# ANUBIS
# ANalyzing Unknown BInarieS
# The automatic Way

**Thomas Mandl, Ulrich Bayer, Florian Nentwich**

25.09.2009, v1.0.02, EN

# People behind ANUBIS – Who are we?

## Ulrich Bayer

- Currently PhD student at Vienna University of Technology
- Main developer and architect of ANUBIS

## Florian Nentwich

- Senior malware analyst at Ikarus labs and maintainer of commercial ANUBIS version

## Thomas Mandl

- Former CTO of Ikarus, now CEO of his own information security consulting company in Austria
- Still contributing to the ANUBIS project

# ANUBIS' Academic Research Members

## Engin Kirda

- Assistant professor at EURECOM Communication Systems
- Former assistant professor at Vienna University of Technology
- http://www.eurecom.fr/people/kirda.en.htm

## Christopher Kruegel

- Assistant professor at UCSB, Dept. of Computer Science
- Former assistant professor at Vienna University of Technology
- http://www.cs.ucsb.edu/~chris/
- Development of Wepawet Tools

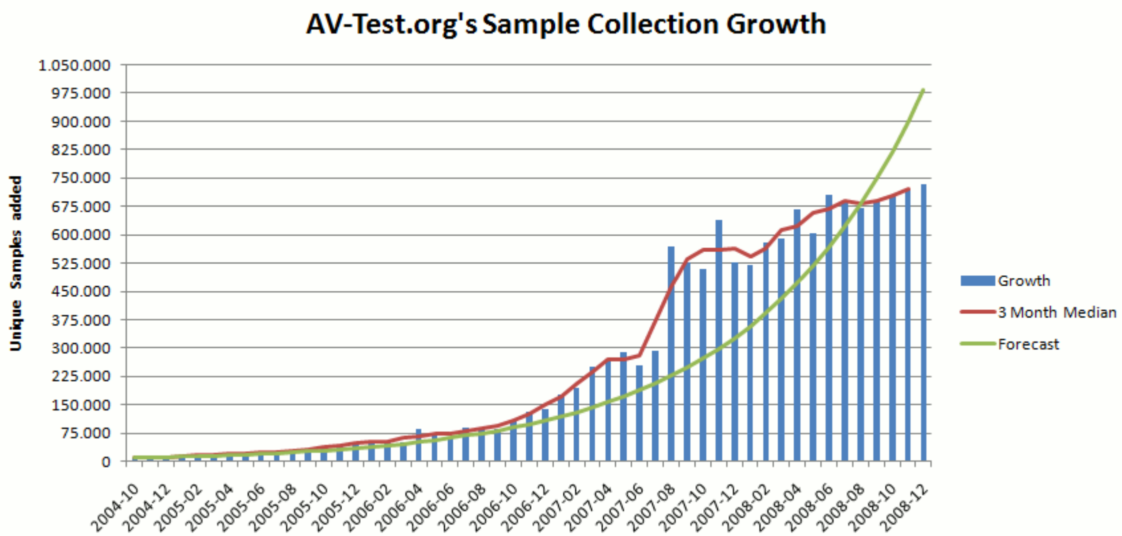
## See also

- http://www.iseclab.org/people.html

# Automated Malware Analysis: Why?

## Too many new malware samples per day

- ~25k - 35k samples per day (unique MD5) (peak up to 50k)
- Increasing number of malware uses runtime packers/code obfuscation methods to trick pattern matching AV
- Increasing FP rate, nobody can handle this load manually!
- Almost no in-house incident response process/RE due to its complexity
  (at least in Austria)
- Among others, this was our primary motivation to create ANUBIS!




IKARUS security software

# A traditional Analysis Approach

- ~35k samples/day
- Manual analysis takes up to several days

- Limited human expert resources
- Experts should concentrate on novel malware

- Response time for signature creation is crucial
- How can we speed up this process?

# What is ANUBIS?

## Framework of several tools for dynamic code analysis

- We run a binary in an emulated PC environment (WinXP/SP3)
- We monitor its actions (SysCalls, Windows API functions, …)
- We generate a detailed report of the sample‘s behavior
- Fully automatically within 4 min. (no human interaction)
- Based on an ANUBIS report, a human expert can decide whether to manually analyze a sample in depth or not.

## Benefits of dynamic code analysis with ANUBIS

- Scalable approach, unaffected by runtime packers, code obfuscation or anti-debug mechanisms of modern malware
- Can handle basic user interactions if required during analysis

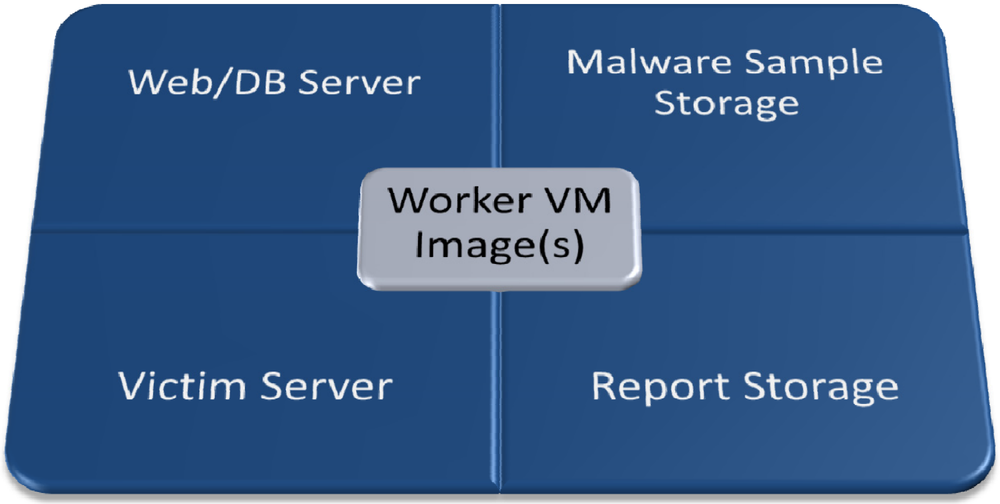
## Community version heavily used by AV and AV researchers

- https://anubis.iseclab.org (public) with limited features

# Architecture and Capabilities

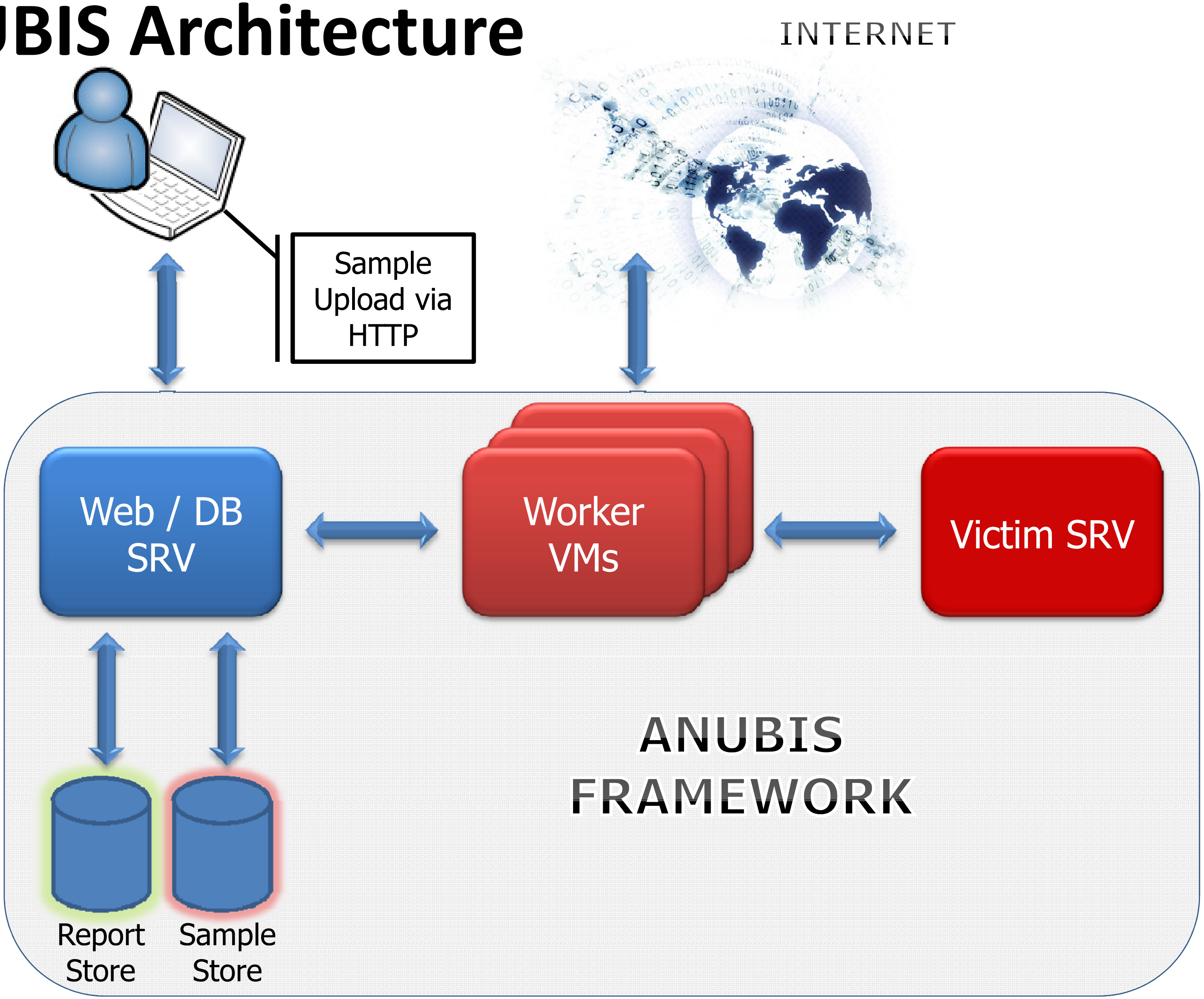
## ANUBIS has 5 primary building blocks

- Web/DB server/HTTP(s) frontend (upload/admin)
  - DB stores reports and references to samples (XML)
  - Enables us to generate lots of statistics!
- Malware sample storage
  - Archives uploaded and already analyzed samples
- Report storage
  - Archives report/result files (traffic dumps, downloaded files...)
  - Comprehensive Archive + 2nd stage malware!
- Victim server
  - Acts as local honey pot for certain services and keeps malicious traffic local!
- Multiple Worker (VM)
  - Snapshot technology! Revert to known state in a second!




IKARUS security software

# ANUBIS Architecture



# Advanced Features of ANUBIS

**Records and analyzes sample's network traffic**

- HTTP, FTP, SMTP, IRC, … are available as PCAP file

**Storage of analysis reports in relational DB**

- Servers contacted, files created, modified, deleted, RegKeys manipulated, and short threat summary

**Several report formats**

- XML, HTML, MHT, PDF, TXT
- Integrates also static analysis with AV scanner/PE scan


**URL analysis (early development stage)**

**ANUBIS was designed to support human experts**

- Gives quick overview of a sample's behavior within minutes
- What makes ANUBIS different from other sandbox solutions?

# Anubis - Analysis Report

## Analysis Report for nepenthes-65c242c013045c678974e3be0796188d-index.html

Comment on this report

### Summary:

| Description | Risk |
|---|---|
| **Creates files in the Windows system directory**: Malware often keeps copies of itself in the Windows directory to stay undetected by users. | |
| **Performs Address Scan**: The executable scans a range of IP Addresses. In most cases these scans identify more potential vulnerable targets. | |
| **Performs File Modification and Destruction**: The executable modifies and destructs files which are not temporary. | |
| **Spawns Processes**: The executable produces processes during the execution. | |
| **Performs Registry Activities**: The executable reads and modifies registry values. It may also create and monitor registry keys. | |

### Table of Contents

expand all collapse all

# Report – Static findings

| | |
|---|---|
| SHA-1: | b616dcf0c05e539b317edd9d279a267a6fadc01e |
| File Size: | 131584 Bytes |
| Command Line: | "C:\nepenthes-65c242c013045c678974e3be0796188d-index.html" |
| Process-status at analysis end: | dead |
| Exit Code: | 0 |

+ Load-time Dlls

+ Run-time Dlls

- SigBuster Output

Allaple_Polymorphic_Packer vna SN: 1647

- Ikarus Virus Scanner

Net-Worm.Win32.Allaple.b (Sig-Id:158175)

# Report – Windows Services

## 3.c) urdvxc.exe - Windows Service Activities

**- Services Created:**

| Name | Type | Path |
|---|---|---|
| MSWindows | SERVICE_AUTO_START | "C:\WINDOWS\system32\urdvxc.exe" /service |

**- Services Changed:**

| |
|---|
| MSWindows |
| MSWindows |

## 7.c) urdvxc.exe - Network Activity

**- ICMP Traffic:**

ICMP Echo Requests sent to 26 hosts

ICMP Echo Replies received from 26 hosts

Scanned a Subnet: 61.229.0.0/16

**- Unknown TCP Traffic:**

**from ANUBIS:1328 to 61.229.113.109:445**

State: Connection established, not terminated - Transferred outbound Bytes: 172 - Transferred inbound Bytes: 0

Data sent:

```
0000 00a8 ff53 4d42 7200 0000 0008 0140    .....SMBr......@
```

**- TCP Connection Attempts:**

**from ANUBIS:1040 to 61.229.113.109:139**

**from ANUBIS:1039 to 61.229.82.160:139**

**from ANUBIS:1038 to 61.229.54.57:139**

**from ANUBIS:1041 to 61.229.118.248:139**

**from ANUBIS:1042 to 61.229.218.221:139**

# Data Tainting in Anubis

## Powerful technique for tracing data flows of a program

- E.g. how network data is processed by a program
- E.g. it enables us to find out if malware uses random file names for infection only during one single analysis run

## How does tainting work?

- Performed on hardware level, invisible for analyzed malware
- Data elements of interest are labeled (tainted)
- When memory values are copied, taint labels (information) are maintained allowing us to identify the data flow process

# Memory Tainting Example

## Consider the following code fragment

```
ticks = GetTickCount()
filename = "c:\\" + ticks + ".exe"
file = CreateFile(filename, ...)
```

**Creates file with random name**

## Enhanced with tainting information

```
ticks = GetTickCount()
```

**ticks → <GetTickCount>**

**Tainting Label**

```
filename = "c:\\" + ticks + ".exe"
```

**filename → <GetTickCount>**

```
file = CreateFile(filename, ...)
```

**=> CreateFile is called with a random filename**

# Resume so far

## By now we have achieved the following

- We can automatically analyze single malware samples
- We known within 4 min. if this sample is malicious or not
- We can provide a non-obtrusive view from outside on our malware’s behavior

## But we still have the following challenges

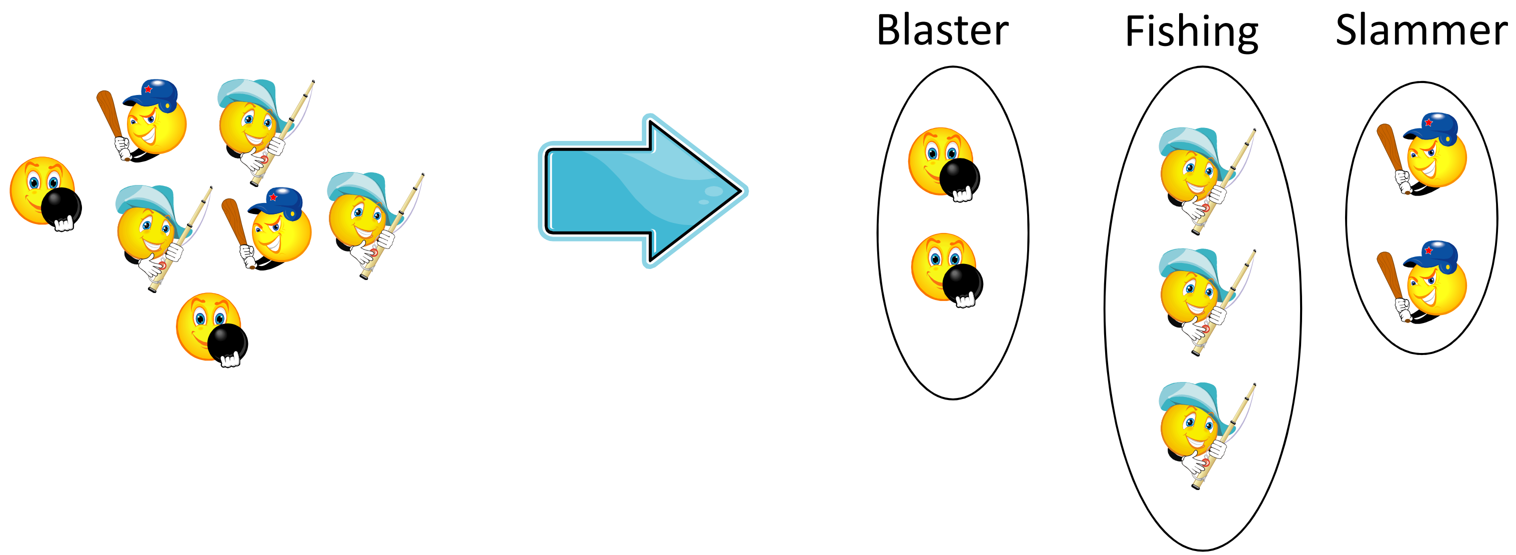
- How to structure thousands of generated analysis reports?
- Wouldn’t it be nice to know (for every new incoming sample) if it belongs to a well-known malware family?

## ANUBIS can also provide this additional information

- This feature is called “clustering”

# Scalable, Behavior-Based Malware Clustering

Malware Clustering: **Find a partitioning of a given set of malware samples into subsets so that subsets share some common traits (i.e., find “virus families”)**



# Malware Clustering – Features

## Behavior-based

- Samples are clustered according to their behavior exhibited at runtime
- Requires prior analysis by Anubis

## Scalable

- Use of LSH (Locality Sensitive Hashing) allows us to avoid computing all $n^2/2$ distances
- Suitable for clustering real-world malware collections

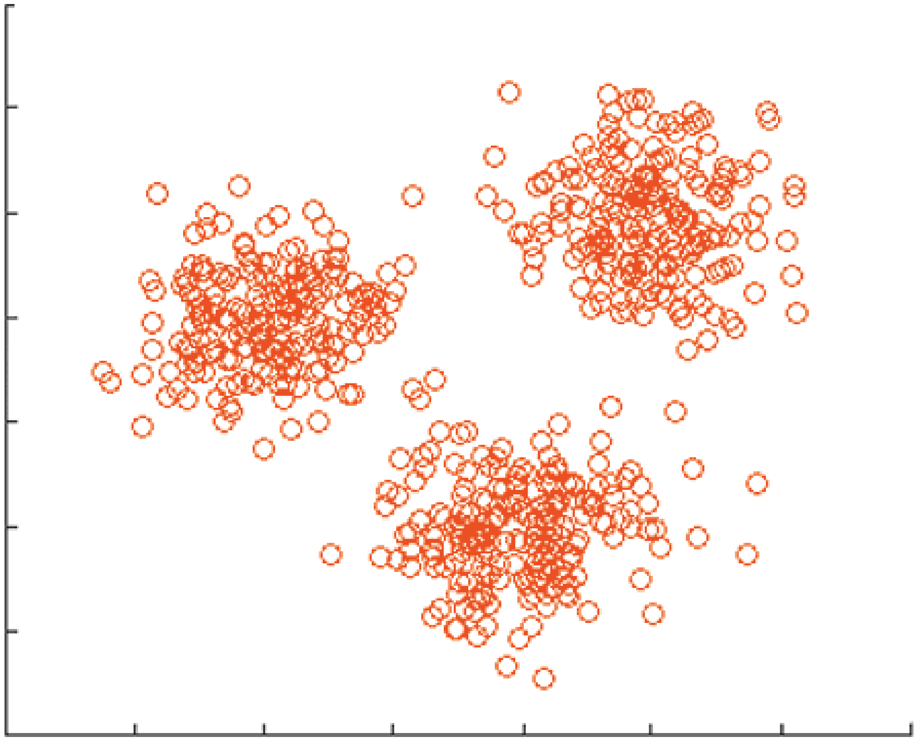
## Details

- Ulrich Bayer, Paolo Milani, Clemens Hlauschek, Christopher Kruegel, and Engin Kirda: *Scalable, Behavior-Based Malware Clustering, NDSS 2009, San Diego, February 2009*

# How about clustering 825k samples…

## …in less than 8 hours?

- Most recent clustering run (August 16h 2009):
- http://anubis.iseclab.org/?action=browse_clusters&task=299



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| **Samples were submitted between:** | 2007-02-07 13:44:00 - 2009-08-16 16:58:53 |

Number of Samples:
*827377*
Anubis Tasks:
*998505*
Unique Behavioral Profiles:
*730539*
Number of Clusters:
*91521*

| Local Sensitive Hashing Parameters | | |
|---|---|---|
| Distance Threshold | = | 0.2 |
| l | = | 87 |
| k | = | 20 |

## Anubis Families 1 - 10 of 91521

| Family Id | # Samples | Top 3 A/V Labels | | next |
|---|---|---|---|---|
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| 6830127 | 17440 | 98% -unlabeled- | 0% trojan-downloader.win32.autoit | 0% packed.win32.klone |
| 6797651 | 16042 | 58% backdoor.win32 | 40% -unlabeled- | |
| 6818183 | 15483 | 69% -unlabeled- | 25% trojan-downloader.win32 | |
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| 6830127 | 17440 | 98% -unlabeled- | 0% trojan-downloader.win32.autoit | 0% packed.win32.klone |
| 6797651 | 16042 | 58% backdoor.win32 | 40% -unlabeled- | |
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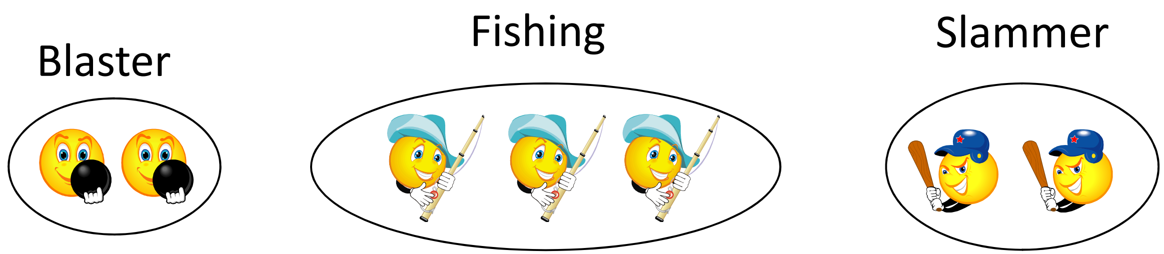
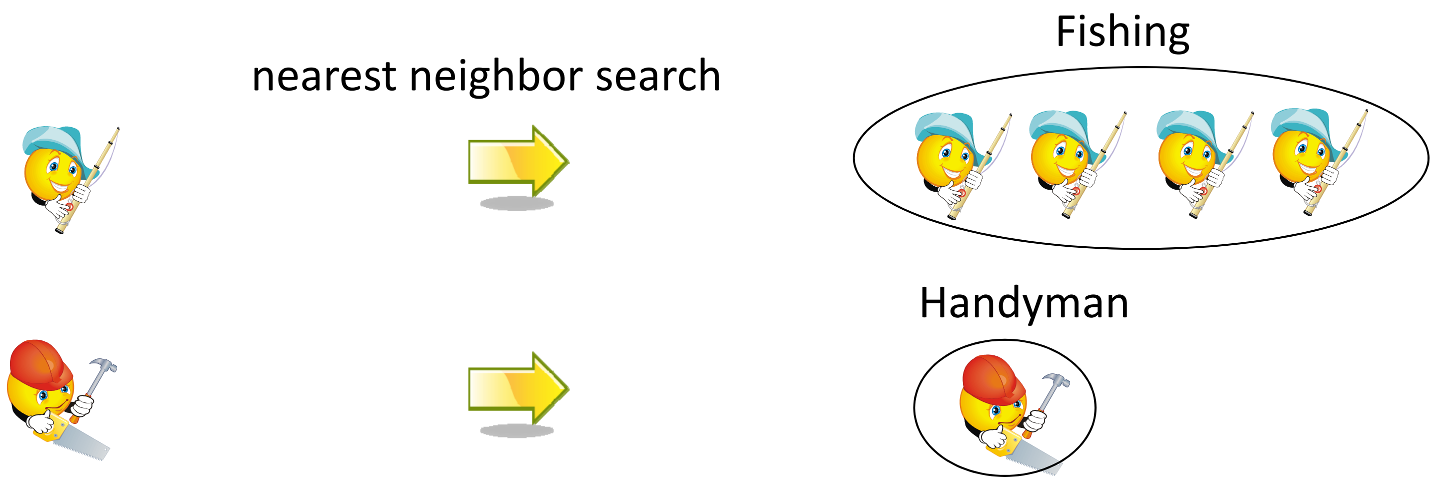
# Clustering Workflow

## 1) Periodic (e.g., weekly) full cluster runs:




## 2) Nearest neighbor search for each new sample:

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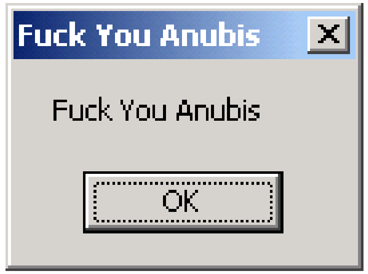
# Lessons learned from 2 Years ANUBIS

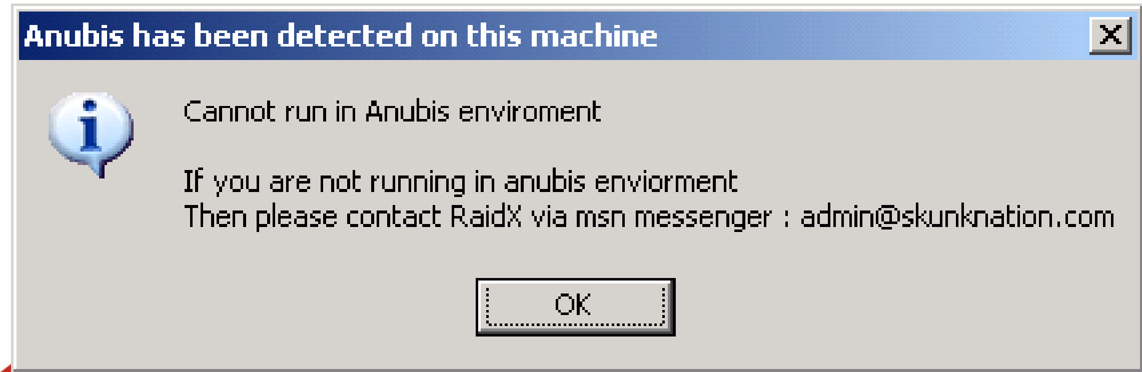
## Bot Analysis

- Bot analysis and IP address blacklisting become a problem
- Bot herders know IP range of <u>public</u> version of ANUBIS

## ANUBIS Detection and Evasion

- Currently we've seen about 0,03% samples ITW with ANUBIS detection capabilities
- ANUBIS is capable of detecting if malware tries to evade ANUBIS



# Some general Sandbox Problems

## Timeout issues (general to automated sandbox analysis)

- Timeouts, how long shall the analysis run?
- Automatic analysis has to quit at some point (when?)

## Most recent timeout problems

- Analysis of Mebroot malware resulted in empty ANUBIS logs
- Mebroot waits several minutes before infecting the system
- Watch out for empty logs!
- Timeout can not be altered in public online version (but in the in-house version this value is customizable)

## Malware waiting for some user interaction

- Mouse movement/clicks, keystrokes, certain URL to be loaded

# Packer with Anti-ANUBIS Features

# Conclusion

## ANUBIS offers technology to speed up malware analysis

- Automatic processing of incoming samples saves valuable time
- ANUBIS improves traditional analysis process flow with its features
- Clustering feature is unique to ANUBIS (AFAIK)
- Can offer additional functionality for "in the cloud" services (already used in academic research projects like WOMBAT/SGNET) See paper for more info on that.

## Public version vs. commercial version

- Commercial version available on request
- Offers more features and keeps your samples in-house
- Offers customization (language, VM OS, 3rd party apps, …)
- Offers integration into you existing pre-sorting process flow

# Questions

**Thank you for your attention!**
**We'd be happy to answer all of your questions!**

**Please send your questions to: anubis@ikarus.at, anubis@iseclab.org or thomas.mandl@mandl-itc.at**