SST Testbed:

An Experimental Platform of Attacks and Defenses for Networked Embedded Systems

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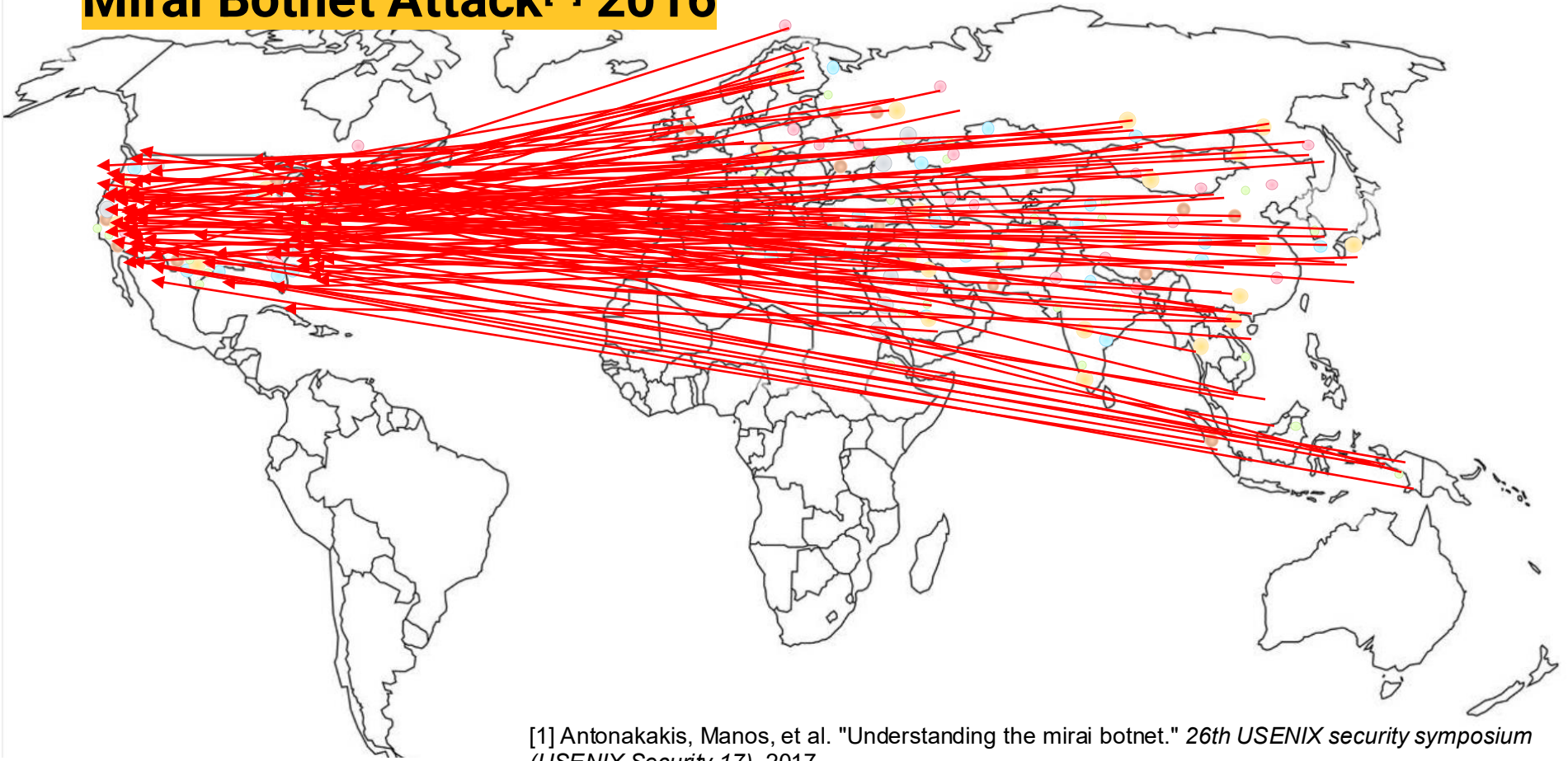
Websites:

- https://labs.engineering.asu.edu/kim/
- https://jakio815.github.io/
- https://hokeun.github.io/

Mirai Botnet Attack[1] 2016



[1] Antonakakis, Manos, et al. "Understanding the mirai botnet." *26th USENIX security symposium (USENIX Security 17)*. 2017.

Motivation

- **Problem**
  - Rapid growth of IoT/embedded devices.
  - Widely integrated into daily life and infrastructure.
  - Limited resources + always connected to Internet→ **highly vulnerable.**
  - Large-scale IoT attacks (e.g. Mirai Botnet)[1] highlight serious risks.

- **Current limitations**
  - Traditional frameworks (e.g., Kerberos) not suitable for constrained devices.
  - Lack of lightweight testbeds for realistic attack/defense experiments.

-> SST Testbed for simulating network attacks on embedded/IoT systems.

[1] M. Antonakakis *et al*., 'Understanding the Mirai Botnet', in *26th USENIX Security Symposium (USENIX Security 17)*, 2017, pp. 1093–1110.

Contributions

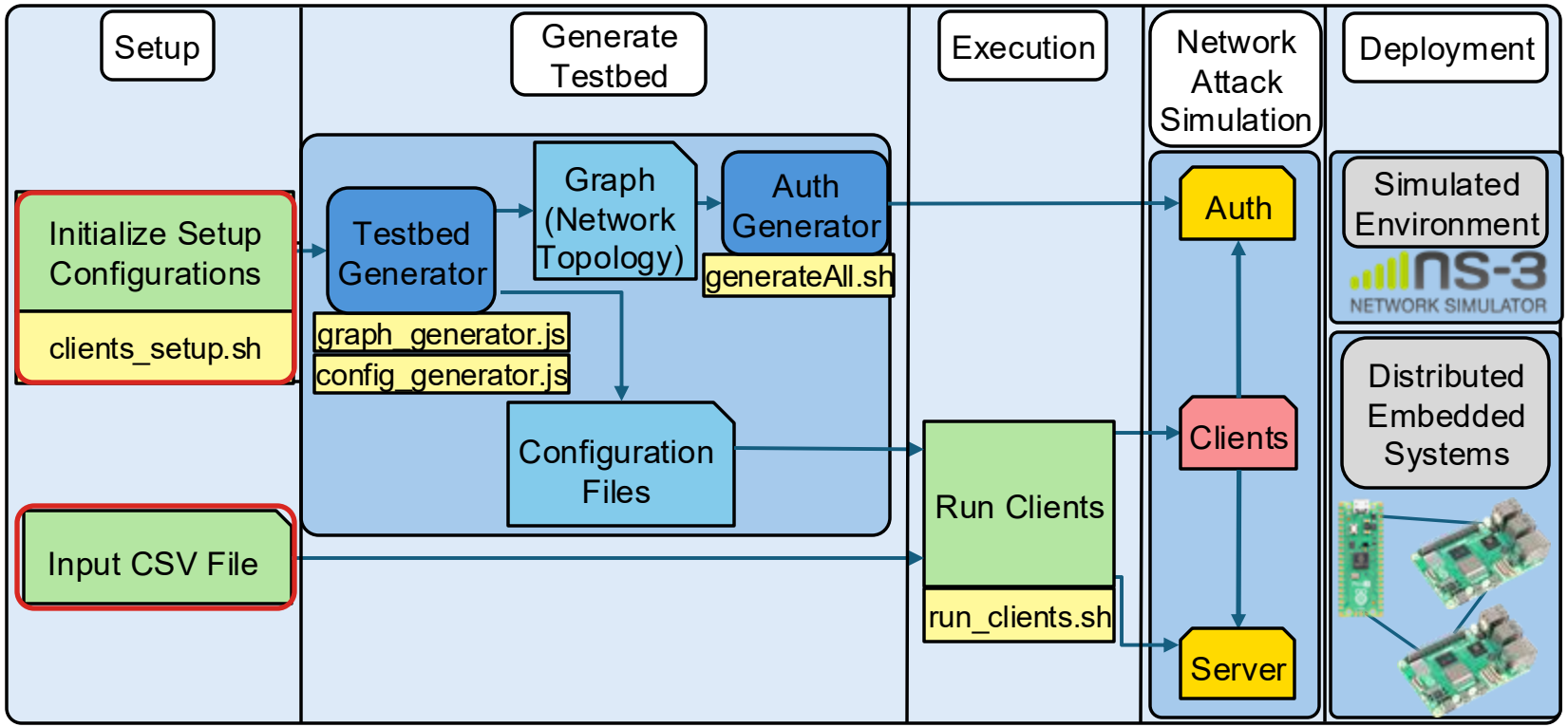
- Propose SST Testbed that **supports common network attacks**, including replay, SYN-flood, DoS & DDoS attacks.
- Support **parameterized inputs** to specify diverse attack scenarios.
- **Fully open-sourced** for researchers and developers.
- Can be used as an **educational tool for hands-on experience** of real world attack and defenses.

Background

- **Network Attacks Supported**
  - **Replay Attacks:** Intercepted messages retransmitted to bypass authentication.
  - **Denial-of-Service (DoS) Attacks:** Overwhelming a service to make it unavailable.
- **Secure Swarm Toolkit (SST)[2]**
  - An open-source secure network tool with key distribution mechanisms for embedded devices.
  - ***Auth***, a local Key Distribution Center (KDC) for IoT sites. https://github.com/iotauth/
    - Provides **authentication and authorization** to local devices.
    - Locally centralized, but globally decentralized.
  - Provides a C API for embedded devices.

[2] Hokeun Kim, Eunsuk Kang, Edward A. Lee, and David Broman. 2017. A Toolkit for Construction of Authorization Service Infrastructure for the Internet of Things. In Proceedings of the Second International Conference on Internet-of-Things Design and Implementation (IoTDI '17). Association for Computing Machinery, New York, NY, USA, 147–158.

Design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Execution
Network Attack Simulation
Deployment
Initialize Setup Configurations
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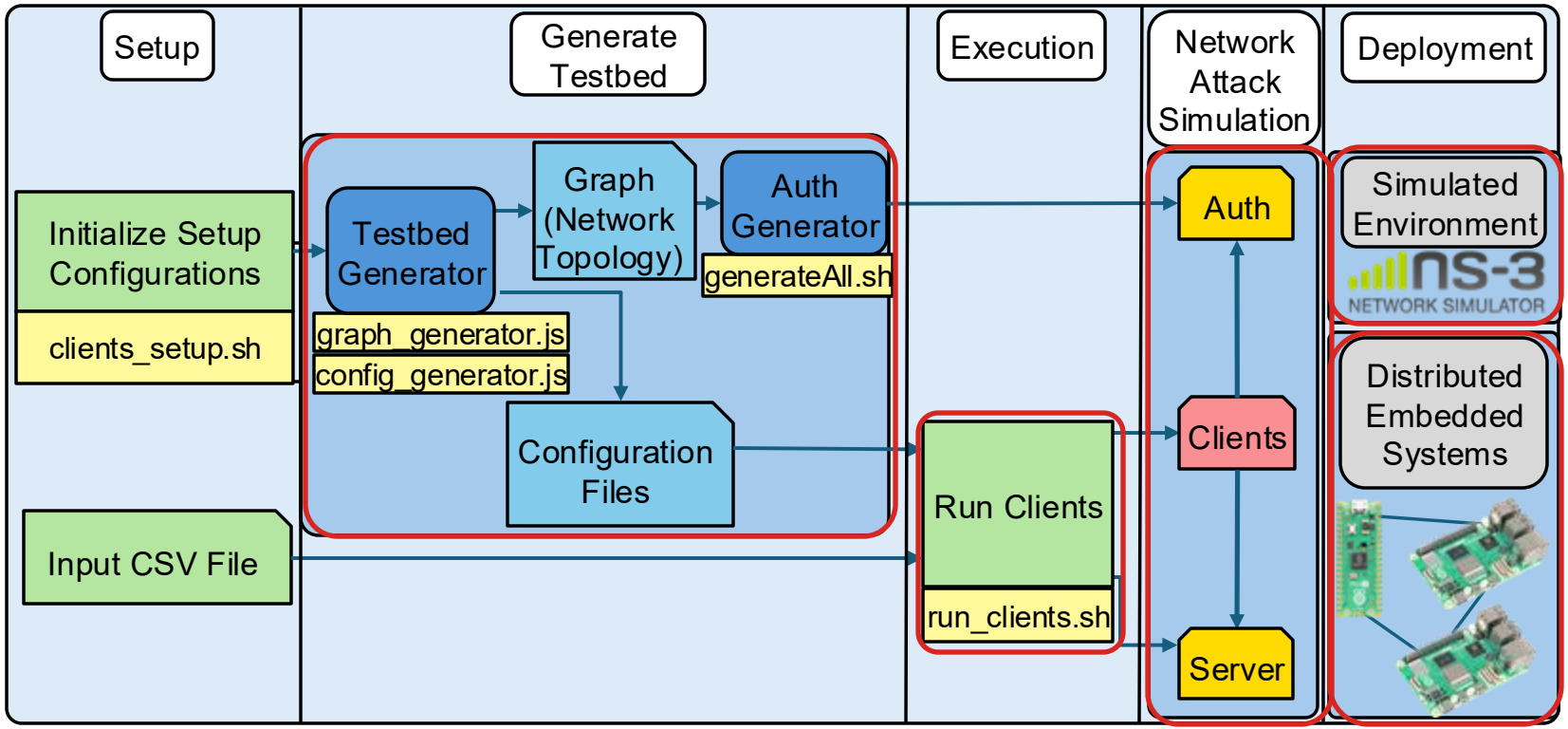
Input CSV File
Testbed Generator
Graph (Network Topology)
Auth Generator
generateAll.sh
graph_generator.js
config_generator.js
Configuration Files
Run Clients
run_clients.sh
Auth
Clients
Server
Simulated Environment
ns-3
NETWORK SIMULATOR
Distributed Embedded Systems

Design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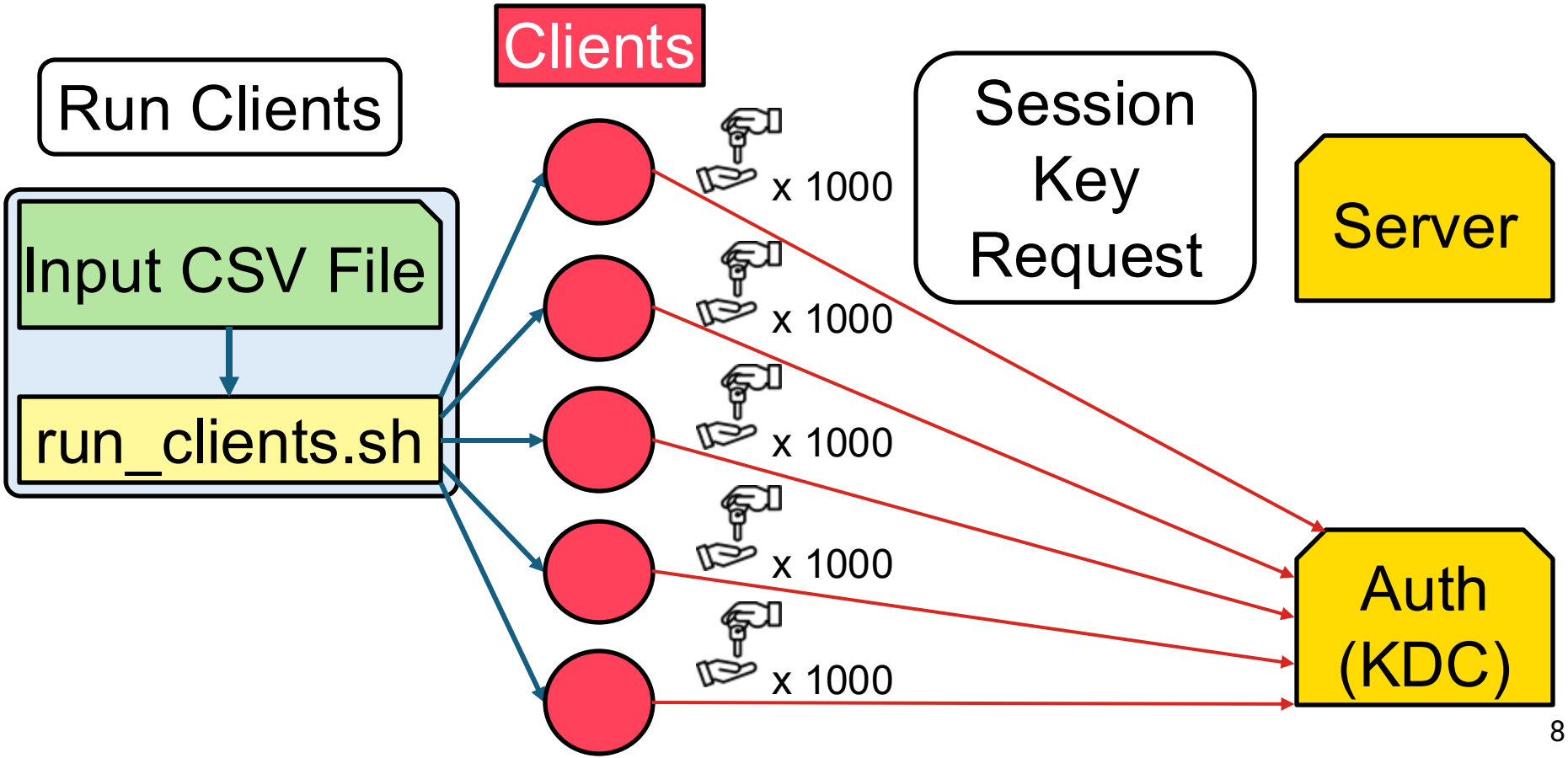
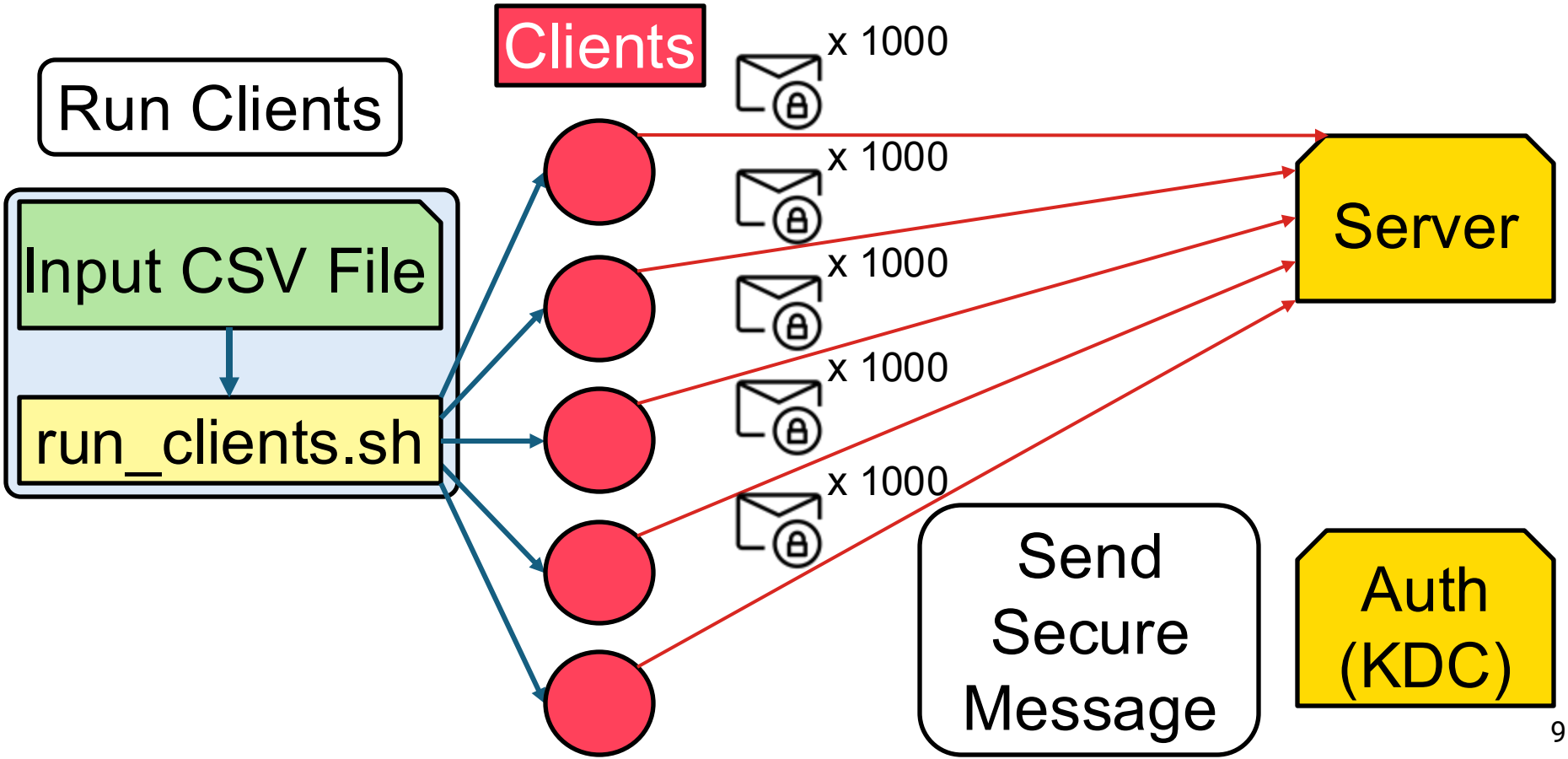
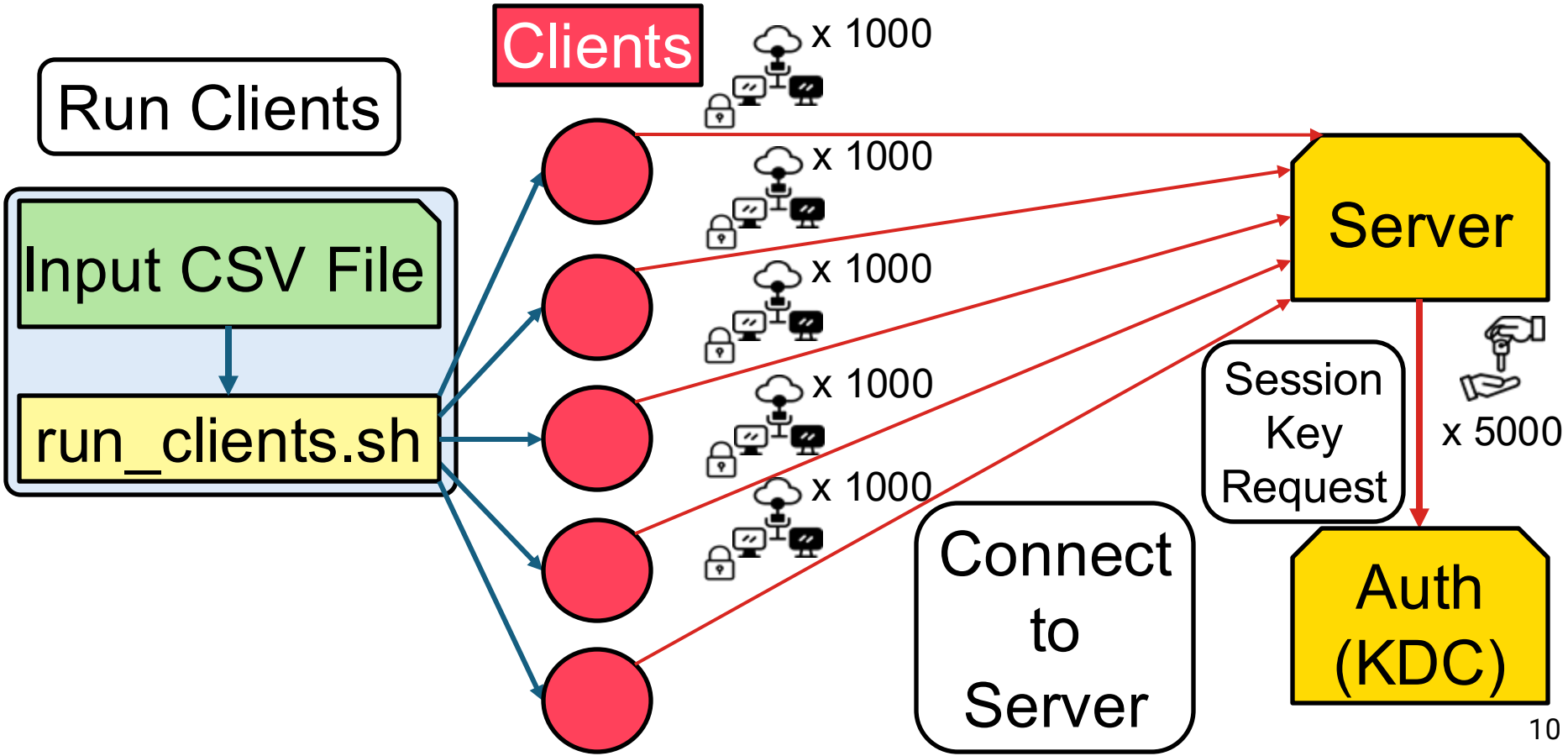
Attack on the Auth (Key Distribtuion Center)



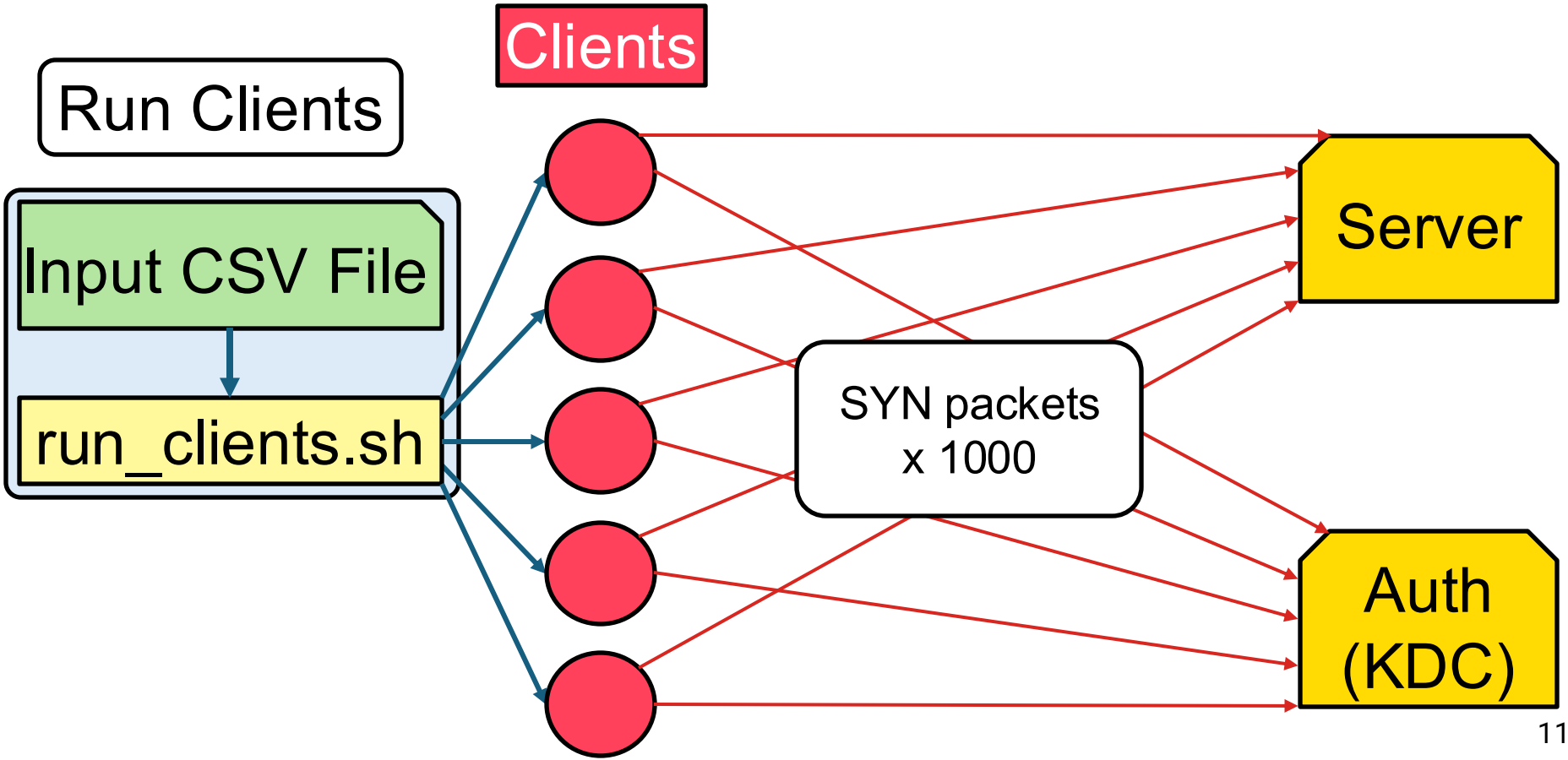
Attack on the Server



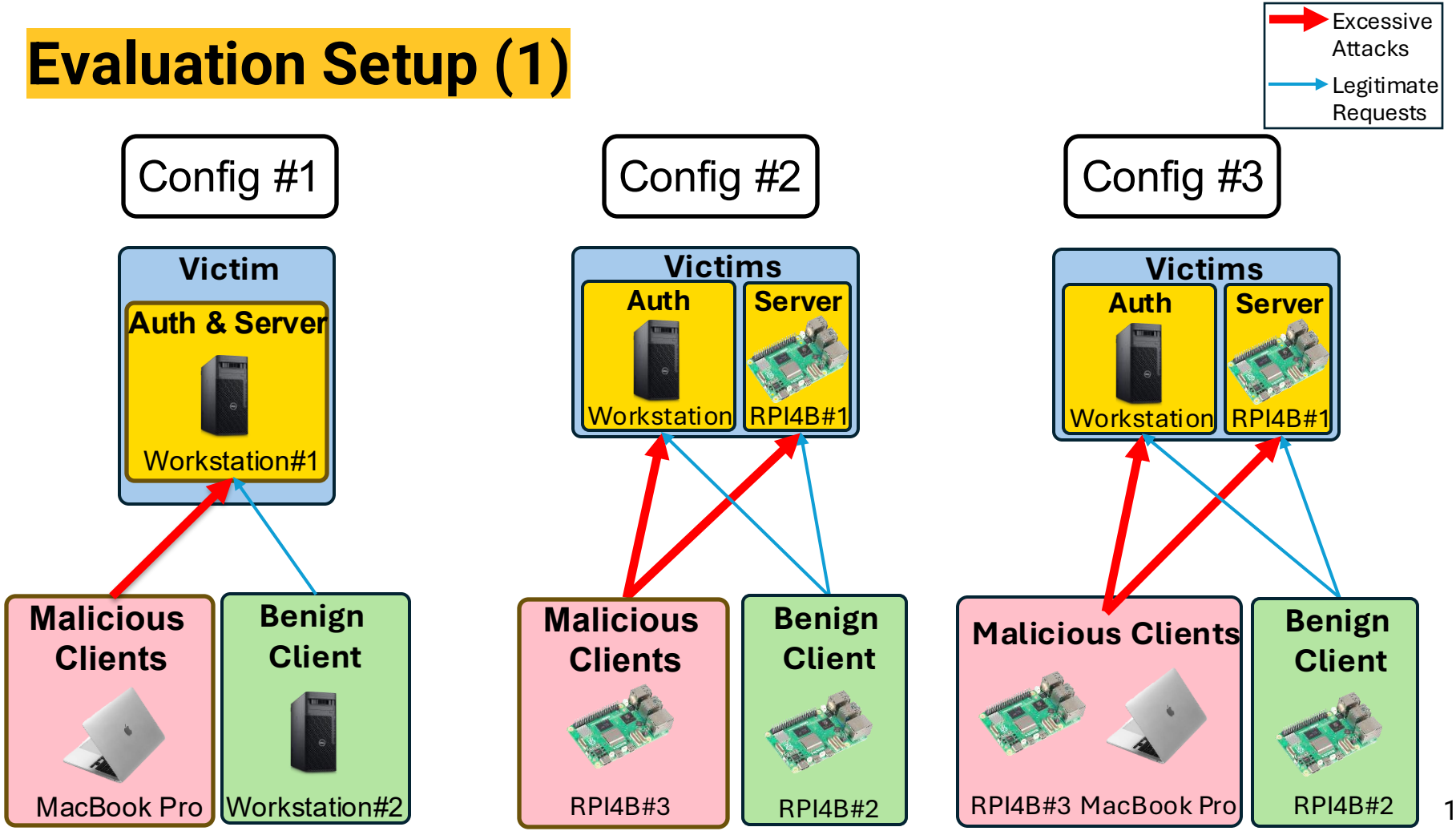
Attack on the Auth (KDC) via the Server



SYN flood attack



Evaluation Setup (1)

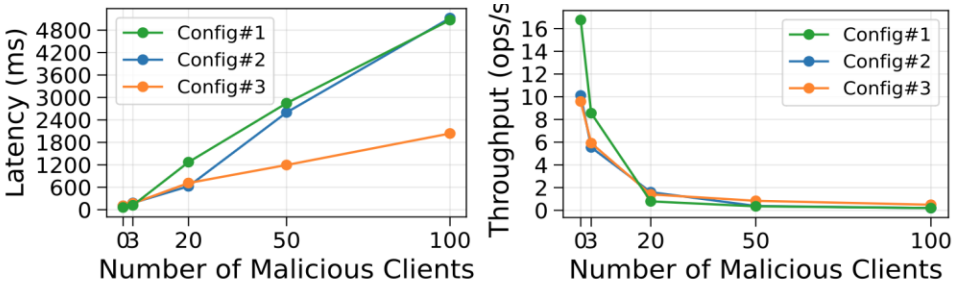


Evaluation Setup (2)

- **Setup**
  - Increase number of malicious clients from **0 to 100.**
  - All in same network.
  - **Latency**: Average response time.
  - **Throughput**: Completed operations per second.

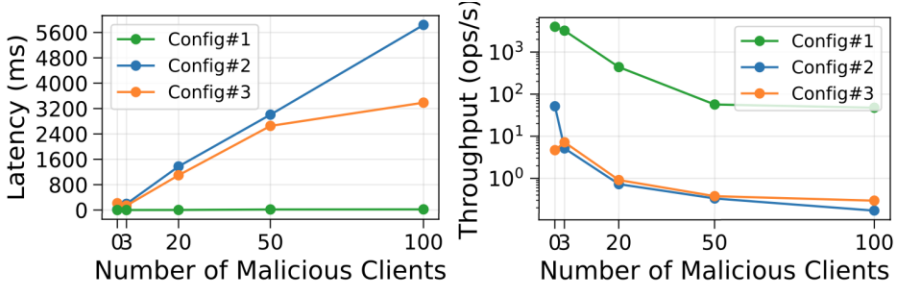
Evaluation Results (1)

- **Performance**
  - **Latency**: Increased up to 301 times.
  - **Throughput**: Decreased up to 99.99 percent.



(a) Latency degradation (b) Throughput degradation

Fig. 6: DDoS Key Attack Latency and Throughput

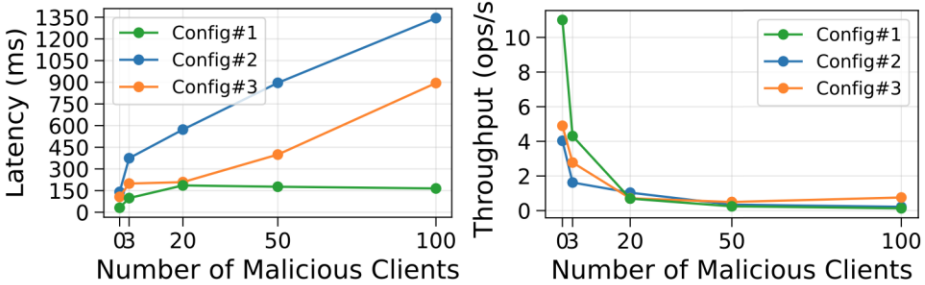


(a) Latency degradation (b) Throughput (log scale)

Fig. 7: DDoS Message Attack Latency and Throughput

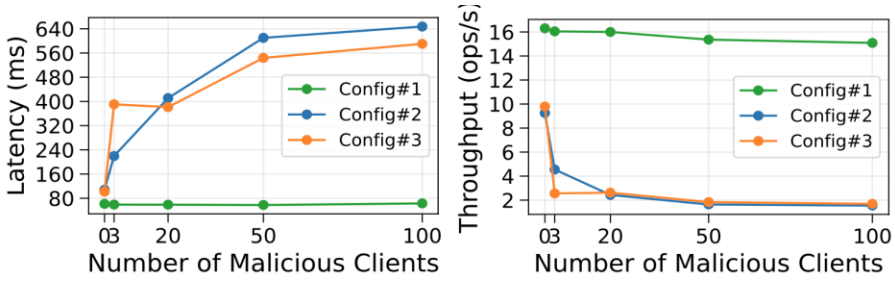
Evaluation Results (2)

- **Further results**
  - **Connect attack:** Legitimate clients fail connections.
  - Successful attacks only using resource –constraint device



(a) Latency degradation (b) Throughput degradation

Fig. 8: DDoS Connect Attack Latency and Throughput



(a) Latency degradation (b) Throughput degradation

Fig. 9: DDoS Syn Flood Latency and Throughput

Summary

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KNOWLEDGEABLE & INTERACTIVE MACHINES

- Propose **SST Testbed, an open-source platform** for simulating network attacks in IoT and embedded systems.
- Support **parameterized inputs** to specify diverse attack scenarios.
- **Evaluation** demonstrates that even a small number of malicious devices can cause severe performance degradation.
- For future work, we plan **to integrate defense mechanisms** into the testbed framework.

https://github.com/iotauth/sst-c-api

IEEE Industrial Electronics Society

Websites:
- https://labs.engineering.asu.edu/kim/
- https://jakio815.github.io/
- https://hokeun.github.io/

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