Meta-IDS Environments: An Event Message Anomaly Detection Approach

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Overview

Introduction

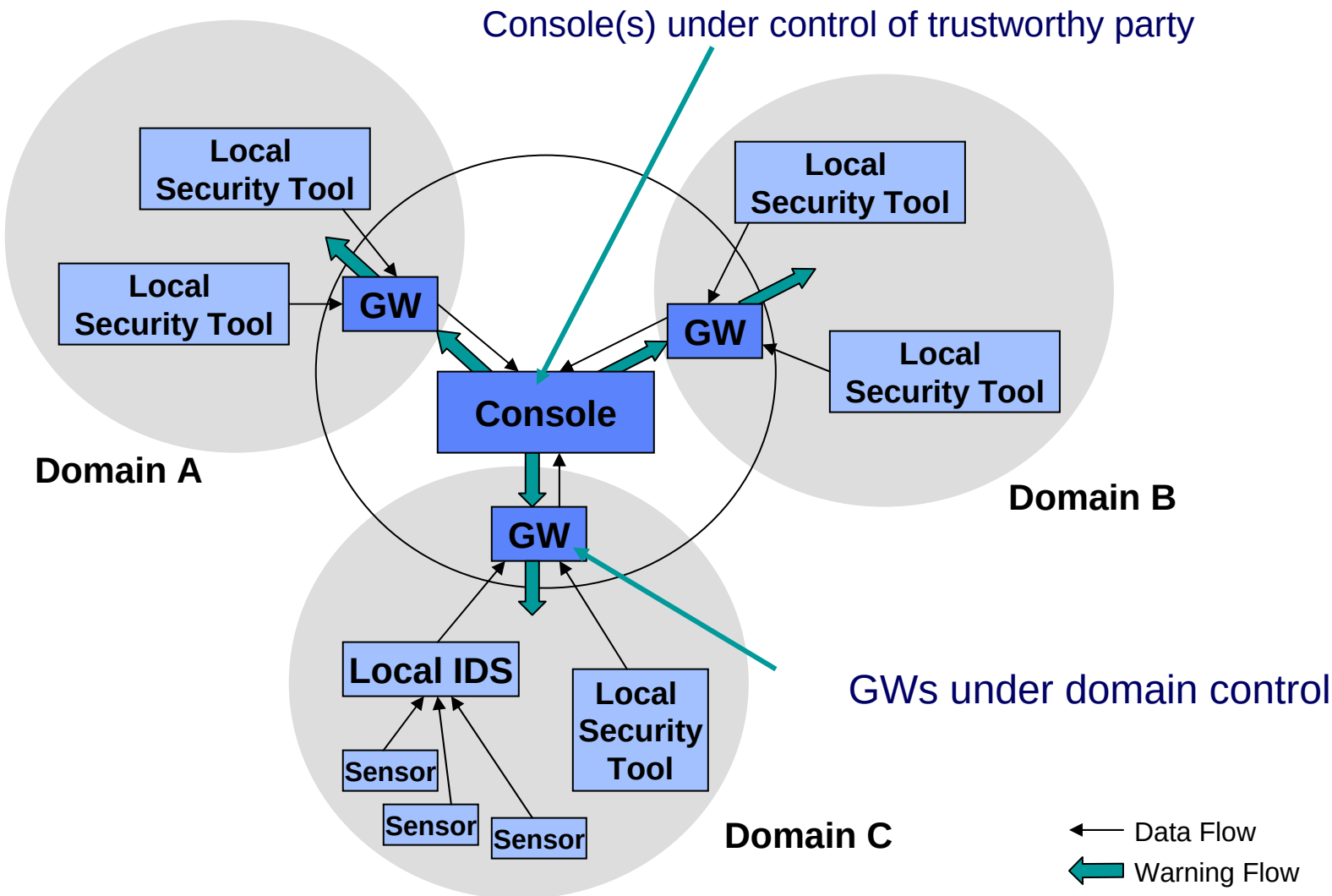
Basic Ideas

Structure Recognition

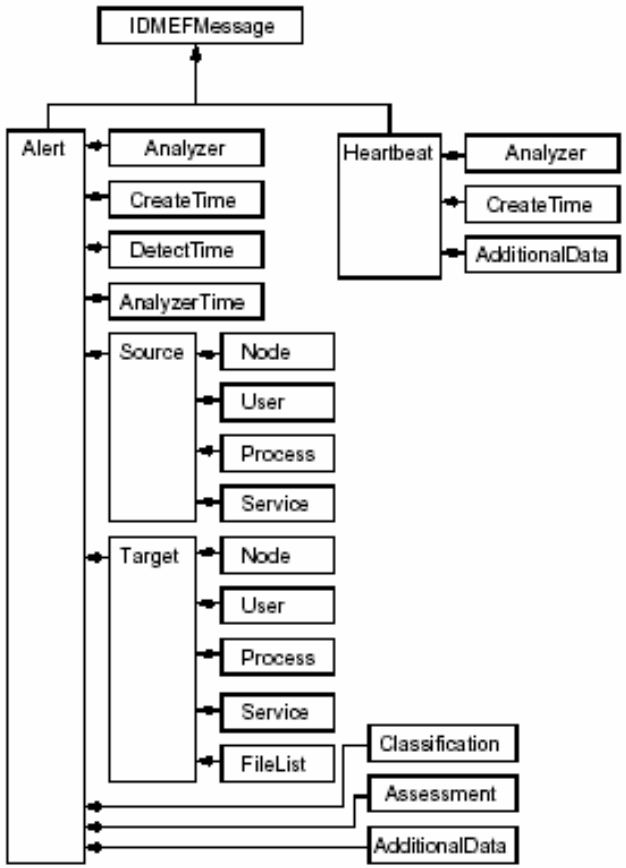
Application: Worm Detection

Summary, Further Work

System Overview



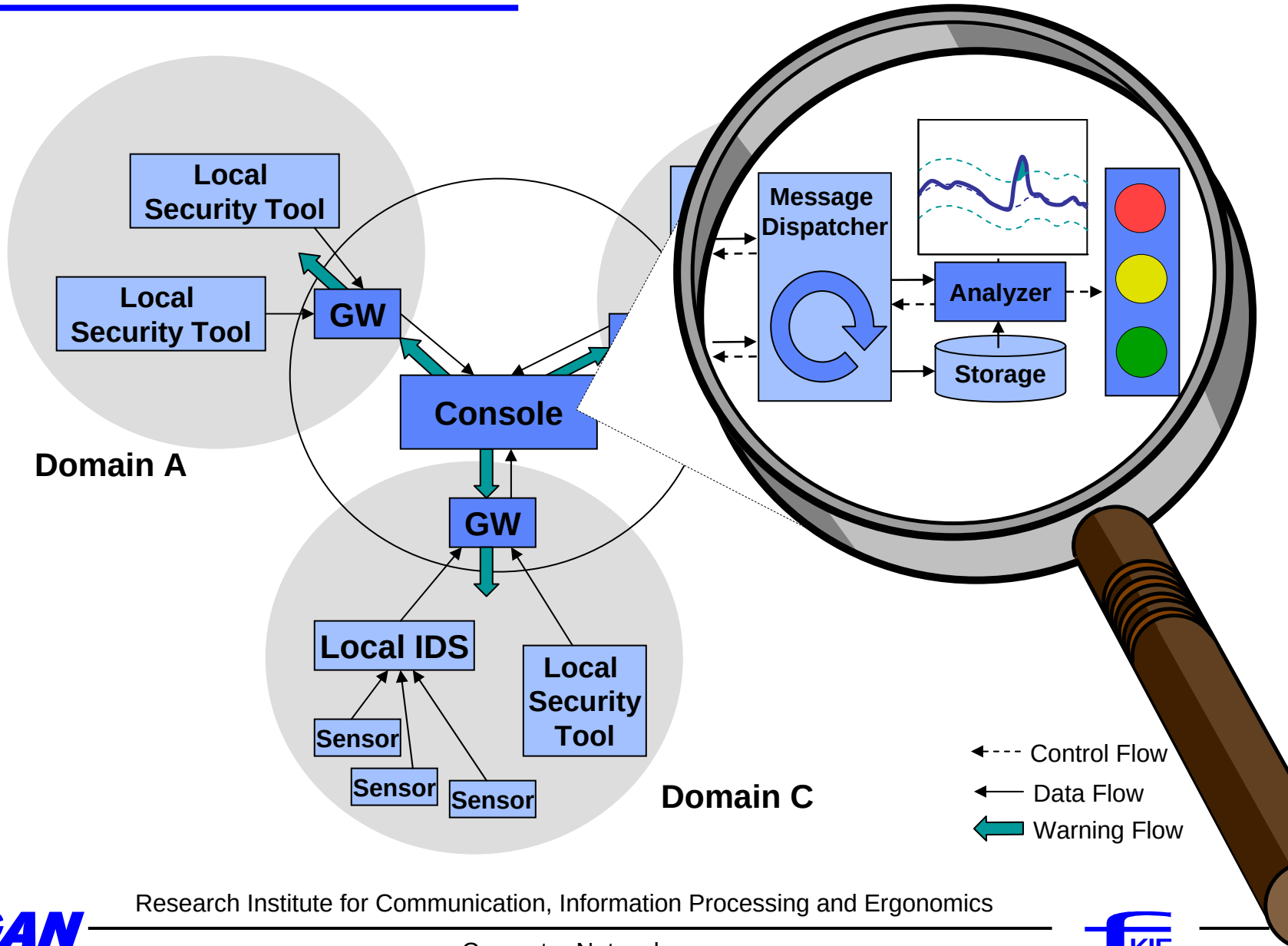
Message Exchange



Intrusion Detection Message Exchange Format (IDMEF)

```
<IDMEF-Message version="1.0">
  <Alert ident="abc123456789">
    <Analyzer analyzerid="hq-dmz-analyzer01">
      <Node category="dns">
        <location>Headquarters DMZ Network</location>
        <name>analyzer01.example.com</name>
      </Node>
    </Analyzer>                                   Who‘s reporting?
    <CreateTime ntpstamp="0xbc723b45.0xef449129">
      2000-03-09T10:01:25.93464-05:00
    </CreateTime>                                 When?
    <Source ident="a1b2c3d4">
      <Node ident="a1b2c3d4-001" category="dns">
        <name>badguy.example.net</name>
        <Address ident="a1b2c3d4-002" category="ipv4-net-mask">
          <address>192.0.2.50</address>
          <netmask>255.255.255.255</netmask>
        </Address>
      </Node>
    </Source>                                     Who?
    <Target ident="d1c2b3a4">
      <Node ident="d1c2b3a4-001" category="dns">
        <Address category="ipv4-addr-hex">
          <address>0xde796f70</address>
        </Address>
      </Node>
    </Target>                                     Where?
    <Classification origin="bugtraqid">
      <name>124</name>
      <url>http://www.securityfocus.com</url>
    </Classification>                             What happened?
  </Alert>
</IDMEF-Message>
```

Anomaly Detection Component



Warning

Anomaly Detection approaches may cause

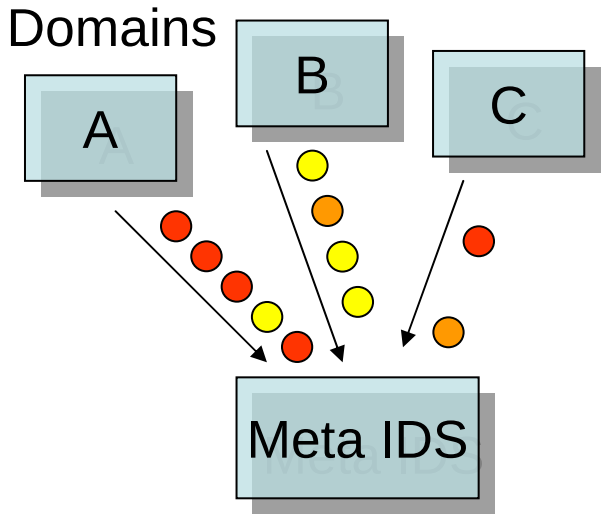
- **false positives** (false alarms)
- and **false negatives** (unreported serious events).

This holds for the system presented here as well.

It is not intended to be a standalone system!

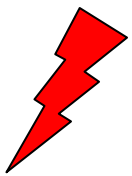
The method supports other intrusion detection approaches.

Basic Idea



Several domains generate different kinds and amounts of event messages.

The **basic idea** is

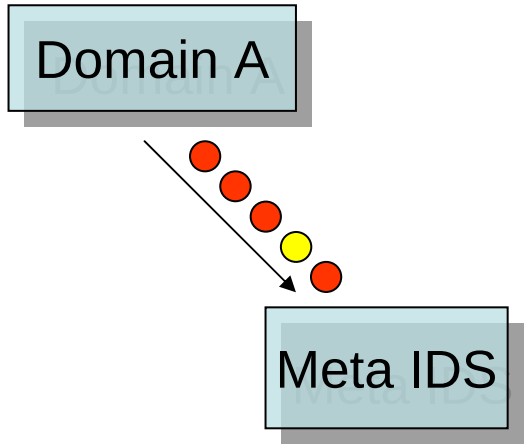


not to focus on the meaning of single event messages,

but

to regard all event messages together as a **stream of data** and check for noticeable behavior.

Event Message Collection



Event message properties may depend on

- **number** and **kind** of installed systems
  (usage of different products)
- local **configuration** of systems
- local **information sharing policies**
  (anonymization, omission of details, filtering of messages)

Different domains may send event messages differing in **form** and **quantity** as a reaction to the same event.

Focus on **typical event message structure.**

Typical Structure

Typical properties (**the structure**) of incoming event messages can be visualized using **graphs**.

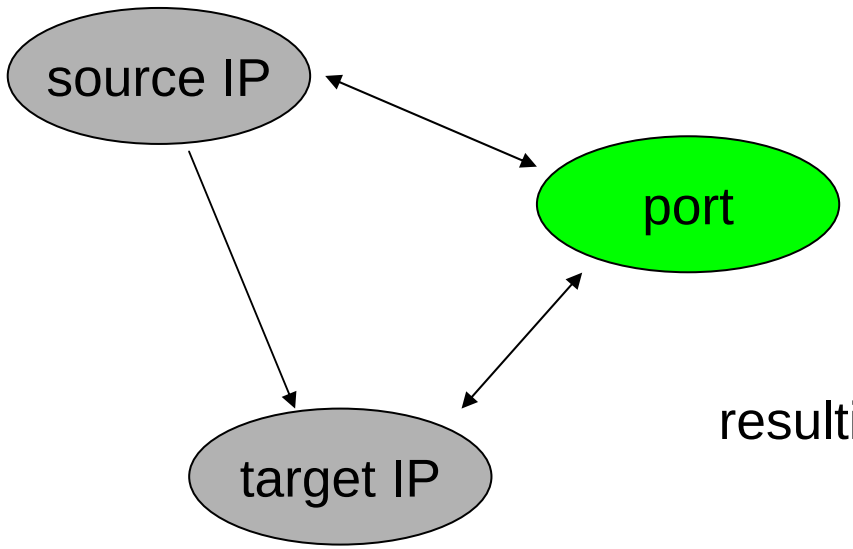
Measurements indicate, that these structures stay quite **stable** during normal system usage.

Fundamental changes are unusual (and therefore an **anomaly**).

Graph Construction

Most event messages contain information on

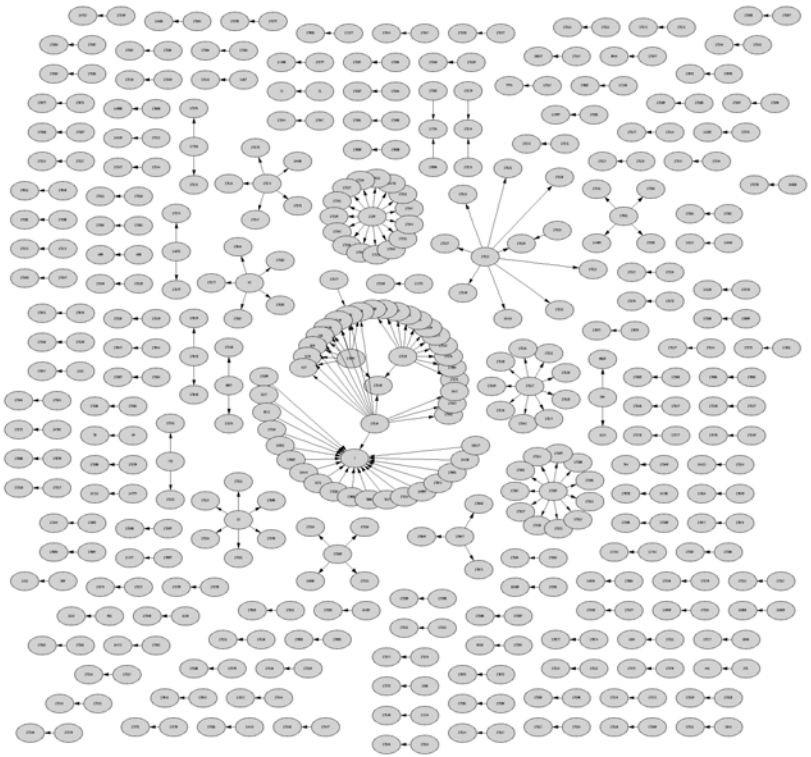
- **assumed source** of a security relevant action **(IP address)**
- **target** of a security relevant action **(IP address)**
- **affected service** **(port)**



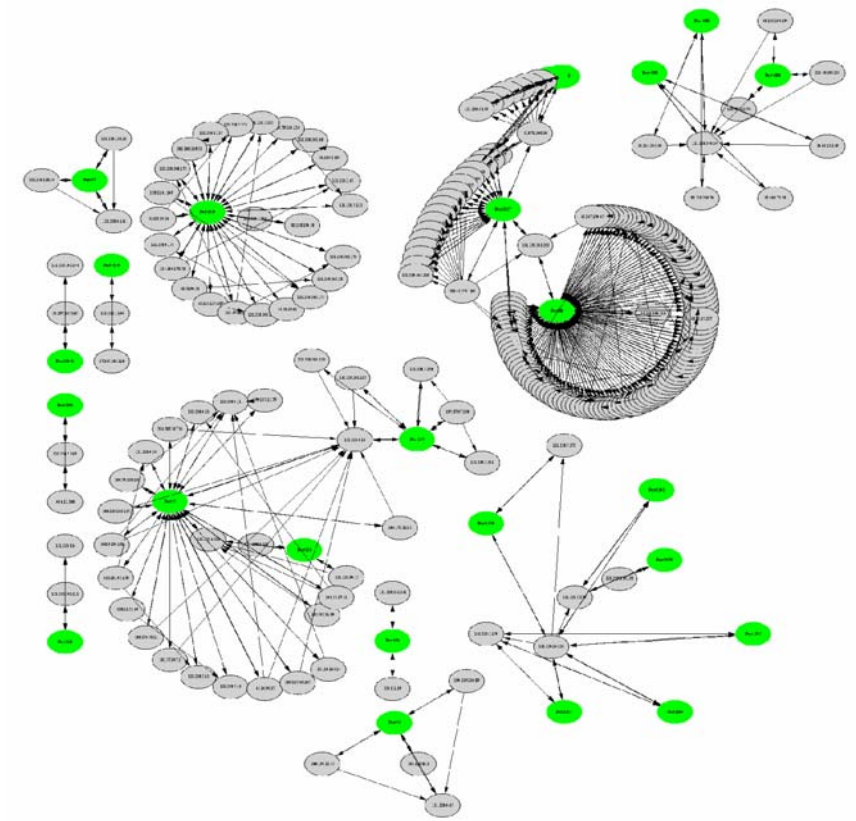
resulting graph

Graph Construction cont'd

Real-life event messages led to the following graphs:



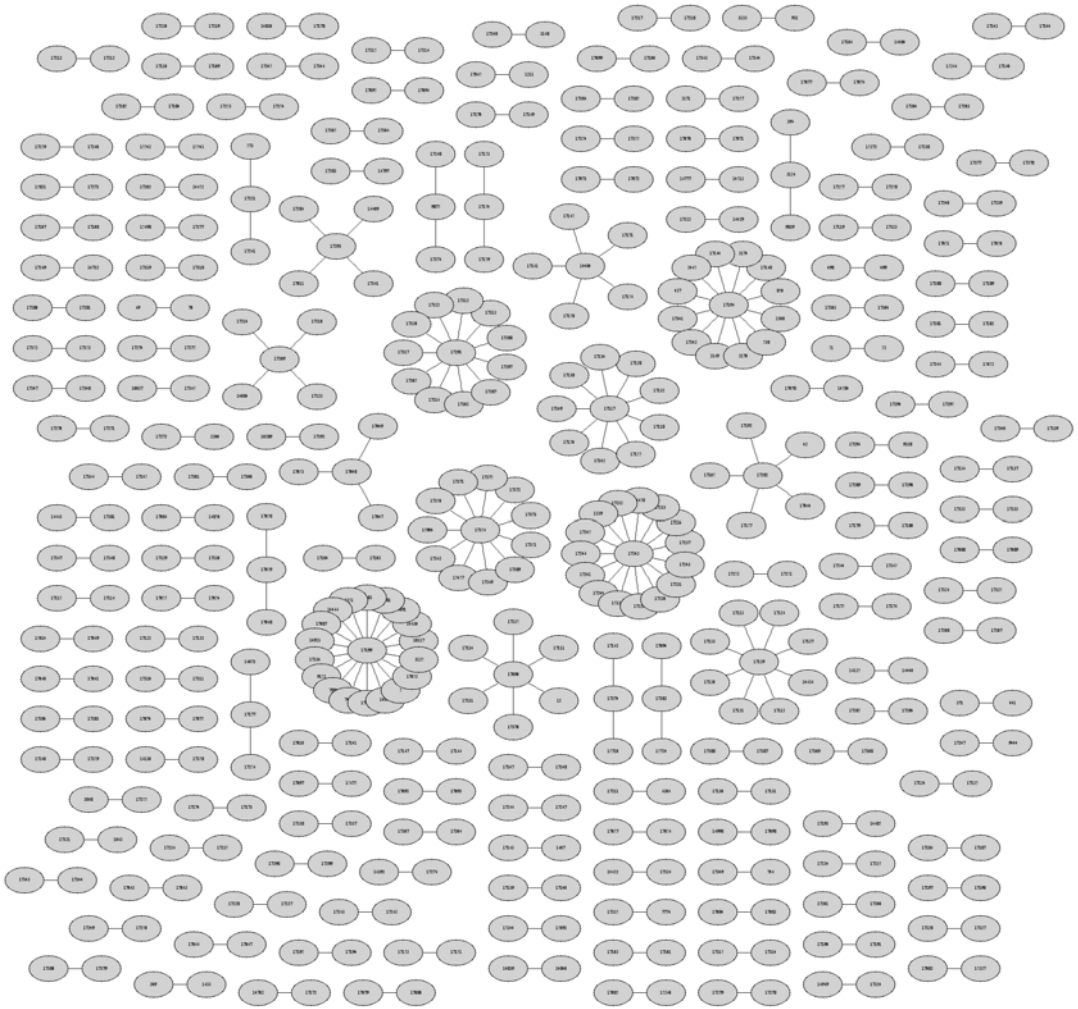
Without…



…and with service (port) information.

Clustering

Graph clustering (grouping of strongly connected nodes, omission of minor edges) **reveals basic structure**



Definition: Clustering

Definition:

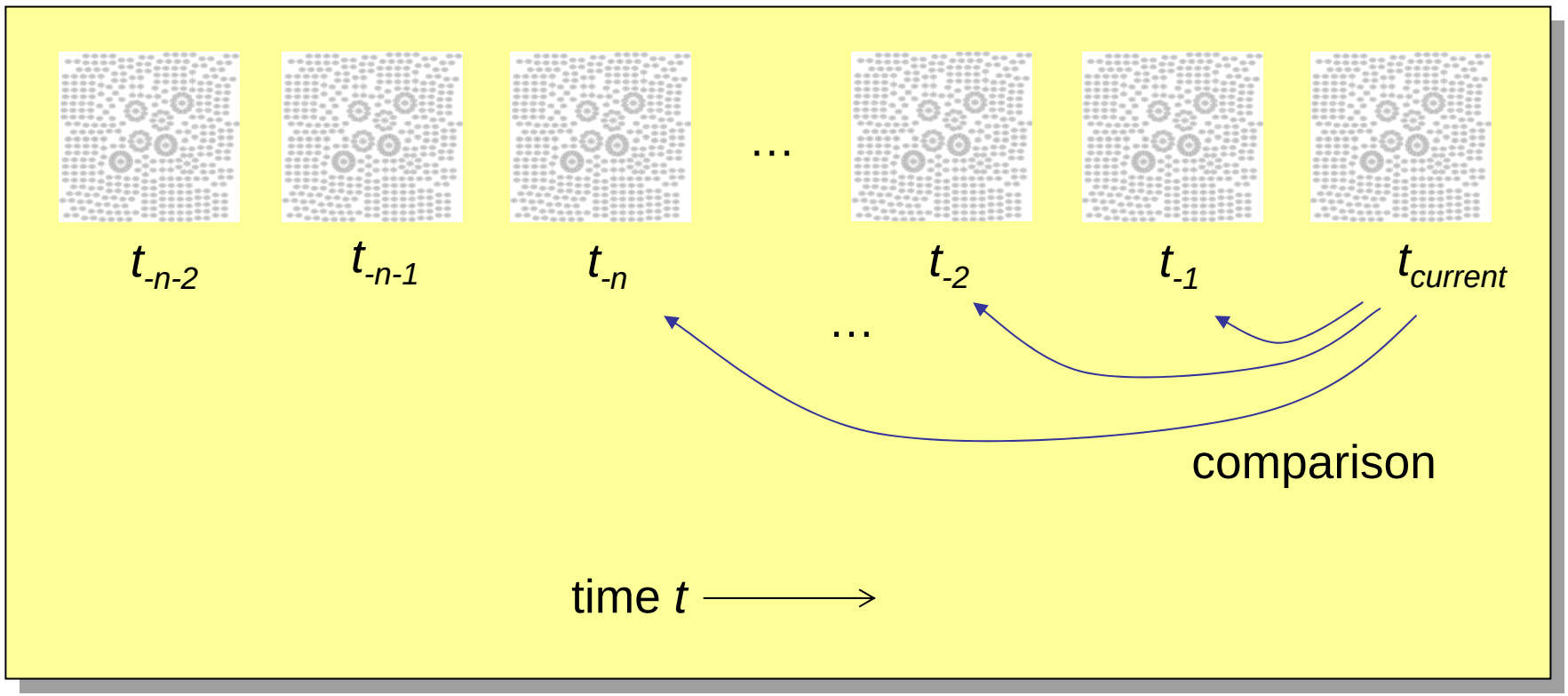
A Clustering $\mathfrak{R}$ of a Graph $G = (V,E)$ is a partitioning into Cluster C_i

- $C_i \subseteq V, C_i \neq \emptyset, 0 \leq i \leq n-1$
- $C_0 \cup C_1 \cup ... \cup C_{n-1} = V$ and
- $\forall 0 \leq i, j \leq n-1, i \neq j : C_i \cap C_j = \emptyset$

Clustering algorithms which need the number of clusters to be detected as input parameter are not suitable for this purpose.

Detection of abnormal System Behavior

Estimation of distance between current and set of *n* preceding clusterings:

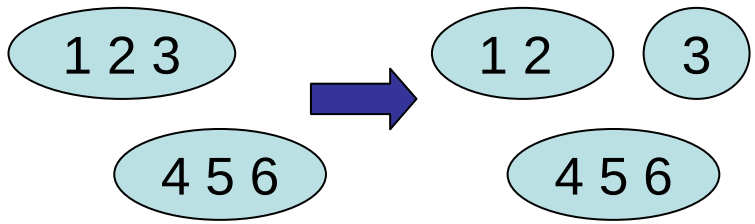


How to measure distance?

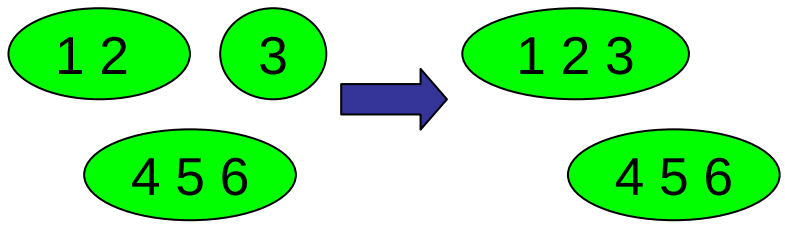
To calculate the **distance** between two clusterings, one feasible method is to estimate the minimum number of **elementary operations** needed to convert clustering 1 to clustering 2.

Elementary operations are

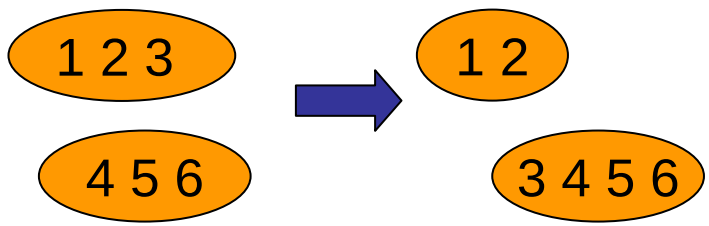
- **splitting** a partition



- **combining** a partition



- (**moving** a subset from one partition to another)



Application: Worm Detection

In case of **newly discovered and exploited vulnerabilities**, signature databases need some time to be updated. Therefore, **misuse detection systems might fail** to discover a worm.

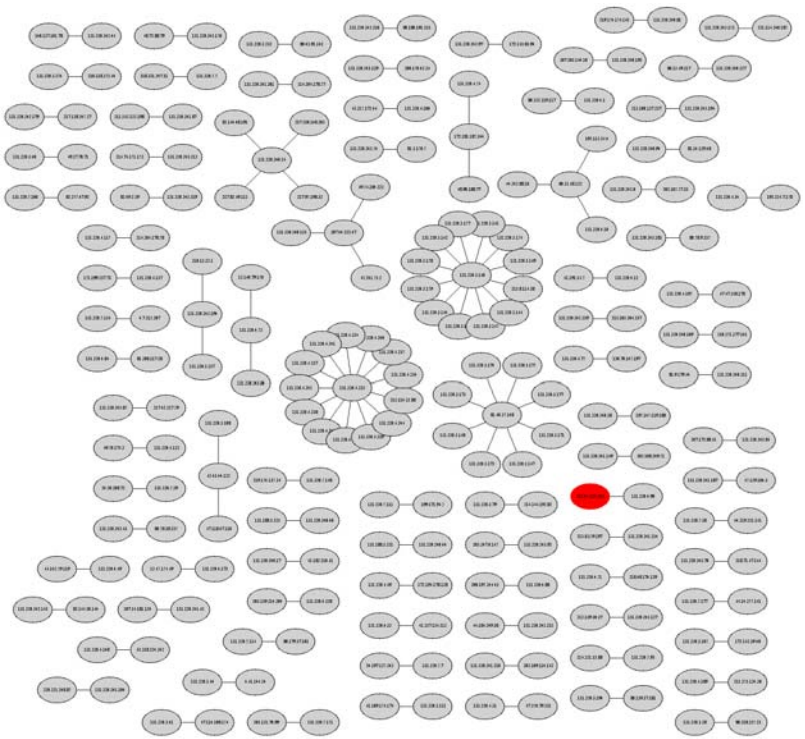
The method described here can be used to **detect internet worms early** and without the help of signatures.

The following slides present an example where real-life data is merged with data of a worm spreading.

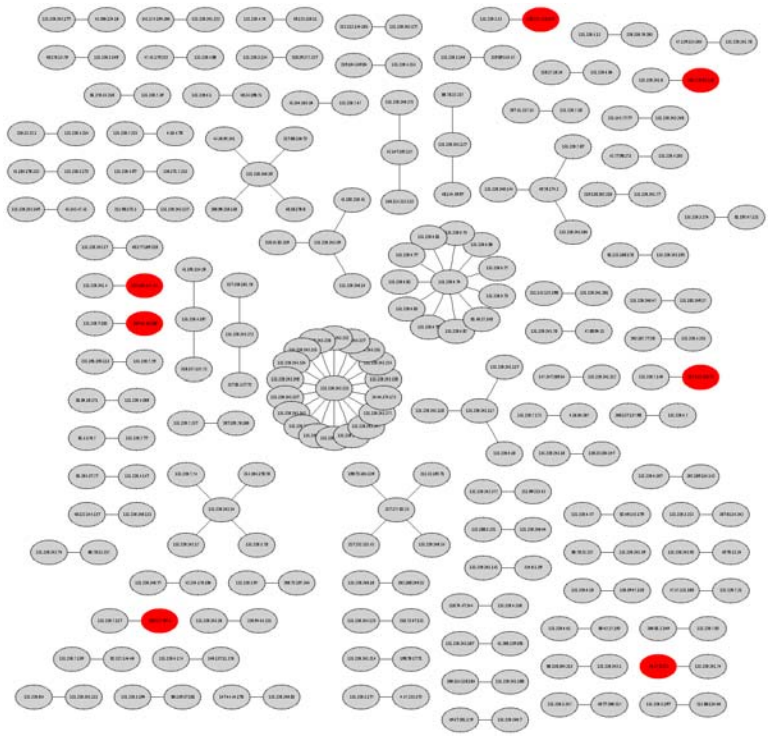
- worm behavior comparable to code red v2
- 360000 vulnerable systems on the internet

Application: Worm Detection cont'd

Visualization:

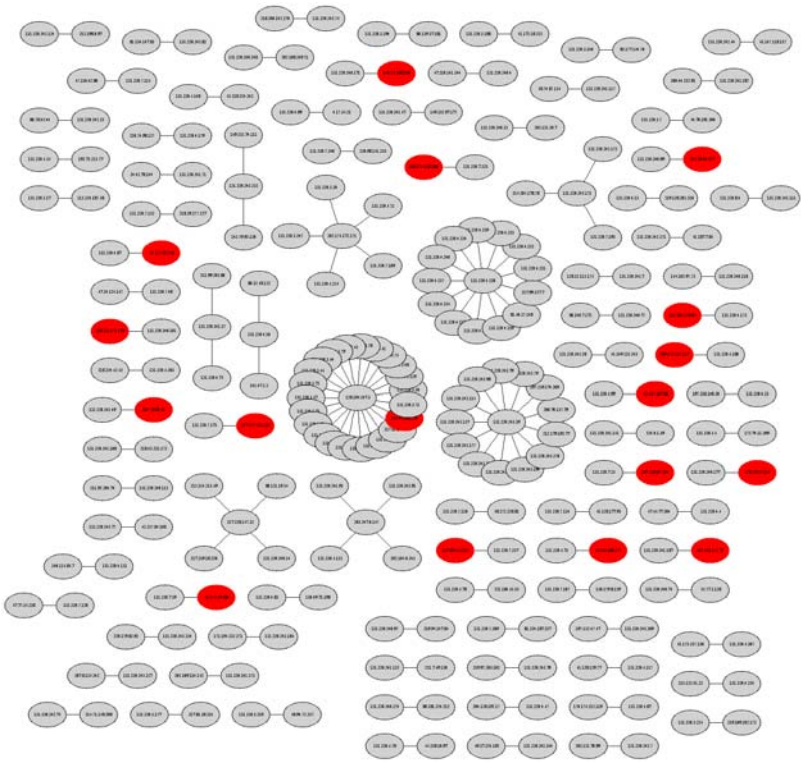


Worm spreading, start…

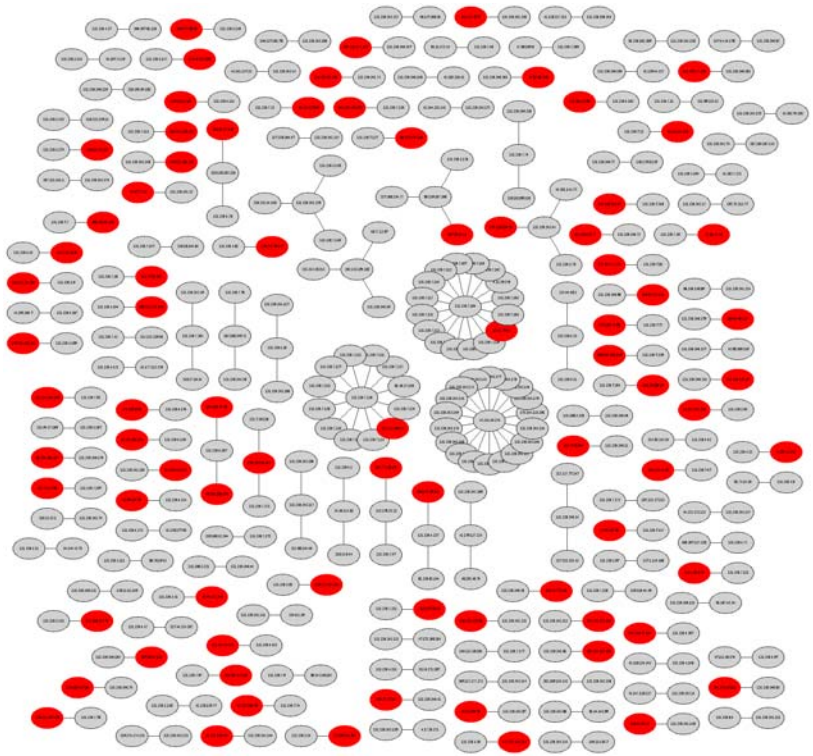


…after one hour…

Application: Worm Detection cont'd



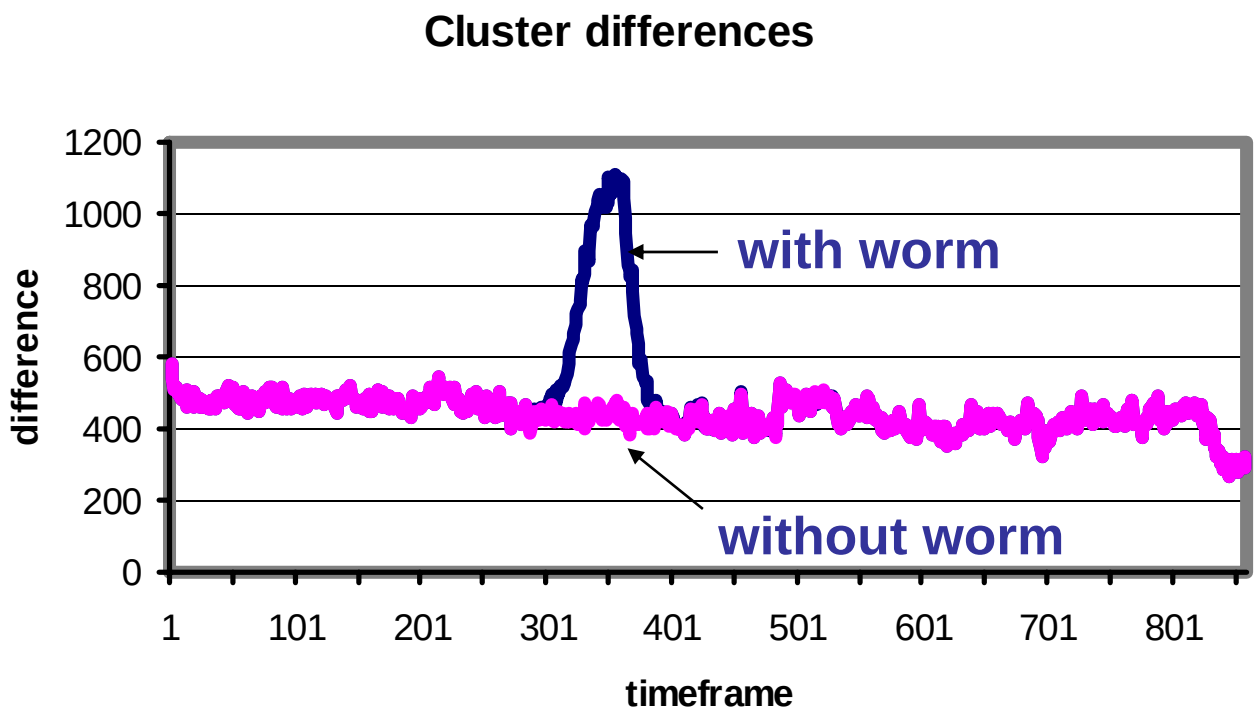
…after two hours and…



…after three hours.

Application: Worm Detection cont'd

The previous slides gave a **visual impression** of the spreading of a worm. This graph presents the calculated cluster differences which are used for **automatic worm warning.**



Summary

- Presentation of an anomaly detection approach based on event message flows
- Building graphs from event messages
- Calculate clustering of graphs to detect typical structures
- Compare consecutive clusterings using distance measures
- Warn administrator if abnormal deviations are detected

Further work

- Optimized automatic determination of reasons for anomalies
- Information extracting for decision and reaction support
- Estimation of influence of anonymized event messages

The End…

Thank you very much for your attention!

Questions?

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