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Generating signatures for zero-day network attacks

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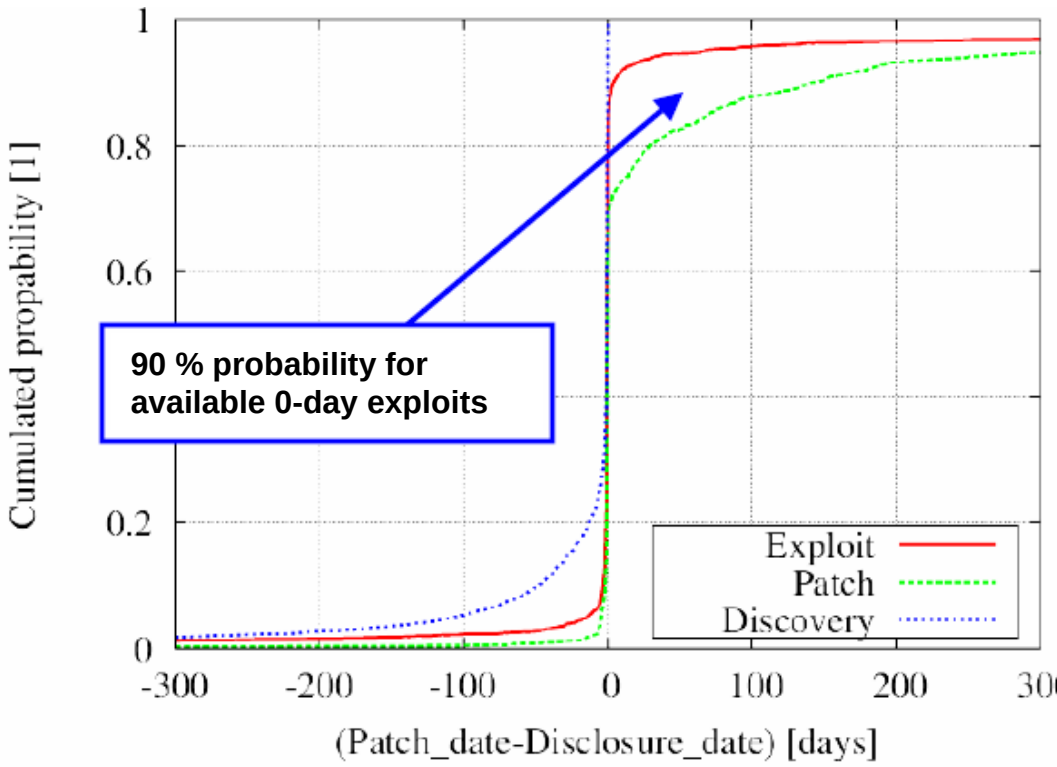
Outline

- Motivation
- Problem Statement
- Automated Signature Generation – Overview
- The NoAH approach
  - Attack Detection
  - Attack Analysis
  - Signature Generation

Motivation: The dynamics of (In)security



Y-Axis:
cumulated probability for exploit- and patch-availability dates

X-Axis:
days from disclosure-date

Data:
- 3416 exploits
- 1477 patches
- from 1996-2006

Source: “The Dynamics of (In)Security“, Stefan Frei, ETH Zurich, BlackHat 2006

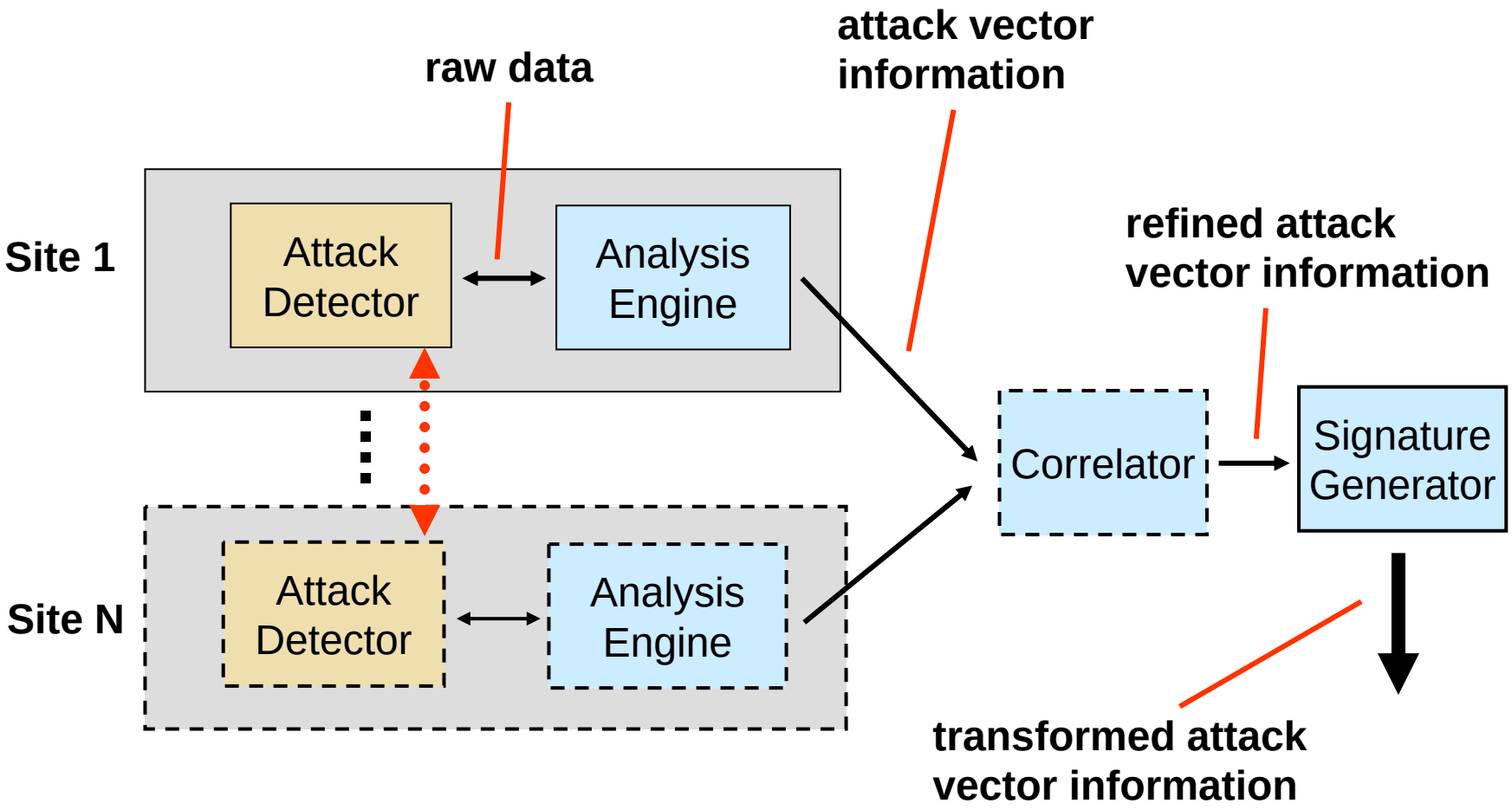
Problem Statement

- Defending against 0-day attacks: Intrusion Detection System (IDS)
  - Separate benign and malicious network traffic
  - Host- or Network-based signatures
  - Most signatures for IDS are hand-craftet by professionals
  - Zero-day exploits make manual signature generation useless
- Problem: Manual signature generation is too slow! Options?

Overview

Techniques for automated signature generation

Building Blocks of an ASG System



The NoAH Approach

EU Project NoAH (Network of Affined Honeypots)

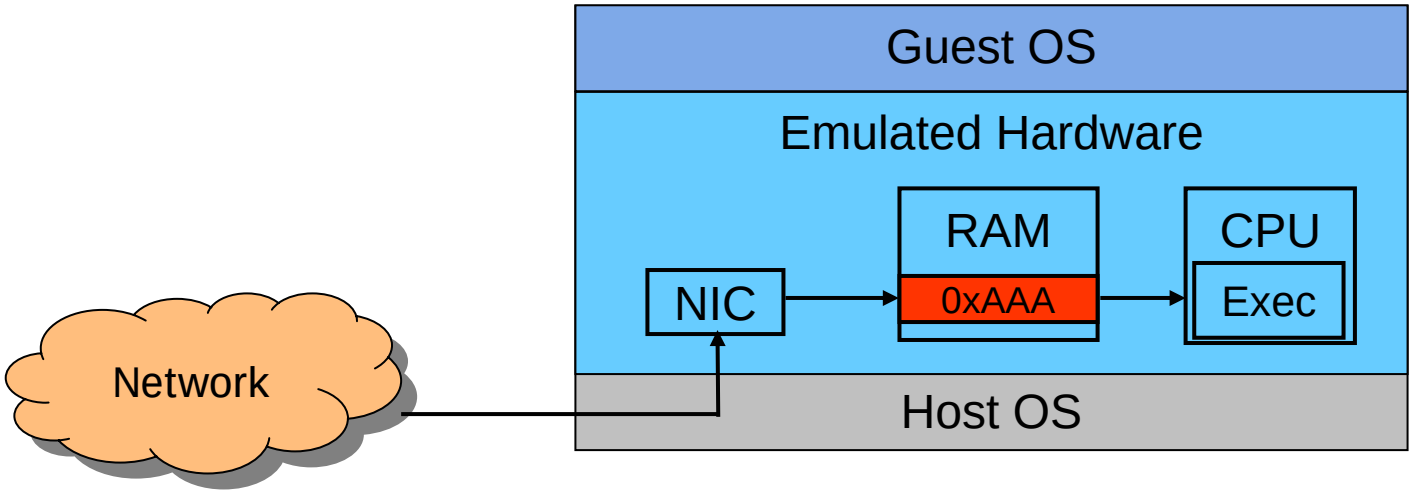
Goals

- NoAH aims at automated
  - detection of unknown attacks
  - generation of signatures to counter 0-day attacks
- Generate signatures for common IDS
- Install full-scale infrastructure across Europe
- Target audience: ISP‘s, NREN‘s, researchers

Attack Detection

NoAH Architecture: Attack Detector Argos

- Detection technique (Argos):
  - OS independent memory tainting (x86 emulator)



> Scope of NoAH: Remote attacks that do not require a human in the loop

Attack Analysis

Combining Analysis Engines

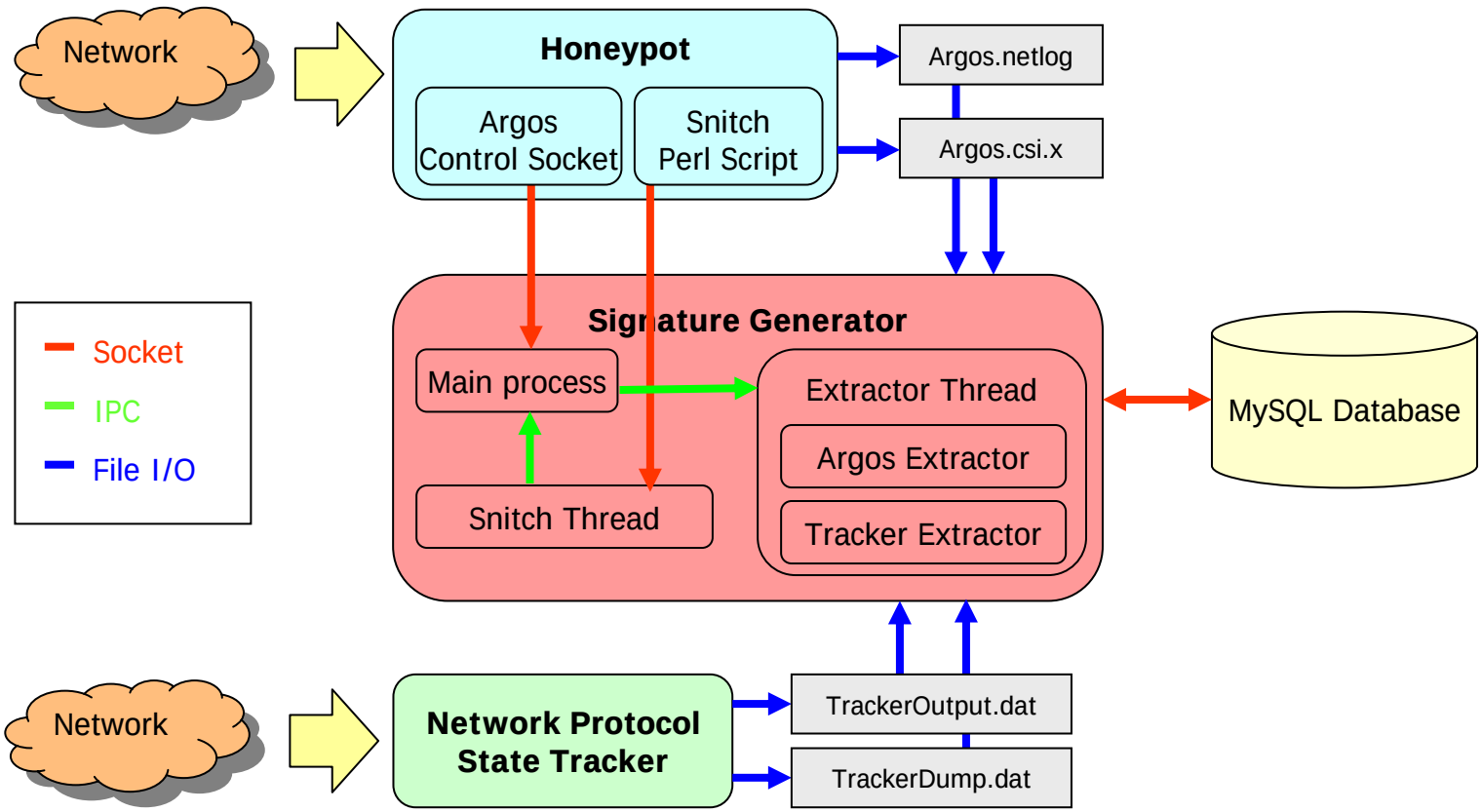
- Different analysis engines (Extractors) which
  - Analyse attack information from different sources
- Extractors can depend on each other
- Meta-signature describes entire set of available attack information
- Quality estimation of meta-signature based on
  - Which extractors succeeded
  - Value and amount of extracted information

Combining host- and network-based analysis

- Extractor #1: Host-based information from Argos
  - Identifies memory content relevant for the attack
  - Identifies OS and attacked process
  - Identifies network traffic bytes involved

- Extractor #2: Network-based information from Protocol State Tracker
  - Protocol field(s) containing network bytes involved
  - Communication/Protocol state history

Basic Architecture of the entire ASG System



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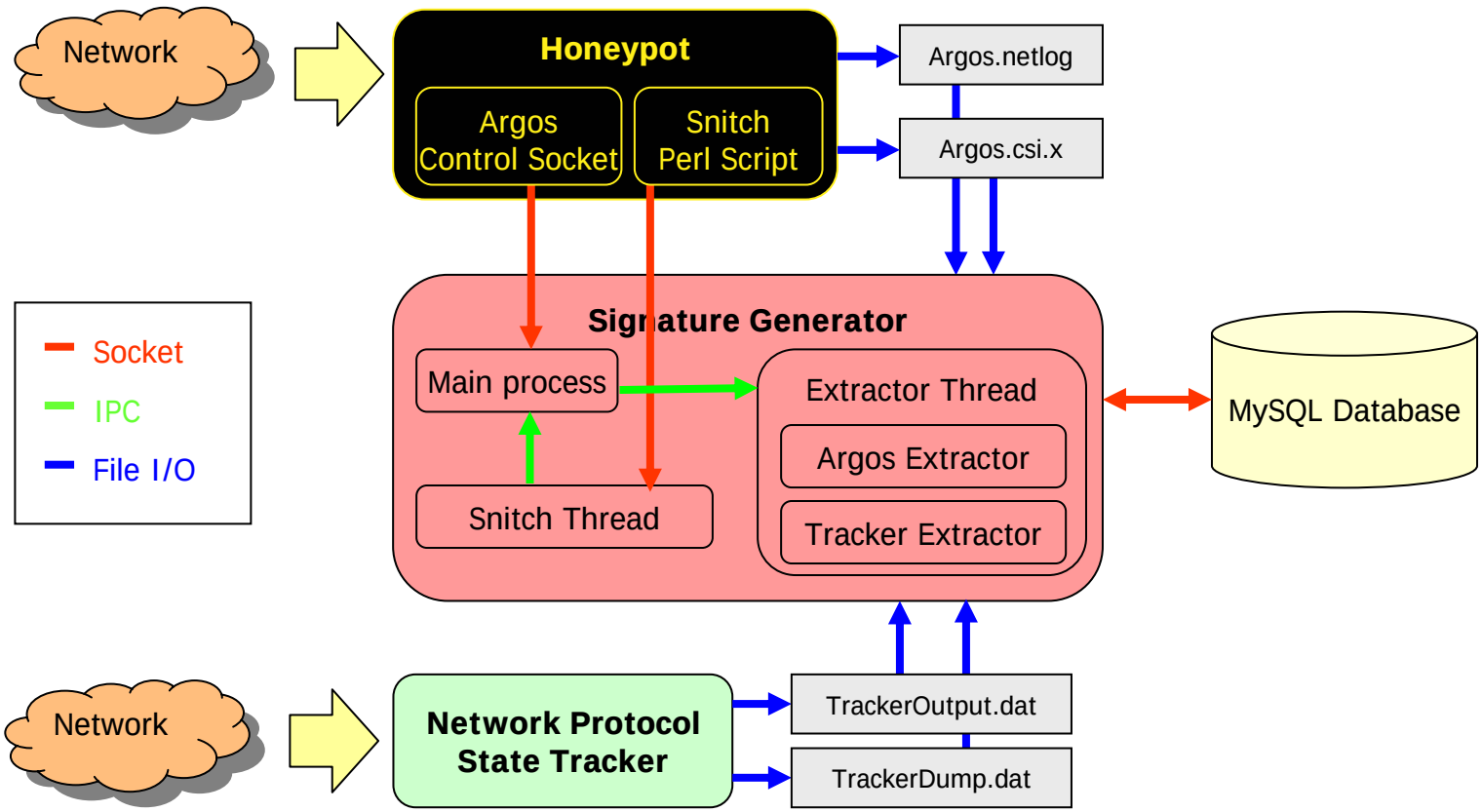

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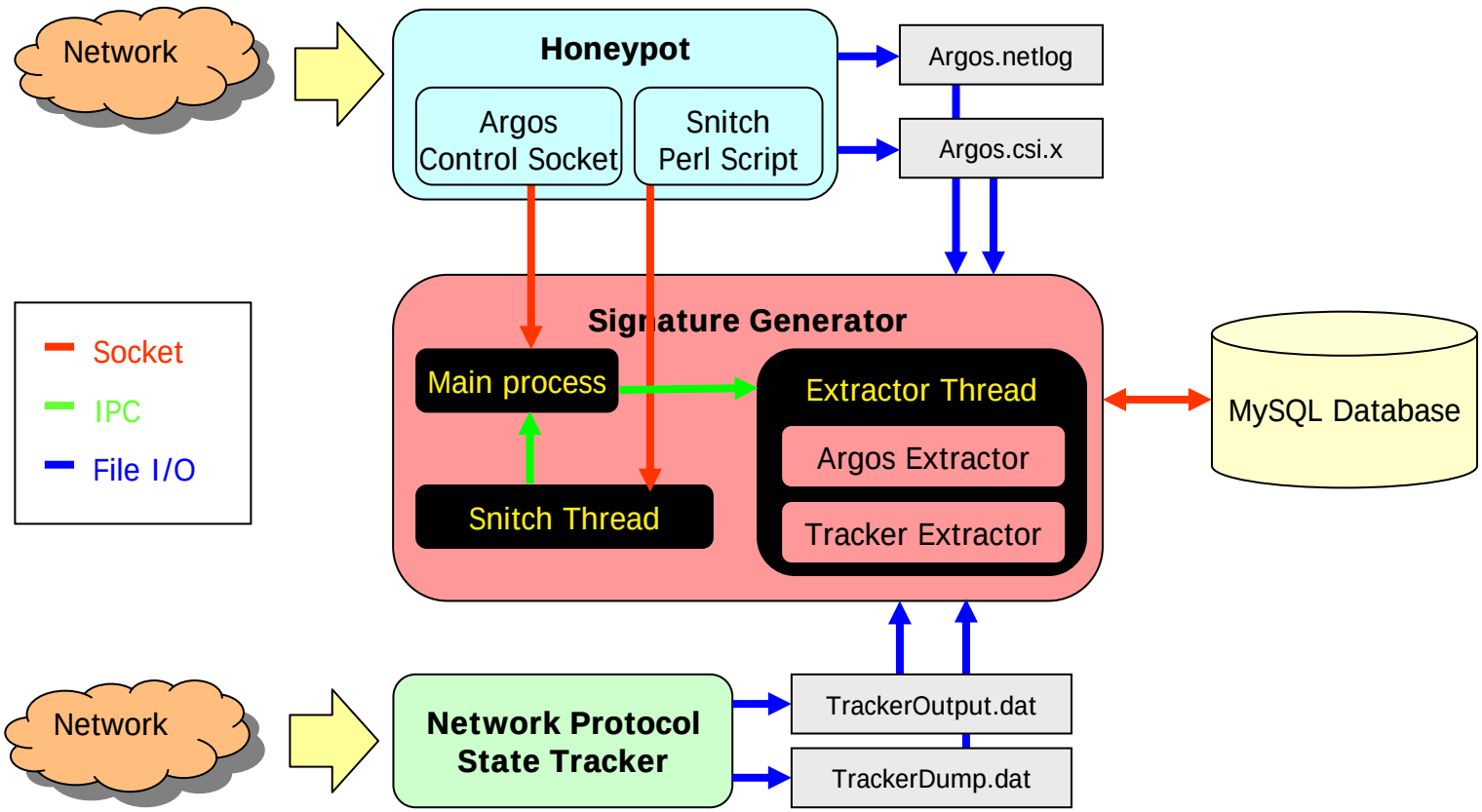

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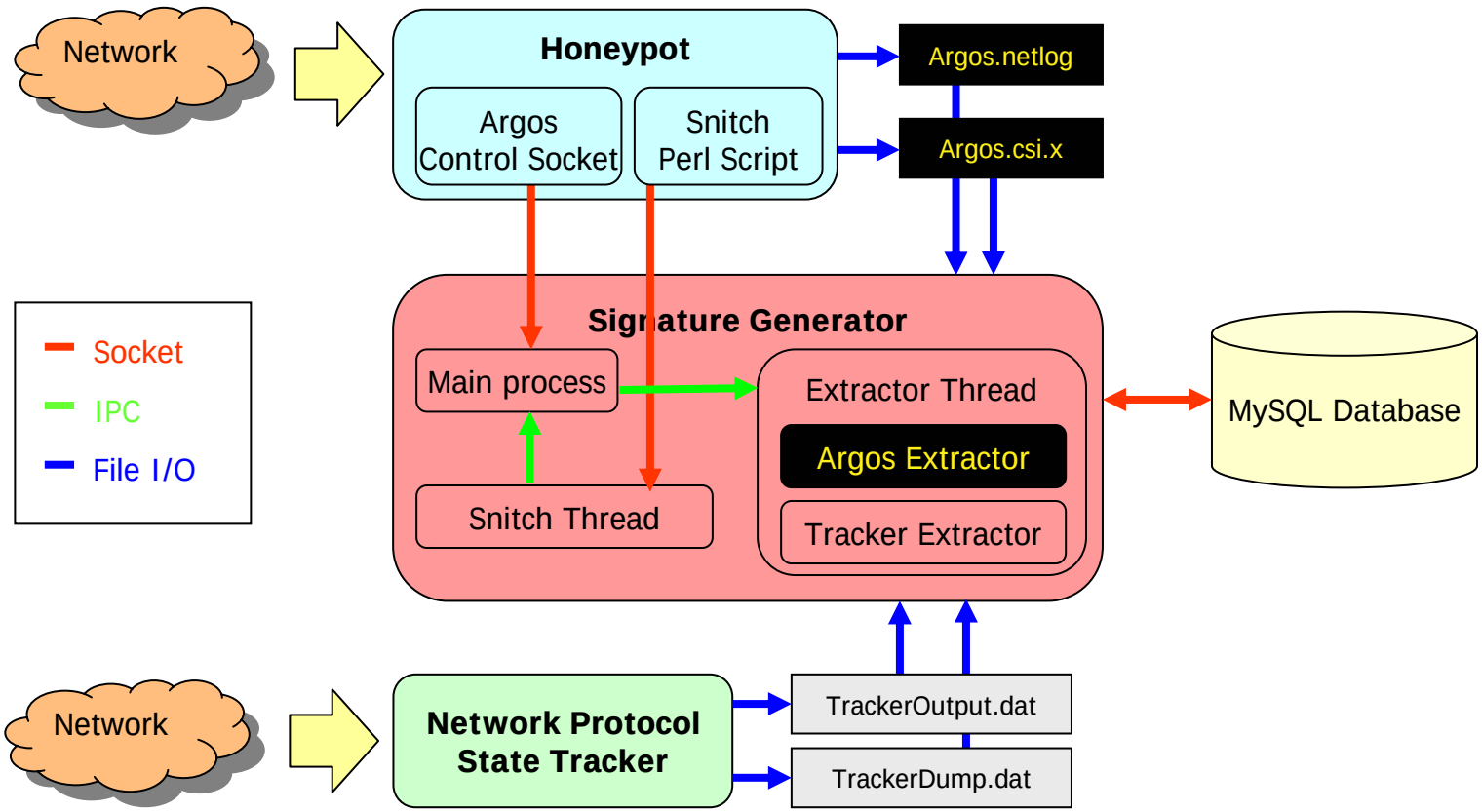

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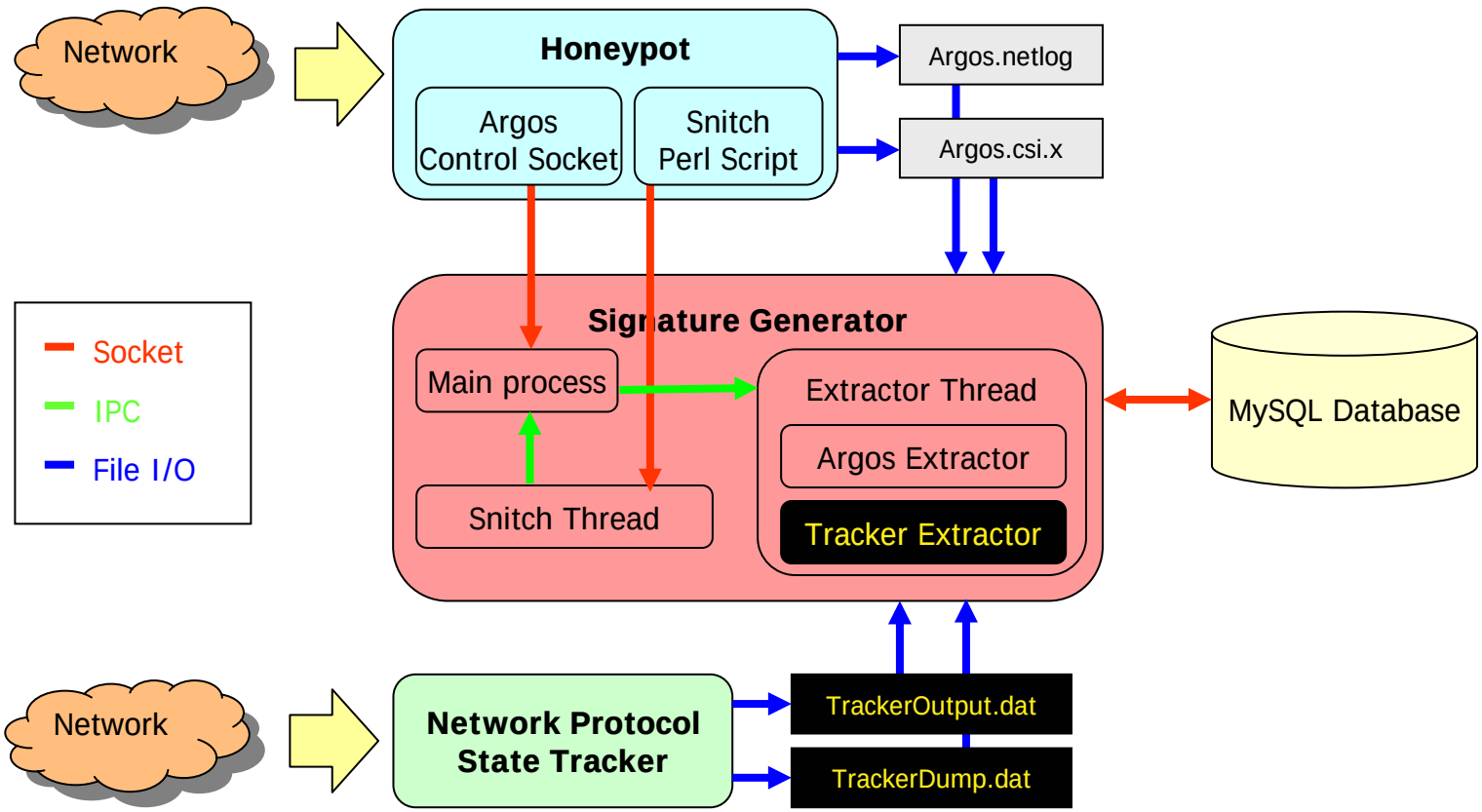

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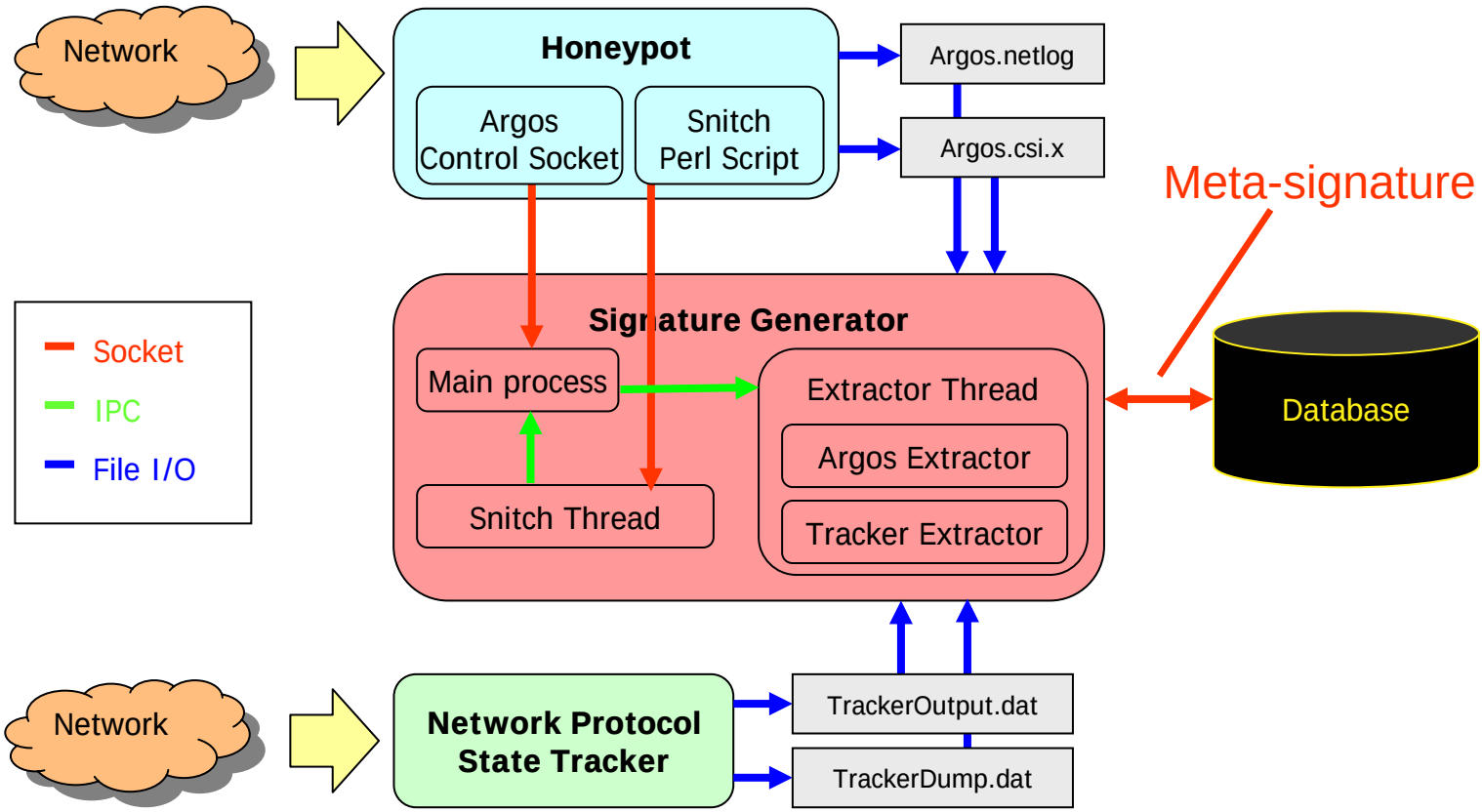


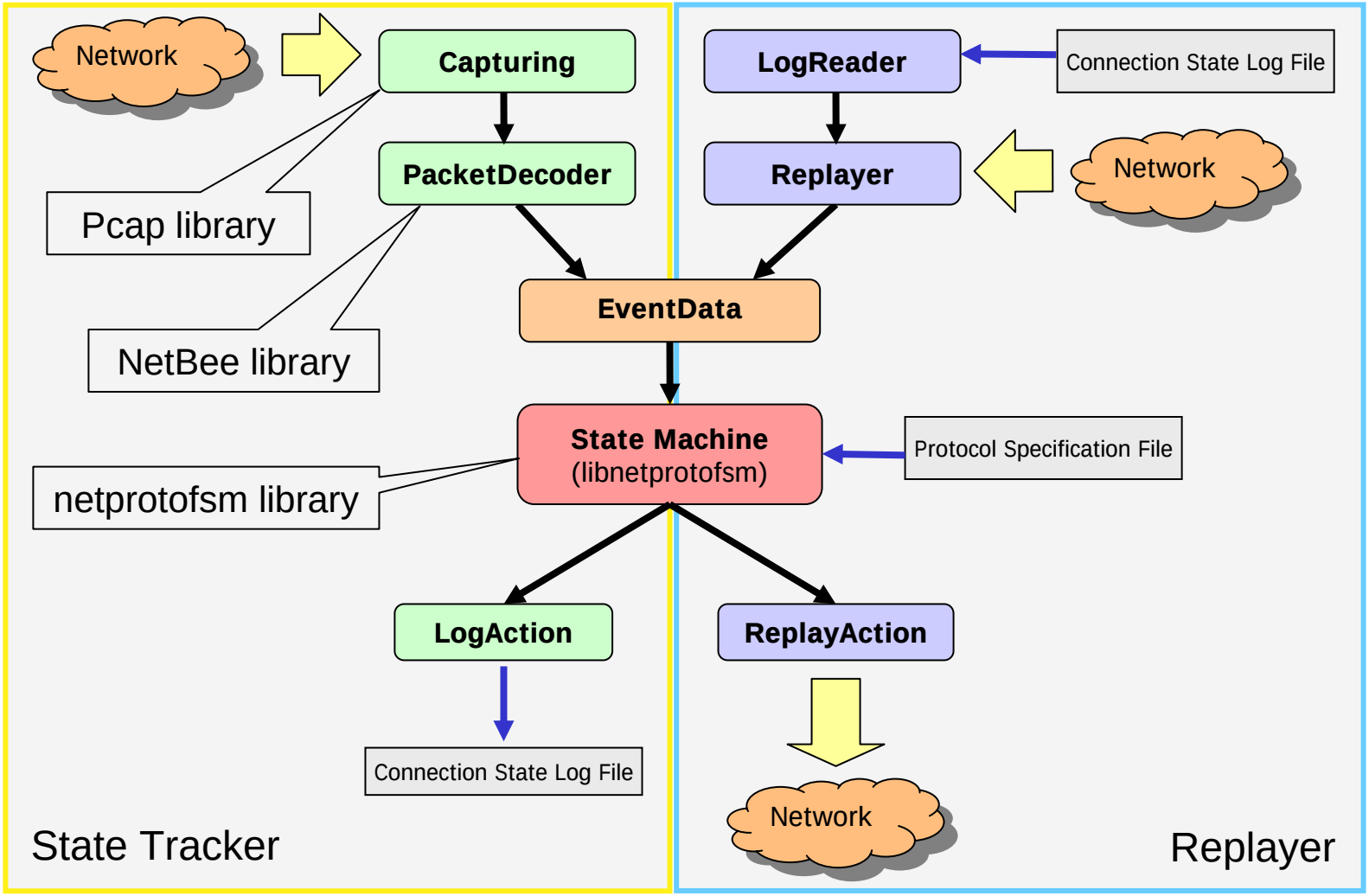
Network Protocol State Tracker

- Tracks the network connections towards one or more honeypot systems
- Logs protocol states for each packet
- User-defined packet and connection analysis possible
- Is highly configurable by relying on various libraries
- State machine configurations currently available for IP, TCP/UDP, FTP

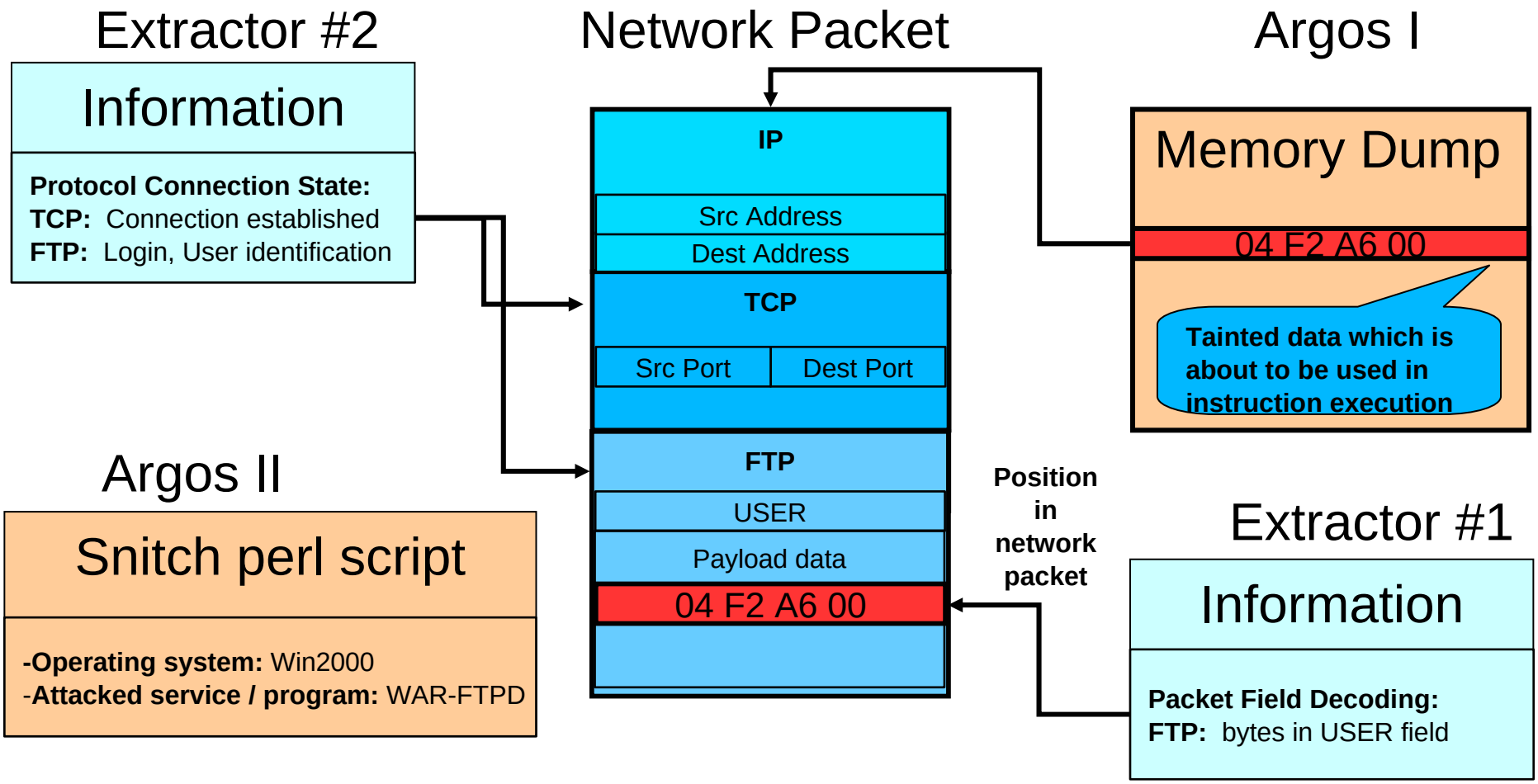
Libraries

- NetBee library
  - Developed by NetGroup at Politecnico di Torino
  - Components for different types of packet processing
  - We integrated Packet Decoding functionality into Tracker
- Netprotofsm
  - Finite state machine library for describing network protocols
  - Our approach is based on work by J. van Gurp and J. Bosch
  - Features:
    - Protocol state machines defined by XML files
    - Resource-gentle
    - Flexible timer mechanism (schedule events, define timeouts)
    - Implement custom actions

Architecture



Example: Attack information extracted



Signature Generation

Signature Generation Flow

- 1. Generate meta-signature
- 2. Determine signature quality
- 4. Save to database
- 5. Use Adapters to create specific signatures
- 6. Store, (correlate and/or distribute) adapted signatures

Snort as Signature Format

- SNORT for Proof-of-Concept
  - SNORT is open source and well-known
  - Simple signature format
- Implications
  - Only a part of extracted attack information can be used, for example
    - We cannot include information about attacked program

Generated signature (WAR-FTPD example)

```
alert tcp any any-> any 21 (msg:
“(NoAH) RET via FTP protocol, USER
command in war-ftpd.exe(win2k)”;

flow: established, from_client;
content:"USER";
content:!"|0D 0A|"; offset: 5; depth:
465;)
```

Signature Properties (WAR-FTPD example)

Connection state information

```
alert tcp any any-> any 21 (msg:
“(NoAH) RET via FTP protocol, USER
command in war-ftpd.exe(win2k)”;

flow: established, from_client;
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Signature Properties (WAR-FTPD example)

State transition trigger

```
alert tcp any any-> any 21 (msg:
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Signature Properties (WAR-FTPD example)

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Vulnerable field(s)

Conclusion

- Our ASG system generates signatures with almost zero false positives
  - For remote code injection attacks
  - If full amount of attack information is extracted
- Signature describes the vulnerability of the application
- Protect server applications from buffer overflows in arbitrary protocols and fields

> Our signatures can compete with other approaches including manually created reference signatures

Questions?

Evaluation

- Prototype implementation
  - IP, TCP, UDP, FTP protocol state machines
- Examplary signature generation tests
- Protocol context aware signatures:
  - Average total generation time: 1,64 s
  - Few false positives
- LCS signatures (fallback strategy):
  - Average total generation time: 3,46 s
  - High rate of false positives depending on strings