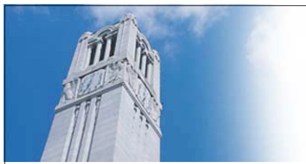


NC STATE UNIVERSITY Computer Science

CSC 474/574
Information Systems Security

Topic 4.2: IP Trace Back

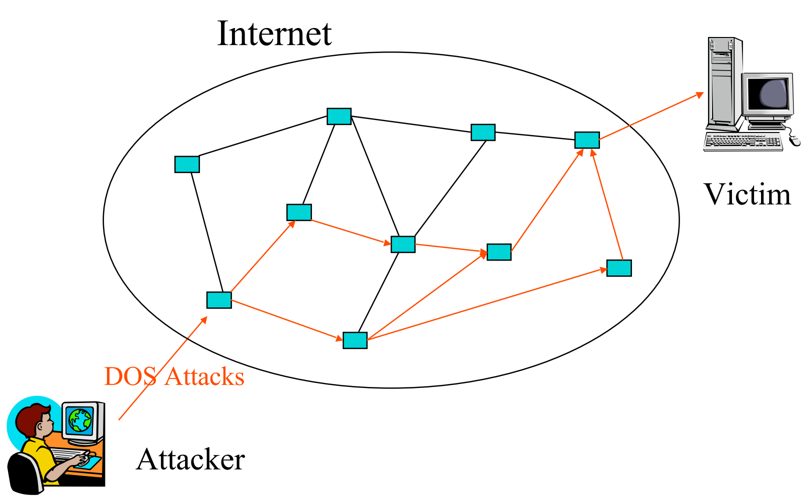
Trace Back Overview

- Why do we need trace back?
  - Stop the attacker at the source
  - Hold the attacker accountable

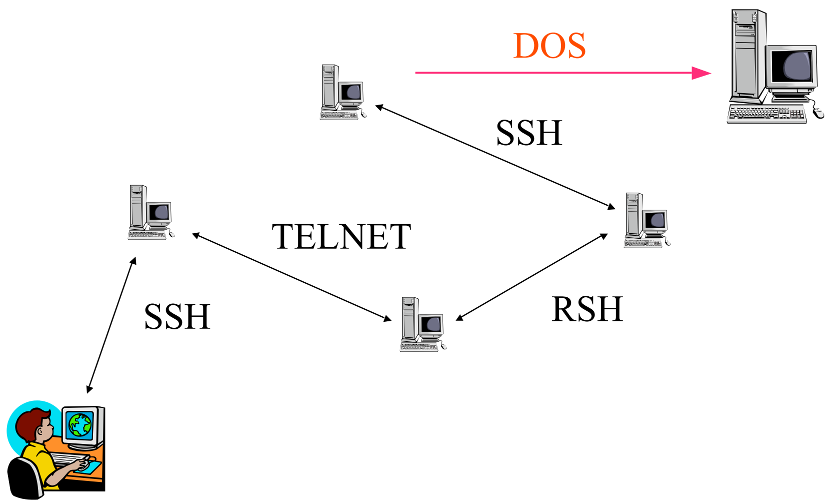
Trace Back Overview (Cont'd)

- Classification
  - – IP trace back
    - IP layer
  - – Trace back through stepping stones
    - Transport/application layer

IP Trace Back

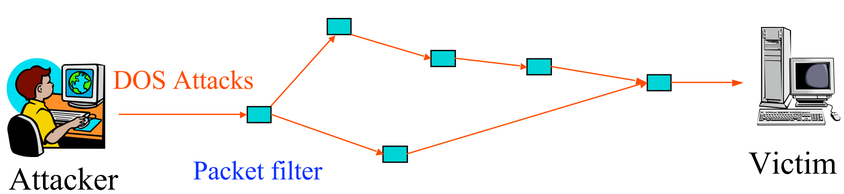


Trace Back through Stepping Stones



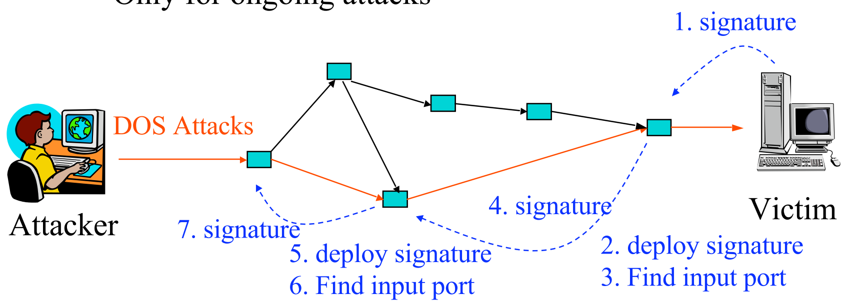
Approaches for IP Traceback

- Ingress filtering
  - Block the packets with illegitimate source addresses
  - Has to examine every packet
  - The router must have sufficient knowledge
    - Not feasible for traffic aggregated from multiple ISPs
  - Requires widespread deployment.
  - DOS attacks are still possible with a customer network.



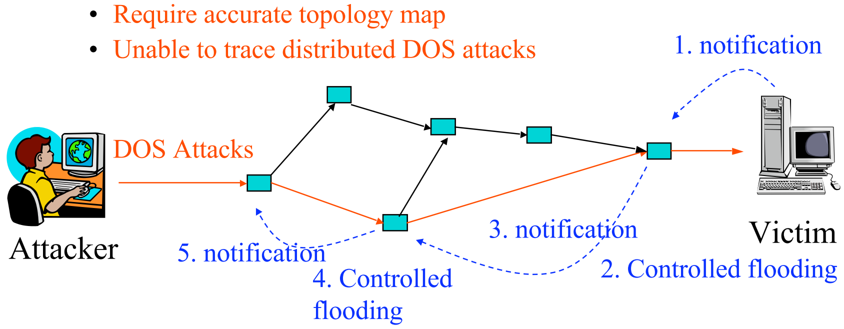
Approaches for IP Track Back (Cont'd)

- Link Testing
  - Input debugging
    - Considerable management overhead
    - Only for ongoing attacks



Approaches for IP Trace Back (Cont'd)

- Link Testing
  - Controlled flooding
    - Upstream router iteratively floods each in coming link
    - Observe change received from the attacker
    - It is a DOS attack itself
    - Require accurate topology map
    - Unable to trace distributed DOS attacks



Approaches for IP Trace Back (Cont'd)

- Logging
  - Log packets at key routers
  - Use data mining techniques to determine the attack path
  - Only work after the attack
  - Storage requirement
  - Database integration problem

Approaches for IP Trace Back (Cont'd)

- ICMP trace back
  - Every router sample with low probability the forwarded packet.
  - Send selected information to the source or the destination in an ICMP traceback message.
    - Forward or backward link
  - Victim reconstructs the attack path using the above information
  - May be filtered out.
  - Requires authentication, and thus key distribution.

Approaches for IP Trace Back (Cont'd)

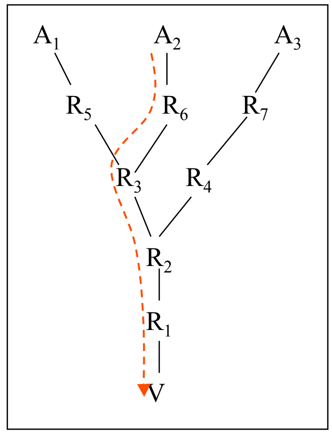
- Probabilistic packet marking
  - Probabilistically mark the packets with the routers' addresses
  - Reconstruct the attack path using these addresses
- Potential advantages
  - No interactive cooperation □ little management overhead
  - No significant additional network traffic
  - Can be used both during and after attacks
  - Low overhead on routers.

Probabilistic Packet Marking

- Our discussion is limited to
  - "Practical Network Support for IP Traceback" by Stefan Savage, et al.

Probabilistic Packet Marking (Cont'd)

- Attack path from A_i
  - The unique ordered list of routers between A_i and V
- The problem
  - Exact traceback
    - Difficult, since the attacker may send false information.
  - Approximate traceback
    - Find the attack path that contains the true attack path as a suffix
  - Marking procedure
  - Reconstruction procedure
  - Convergence time



Assumptions

- An attacker may generate any packet
- Multiple attackers may conspire
- Attackers may be aware they are being traced
- Packets may be lost or reordered
- Attackers send numerous packets
- The route between attacker and victim is fairly stable
- Routers are both CPU and memory limited
- Routers are not widely compromised

Marking Algorithm (1)

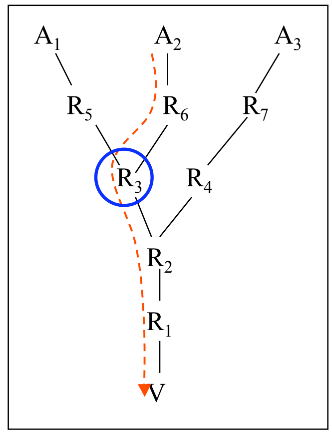
- Node Append
  - At each router *R*
    - For each packet *w*, append *R* to *w*
  - At victim *v*
    - For any packet w from attacker
      - Extract path ($R_i \ldots R_j$) from the suffix of *w*
- Problems
  - High router overhead
  - Unbounded space requirement in the packets
    - Any reserved space may be filled up by the attacker.

Marking Algorithm (2)

- Node Sampling
  - Reserve one *node* field in the packet header
  - At each router *R*
    - For each packet *w*, write *R* into *w.node* with probability *p*
  - At victim *v*
    - The order of the routers is not preserved in the order of received packets.
    - How to construct an ordered path?

Node Sampling (Cont'd)

- Assume all routers mark their addresses with equal probability *p*.
- What's the probability that *v* receives a packet marked by a router *d* hops away?
  - ____________
- Observation:
  - The farther away *R* is, the less chance *v* receives packets marked by *R*.



Node Sampling (Cont'd)

- Reconstruction procedure at victim v
  - Count the number of packets marked by each router
  - Sort the routers by this count in increasing order
  - The ordered router list □ attack path.
- Limitations
  - Slow convergence
    - d =15 and p=0.51 □ need 42,000 packets
  - Cannot deal with multiple attackers

Marking Algorithm (3)

- Edge Sampling
  - Idea: put *edge* instead of *node* into the packets
  - Reserve *start*, *end*, and *distance* fields in packet header
    - (start, end): the marked edge (link)
    - distance: the distance from start to the victim

Edge Sampling (Cont'd)

- At each router *R*
  - For each packet *w*
    - With probability *p*, write *R* into *w.start* and 0 into *w.distance*
    - If *R* doesn't write *w.start*
      - If *w.distance* = 0 (i.e., the previous router just marked start), write *R* into *w.end*
      - Increment *w.distance*

Edge Sampling (Cont'd)

- At victim *v*
  - Let G be a tree with root *v*
  - Let edges in G be tuples (start, end, distance)
  - For each packet *w* from attacker
    - If *w.distance* = 0 then
      - Insert (*w.start, v,* 0) into G
    - Else
      - Insert edge (*w.start, w.end, w.distance*) into G
  - Remove edges (*x, y, d*) with d ≠ distance from *x* to *v* in G
    - Remove inconsistent edges.
  - Extract path (R_i, …, R_j) by listing acyclic paths in G.

Edge Sampling (Cont'd)

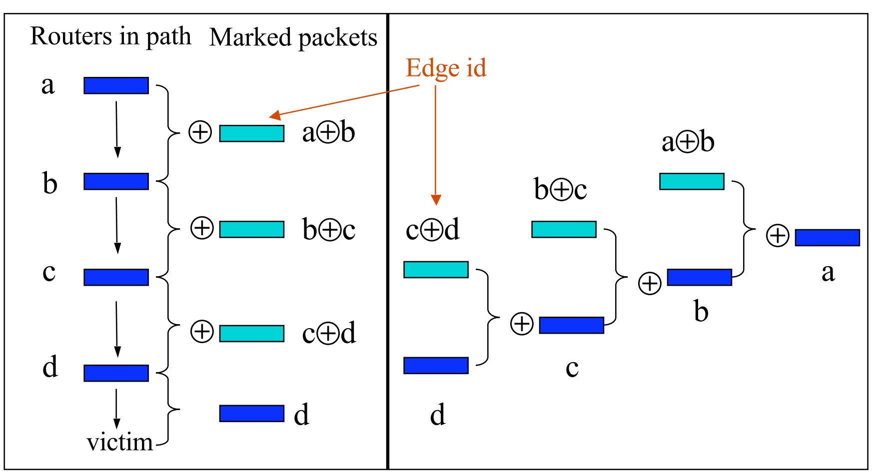
- effectiveness
  - Can discern multiple attackers
  - Robust: impossible for any edge closer than the closest attacker to be spoofed
  - Number of packets needed to reconstruct all paths is linear in the number of attackers.
- Limitations
  - Require additional space in IP packet header
  - Two 32 bit IP addresses + 8 bit distance 72 bits

Encoding

- Problem:
  - Where to save the edge samples?
- Idea
  - compress the edge sample and store it in the identification field (16 bits for fragmentation)
- Three techniques

Encoding (Cont'd)

- Technique 1: Send XOR of the two nodes of an edge.

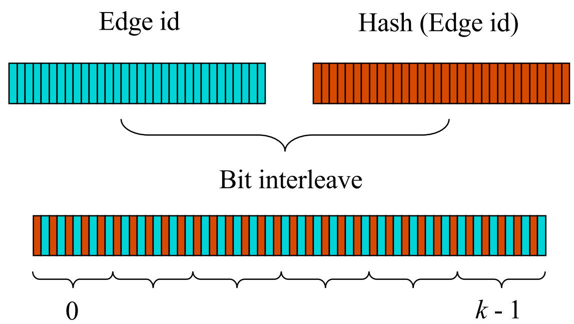


Encoding (Cont'd)

- Technique 2: reduce per-packet space requirement by splitting each edge-id into *k* fragments.
  - Each fragment is associated with $32/k$ bit data + log_2k bit offset
  - Reconstruct fragments with the same distance
    - Doesn't work if there are multiple attack paths.

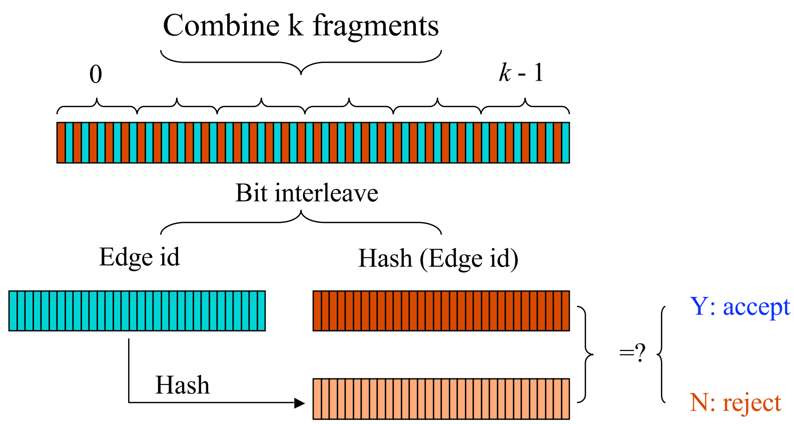
Encoding (Cont'd)

- Technique 3: Interleaving edge-id and its hash and then fragment



Encoding (Cont'd)

- Techniques 3 (Cont'd): reconstruction



Further Reading

- Dawn Song, Adrian Perrig: Advanced and Authenticatd Marking Schemes for IP Traceback, IEEE Infocom 2001
- Heejo Lee, Kihong Park: On the Effectiveness of Probabilistic Packet Marking for IP Traceback under Denial of Service Attack. INFOCOM 2001: 338-347
- Tao Peng, Christopher Leckie, Kotagiri Ramamohanarao: Adjusted Probabilistic Packet Marking for IP Traceback. NETWORKING 2002: 697-708
- Micah Adler: Tradeoffs in probabilistic packet marking for IP traceback. STOC 2002: 407-418
- Michael T. Goodrich: Efficient packet marking for large-scale IP traceback, ACM CCS 2002.