SIP Intrusion Detection and Prevention: Recommendations and Prototype

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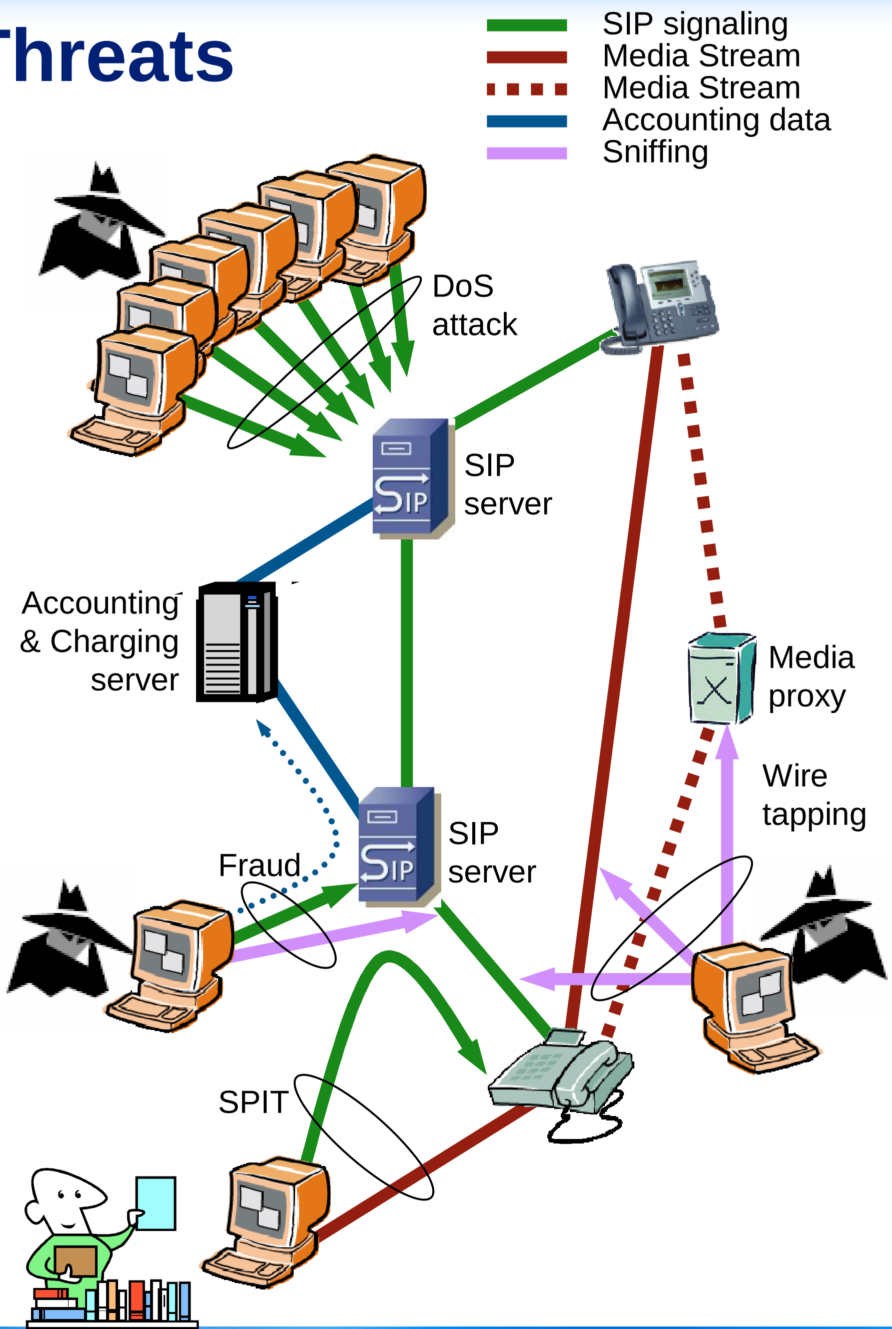
Security Threats

- **VoIP protocols (like SIP) are vulnerable to many attacks**
  - Interruption of Service attacks (Denial of Service, DoS)
    - attacks against infrastructures and terminals
  - Social attacks (SPam over Internet Telephony, SPIT)
    - disturbances and interruptions of work by ringing phone for unsolicited calls
  - Fraud
    - placing calls on other customer’s bills, etc.
  - Interception (wire tapping) and Modification of calls
    - conversations may be intercepted (lack of confidentiality)
    - conversations may be modified (lack of integrity)
- see VOIPSA taxonomy



Security Threats: available solutions?

- **Standard security mechanisms**
  - See talk of this morning by Cullen Jennings
- **Intrusion Detection and Prevention systems (IDS/IPS) needed on top of such standards**
  - to better secure the deployment
    - block the attackers bypassing security mechanisms
  - should control both signaling and media path
    - correlation needed among the two paths
      - media communication can be routed independently of the call setup path
  - three common types of IDS systems
    - host-based
    - network-based
    - stack-based
  - IPS systems can take immediate action
  - techniques
    - signatures (knowledge-based)
    - statistical observation (behavior-based)

VoIP Intrusion detection and prevention

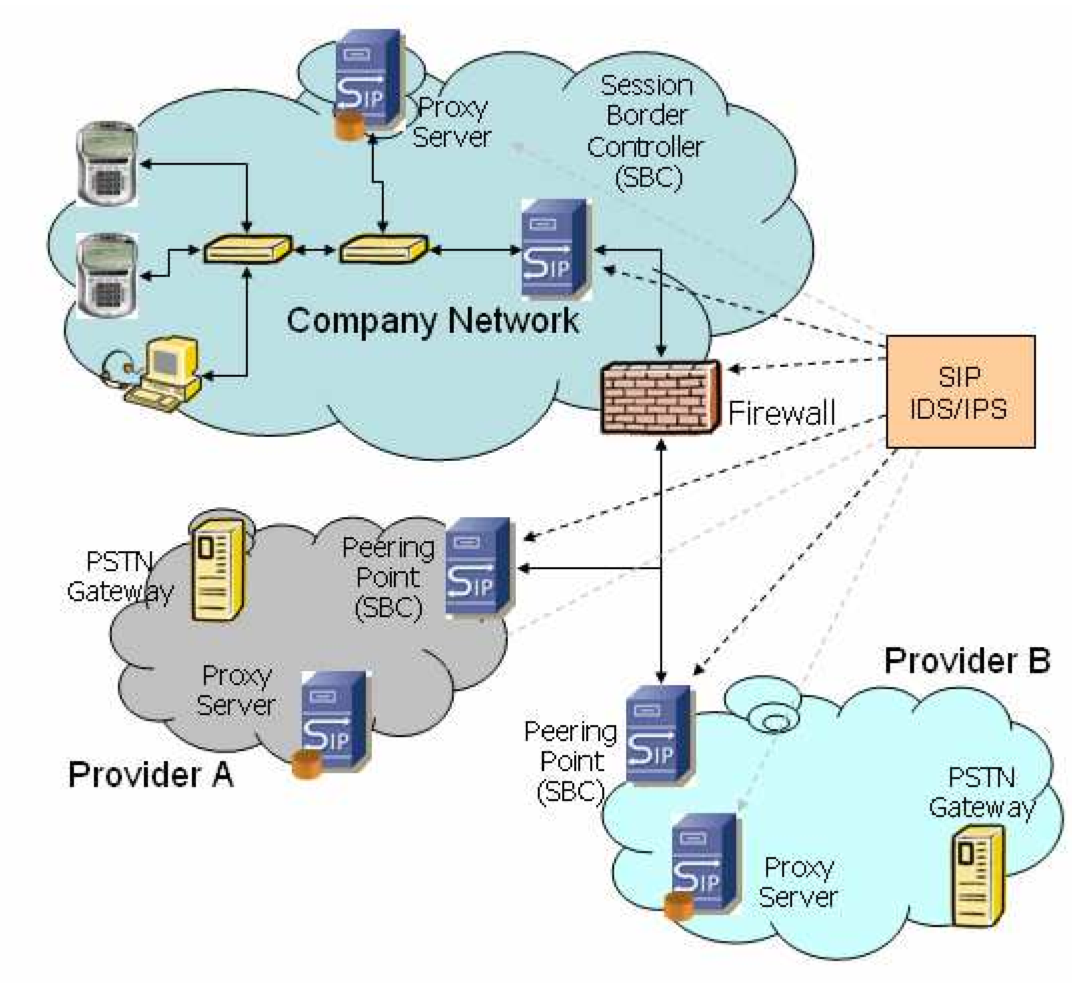
- **Attacks to traditional server oriented applications**
  - **the security target is only the server**
    - **e.g. HTTP, FTP, E-MAIL**
- **VoIP deployments have different characteristics**
  - **a much higher number of systems to be protected**
    - **VoIP servers, e.g. Proxies and Gateways**
    - **terminals**
  - **stricter requirements in terms of security checks**
    - **no need of sending high rates of messages**
    - **few messages are able to cause crashes or reboots**

Which IDS/IPS for VoIP?

- Network-based IDS
  - good matching of requirements
- Host-based/Stack-based
  - not scalable (unless you want to protect only some servers)
- Techniques
  - knowledge-based first
    - blocking malicious traffic
  - behavior-based second
    - statistical analysis
- Knowledge-based techniques share info with behavior-based
  - writing info in a shared memory area
    - IP addresses
    - SIP URIs
    - Ports
    - Message rate
  - increase in scalability (message known to be malicious are already filtered out)
  - decrease in false positives

Network-based IDS

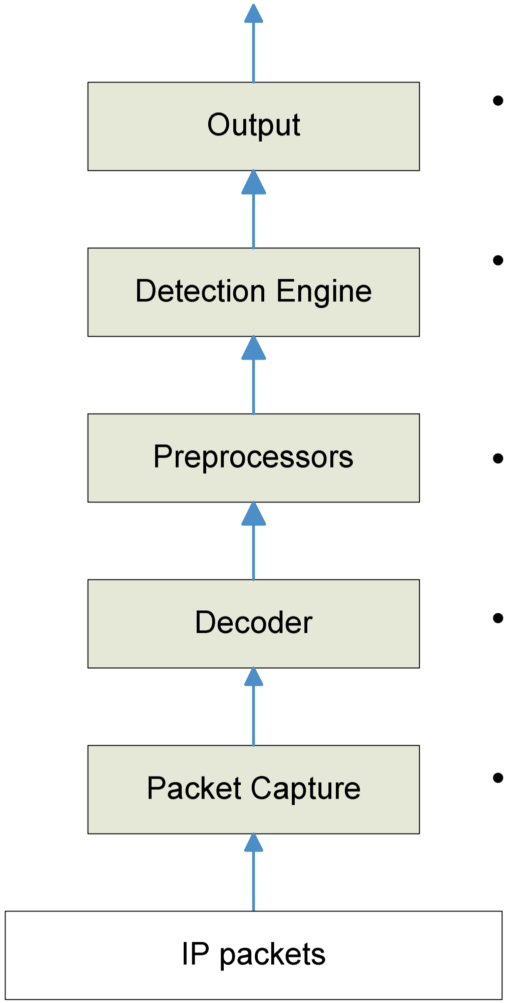
- **Must be implemented in devices able to observe the traffic to be analyzed**
  - **the entry point of the SIP network is the most suited point**
- **SIP devices**
  - **SIP-aware firewall**
  - **Peering points**
    - **Session Border Controllers (SBCs)**
      - **B2BUA in SIP**
    - **SIP gateways**



SIP IDS/IPS prototype

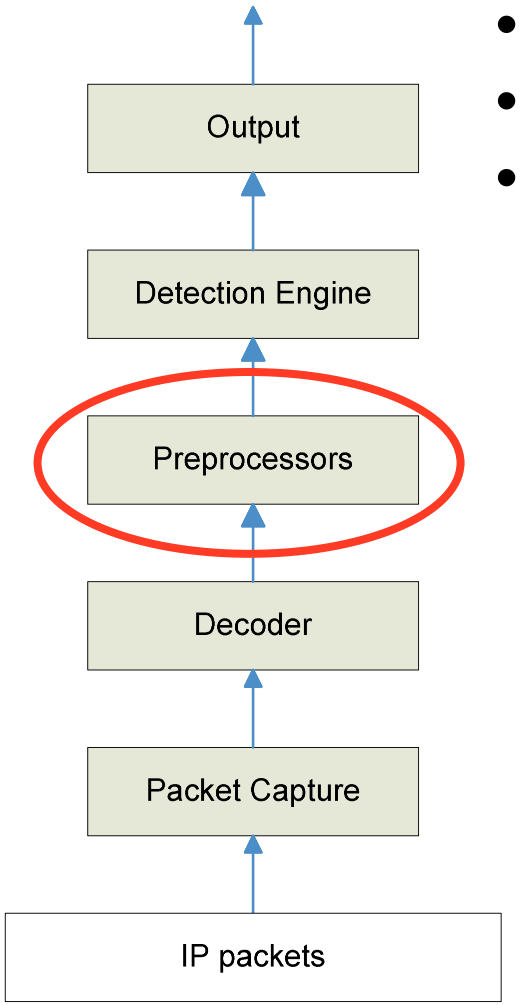
- **We used Snort_Inline framework**
- **Snort is capable of performing real-time traffic analysis and packet logging**
  - **acts only as IDS (can only detect. not block packets)**
  - **it perform protocol analysis and content searching/matching**
- **Using Snort_Inline as IPS**
  - **modification and blocking of packets (accepts packets from IPTABLES using the ip_queue module)**
  - **works in bridge modality, invisible to attackers**

Snort architecture



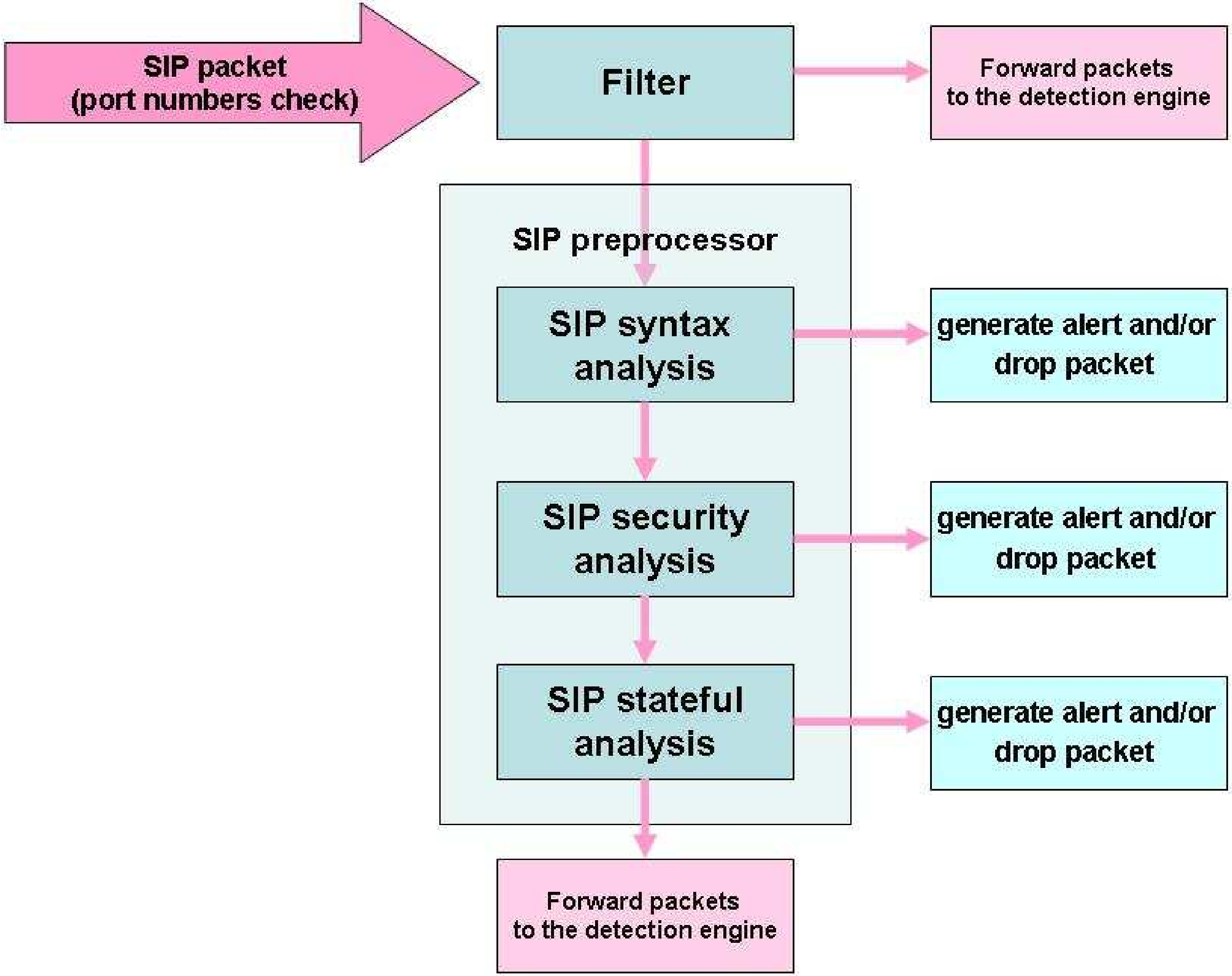
- **Output block**
  - manages the log output
  - output log is configurable (e.g. text files, databases or user-defined)
- **Detection Engine block**
  - analysis of protocols of any layer using signatures and rules
  - stateless mode
  - rule sets defined before start time
- **Preprocessors block**
  - analysis of protocols of any layer using custom made C/C++ programs
  - stateful mode
- **Decoder block**
  - syntax analysis at layer 2, 3 and 4 of the IP packet (MAC, IP and TCP/UDP)
  - Layer 2, 3 and 4 headers are inserted in a shared portion of memory
- **Packet Capture block**
  - capture the packets, it uses either libpcap or iptables depending on the Snort mode

SIP IDS/IPS prototype software (I)



- SIP preprocessor wrote from scratch
- It uses oSIP libraries
- What it does
  - SIP syntax analysis (parsing)
  - Security check
    - looks at mandatory fields in a SIP message
  - Stateful analysis (soft states are used)
    - it computes message rate and compare them to a threshold
      - by looking at SIP URIs
      - by looking at IP addresses
    - it is customizable to prevent specific DoS/SPIT attacks
  - Generation of logs of suspicious packets in a tcpdump format
    - can be later analyzed using Ethereal
    - can be exported to correlate with media analysis

SIP IDS/IPS prototype software (II)



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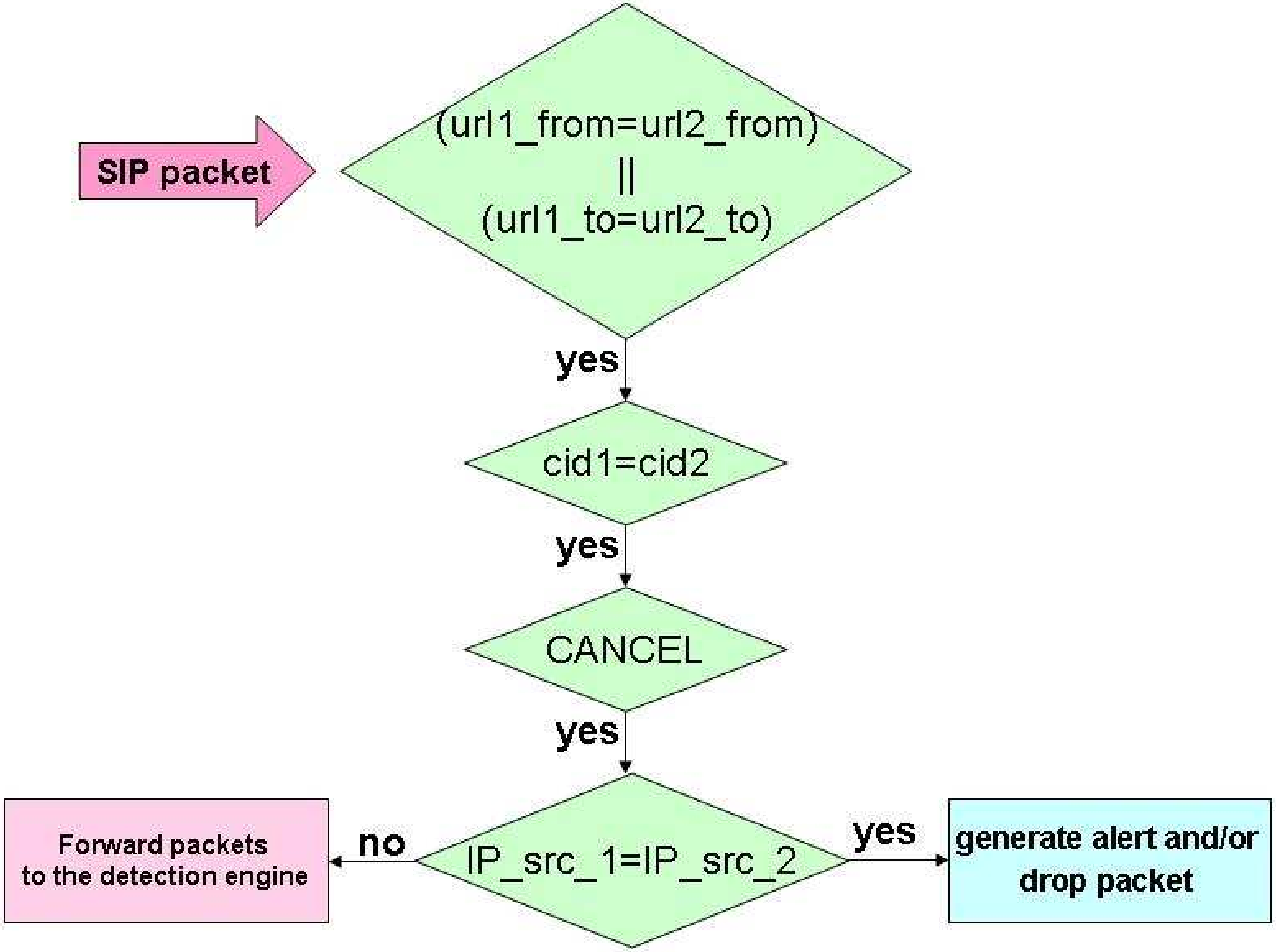
Examples of additional features implemented

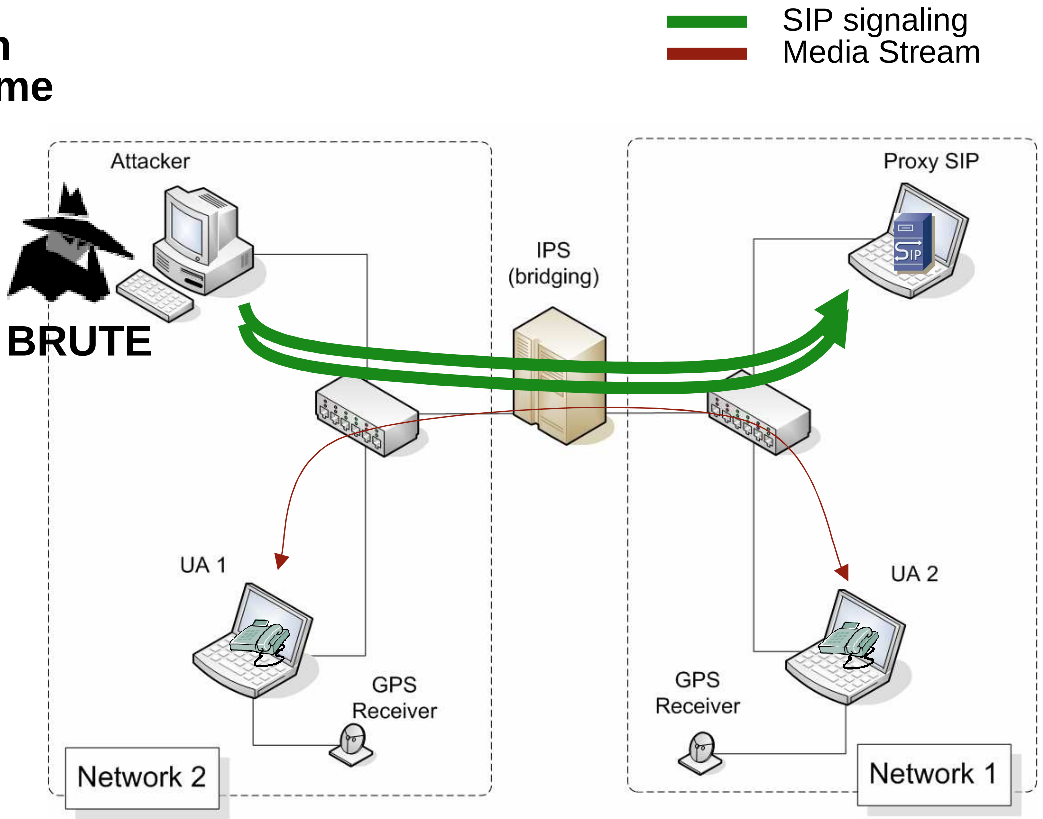
- **Blocking SPIT attacks**
  - checking the INVITE rate
    - of a SIP URI
    - of a source IP address
      - configurable thresholds if UA or Proxy Server
- **Blocking DoS attacks**
  - checking total SIP message rate
    - of a SIP caller
    - of a source IP address
      - configurable thresholds if UA or Proxy Server
- **Blocking Call Tear-Down attacks**
  - checking that CANCEL/BYE comes from one of the parties involved in the call
    - looking at IP addresses
  - this attack can be done only spoofing To; From; Call-ID fields

Blocking Call Tear-Down attacks



Prototype testing

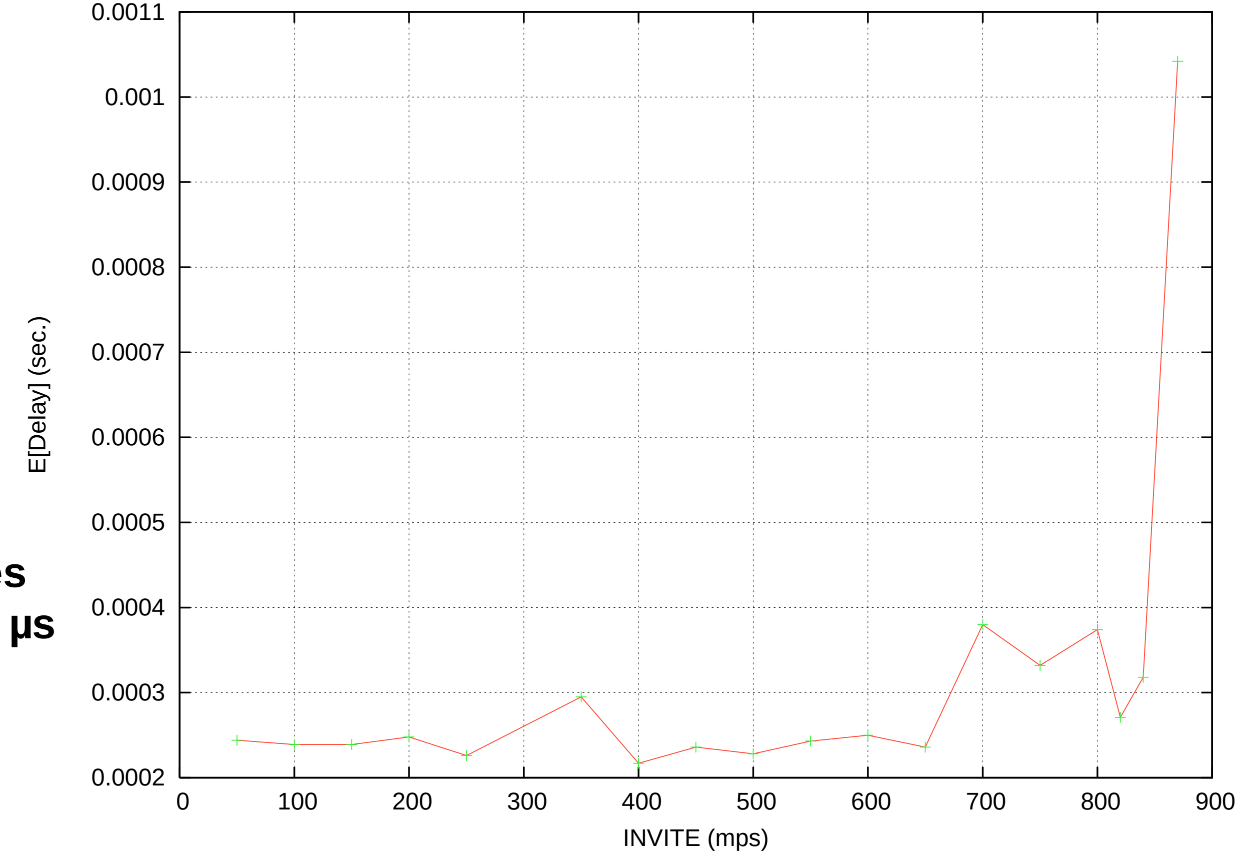
- **What happens to QoS of communications?**
  - **We stressed the IDS/IPS knowledge-based techniques generating malformed messages with different rates**
    - **wrote SIP plug-in generator for BRUTE**
      - **high performance packet generator**
      - **precise message rate**
  - **RTP media session between UA1 and UA2 at the same time**
    - **mean end-to-end delay**
    - **packet losses**
    - **mean jitter**
    - **packets with jitter > 50 ms**



- **Experimental set-up**
  - **SIP proxy (SIP Express Router, SER)**
  - **SIP UAs (Kphone)**
    - **running on Linux OS GPS-synchronized to compute One Way Delay**
  - **Attacker (BRUTE generator)**

End-to-end delay

- **Message generation rate lower than 860 mps**
  - **mean end-to-end delay introduced by IDS/IPS ok**
- **Message generation rate higher than 860 mps**
  - **ip_queue module receiving packets from the iptables becomes full**



- **Other parameters**
  - **rate < 860 mps**
    - **no packet losses**
    - **mean jitter: 180 μs**
    - **jitter > 50 ms: 10 out of 15000 packets**

Conclusions/Future work

- **Guidelines for IDS/IPS for VoIP deployments**
- **Prototype implementation on top of Snort framework**
- **SIP plug-in for high performance tool (BRUTE)**
- **Evaluation of prototype implementation**

- **Future work**
  - **hybrid solution with knowledge-based checks implemented at OS kernel level (modification to iptables)**
    - **behavior-based techniques still in user space because of the flexibility required**
  - **modeling VoIP-specific DoS attacks**
  - **modeling VoIP communications**
  - **advanced stateful analysis**
  - **statistical pattern filter**
  - **signaling/media correlation**

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