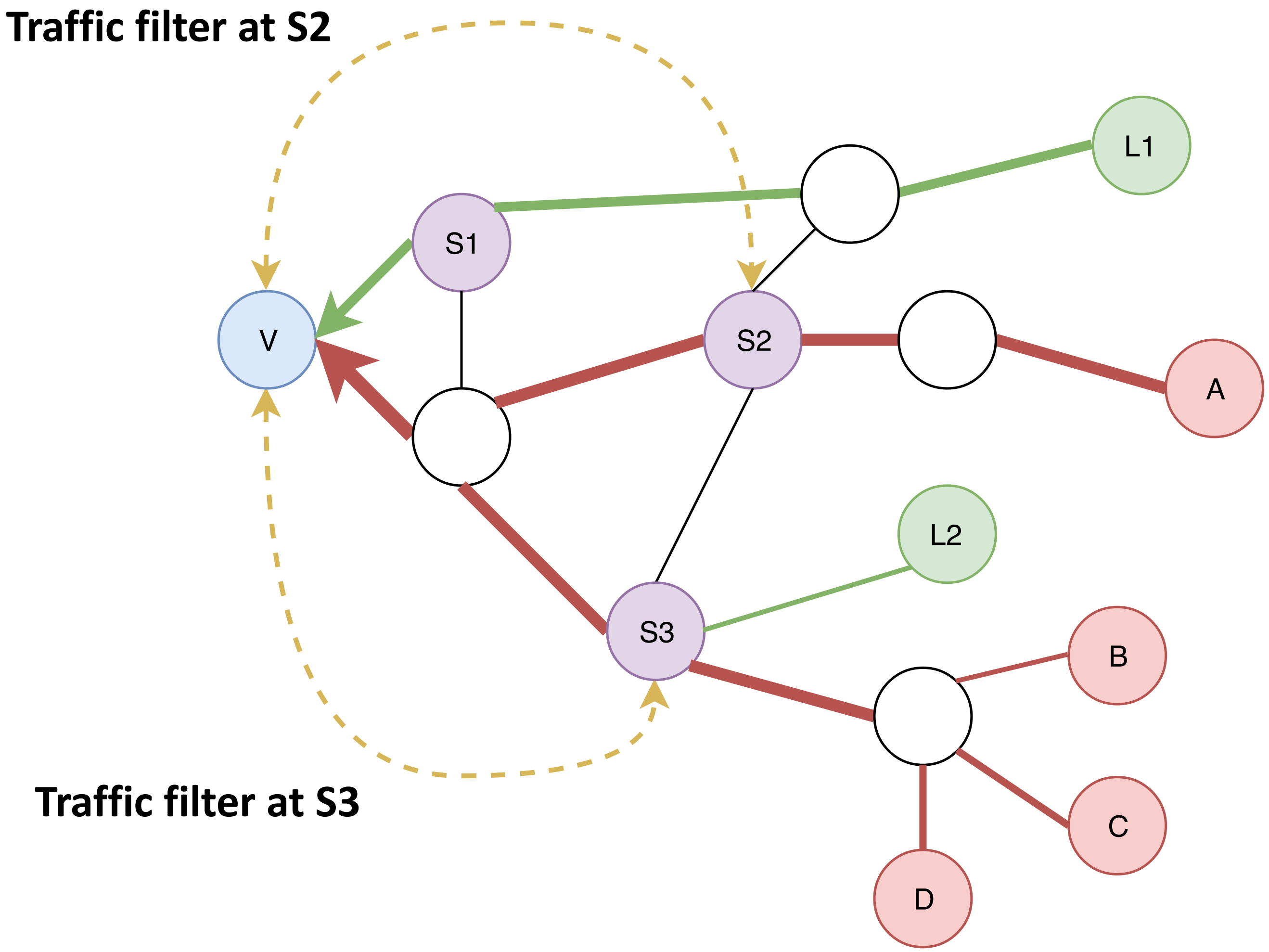

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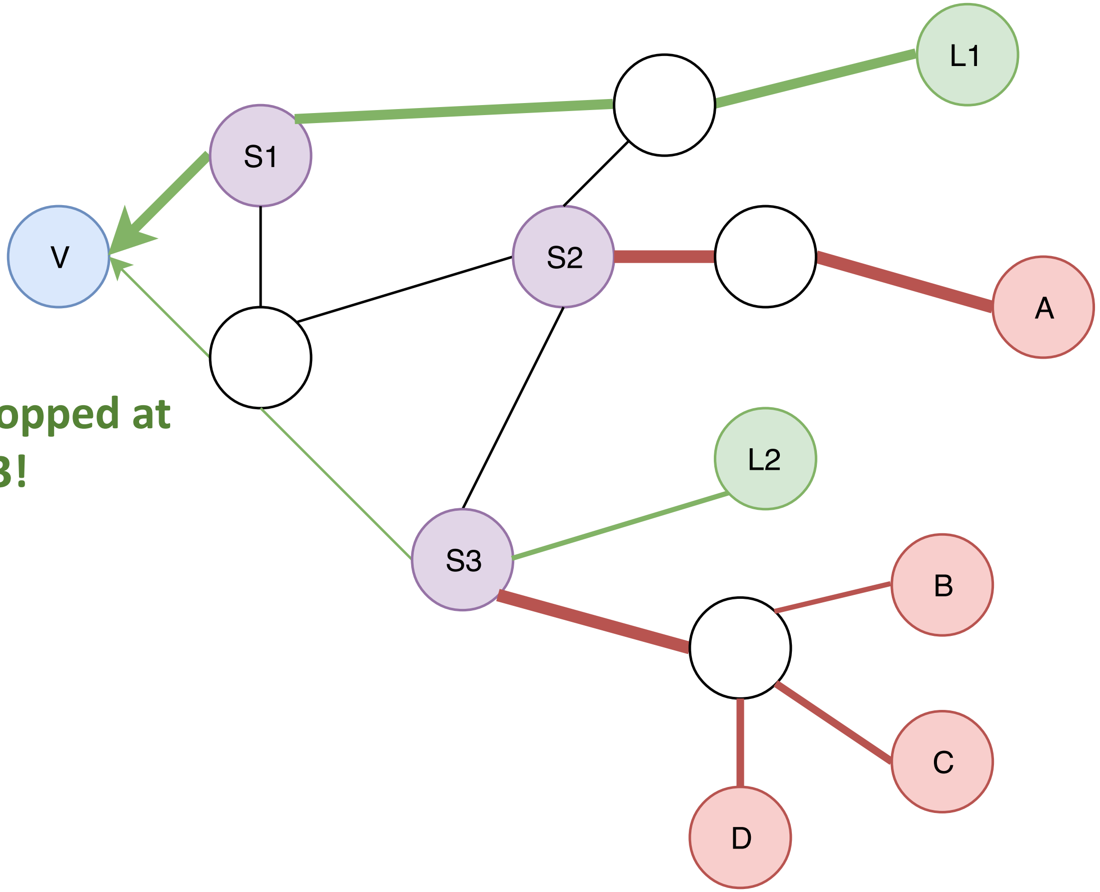

Attack stopped at S2 and S3!

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Securing communication

- SENSS allows client to issue requests only to its own prefixes
  - SENSS client binds a proof of ownership certificate with every request
- Proof can be created using RPKI Route Origin Authorization (ROA) certificates
  - Alternatively we can issue custom certificates
- Communication between SENSS client and SENSS server is secured using TLS and occurs over HTTPS
  - If the privacy of key is compromised, SENSS server can purge all existing client requests

Challenges

- Router's TCAM space is limited
    - Coarse rules are enough to mitigate large volumetric attack
    - Finer rules can be prevented by SENSS ISP's or discourage users by charging higher prices
- ISP's privacy concerns
    - Traffic replies can contain anonymized ID's to cover neighboring peers
- ISP is in control
    - Can reject demote requests which may not be optimal

Handling misbehavior

- **SENSS clients** have low incentive to misbehave
  - Excessive requests are unlikely as clients need to pay for each request
  - Requests can be made only for their own prefixes
- **SENSS servers** could lie about observations and/or fail to implement control actions
  - Legacy: Lie about client’s traffic and make it look smaller, increasing the cost of client but does not drop traffic
  - Dropper: Lie about client’s traffic and make it look larger causing client to issue traffic control to drop traffic
    - But dropper liars are already on the path of traffic, SENSS does not make it worst

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Evaluation objectives

- Extent of SENSS adoption by ISP required for effective protection?
- How will different customers benefit from SENSS adoption?
- SENSS comparison with existing cloud solutions

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    - 0.7—3.8% deployment of SENSS in large ISPs can protect most customers
- How will different customers benefit from SENSS adoption?
    - All direct single homed customers of SENSS ISPs are protected from direct floods and reflector attacks
    - 90% of direct multi homed or remote customers are protected from floods without signature and reflector attacks with just 1—3.8% of SENSS adoption
- SENSS comparison with existing cloud solutions

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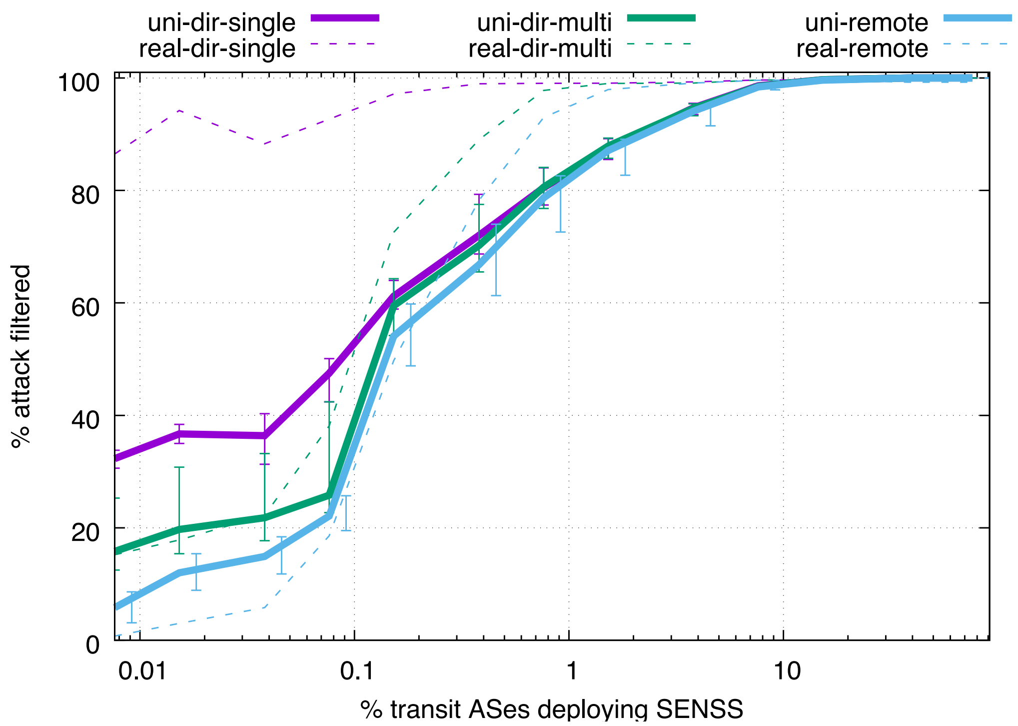
- SENSS comparison with existing cloud solutions
  - SENSS outperforms all after 0.4% of top transit deployment

Evaluation

- Conducted emulation and simulation over AS-level topology
- Used two strategy for SENSS server deployment
  - Top: SENSS is deployed in top *N* ASes ordered in decreasing customer size
  - Random: SENSS is randomly deployed in *N* Ases
- Two types of traffic
  - Uniform: Attack traffic are equally distributed among random ASes
  - Realistic: Attack traffic from only from residential network hosting Mirai botnet

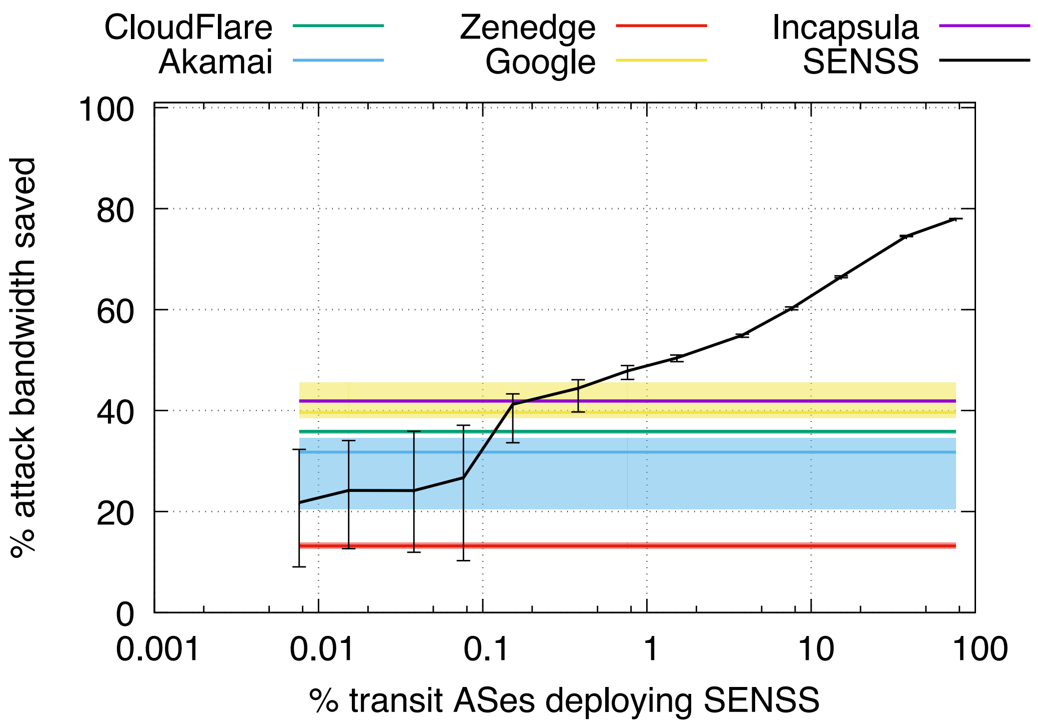
DDoS without signature

- SENSS is very effective in sparse deployment
- Deployment of 1.5% of top ASes achieves 90% for direct/single homed customer
- Deployment of 3.8% of top ASes achieves 90% of multi homed customers and remote customers



Comparison of SENSS with cloud deployments

- Estimate saved bandwidth by SENSS and cloud deployment strategies
- Saved bandwidth is the difference between bandwidth consumed with and without defense strategy
  - Ideal solution would have 100% saved bandwidth
- Existing solution save 13—46%
- For 10% deployment, SENSS saves 60% of bandwidth, 1.5—8 times more bandwidth than others



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- SENSS is a collaborative defense where victims under volumetric DDoS attacks can request help from upstream ISPs
- SENSS API provides building blocks for clients to build custom defense to mitigate attacks
- SENSS servers are simple to deploy with monitory incentives to ISPs
- SENSS is effective in sparse deployment
- SENSS is more effective in saving bandwidth than other existing cloud based defense