Detecting DDoS Attacks on ISP Networks

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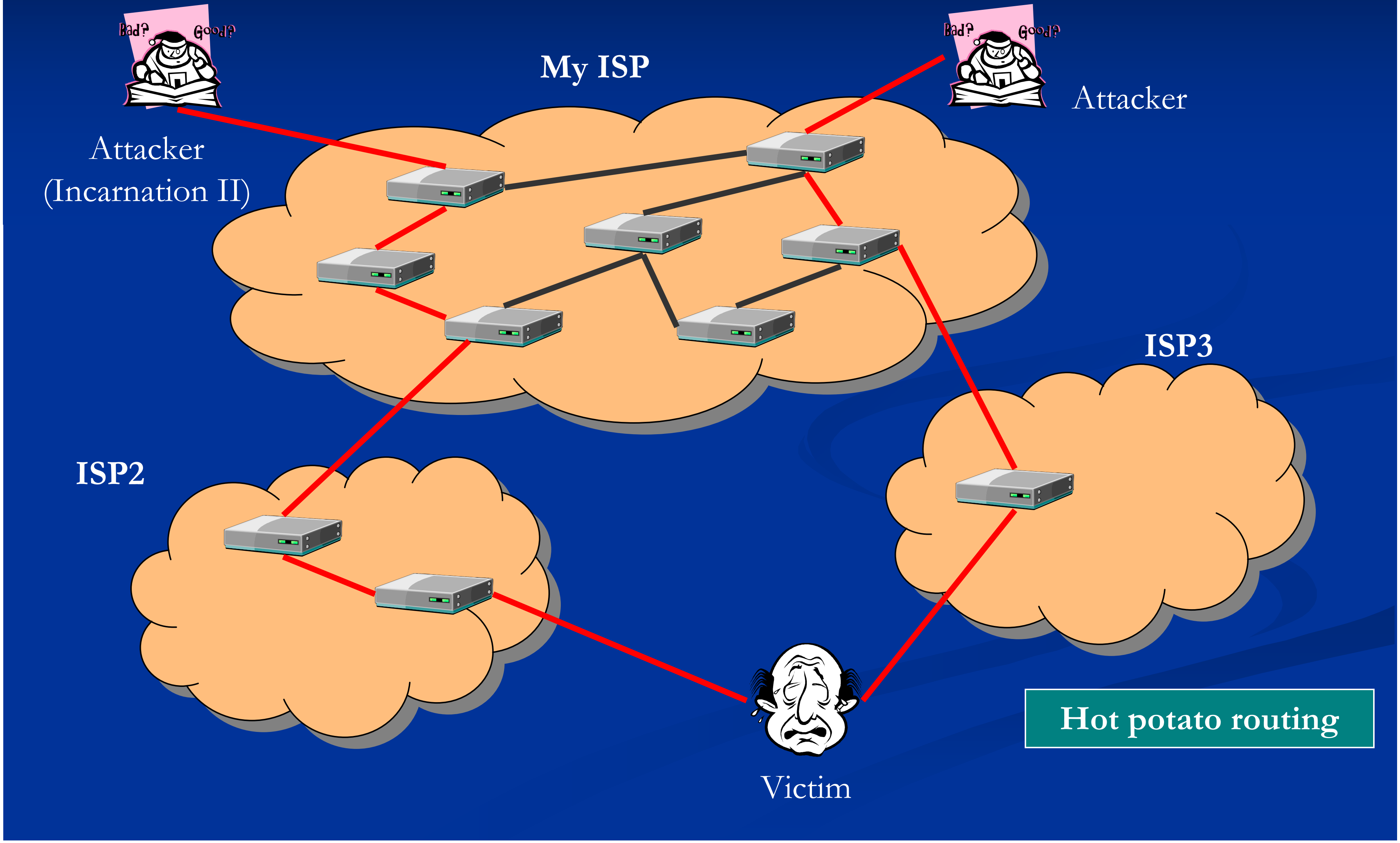
ISP Perspective of DDoS Attack

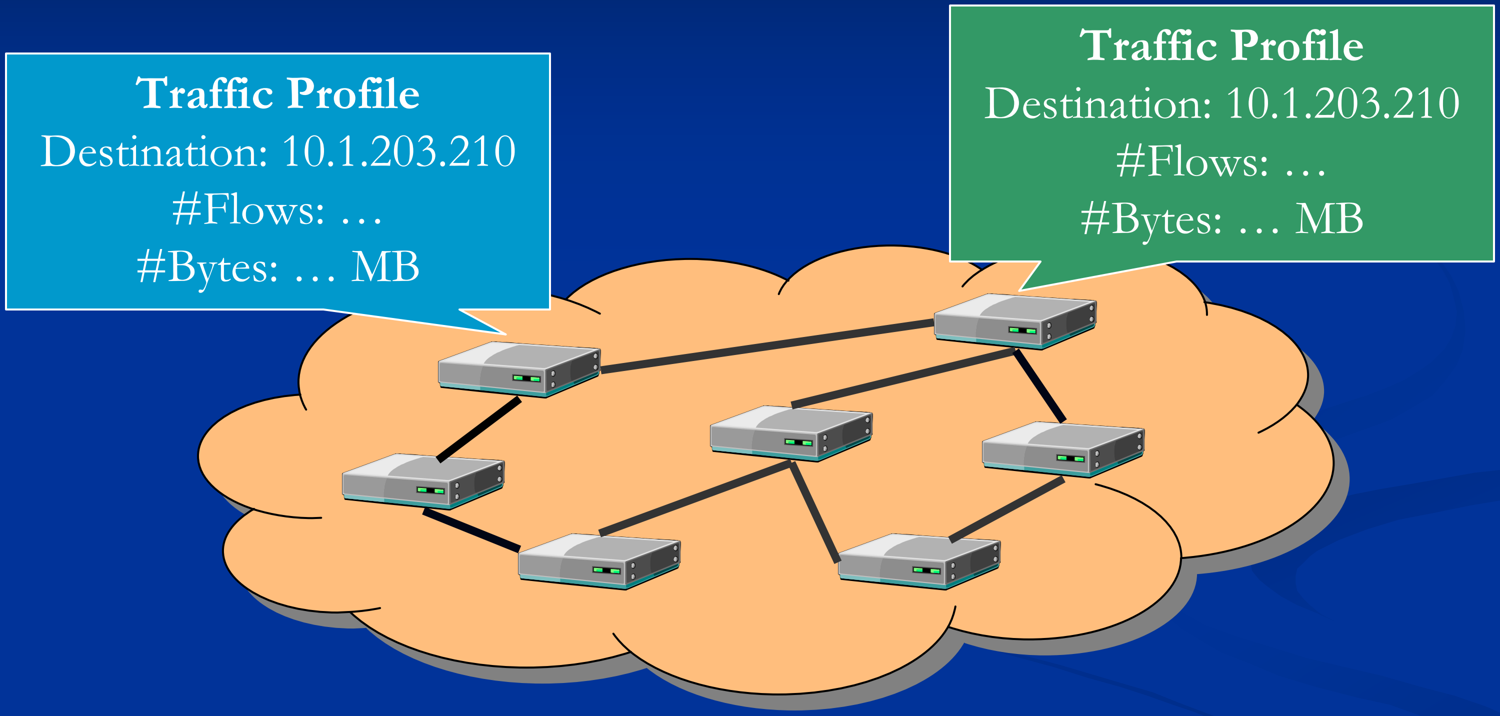


Hot potato routing

Problem Statement

- How can an ISP find out if:
  - Its Backbone is carrying “useless” attack traffic?
  - Its Backbone is itself under attack?
- Focus of this talk:
  - Sketch a solution approach
  - Discuss the main challenges

Approach



Traffic Profile
Destination: 10.1.203.210
#Flows: …
#Bytes: … MB

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- Record "normal" traffic at routers; identify anomalies
- Exchange suspicions among routers to reinforce anomaly detection

Basic Approach

1. Record “normal” traffic at routers
2. Detect “abnormalities” in traffic

Challenges

a. What is normal and what is abnormal?

b. Is it robust?

c. How quickly can we identify deviations?

d. Can it really be implemented on a backbone router?

e. Response strategy?

Proposed Solution

Maintain Traffic Profiles

- Each router constructs *profiles* of traffic
  - Longer time-windows → *normal* traffic
  - Smaller time-windows → *current* traffic
- Become suspicious if current profile violates normal profile

Important Challenges

1. Day-of-week and Time-of-day effects
    - Maintain per-day per-daytime statistics
2. Flash crowds
    - Example of “harmless” but infrequent event
        - Attack-volume alone is not a sufficient indicator
    - “Fingerprint” the destination-bound traffic
        - Number of sources, source-subnets, flows, distribution of flow lengths, etc.

Traffic Fingerprints

Some examples

- Total traffic to destination
- Source subnet characterization
  - Total number of "flows" to a destination
  - How many /24 subnets are observed in the traffic to this destination
- Flow-length distribution
  - E.g., are there a lot of small flows?

Stream Sampling

- Memory/computation constraints at routers
  - Keep statistics about every destination?
    - Only for popular ones → traffic to whom exceeds a fraction θ of link capacity
    - Use **sample-and-hold** or **multistage filters** [Estan01]
  - Count unique subnets in a packet stream
    - Memory = Ω(size of stream)!
    - Use F_0 computation algorithms [Alon96, Gibbons01]
    - Do it in much smaller (constant!!) space and time

Proposed Solution
Increasing Robustness

- Single router has only local view → can make mistakes
  - Traffic perturbations due to traffic engineering
    - False alarms!
  - Suppose attacker "mimics" normal traffic at a router
    - Attack goes undetected!
- Mimicking at more than a few routers within an ISP would be hard!
- Use router consensus for reinforcing suspicions across routers

Preliminary Results

Single Router Detection Accuracy

Experimental Setup

- Abilene-II traffic trace (70 minutes)
  - Samples taken across a window of about 1 minute
- Synthetic attack traffic (trinoo, TFN, TFN2k, etc.)

Attack Detection Accuracy

- False positive rates ≤ 6%, lower for "unpopular" destinations
- False negative rates decrease rapidly as the "rate" of attack traffic increases

Conclusions and Future Work

- Conclusions
  - Fingerprinting traffic allows for detection of subtle attack patterns not apparent from volume alone
  - Distributed detection makes it harder for an attacker to mimic traffic at multiple routers
- Directions for future work
  - Identify various attack scenarios
  - Optimize computation/space requirements
  - Consensus algorithm; convergence and effectiveness
  - Validate over real attack datasets

Backup Slide

Overheads

Counting unique items in a stream (zeroeth moment F_0)

Algorithms	AMS96	GT01
Accuracy	$1+\varepsilon, \varepsilon > 1$	$1 \pm \varepsilon, \varepsilon > 0$
Memory (bytes)	4	$36/\varepsilon^2$
Byte operations	~4	~6

- Use $\varepsilon = 0.1$ → memory ~ 3600 bytes *per destination*
- Approximate number of popular destinations = $1/\theta$ where θ is the fraction of link capacity
- 360 KB per statistic – if we use $\theta = 1\%$
- Can a high-end router have a few MBs of SRAM?