Overlay-based Active Monitoring and Security

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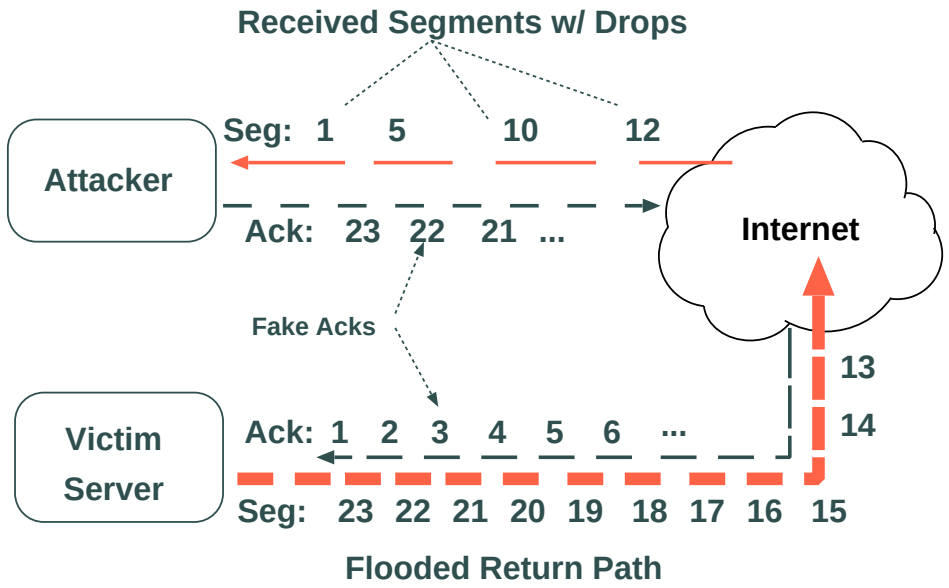
A minor aside

- The *Schnell* attack on TCP

  with Rob Sherwood



- Attack network core by causing well-provisioned servers to send

  lots of traffic (GBs) into the core

  by sending fake TCP ACKs

Is this feasible?

- The ACK estimating etc. has been implemented

  real attack: 128 Kbps user causes server to send 32 Mbps.

- Good news: there is an elegant fix (See TR)

- Bad news: There are probably other Schnells . . .

  . . . and of course all other well known attacks

- Lot of fixes require Internet-wide deployment of new functionality

Not clear if this is feasible or practical, in the short or the long term

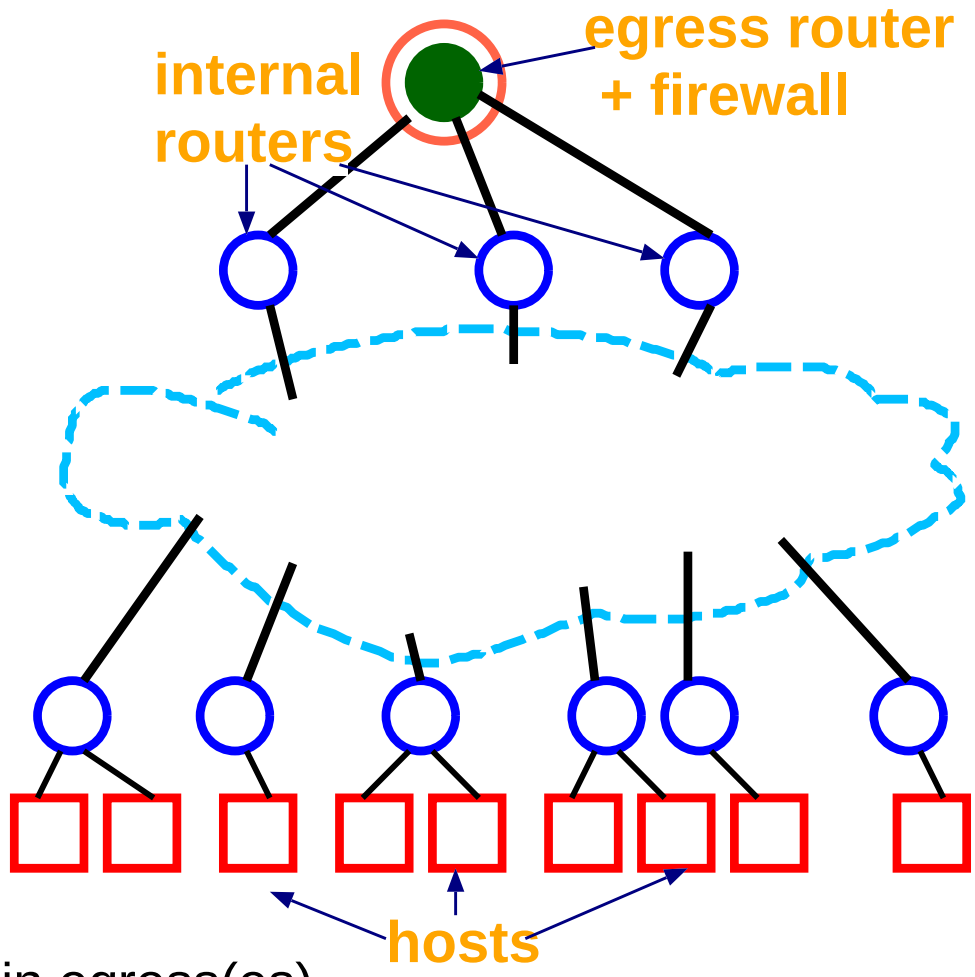
Inter-domain Monitoring and Security using an Overlay

- Monitor and stop attacks at the *source* of the attack

  source $\equiv$ first domain not entirely controlled by attacker

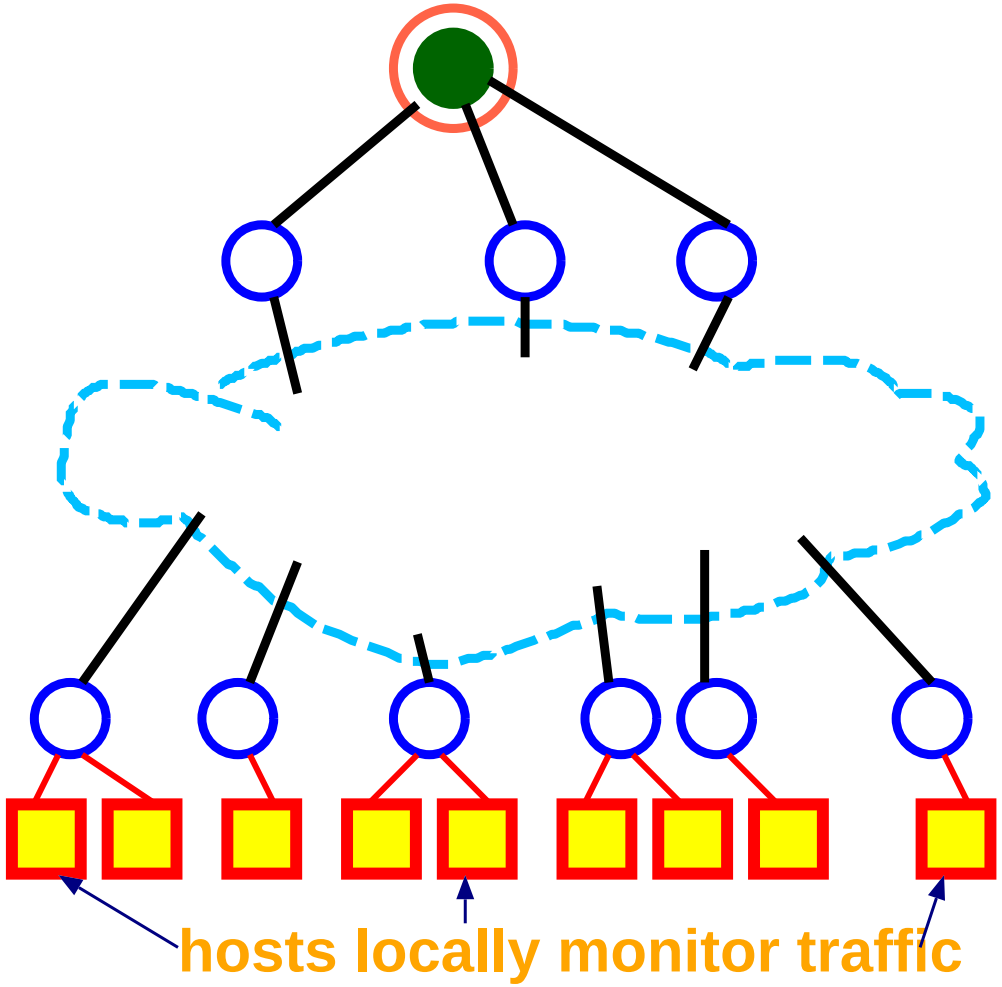
- Most efficient solution — attacks are stopped before they can do much damage
- Does not require Internet-wide deployment
- Shares the cost of attack monitoring and prevention

Approaches



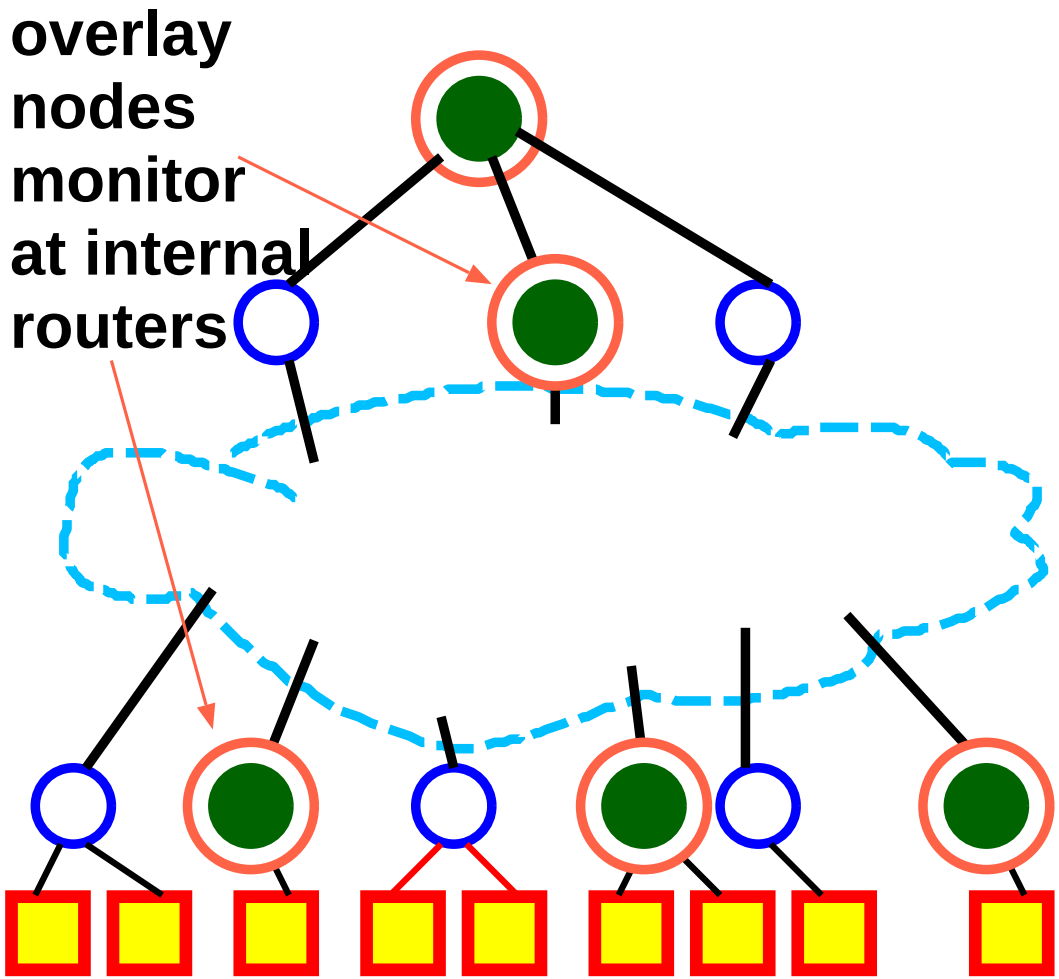
- Firewall at the domain egress(es)

Approaches



- Monitor at each host

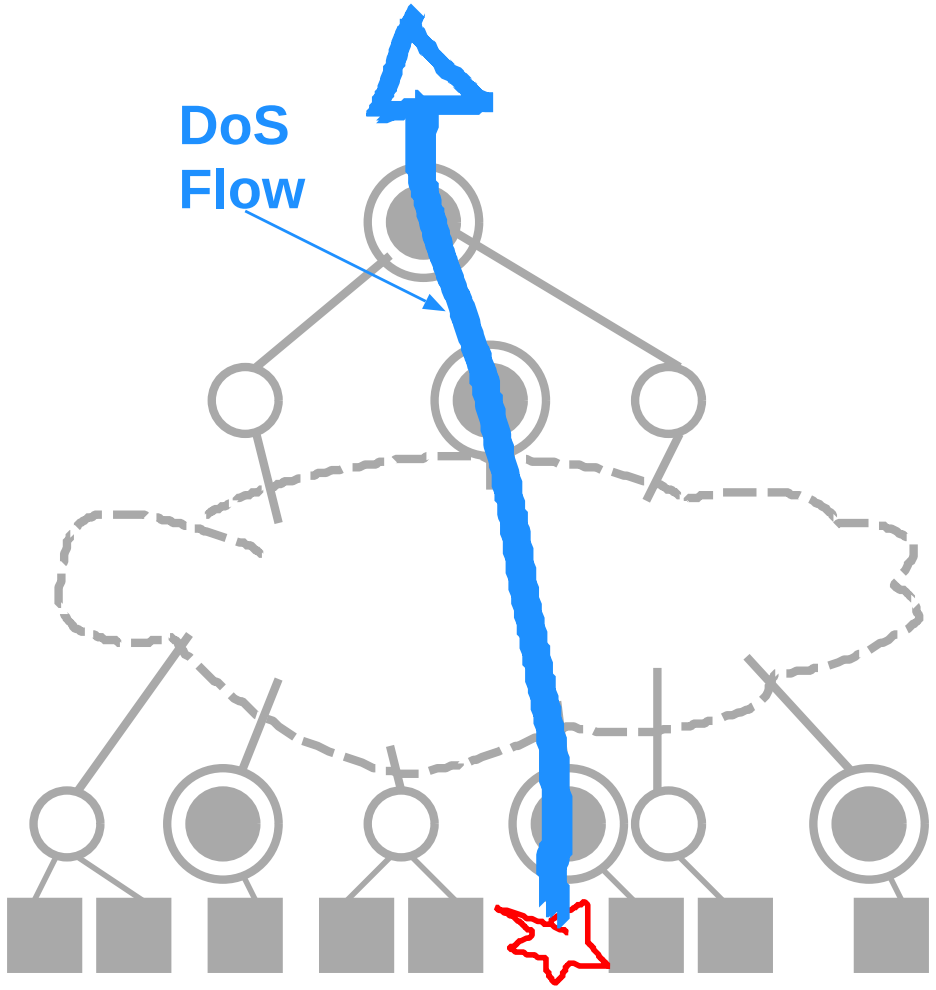
Approaches



- Overlay-based

Solution components — new ideas

- Coordinate and Correlate information between nodes



- Local Oracle

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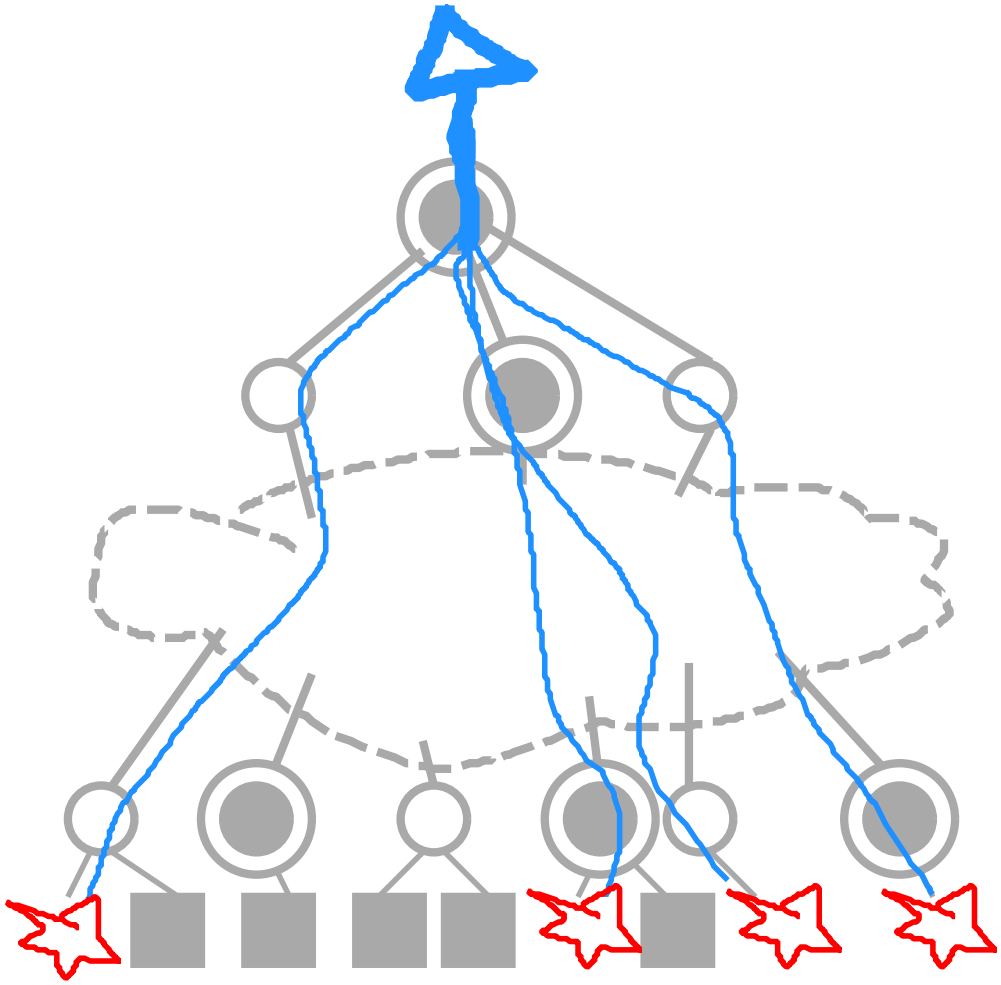


- Local Oracle

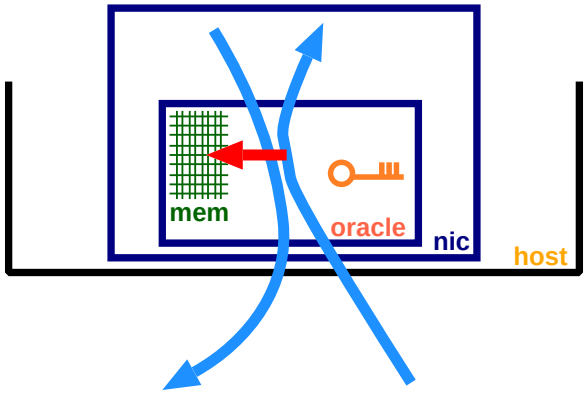
Local Oracle (Hardware)

- Pass-through processor on NIC with a physically secure key $\mathcal{K}$

  Cannot be controlled via host software

- Passive monitor of all network traffic

  Logs (compressed) all traffic [headers+snippet]



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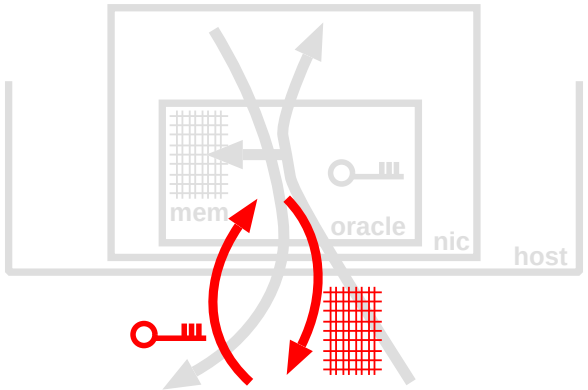
  Log requires 1 MBytes storage per minute of data (avg.)

  worst case 1 order of magnitude worse.



- Log dumped to sender when packet with $\mathcal{K}$ intercepted

  Consider adding rudimentary filtering instead of log dump?

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Attackers (can) know of the oracle, but cannot modify its operation

What can such a system do . . . ?

- Detect different attacks — DoS, malicious packets
  - More capable than single node systems
  - Aggregation of local information towards root $\longrightarrow$ correlation
  - Adaptively locate problems towards leaves $\longrightarrow$ refinement
- Complete single packet traceback (using local oracle)

  does not require global deployment

So, is distributed monitoring really *necessary?*

- Consider current hardware

  OK, say *only* 1 Tbps access link [$\sim$1 ns/avg.packet]

  Even Gbps links must be serviced in 320 ns

  SDRAM acces times [10 ns*]; expensive

  L1 caches [$<$1ns access]; prohibitively expensive

- Implications:

  Extremely limited per packet processing

  Infeasible to keep per flow state

  Incomplete information [sampling]

So, is distributed monitoring really *necessary?*

Answer: Yes.

Multi-node solutions provide exponential benefi t

Example: Detection of a single DoS flow

- Assume binary tree topology, one op. per packet [worst case for multi-node]
- Assume N flows, mapped to k bins

  Single node, in one round

  reduces # of suspected nodes to N/k
- Suppose, instead, we have t overlay nodes (anywhere on path)

  Worst case, in one round + 1 prop. delay

  # suspected flows reduced to $\frac{N}{2^t k^t}$

  Overhead: 1 bit/packet inline, or O(t) extra comm.

Example: Detection of a single DoS flow

- Assume 100K flows, 1024 bins

  Single node, in one round

  # of suspected flows — 100

- With overlay monitoring, suppose 1M flows and only 100 bins per node

# monitors:	2	3
# suspected flows:	244	<1

- With 1000 bins per node, 3 nodes can detect 1 in 8 billion flows in 1 round of detection + communication

Summary: General Approach

- Overlay Communication infrastructure — provides general primitives such as multicast, naming

  useful beyond monitoring/security

- Specific statistical tests implemented in a distributed manner using comm. primitives over input data

  primarily borrow from existing literature

- Input data locally generated for specific tests/attacks

  defined by environment, node capabilities, range of attacks

Current work and Future Directions

- Tests for various types of DoS attacks, and also a traceback mechanism

- Ideally, we'd like to BUILD the local oracle hardware
- Extend current work to handle multiple egresses
- Fully develop general approach with multiple examples of tests and distributed statistical computations
- Develop more tests — possibly extending into virus detection