MineHunter: A Practical Cryptomining Traffic Detection Algorithm Based on Time Series Tracking

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BACKGROUND

- Cryptomining is a process in which transactions for various forms of cryptocurrency are verified and added to the blockchain digital ledger.
- Cryptojacking, the unauthorized use of someone else’s computer for cryptomining, has become a popular attack similar to ransomware since 2018.
LIMITATIONS OF EXISTING METHODS

- **Malicious mining codes in the websites:**
  - Install a plug-in in the user’s browser, which analyzes the JavaScript code in the website and the usage of the computing resources.
  - Require the cooperation of users and browser vendors and difficult to deploy on a large scale environment.

- **Cryptojacking malware in the host:**
  - Similar to the detection method of malware, mainly by deploying anti-virus software on the host.
  - Only support the general computers and difficult to deploy effectively.

- **Our solutions:**
  - Instead of deploying at the hosts, **MineHunter** detects the cryptomining traffic at the entrance of enterprise or campus networks by traffic analyzing method.
CHALLENGES

- **Extremely unbalanced datasets.**
  - Data imbalance is the core challenge in the field of traffic anomaly detection. Machine learning algorithms usually require a relatively balanced dataset.

- **Uncontrollable number of alarms.**
  - Traditional network traffic anomaly detection algorithms usually have the problem of high false positives and cannot guarantee the specific number of false positives.

- **Traffic confusion.**
  - Common obfuscation techniques include adding proxy, load encryption, port replacement, and packet padding.

- **Online detection.**
  - Due to the rapid growth of network bandwidth in the actual network environment, there are strict restrictions on the computational complexity of the detection algorithm.
INTUITIVE IDEA

- **Two essential characteristics.**
  - One is that the time of task packet issued by a proxy or a mining pool is the same as the time when a new block is created.
  - The other is that cryptomining requires a long period of communication.
**DETECTOR DESIGN**

- **Overview**

![Diagram]

- **Flow data acquisition and preprocessing**
  - Entrance Gateway
  - Mirror
  - Traffic Collection Server
  - Flow Extract

- **Block creation time series acquisition**
  - CryptoCurrency P2P network
  - BlockInfo Collection Server
  - Block Created Timeline

- **Core Detection Algorithm**
  - Interval 1: Flow 1: $s_{11}^1$
  - Interval 1: Flow 2: $s_{12}^1$
  - Interval 1: Flow n: $s_{1n}^1$
  - Interval 2: Flow 1: $s_{21}^2$
  - Interval 2: Flow 2: $s_{22}^2$
  - Interval 2: Flow n: $s_{2n}^2$
  - Interval k: Flow 1: $s_{k1}^k$
  - Interval k: Flow 2: $s_{k2}^k$
  - Interval k: Flow n: $s_{kn}^k$

- **Local Similarity Table**
  - Flow 1: $s_{11}^1$
  - Flow 2: $s_{12}^1$
  - Flow n: $s_{1n}^1$

- **Global Similarity Table**
  - Flow 1: $s_{21}^2$
  - Flow 2: $s_{22}^2$
  - Flow n: $s_{2n}^2$

- **Result**
  - Flow Extract
  - Alerts
CRYPTOMINING TRAFFIC DETECTION ALGORITHM

Cryptomining Traffic Detection Algorithm

- Problem & Target Formulation
  
  Flow set: \( F = \{ f_1, f_2, ..., f_n \} \)
  
  Time Series: \( f = \{ p_1, p_2, ..., p_m \} \)
  
  Time Interval: \([t_s, t_e]\)
  
  Target: for every \( f \) in \( F \) within \([t_s, t_e]\), \( MH(f| [t_s, t_e]) = S \), \( S \in [0, 1] \)

- Local Similarity Algorithm
  
  Naïve Algorithm

  Local interval distance: \( e(f^k) = \min_{x_{k-1} < p < x_k} dis(p, x_{k-1}) \)
  
  \[ dis(p, x_k) = p - x_{k-1} \]

  Local interval Similarity: \( s_l(f^k) = 1 - \frac{e(f^k)}{x_k - x_{k-1}} \)
CRYPTOMINING TRAFFIC DETECTION ALGORITHM

- **Two noisy scenarios**
  - high-frequency and large-scale data communications.
  - periodic heartbeat signals for a long time.
- **Solutions:**
  - Local similarity algorithm based on credible probability estimation
    
    \[ s_l(f^k) = \alpha \cdot (1 - \frac{e(f^k)}{x_k - x_{k-1}}) \]
    
    Random Sequence: \( m_k \) packets, \( n_k \) interval length, \( e_k \) interval distance
    
    \[ P(e = e_k) = \left( \frac{n_k - e_k}{n_k} \right)^{m_k} - \left( \frac{n_k - e_k - 1}{n_k} \right)^{m_k} \]
    
    \[ \alpha = P(e > e(f^k)) \]
CRYPTOMINING TRAFFIC DETECTION ALGORITHM

- **An exemple of** $\alpha$
  - Red: Cryptomining flow
  - Green: high-frequency noise
  - Yellow: low-frequency periodic noise

- **Global Similarity Table (GST)**
  - Iterative algorithm
    - addition increment
    - subtraction decrement

<table>
<thead>
<tr>
<th>Distance</th>
<th># Packets</th>
<th>1</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>60</th>
<th>120</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td></td>
<td>0.992</td>
<td>0.983</td>
<td>0.959</td>
<td>0.920</td>
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<td>0.919</td>
<td>0.846</td>
<td>0.365</td>
<td>0.133</td>
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<tr>
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<td></td>
<td>0.976</td>
<td>0.951</td>
<td>0.881</td>
<td>0.777</td>
<td>0.219</td>
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<tr>
<td>3</td>
<td></td>
<td>0.968</td>
<td>0.935</td>
<td>0.844</td>
<td>0.713</td>
<td>0.131</td>
<td>0.017</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>0.960</td>
<td>0.919</td>
<td>0.808</td>
<td>0.654</td>
<td>0.078</td>
<td>0.006</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>0.952</td>
<td>0.903</td>
<td>0.773</td>
<td>0.599</td>
<td>0.046</td>
<td>0.002</td>
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<tr>
<td>10</td>
<td></td>
<td>0.912</td>
<td>0.826</td>
<td>0.618</td>
<td>0.382</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>0.872</td>
<td>0.751</td>
<td>0.488</td>
<td>0.239</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>0.832</td>
<td>0.681</td>
<td>0.382</td>
<td>0.147</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>
## EVALUATION

### Background Traffic

<table>
<thead>
<tr>
<th>Duration time</th>
<th>Active host number</th>
<th>Total packet number</th>
<th>Total throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 23, 2020-Nov 23, 2020</td>
<td>4096</td>
<td>30 billion</td>
<td>28 TeraByte</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum packets per second</th>
<th>Maximum bits per second</th>
<th>Average flow number per day</th>
<th>Average packet numbe per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>280533 pps</td>
<td>1.3 Gbit/s</td>
<td>4.7 million</td>
<td>0.9 billion</td>
</tr>
</tbody>
</table>

### CryptoMining Traffic

- 21 Monero mining pool nodes
- cover nearly 80% computing power
- all through TLS protocol
- duration time same as background traffic
- Merge traffic by mergecap
- Replay the traffic for detection

### Ethical Considerations

- IP addresses anonymized, Payload removed.
- Accordance with the policies defined by our institution.
EVALUATION RESULTS

- Challenge 1: Extremely unbalanced data
- Detection case number: $21 \times 48 \times 32 = 30000$ cases for $t_i=0.5$ h
- Evaluation results of Minehunter (2h-0.6, precision 97%, recall 99.7%)
EVALUATION RESULTS

- **Challenge 2: Uncontrollable number of alarms**

- Alert Condition: Check from the head of the table, and stop checking if a false alarm is found.

- When the detection time is set to 2h, the algorithm’s recall can reach 99.8%.
EVALUATION RESULTS

- **Challenge 3: Traffic confusion**
- Common method: proxy, load encryption, port replacement, and packet padding
- “White Box”:
  - Packet Delay:
    - When the delay time is less than 10s, the overall performance of the algorithm is less affected.
  - Packet amplification:
    - The algorithm can effectively combat packet amplification by 10 times.
EVALUATION RESULTS

- **Challenge 4: Online detection**
- **Average Speed:** 350,000 pps

### Scalability

- Different cryptocurrencies
- Websites with embedded mining code

<table>
<thead>
<tr>
<th>Mining Service</th>
<th>Cryptocurrency</th>
<th>Protocol</th>
<th>Proxy IP</th>
<th>Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CryptoLoot[6]</td>
<td>Uplexa</td>
<td>TLSv1.2</td>
<td>45.79.218.212</td>
<td>0.80</td>
</tr>
<tr>
<td>Crypto Webminer[7]</td>
<td>Sumokoin</td>
<td>TLSv1.2</td>
<td>185.163.119.151</td>
<td>0.78</td>
</tr>
<tr>
<td>Monerominer.rock[22]</td>
<td>Masari</td>
<td>TLSv1.2</td>
<td>157.230.173.68</td>
<td>0.93</td>
</tr>
</tbody>
</table>
In this work, we propose **MineHunter**, a practical cryptomining traffic detection algorithm, which can be deployed at the entrance of enterprise or campus networks.

Our algorithm has attempted to solve the four core challenges faced in the actual network environment, including extremely unbalanced datasets, controllable alarms, traffic confusion, and efficiency.

We conduct a large-scale evaluation experiment in a campus network environment within one month. The experimental results show that our algorithm can achieve 97.0% precision and 99.7% recall on the extremely unbalanced dataset.
THANKS FOR LISTENING

Public codes and datasets: https://github.com/zsz147/MineHunter
For more information, please contact me.

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