University of Trento

Department of Industrial Engineering

MASTER'S DEGREE IN MECHATRONICS
ENGINEERING

Master's Thesis

Algorithm for Tire Contact Patch Evaluation in Soft Real Time

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Abstract

This dissertation details …

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IDS Intrusion Detection System

IP Internet Protocol 9

SOM Self Organizing Map 9

TCP Trasmission Control Protocol 9

TTL Time To Live 9

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Computation Geometry Algorithms 2

2.1 Ray-Triangle Intersection Algorithm

One of the many problems in Computer Graphics is the ray-triangle intersection.

2.1.1 The Möller-Trumbore Algorithm

The inputs of the Möller-Trumbore algorithm are:

- Triangle vertices (V_1, V_2, V_3);

- Segment points (Q_1, Q_2).

With Back-Face Culling

```
$Q = Q_2 - Q_1$
$E_1 = V_2 - V_1$
$E_2 = V_3 - V_1$
$A = Q \times E_2$
$D = A \cdot E_1$
**if** $(D > \varepsilon)\{$
    $T = Q_1 - V_1$
    $u = A \cdot T$
    **if** $(u < 0.0 \,||\, u > D)\{$
        **return false**
    $\}$
    $B = T \times E_1$
    $v = B \cdot Q$
    **if** $(v < 0.0 \,||\, u + v > D)\{$
        **return false**
    $\}$
$\}$ **else if** $(D < -\varepsilon)\{$
    $T = Q_1 - V_1$
    $u = A \cdot T$
    **if** $(u > 0.0 \,||\, u < D)\{$
        **return false**
    $\}$
    $B = T \times E_1$
    $v = B \cdot Q$
    **if** $(v > 0.0 \,||\, u + v < D)\{$
        **return false**
    $\}$
$\}$ **else** $\{$
    **return false**
$\}$
$D_{inv} = 1.0/D$
$t = (B \cdot E_2) * D_{inv}$
**if** $(t > 0.0)\{$
    $P = Q + D * t$
    **return true**
$\}$ **else** $\{$
    **return false**
$\}$
```

Without Back-Face Culling

```
$Q = Q_2 - Q_1$
$E_1 = V_2 - V_1$
$E_2 = V_3 - V_1$
$A = Q \times E_2$
$D = A \cdot E_1$
**if** $(D < \varepsilon)\{$
    **return false**
$\}$
$T = Q_1 - V_1$
$u = A \cdot T$
**if** $(u < 0.0 \,||\, u > D)\{$
    **return false**
$\}$
$B = T \times E_1$
$v = B \cdot Q$
**if** $(v < 0.0 \,||\, u + v > D)\{$
        **return false**
$\}$
$D_{inv} = 1.0/D$
$t = (B \cdot E_2) * D_{inv}$
**if** $(t > 0.0)\{$
    $P = Q + D * t$
    **return true**
$\}$ **else** $\{$
    **return false**
$\}$
```

A Chapter of Examples 3

3.1 A Table

Feature	Misuse-based	Anomaly-based
Modeled activity:	Malicious	Normal
Detection method:	Matching	Deviation
Threats detected:	Known	Any
False negatives:	High	Low
False positives:	Low	High
Maintenance cost:	High	Low
Attack desc.:	Accurate	Absent
System design:	Easy	Difficult

Table 3.1: Duality between misuse- and anomaly-based intrusion detection techniques. Note that, an anomaly-based IDS can detect "Any" threat, under the assumption that an attack always generates a deviation in the modeled activity.

3.2 Code

```
/* ... */ cd['<'] = {0.1, 0.11} cd['a'] = {0.01, 0.2} cd['b'] =
{0.13, 0.23} /* ... */

b = decode(arg3_value);

```

```
if ( !(cd['c'][0] < count('c', b) < cd['c'][1]) ||\
     !(cd['<'][0] < count('<', b) < cd['<'][1]) ||\
     ... || ...)  fire_alert("Anomalous content detected!");
/* ... */
```

[1] [2] [4] [3]

3.3 A Sideways Table

Approach	Time	Header	Payload	Stochastic	Determ.	Clustering
[phad]		●				●
[kruegel:sac2002:anomaly]		●	●	●		
[protocolanom]		●		●	●	
[ramadas]			●			●
[rules-payl]	●		●		●	
[zanero-savaresi]		●	●			●
[wang:raid2004:payl]			●	●		
[zanero-pattern]		●	●			●
[DBLP:conf/iwia/BolzoniEHZ06]		●	●			●
[wang:raid2006:anagram]			●	●		

Table 3.2: Taxonomy of the selected state of the art approaches for network-based anomaly detection.

3.4 A Figure

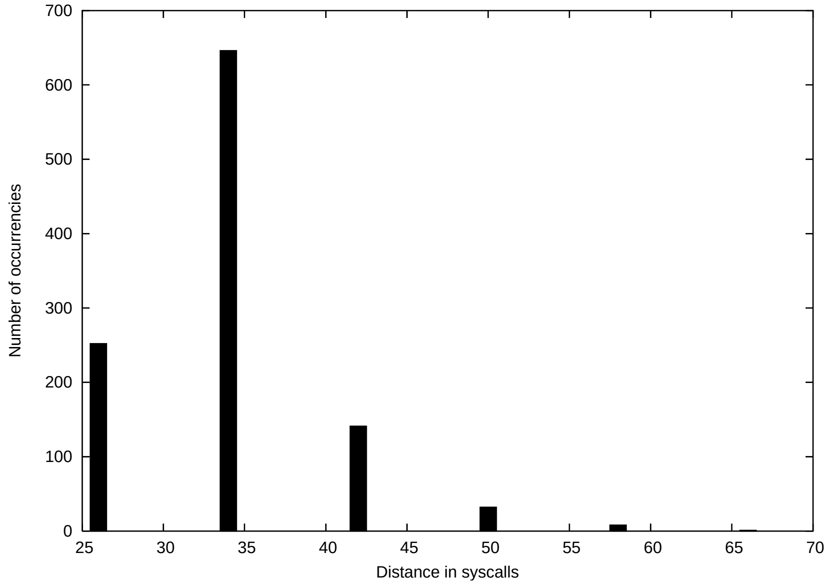

Figure 3.1: `telnetd`: distribution of the number of other system calls among two `execve` system calls (i.e., distance between two consecutive `execve`).

3.5 Bulleted List

- O =“Intrusion”, $\neg O$ =“Non-intrusion”;
- A =“Alert reported”, $\neg A$ =“No alert reported”.

3.6 Numbered List

1. O =“Intrusion”, $\neg O$ =“Non-intrusion”;
2. A =“Alert reported”, $\neg A$ =“No alert reported”.

3.7 A Description

Time refers to the use of *timestamp* information, extracted from network packets, to model normal packets. For example, normal packets may be modeled by their minimum and maximum inter-arrival time.

Header means that the *Trasmission Control Protocol* (TCP) header is decoded and the fields are modeled. For example, normal packets may be modeled by the observed ports range.

Payload refers to the use of the payload, either at *Internet Protocol* (IP) or TCP layer. For example, normal packets may be modeled by the most frequent byte in the observed payloads.

Stochastic means that stochastic techniques are exploited to create models. For example, the model of normal packets may be constructed by estimating the sample mean and variance of certain features (e.g., port number, content length).

Deterministic means that certain features are modeled following a deterministic approach. For example, normal packets may be only those containing a specified set of values for the *Time To Live* (TTL) field.

Clustering refers to the use of clustering (and subsequent classification) techniques. For instance, payload byte vectors may be compressed using a *Self Organizing Map* (SOM) where class of different packets will stimulate neighbor nodes.

3.8 An Equation

$$d_a(i,j) := \begin{cases} K_a + \alpha_a \delta_a(i,j) & \text{if the elements are different} \\ 0 & \text{otherwise} \end{cases} \tag{3.1}$$

3.9 A Theorem, Proposition & Proof

Theorem 3.9.1 $a^2 + b^2 = c^2$

Proposition 3.9.2 $3 + 3 = 6$

Proof 3.9.1 *For any finite set* $\{p_1, p_2, ..., p_n\}$ *of primes, consider* $m = p_1 p_2 ... p_n + 1$. *If* m *is prime it is not in the set since* $m > p_i$ *for all* i. *If* m *is not prime it has a prime divisor* p. *If* p *is one of the* p_i *then* p *is a divisor of* $p_1 p_2 ... p_n$ *and hence is a divisor of* $(m - p_1 p_2 ... p_n) = 1$, *which is impossible; so* p *is not in the set. Hence a finite set* $\{p_1, p_2, ..., p_n\}$ *cannot be the collection of all primes.*

3.10 Definition

Definition 3.10.1 (Anomaly-based IDS) *An* anomaly-based IDS *is a type of IDS that generate alerts $\mathbb{A}$ by relying on normal activity profiles.*

3.11 A Remark

Remark 1 *Although the network stack implementation may vary from system to system (e.g.,* Windows *and* Cisco *platforms have different implementation of TCP).*

3.12 An Example

Example 3.12.1 (Misuse *vs.* Anomaly) *A misuse-based system M and an anomaly-based system A process the same log containing a full dump of the system calls invoked by the kernel of an audited machine. Log entries are in the form:*

```
<function_name>(<arg1_value>, <arg2_value>, ...)
```

3.13 Note

Note 3.13.1 (Inspection layer) *Although the network stack implementation may vary from system to system (e.g.,* Windows *and* Cisco *platforms have different implementation of TCP), it is important to underline that the notion of IP, TCP, HTTP* packet *is well defined in a system-agnostic way, while the notion of* operating system activity *is rather vague and by no means standardized.*

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