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

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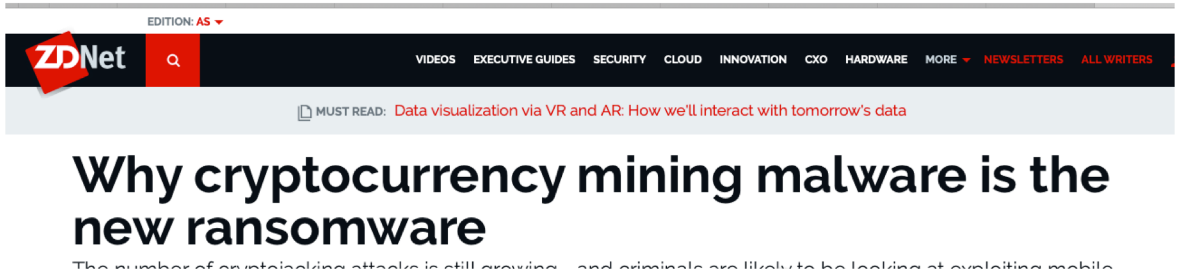
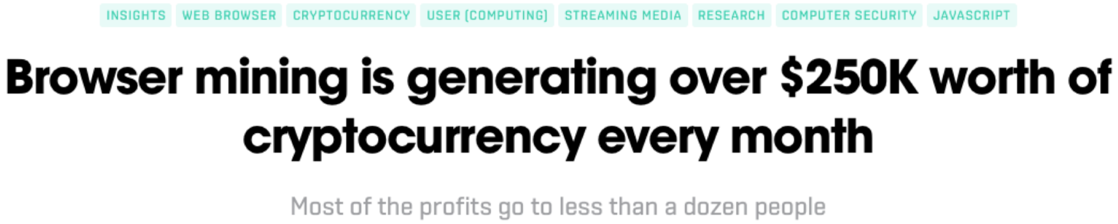
BACKGROUND

- 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

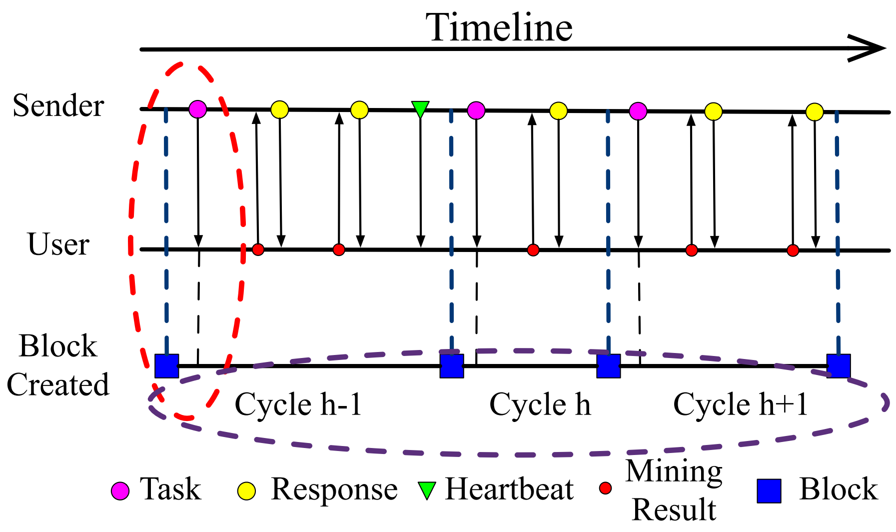
- **Malicious mining codes in the websites:**
  - Install a plug-in in the user's browser, which analyzes the JavaScript code in the website and the usage of the computing resources.
  - Require the cooperation of users and browser vendors and difficult to deploy on a large scale environment.
- **Cryptojacking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

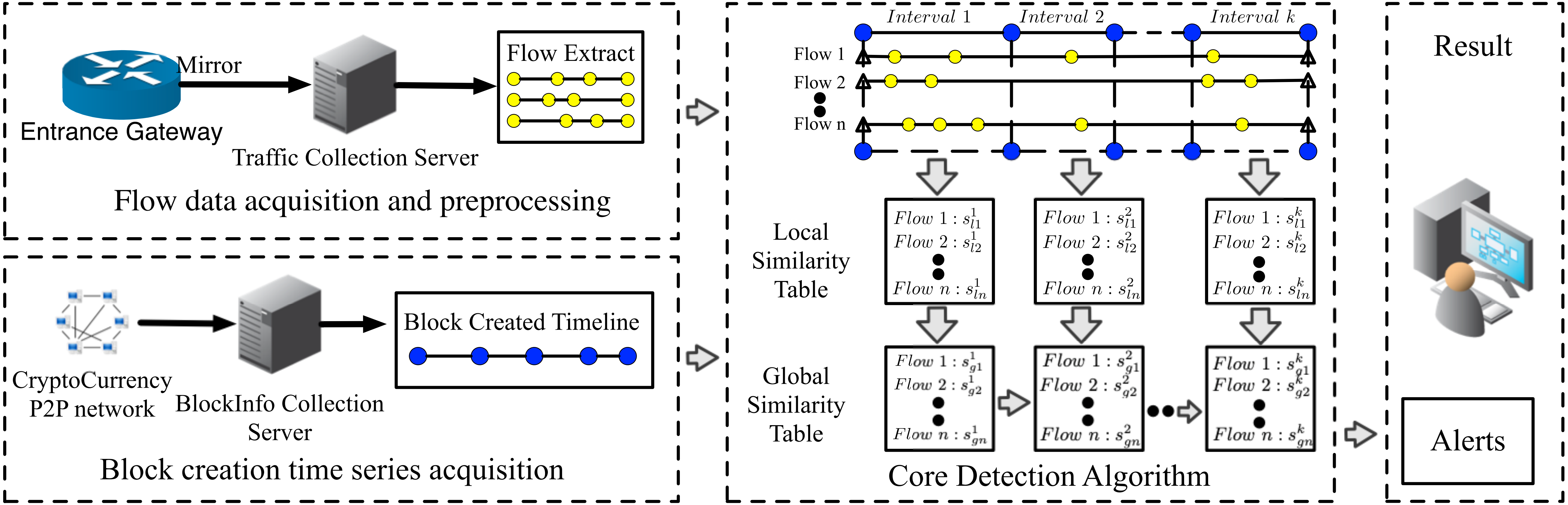
INTUITIVE IDEA

- **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**



CRYPTOMINING TRAFFIC DETECTION ALGORITHM

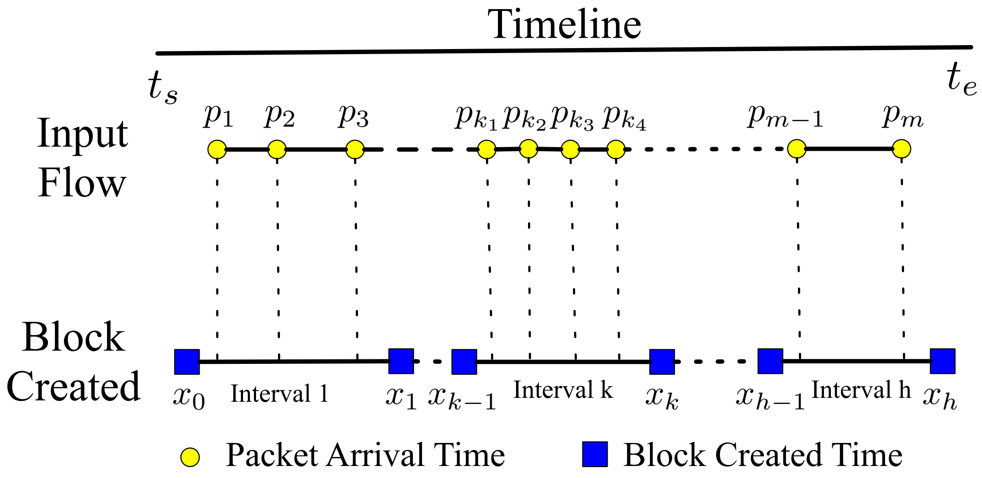
- **Cryptomining Traffic Detection Algorithm**
  - **Problem & Target Formulation**

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

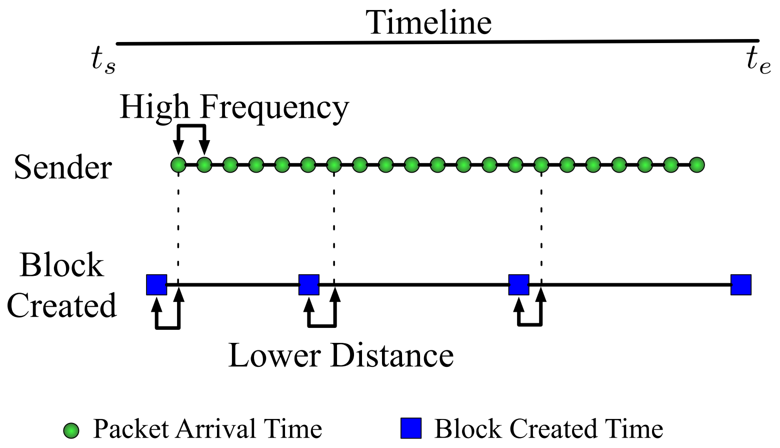
- **Two noisy scenarios**
  - ➢ high-frequency and large-scale data communications.
  - ➢ periodic heartbeat signals for a long time.
- **Solutions:**
  - Local similarity algorithm based on credible probability estimation

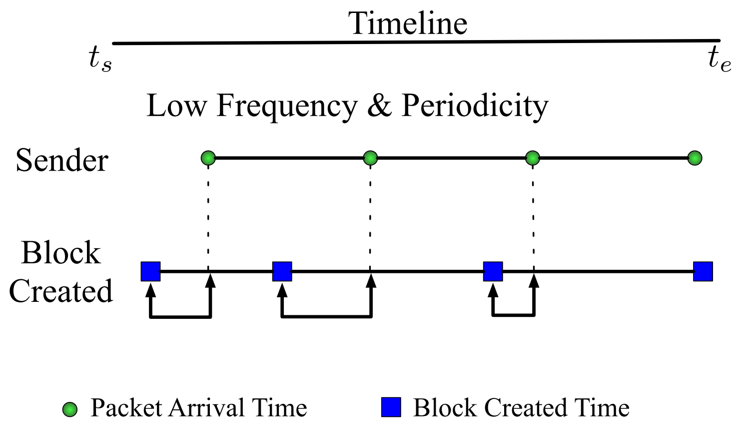
$$s_l(f^k) = \alpha * (1 - \frac{e(f^k)}{x_k - x_{k-1}})$$

Random Sequence: m_k packets, n_k interval length, e_k interval distance

$$P(e = e_k) = (\frac{n_k - e_k}{n_k})^{m_k} - (\frac{n_k - e_k - 1}{n_k})^{m_k}$$

$$\alpha = P(e > e(f^k))$$





CRYPTOMINING TRAFFIC DETECTION ALGORITHM

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

Distance \ # Packets	1	2	5	10	60	120
0	0.992	0.983	0.959	0.920	0.605	0.366
1	0.984	0.967	0.919	0.846	0.365	0.133
2	0.976	0.951	0.881	0.777	0.219	0.048
3	0.968	0.935	0.844	0.713	0.131	0.017
4	0.960	0.919	0.808	0.654	0.078	0.006
5	0.952	0.903	0.773	0.599	0.046	0.002
10	0.912	0.826	0.618	0.382	0.003	0.001
15	0.872	0.751	0.488	0.239	0.001	0.001
20	0.832	0.681	0.382	0.147	0.001	0.001

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

EVALUATION

- **Background Traffic**

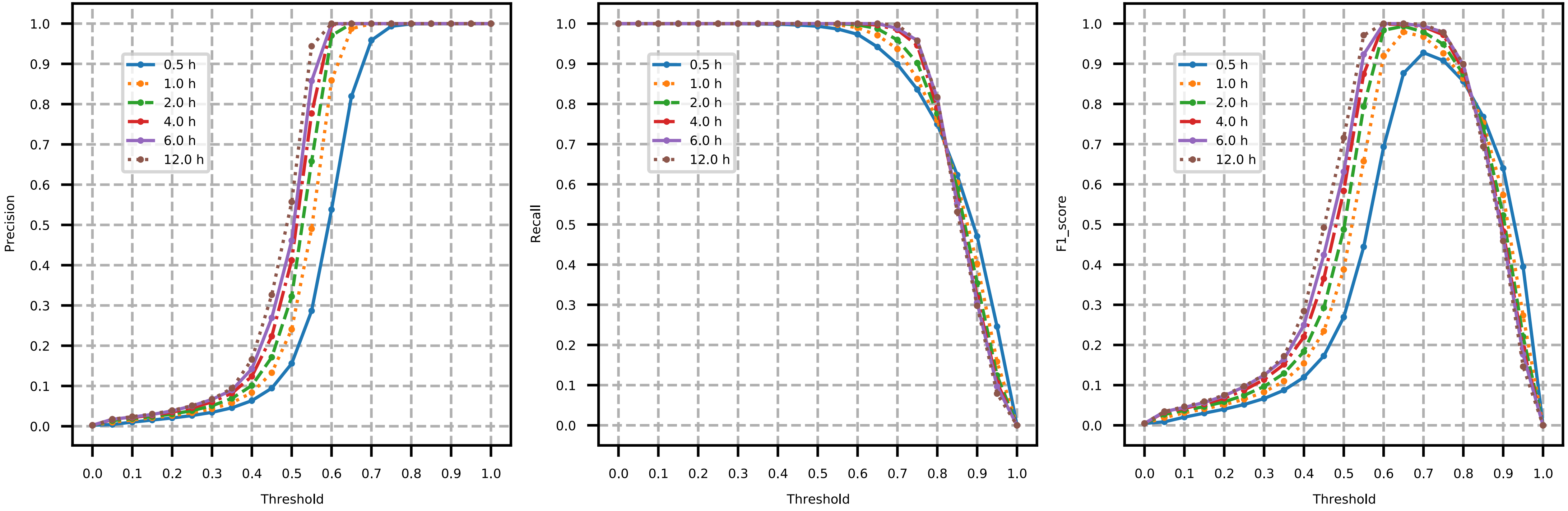
Duration time	Active host number	Total packet number	Total throughput
Oct 23, 2020-Nov 23, 2020	4096	30 billion	28 TeraByte
Maximum packets per second	Maximum bits per second	Average flow number per day	Average packet numbe per day
280533 pps	1.3 Gbit/s	4.7 million	0.9 billion

- **Ethical Considerations**
  - IP addresses anonymized, Payload removed.
  - Accordance with the policies defined by our institution.

- **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

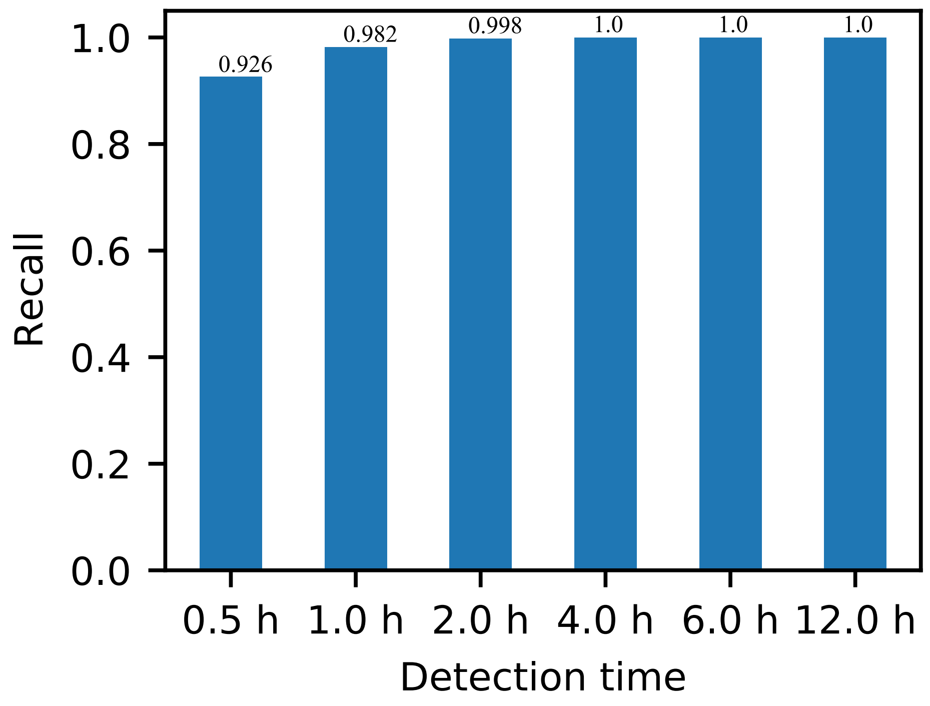
EVALUATION RESULTS

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



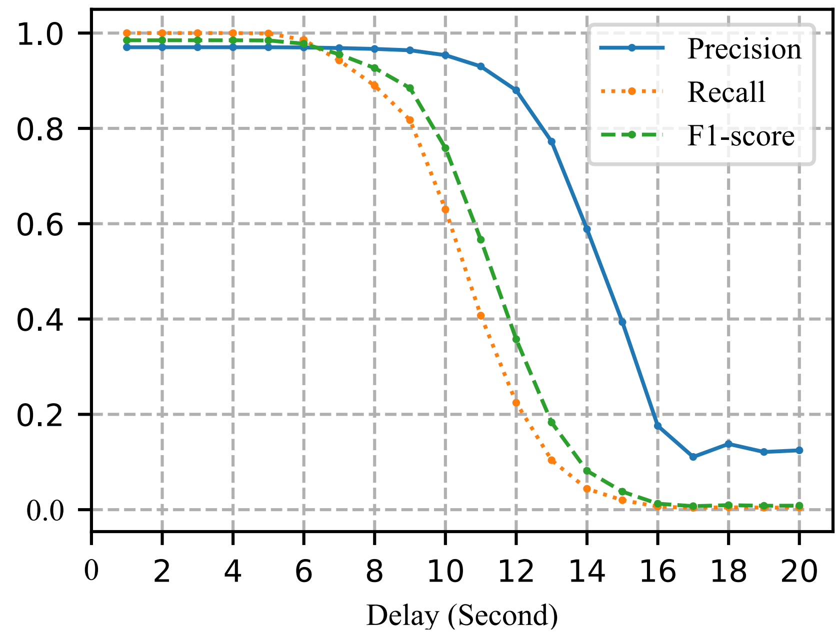
EVALUATION RESULTS

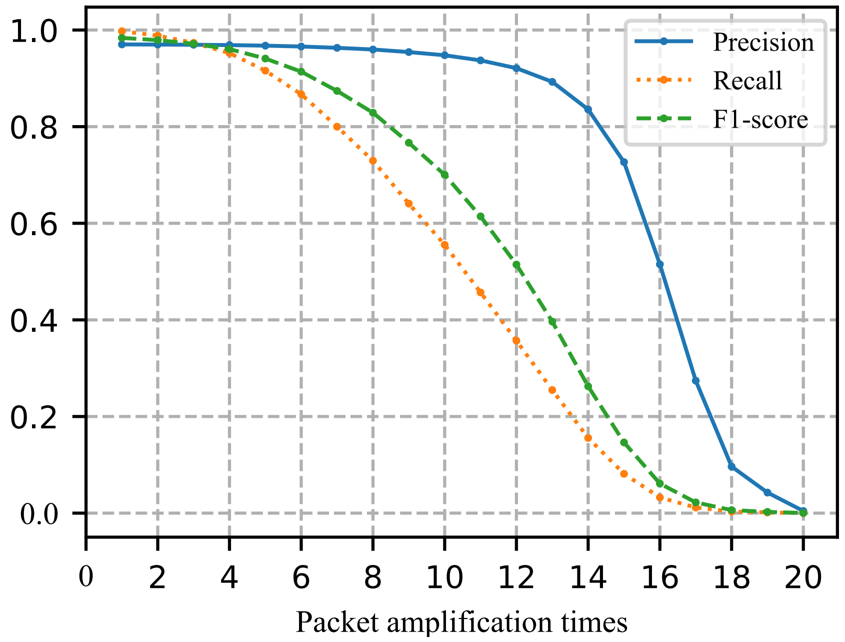
- **Challenge 2: Uncontrollable number of alarms**
- Alert Condition: Check from the head of the table, and stop checking if a false alarm is found.
- When the detection time is set to 2h, the algorithm's recall can reach 99.8%.



EVALUATION RESULTS

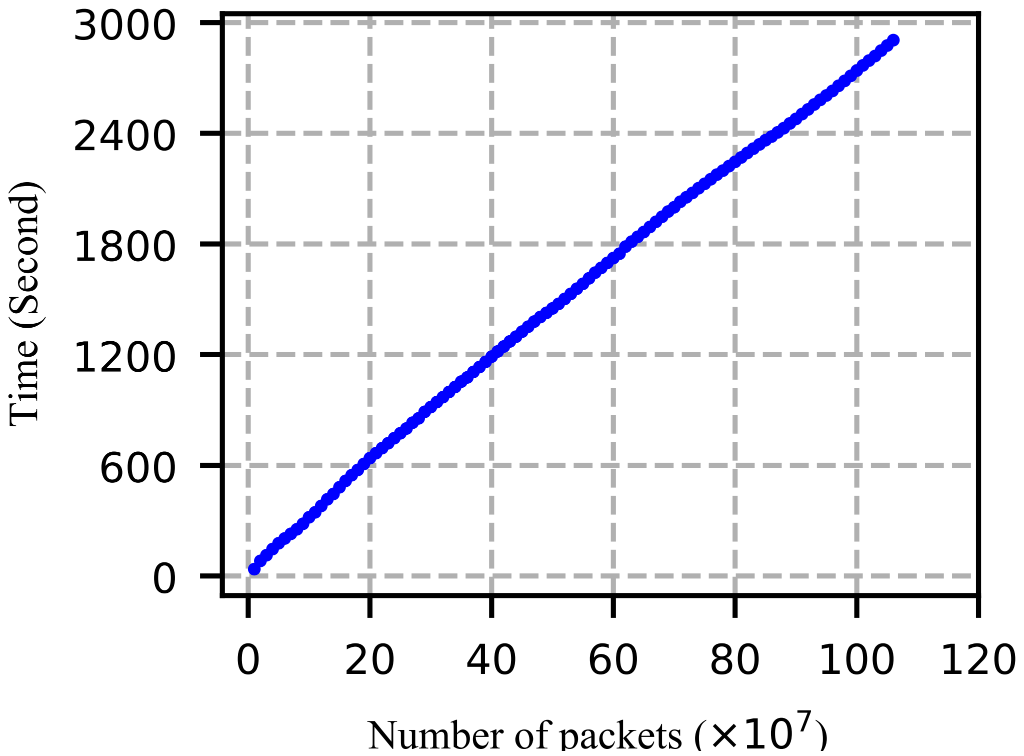
- **Challenge 3: Traffic confusion**
- Common method: proxy, load encryption, port replacement, and packet padding
- “White Box”:
  - Packet Delay:
    - When the delay time is less than 10s, the overall performance of the algorithm is less affected.
  - Packet amplification:
    - The algorithm can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



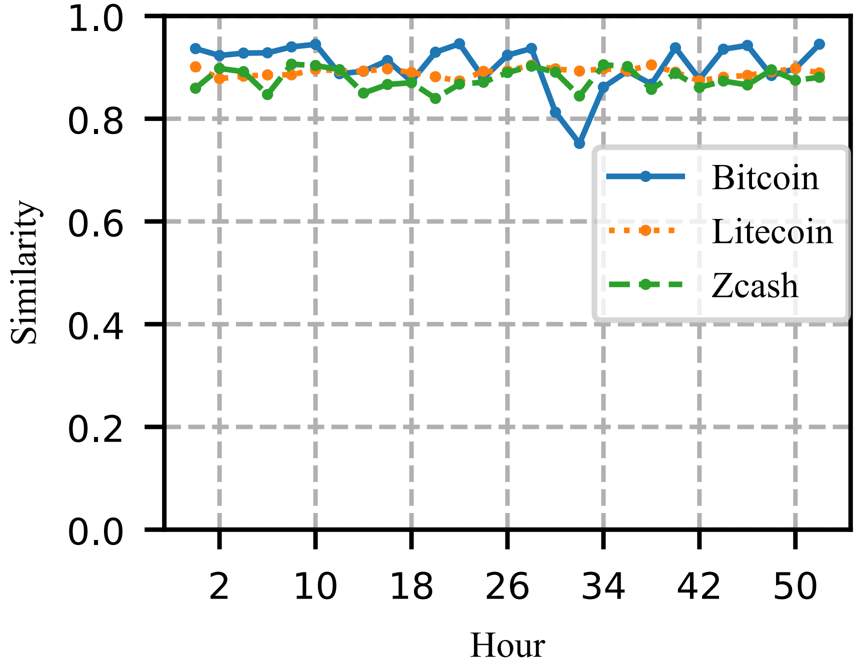


EVALUATION RESULTS

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



- **Scalability**
  - Different cryptocurrencies
  - Websites with embedded mining code



Mining Service	Cryptocurrency	Protocol	Proxy IP	Similarity
CryptoLoot[6]	Uplexa	TLSv1.2	45.79.218.212	0.80
Crypto Webminer[7]	Sumokoin	TLSv1.2	185.163.119.151	0.78
Moneromimer.rock[22]	Masari	TLSv1.2	157.230.173.68	0.93

CONCLUSION

- 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

Q & A

Public codes and datasets: https://github.com/zsz147/MineHunter

For more information, please contact me.

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