Invisible Probe: Timing Attacks with PCIe Congestion Side-channel

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PCIe protocol

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- De facto protocol to connect CPU and peripheral devices

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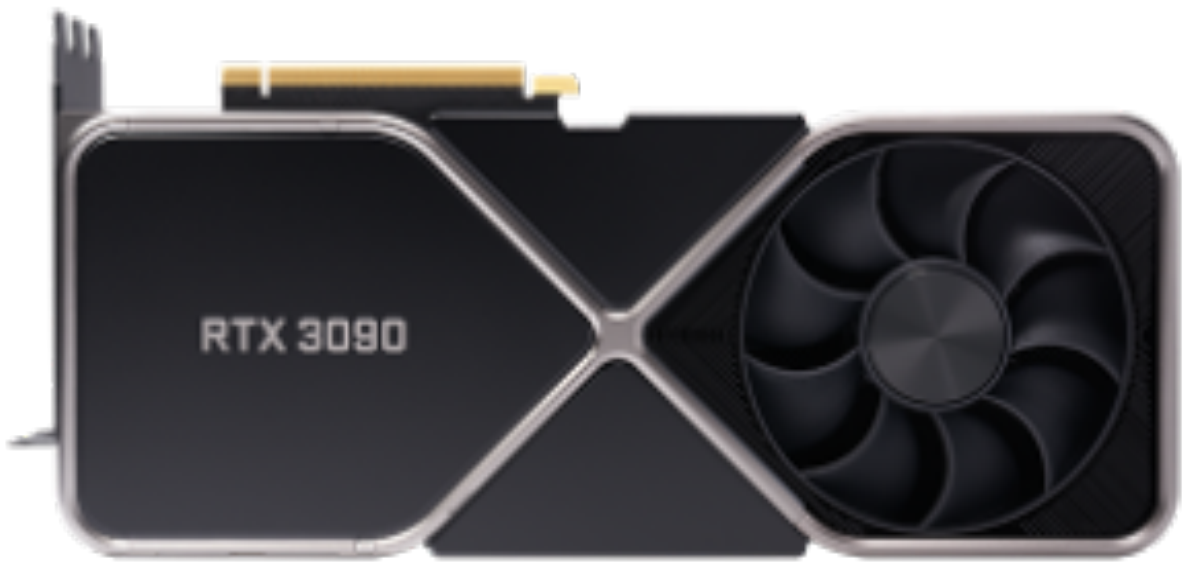
GAP!



IO Switches to support more PCIe interfaces

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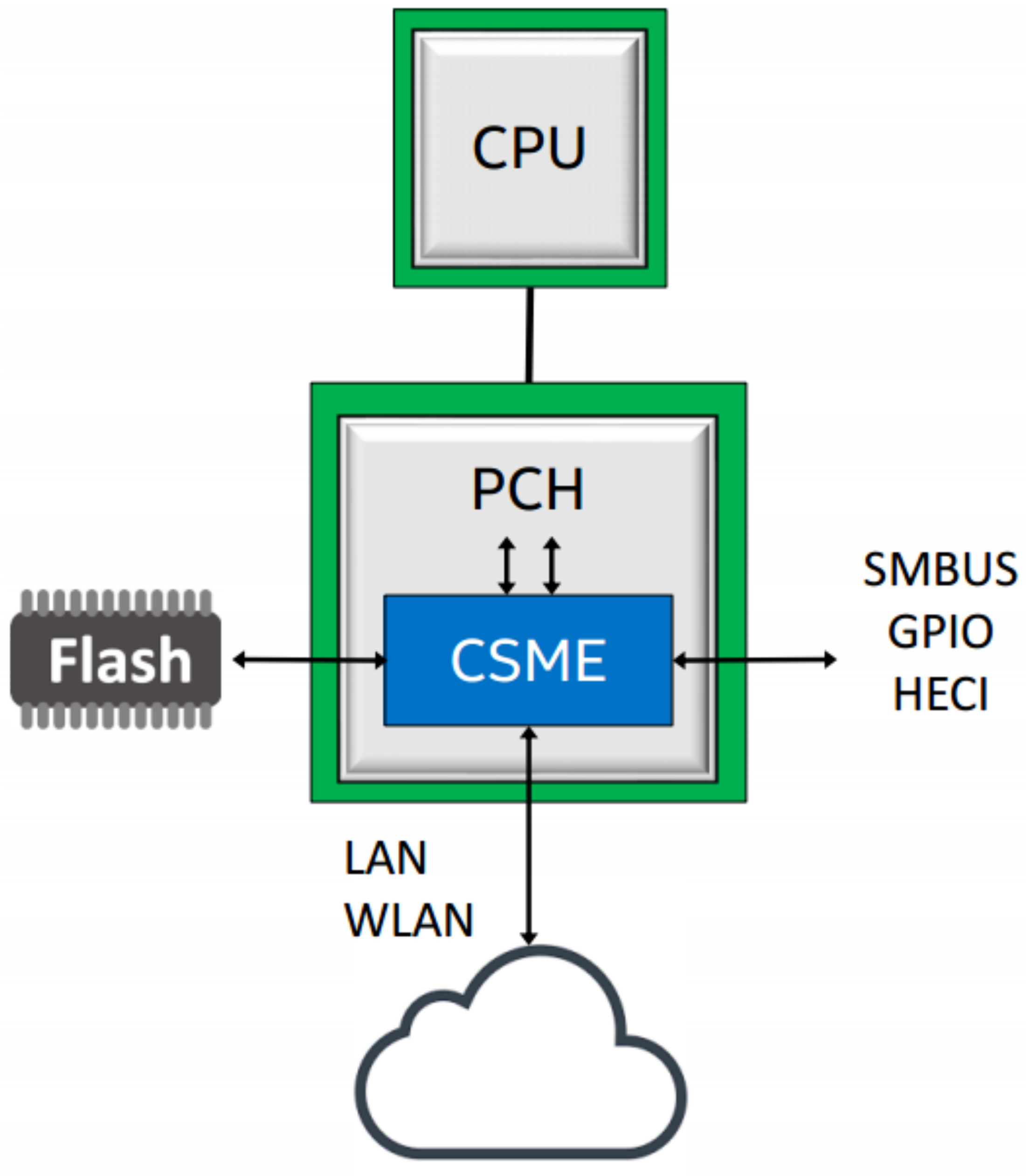
Platform Controller Hub (PCH)



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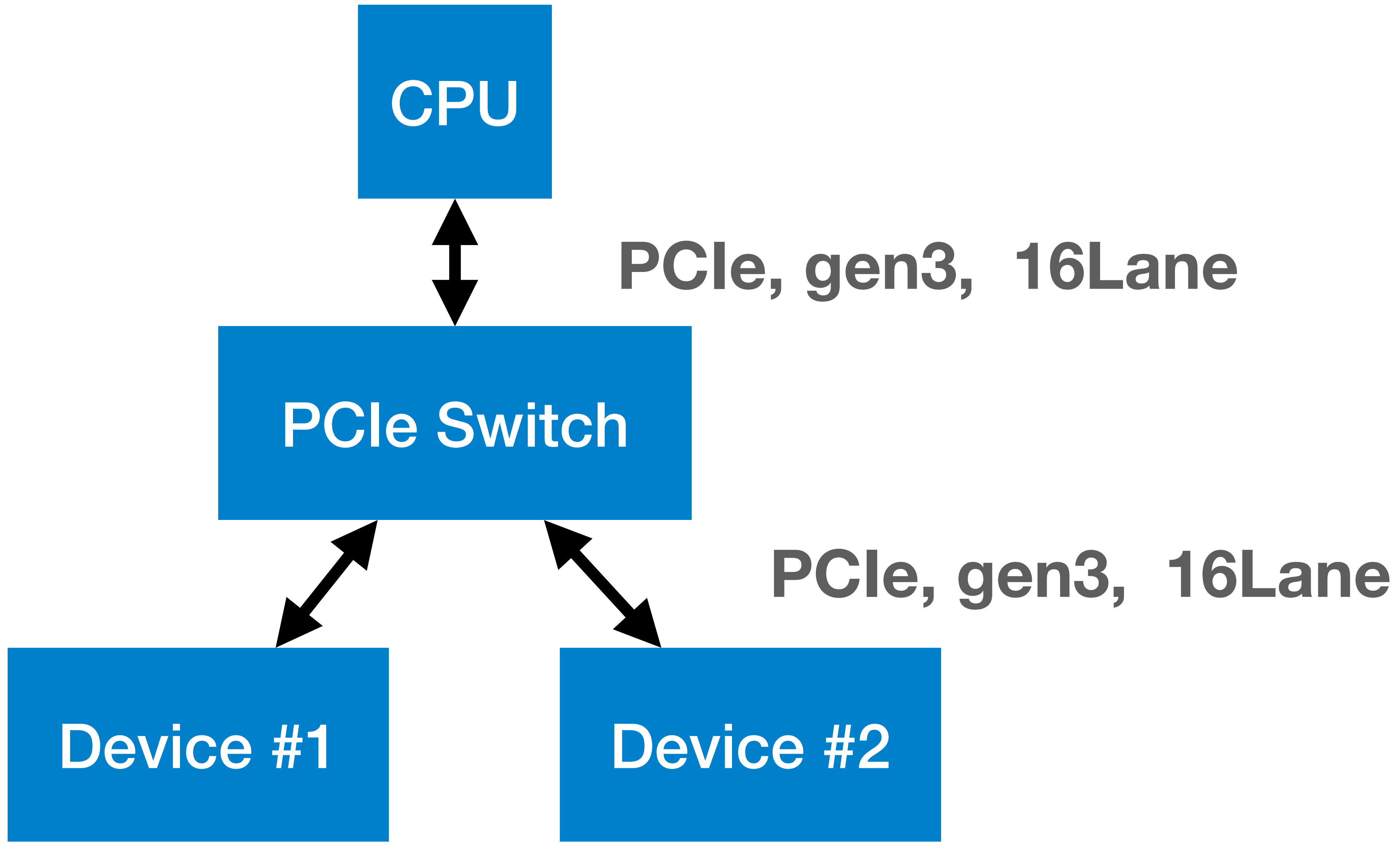
PCIe Switch



Problems of sharing channels

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- Throughput decrease

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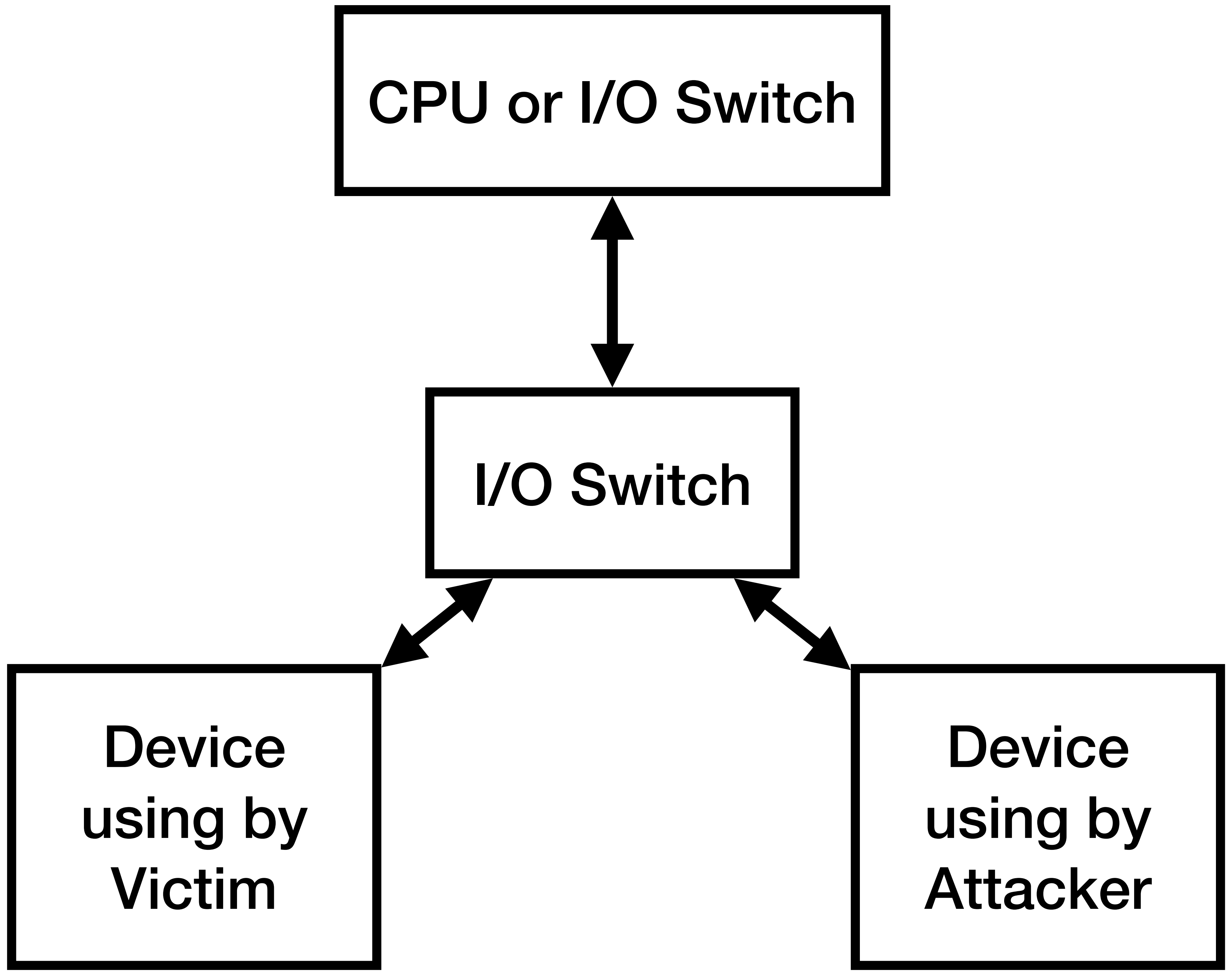
- Delays introduced
- Secrets leaking! (Side Channel Attack)

Threat Model



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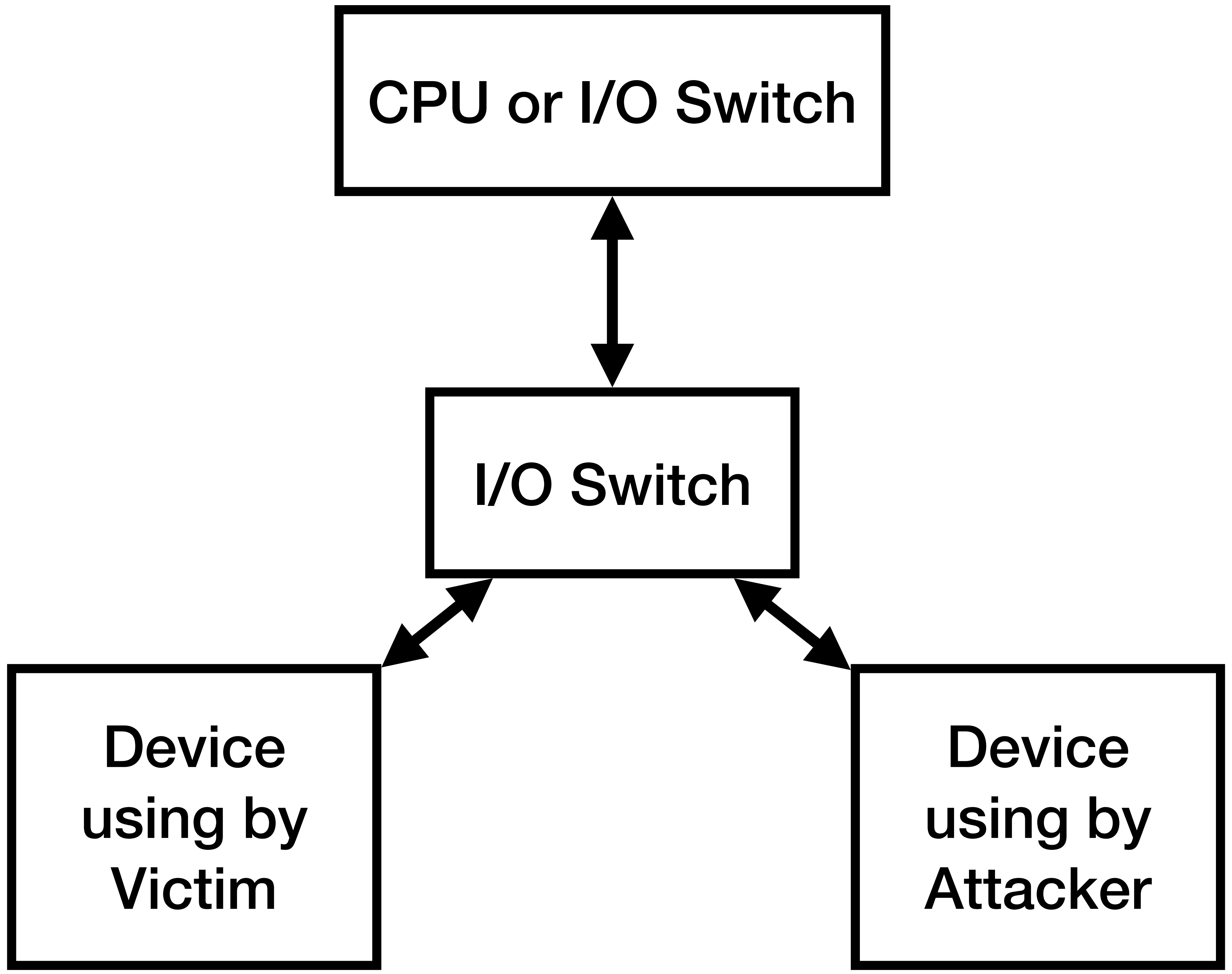

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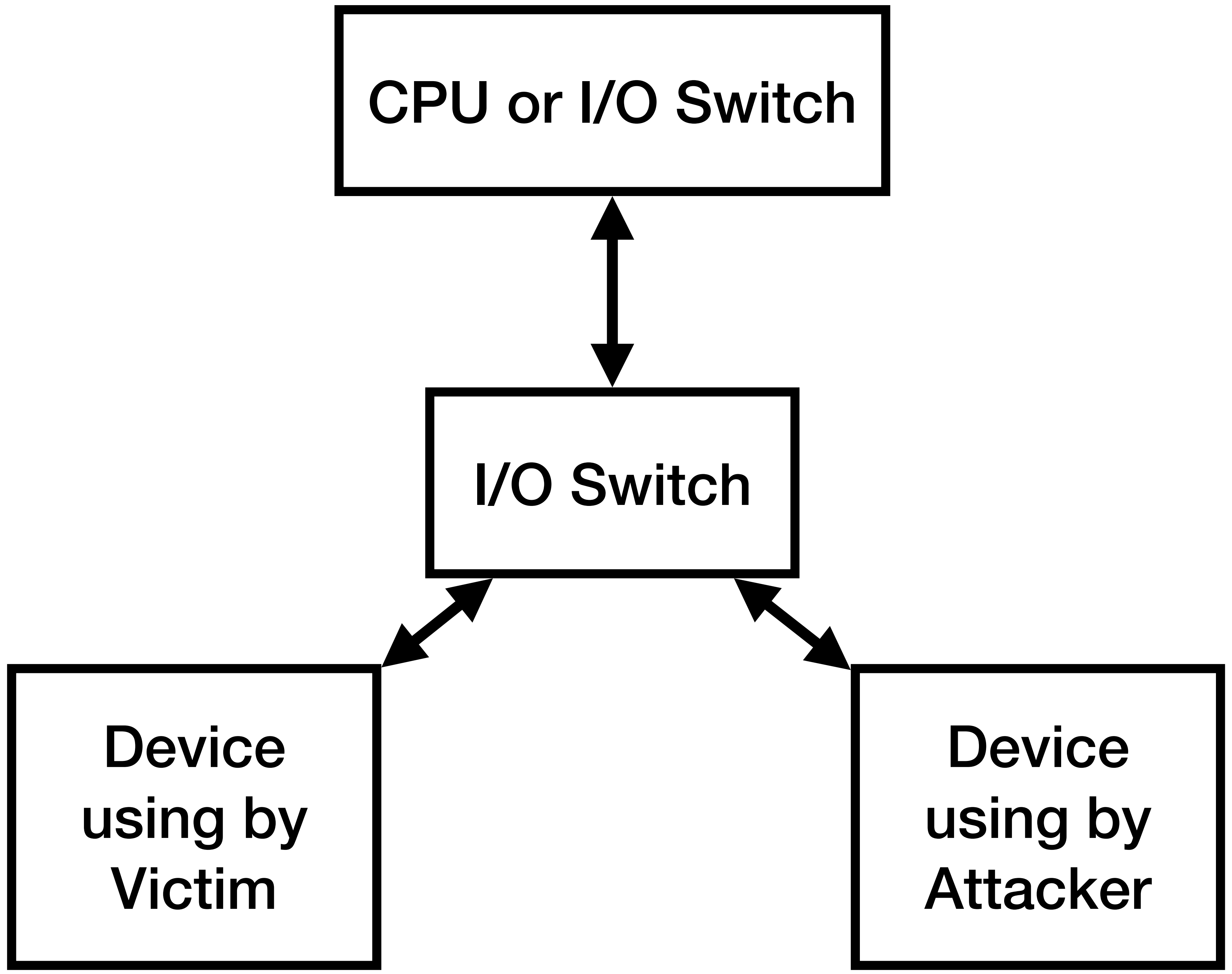

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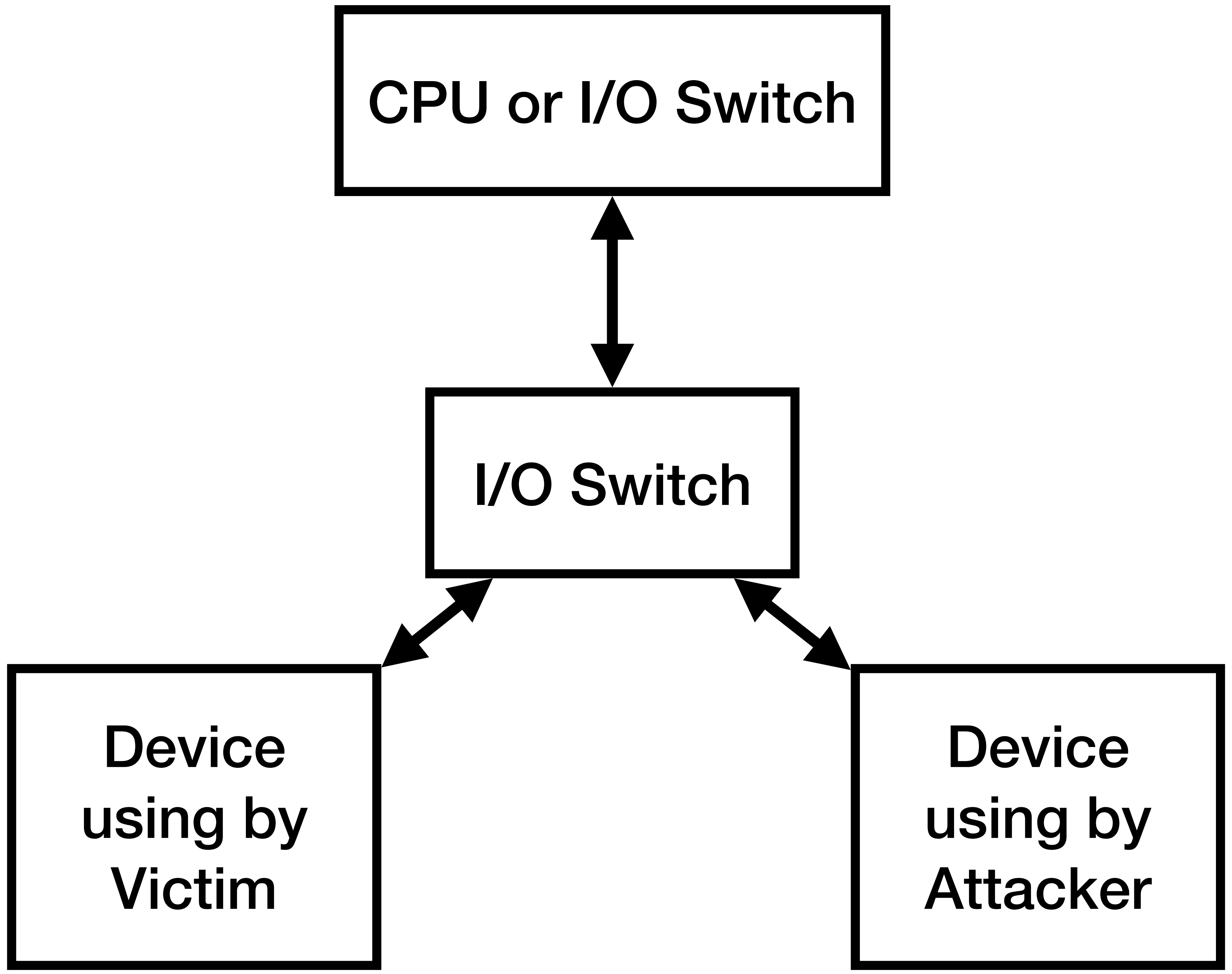

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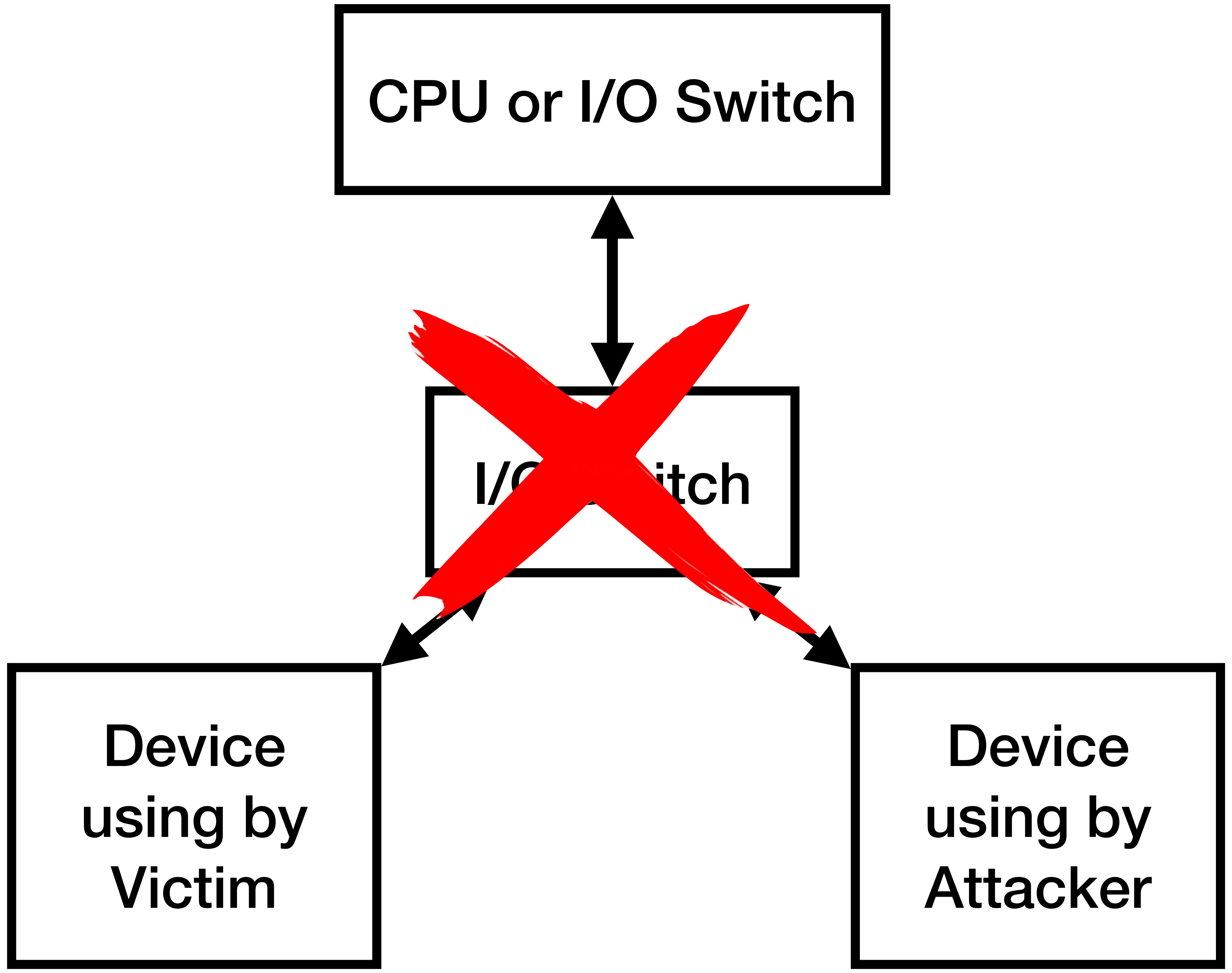

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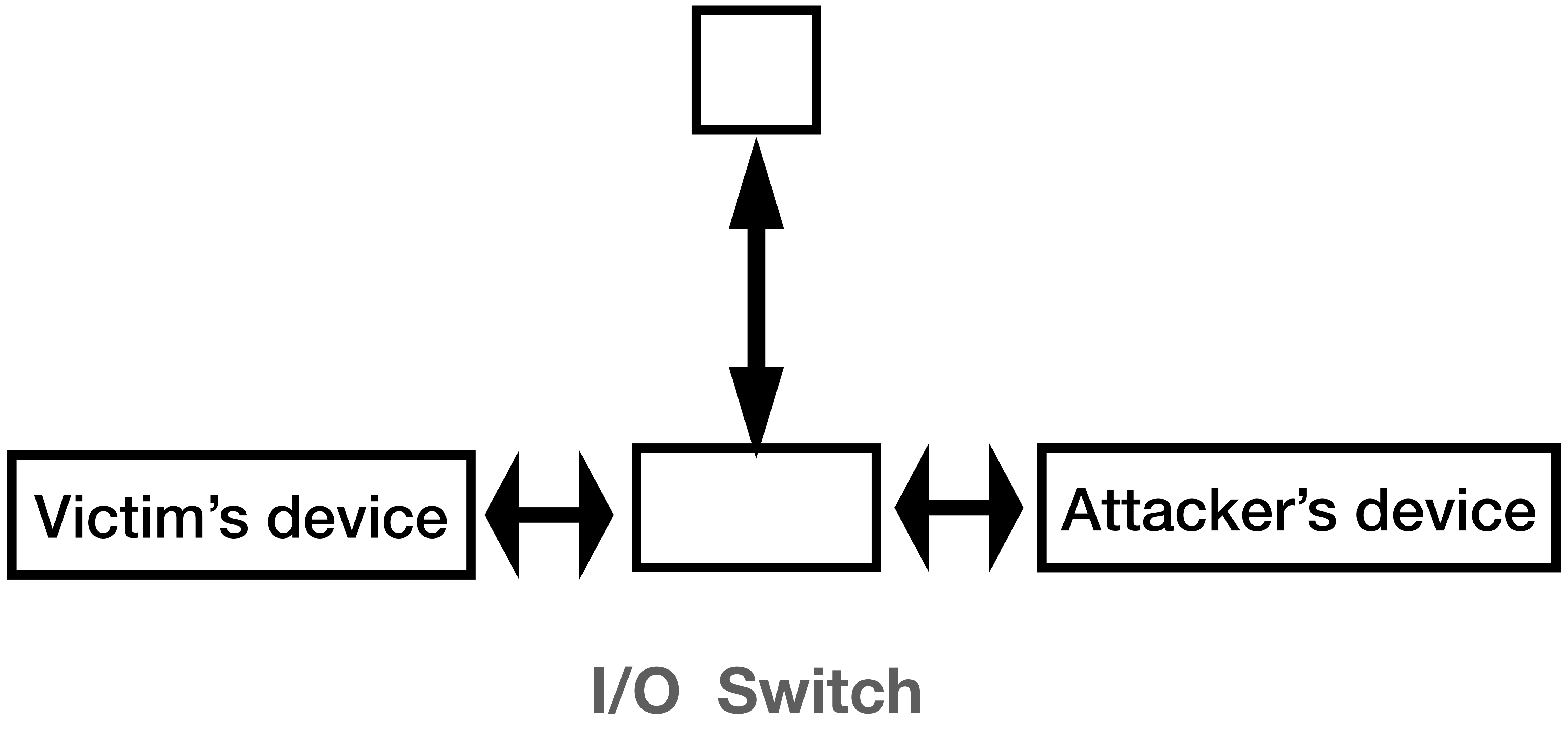

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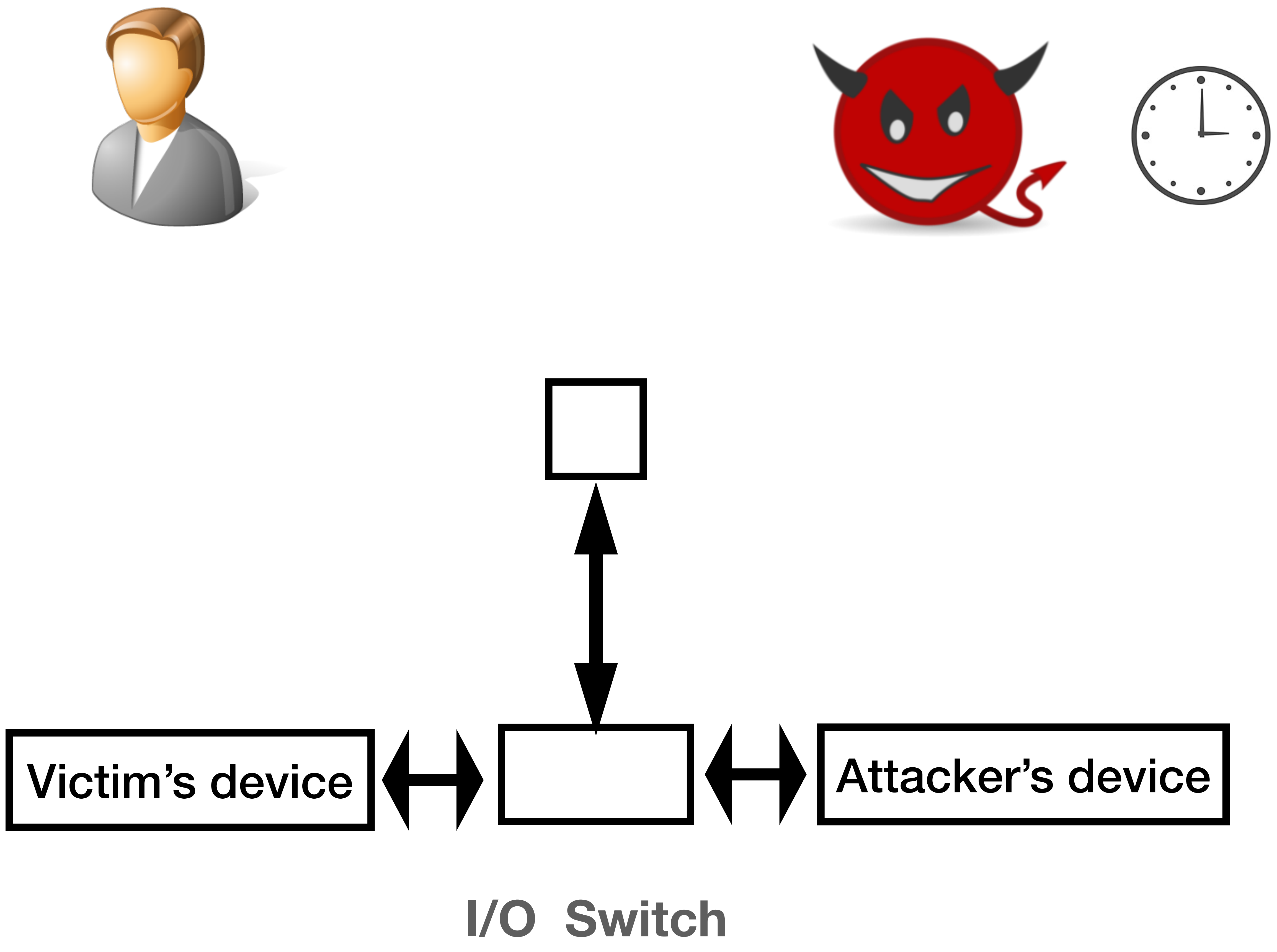

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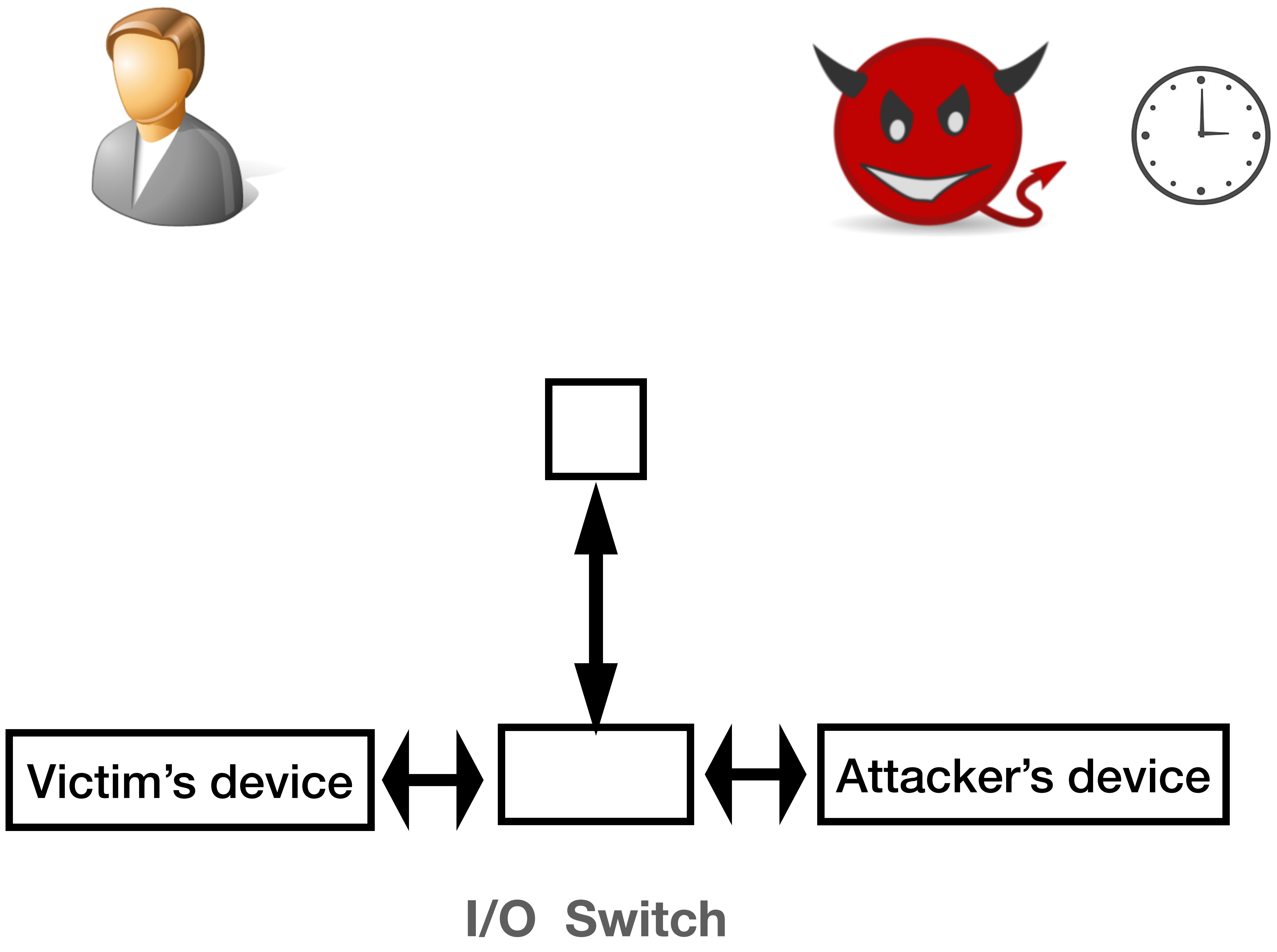

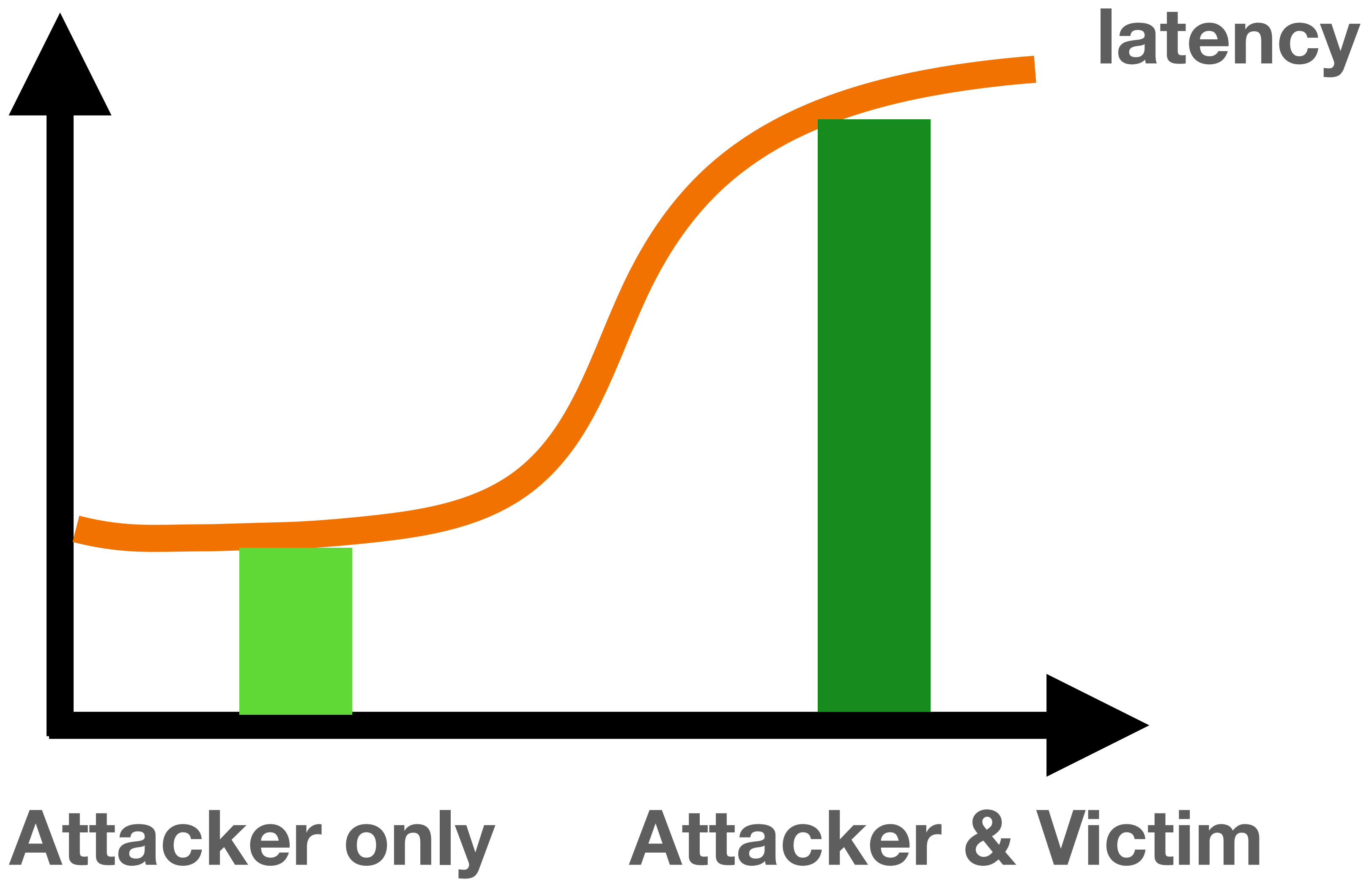

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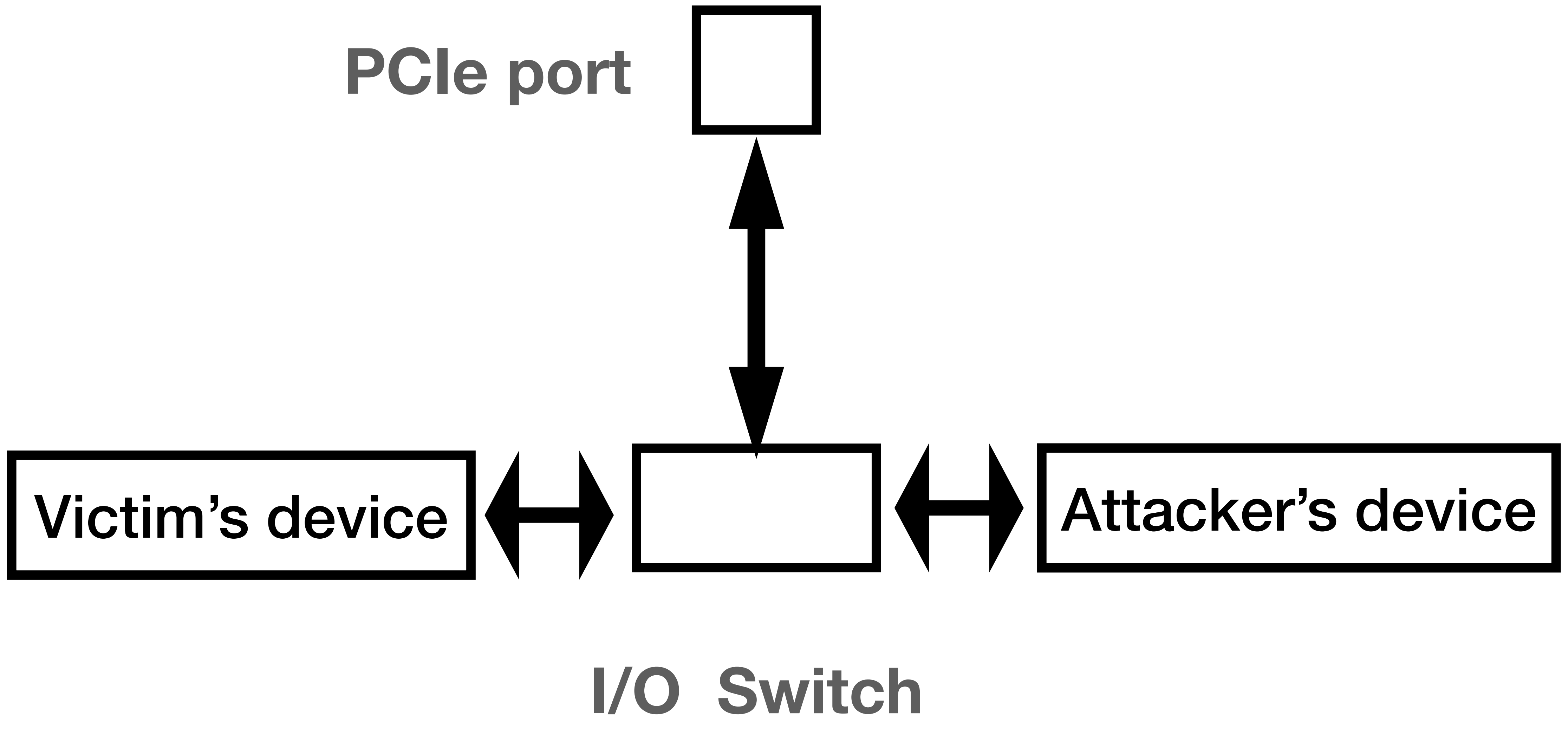

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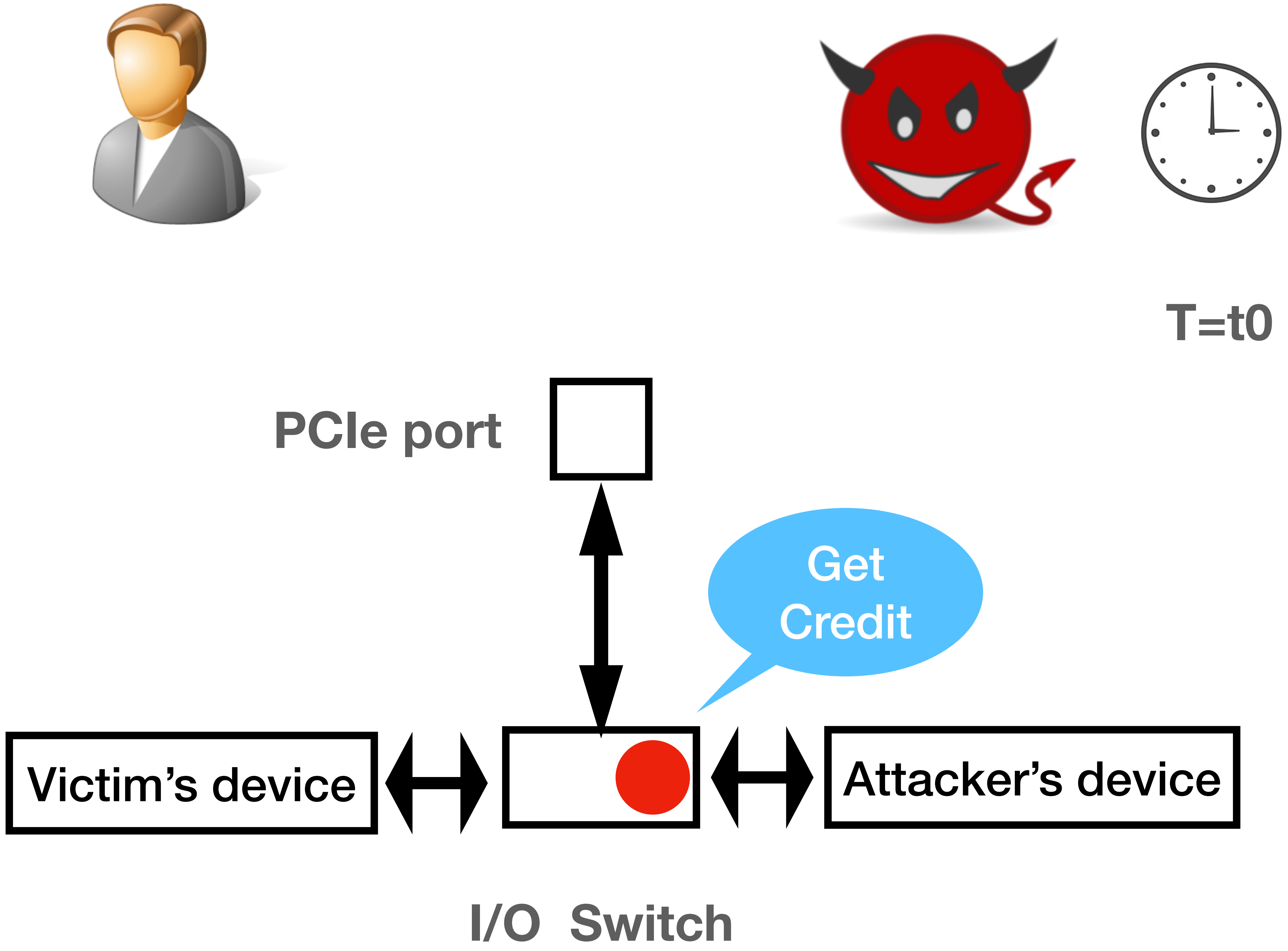

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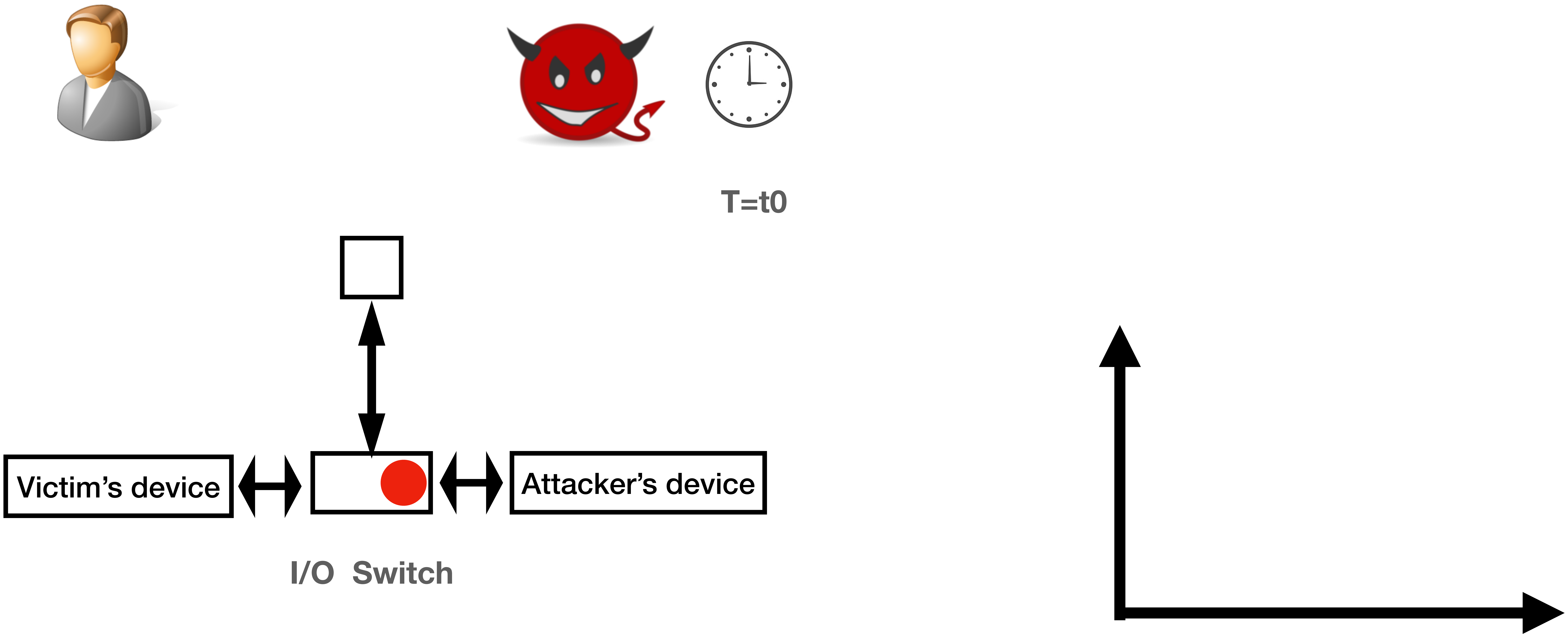

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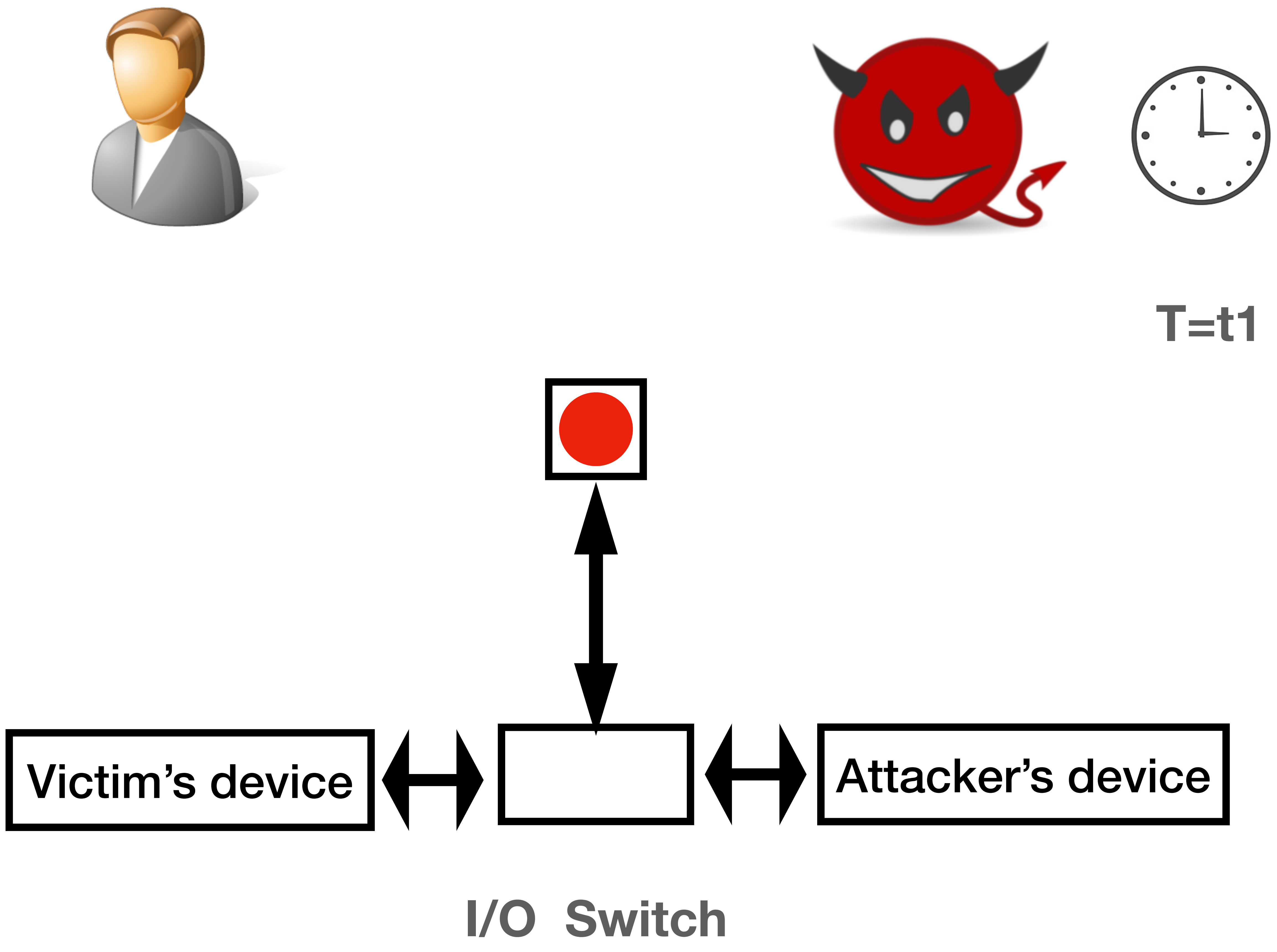

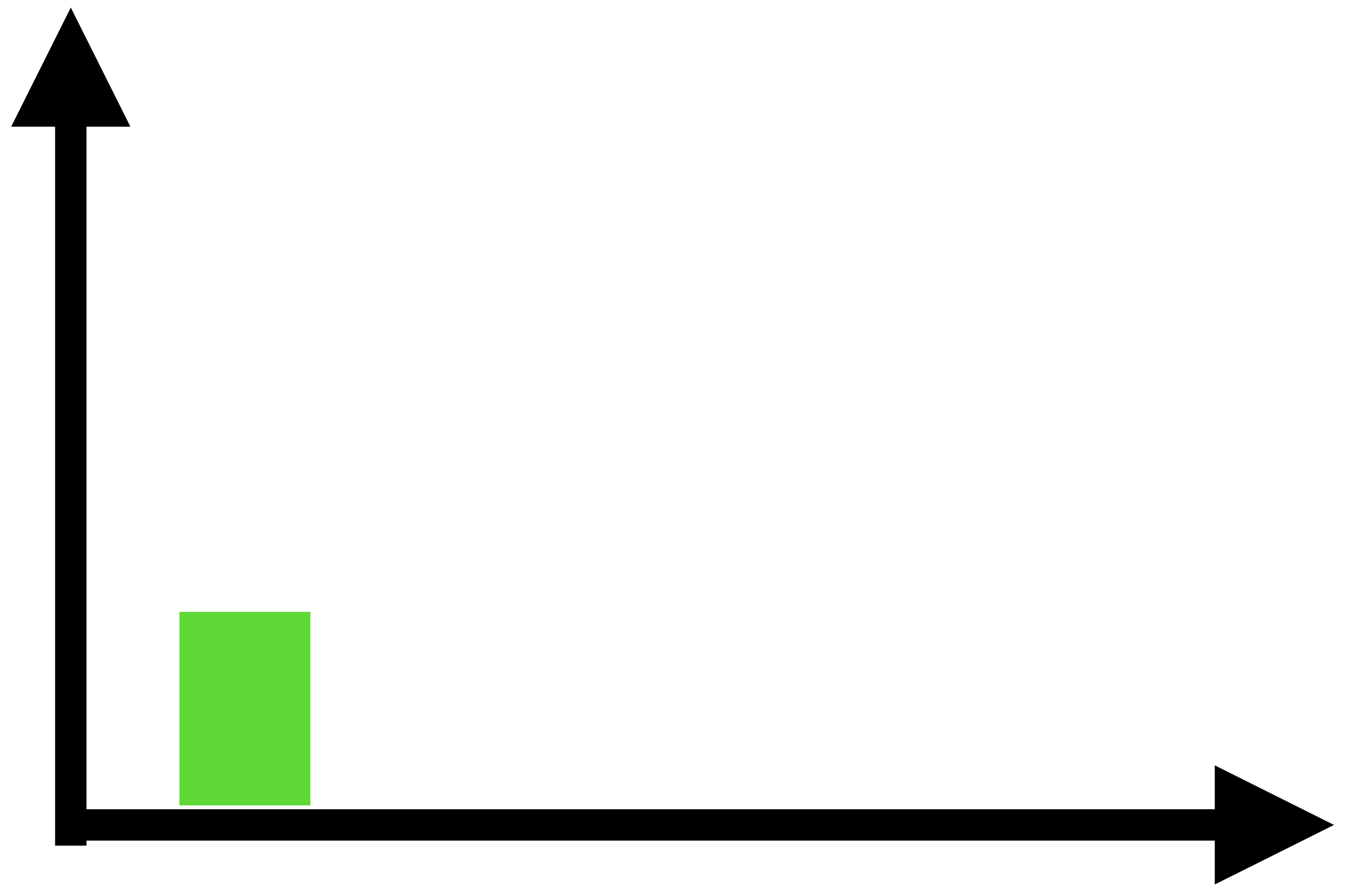

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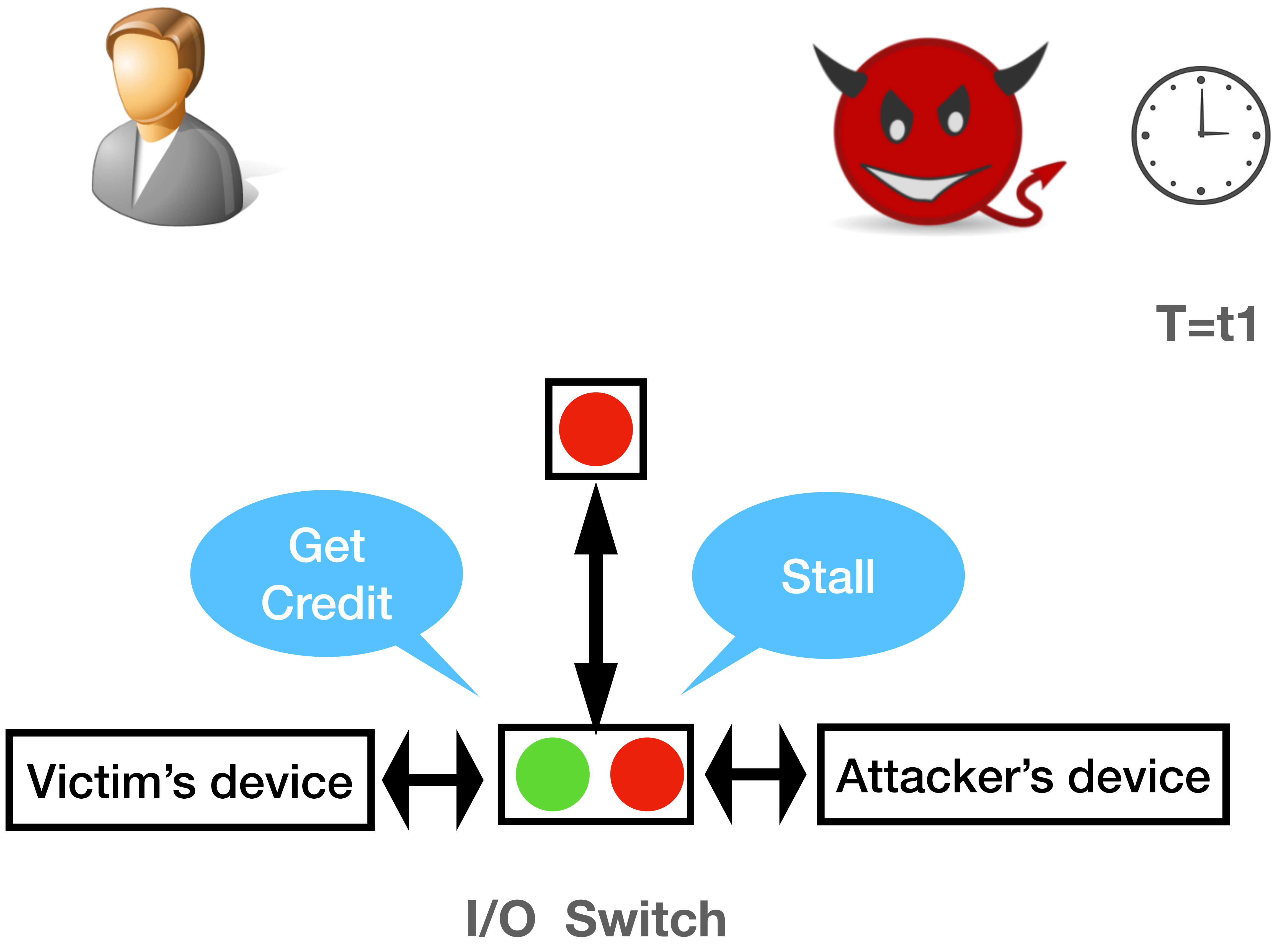

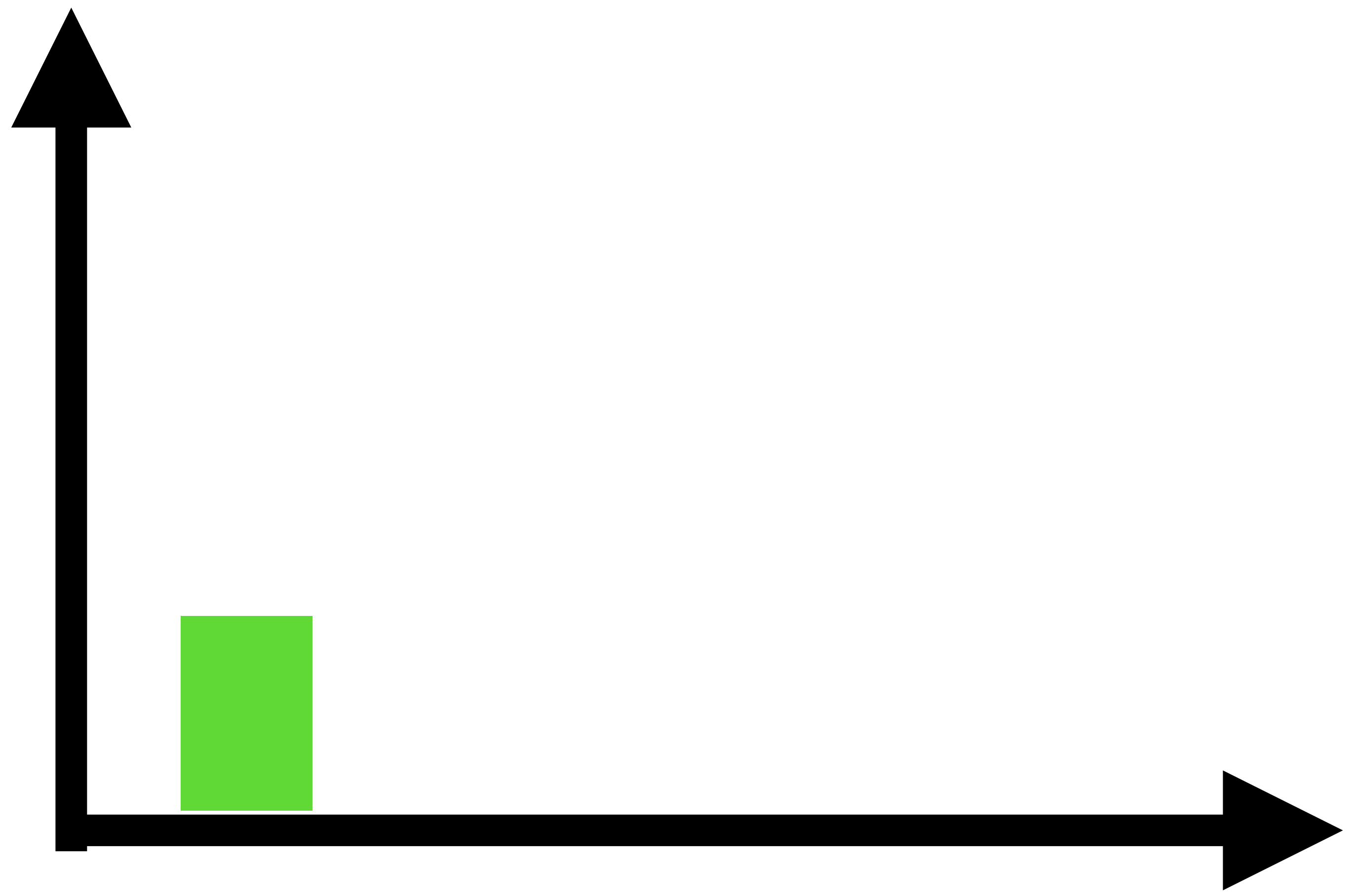

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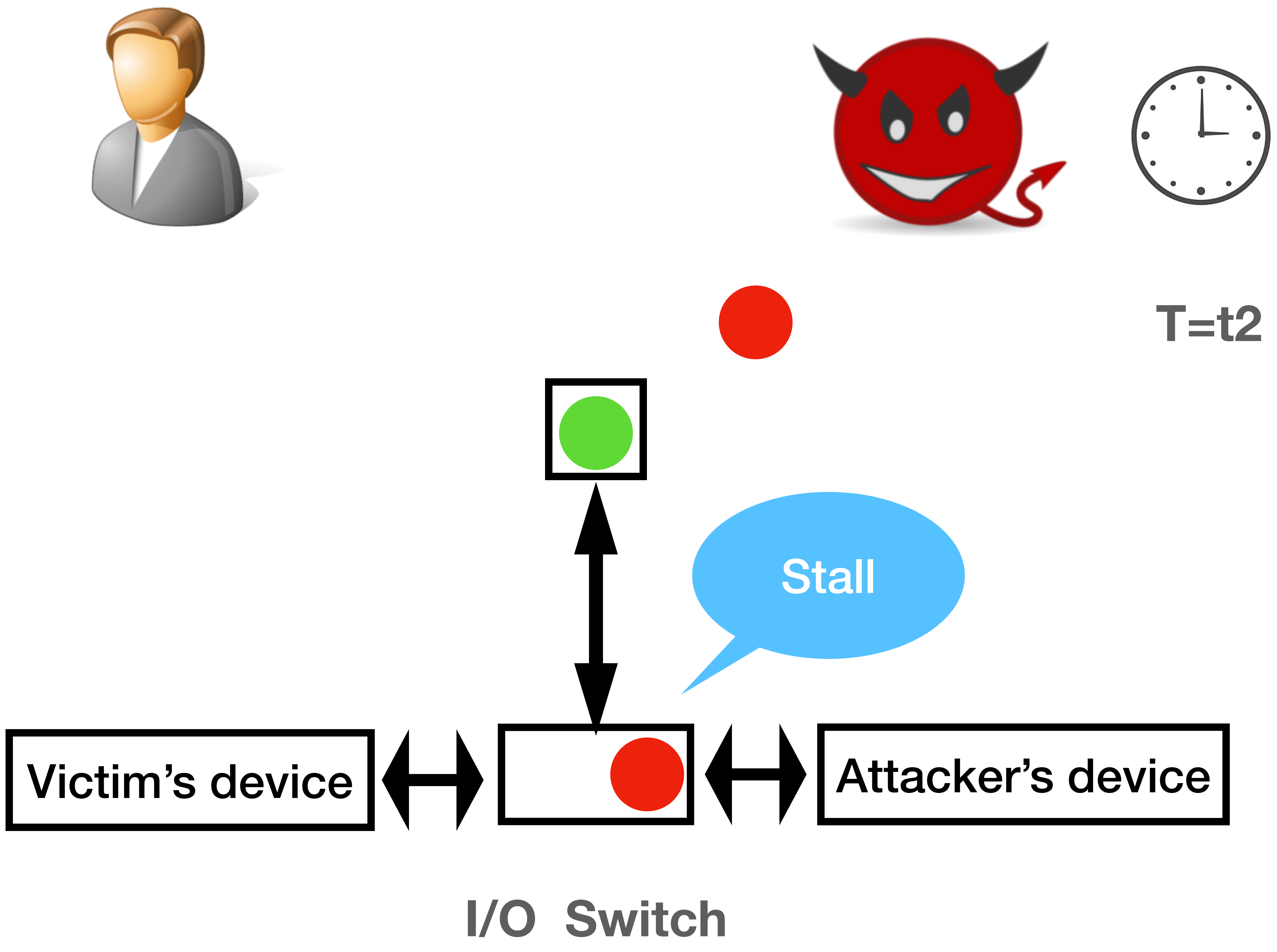

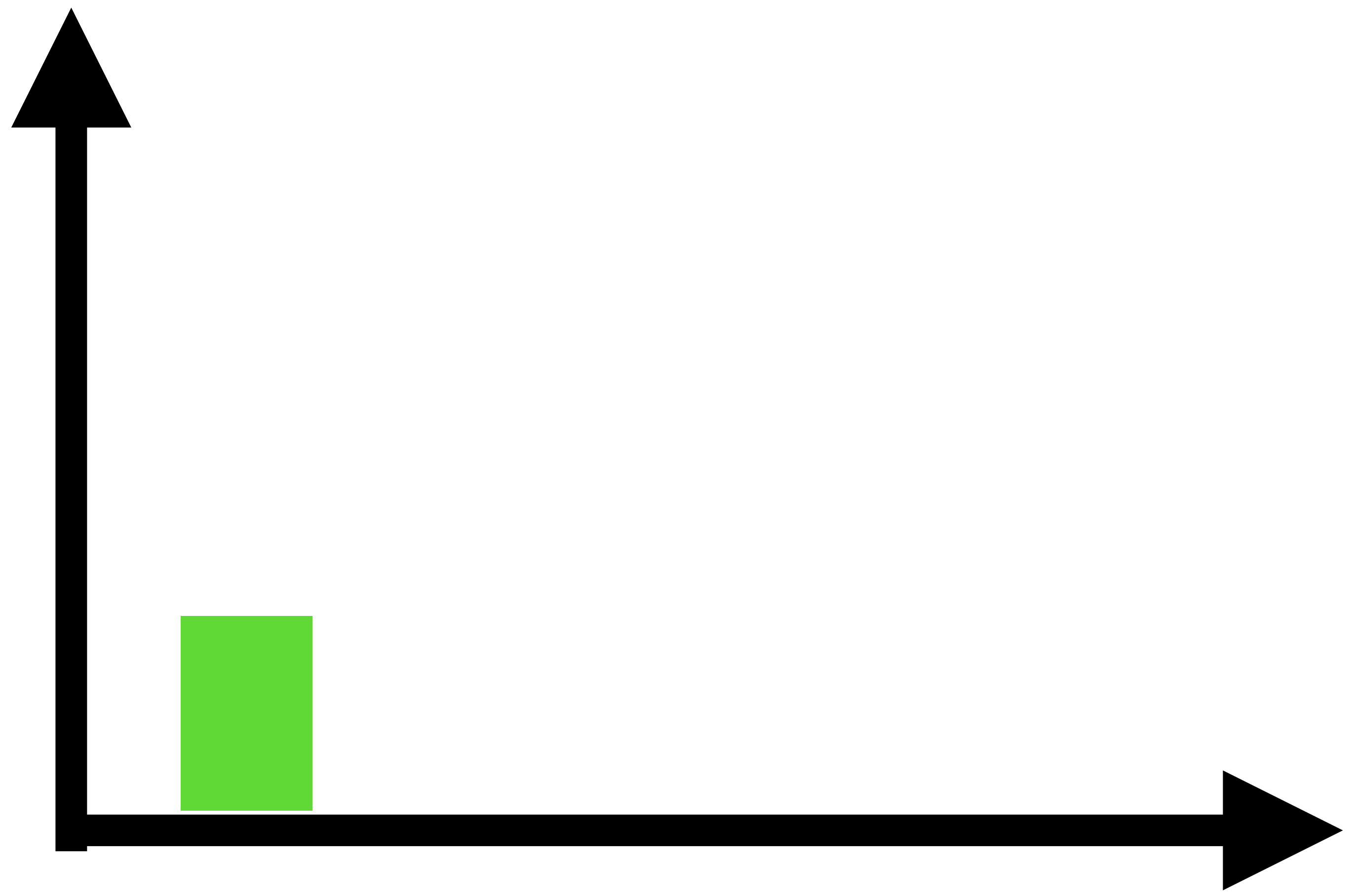

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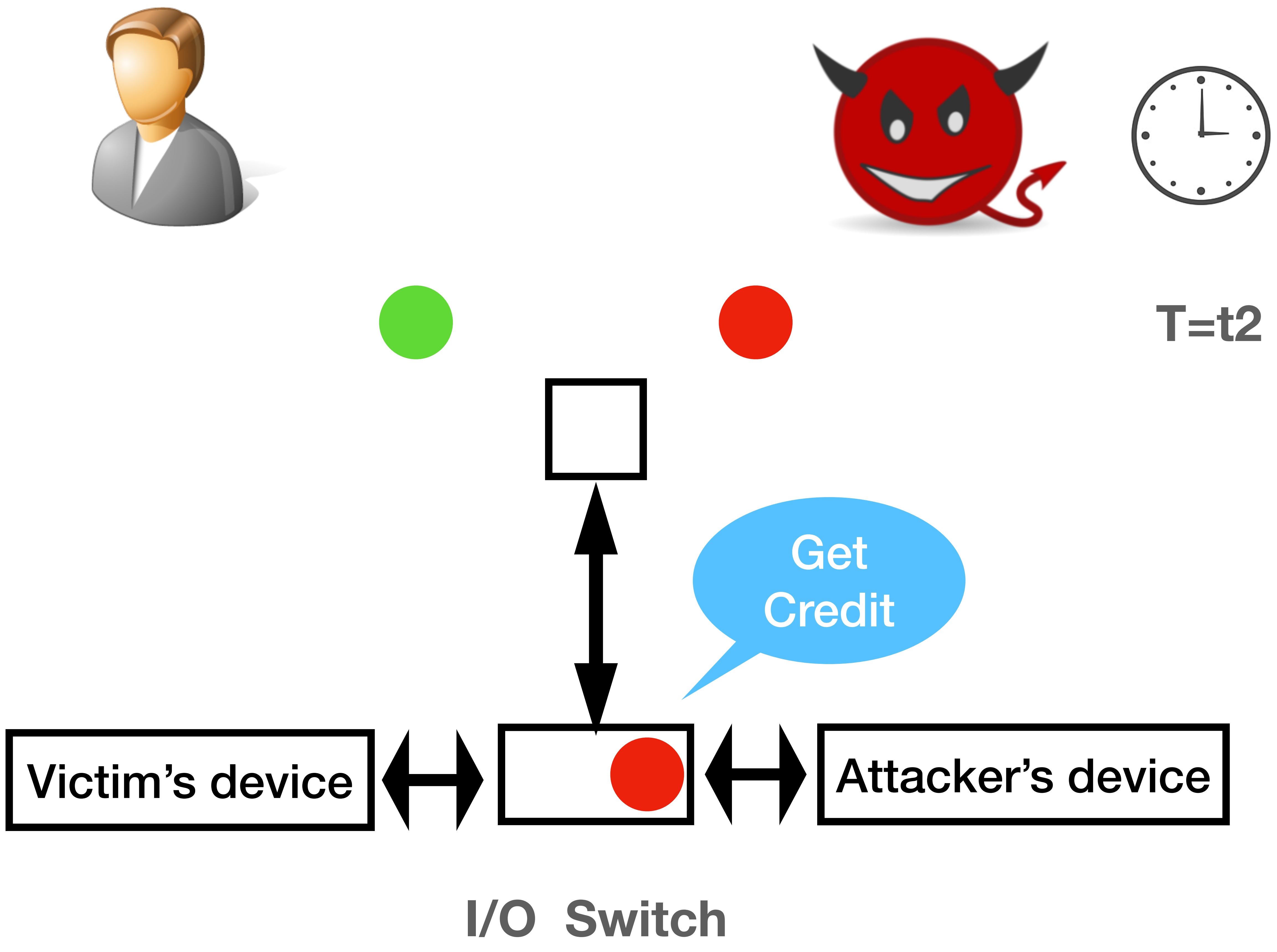

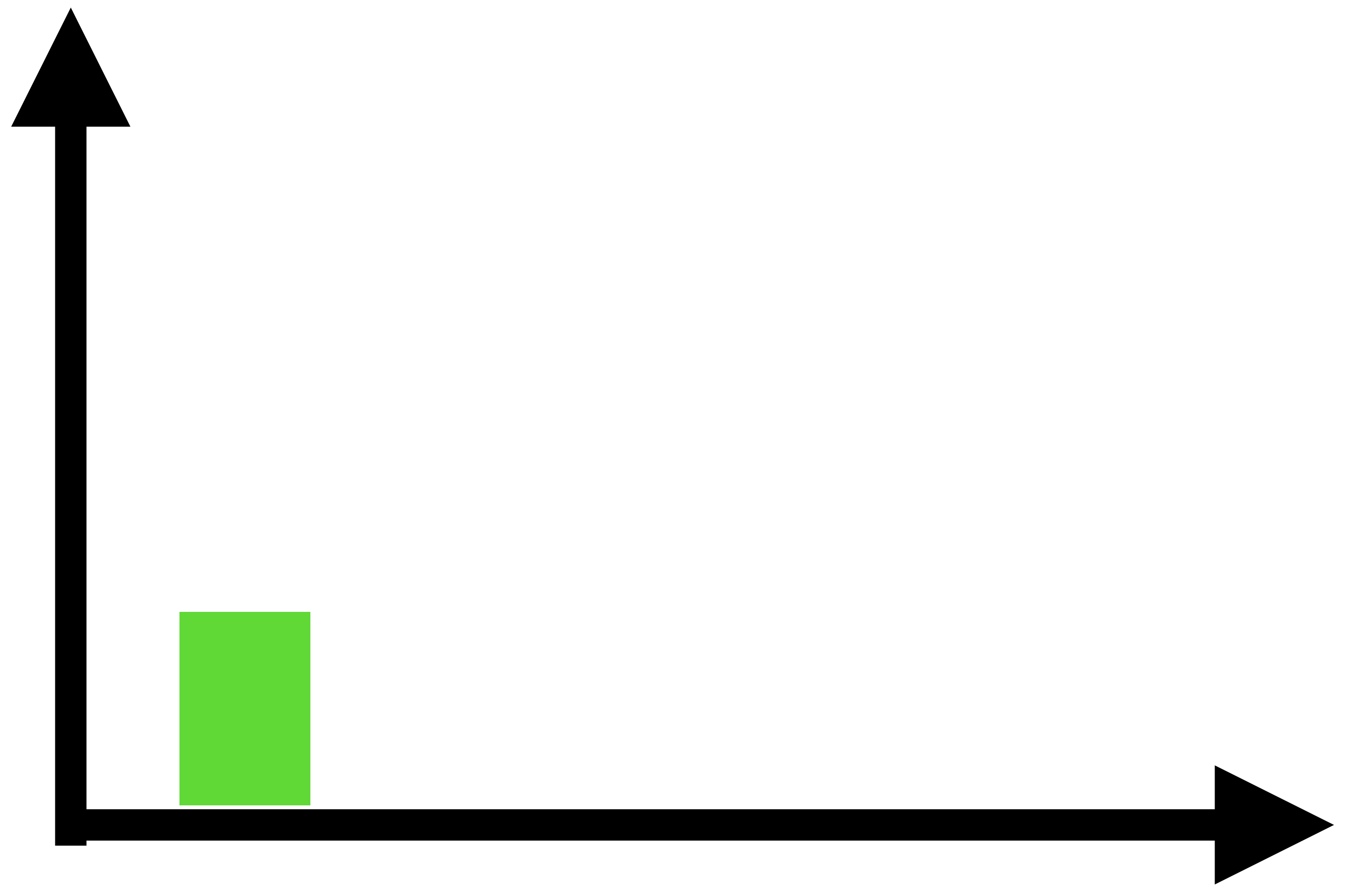

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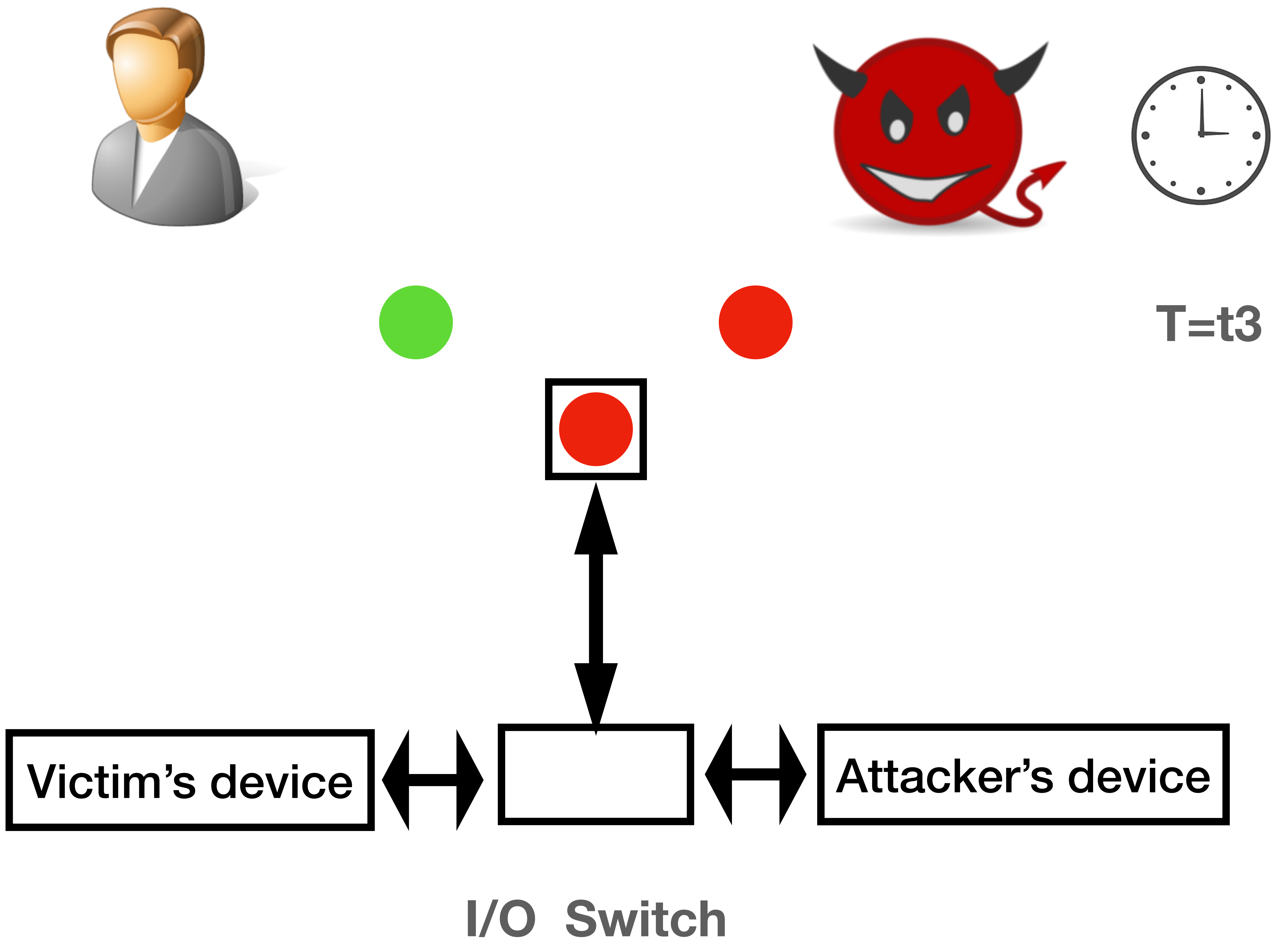

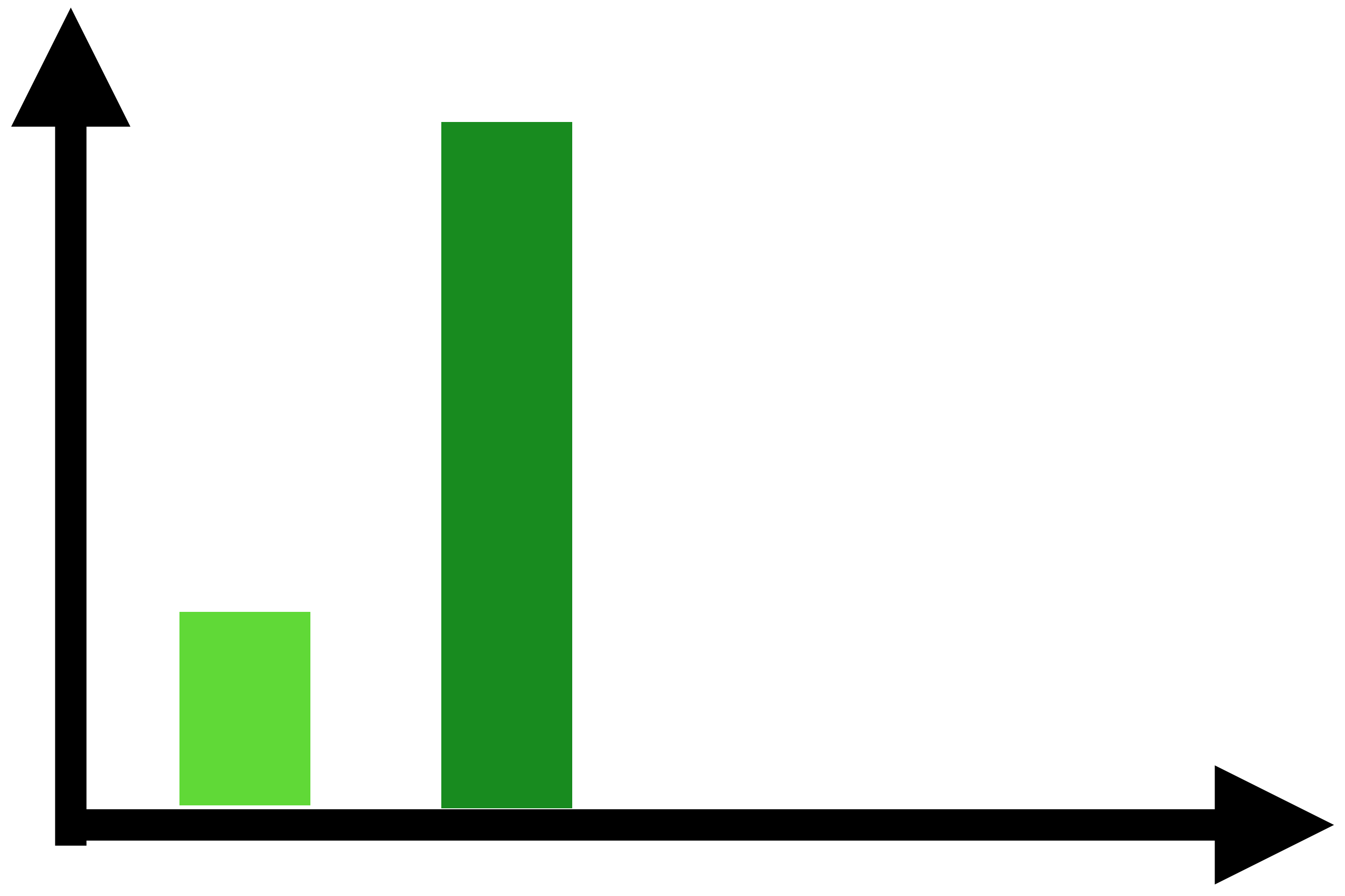

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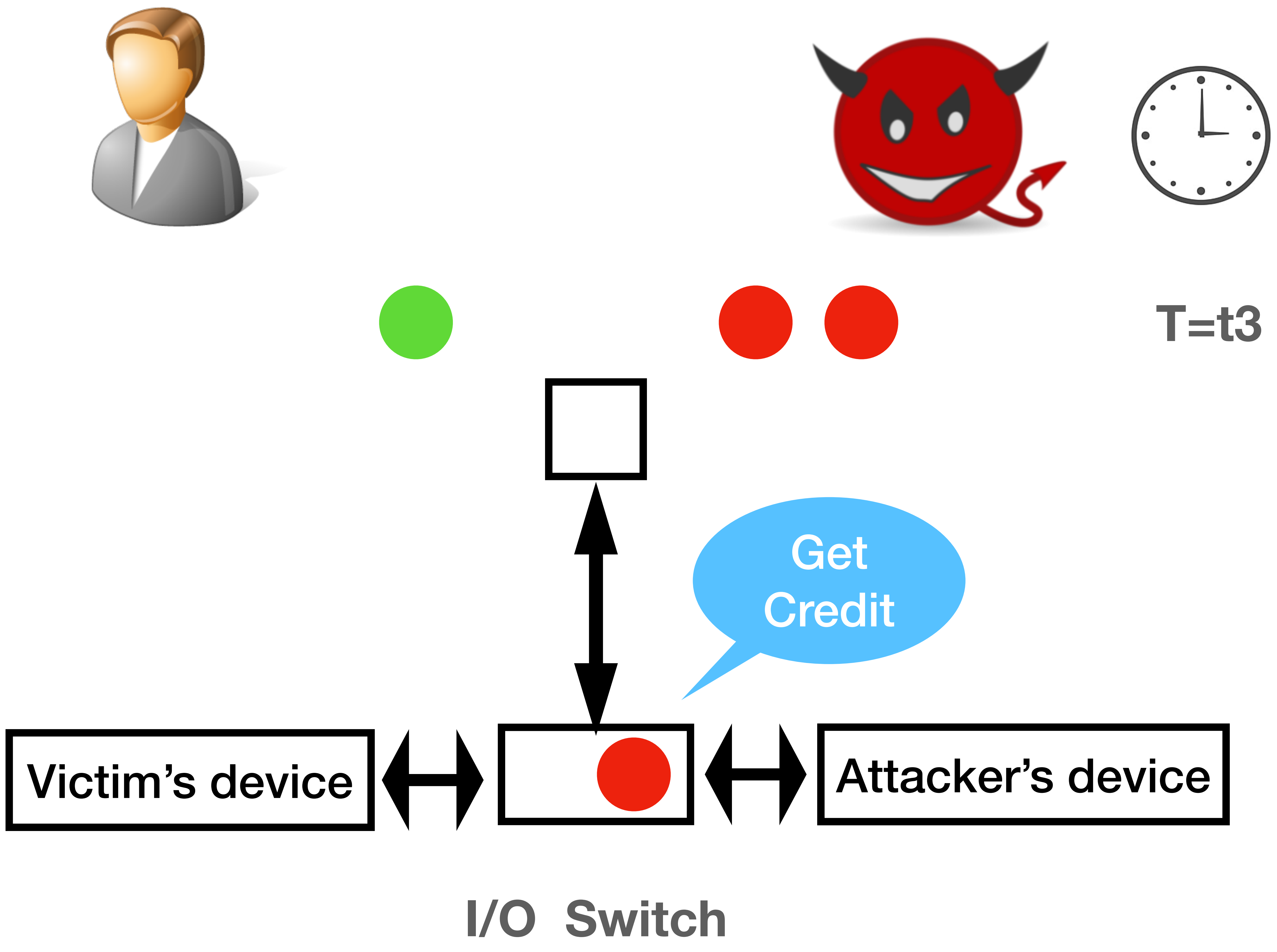

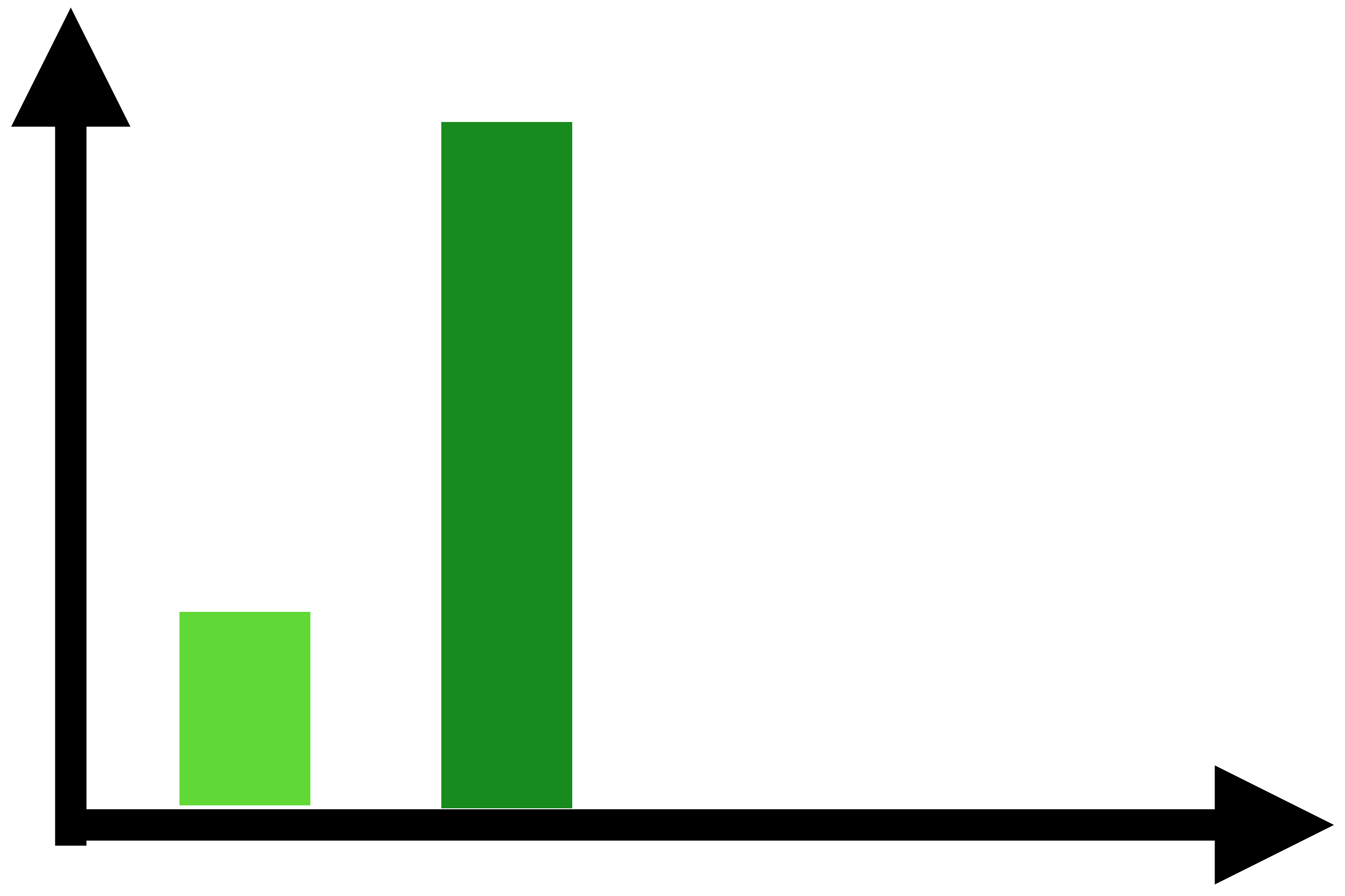

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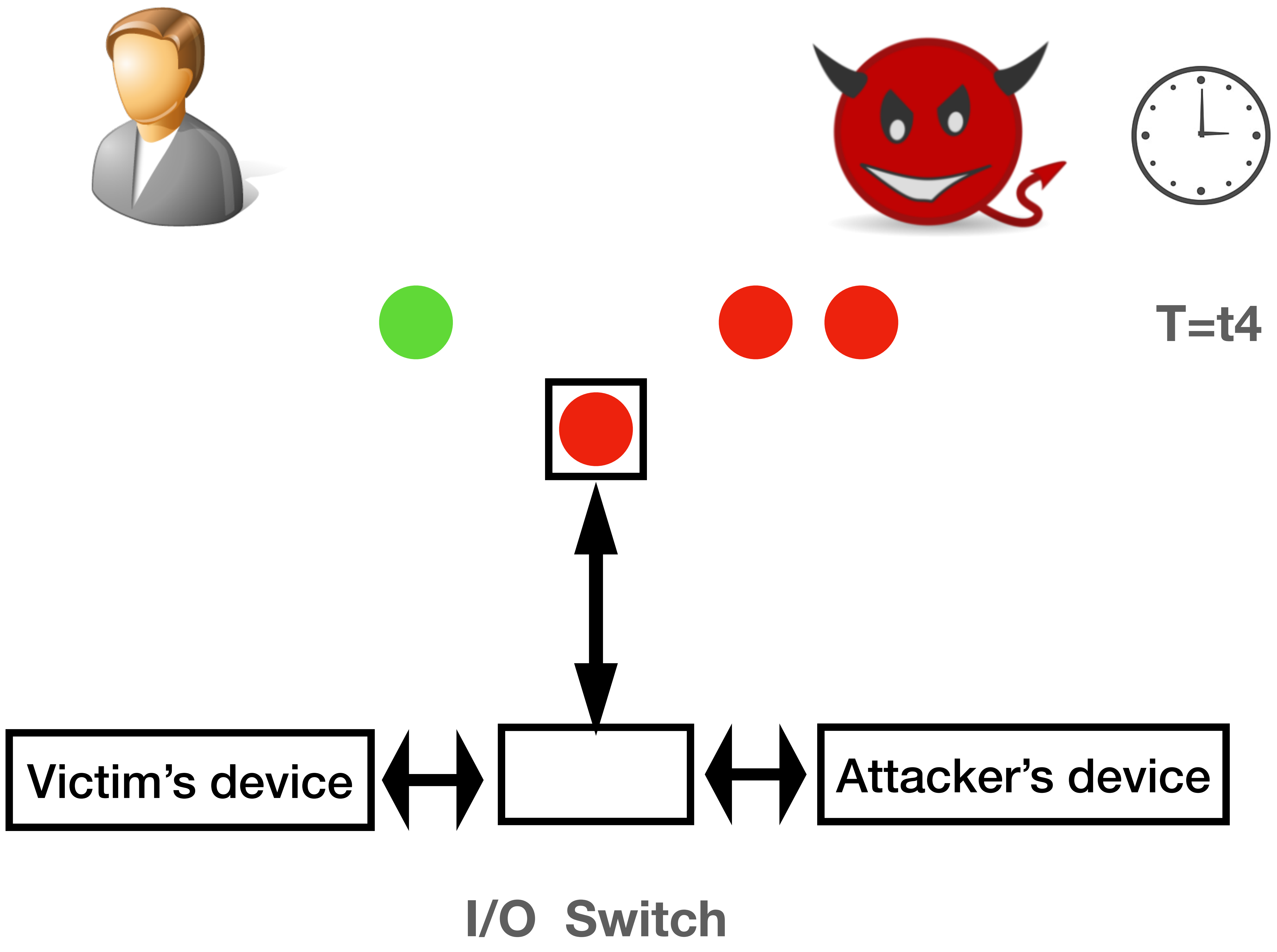

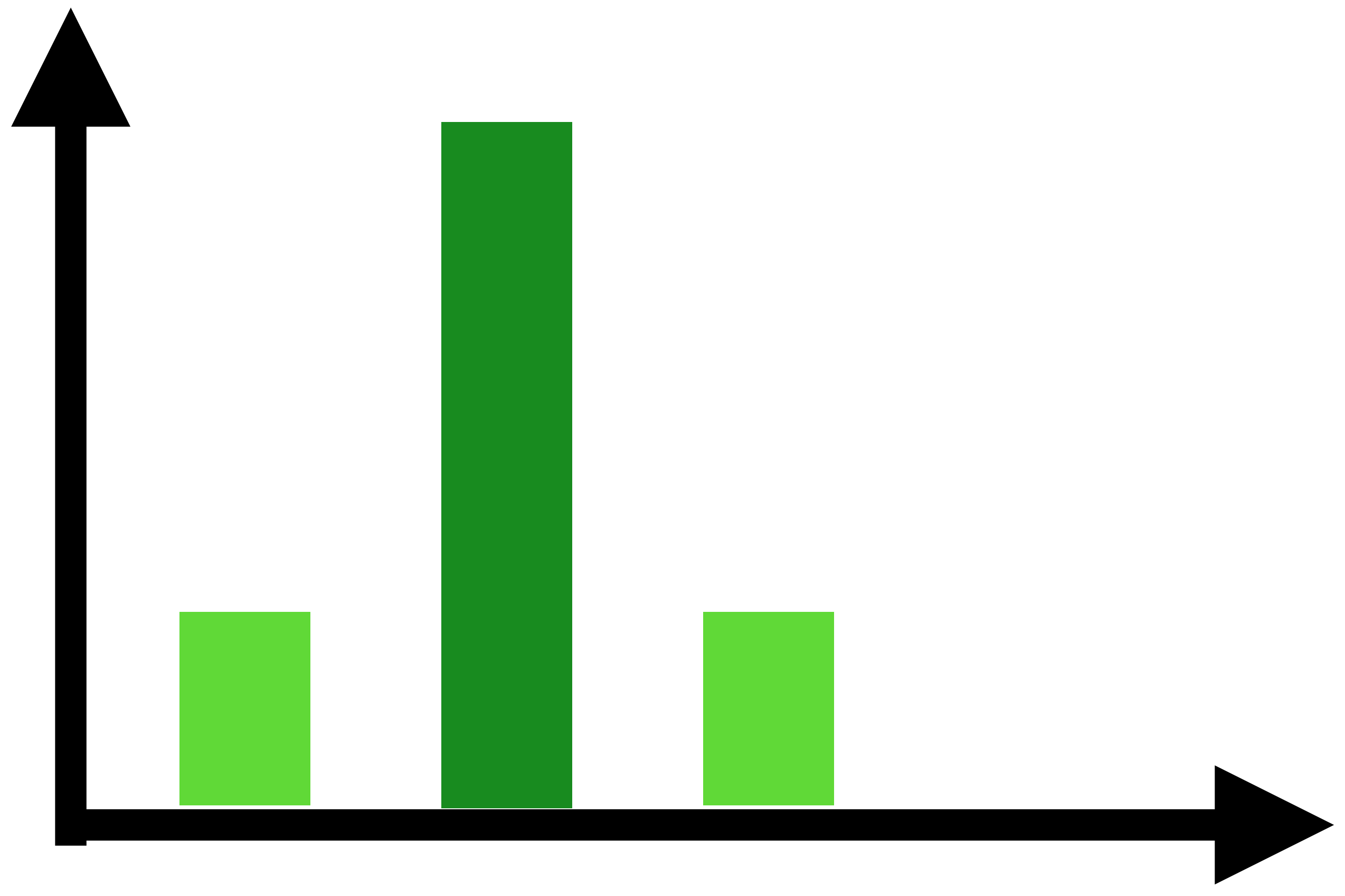

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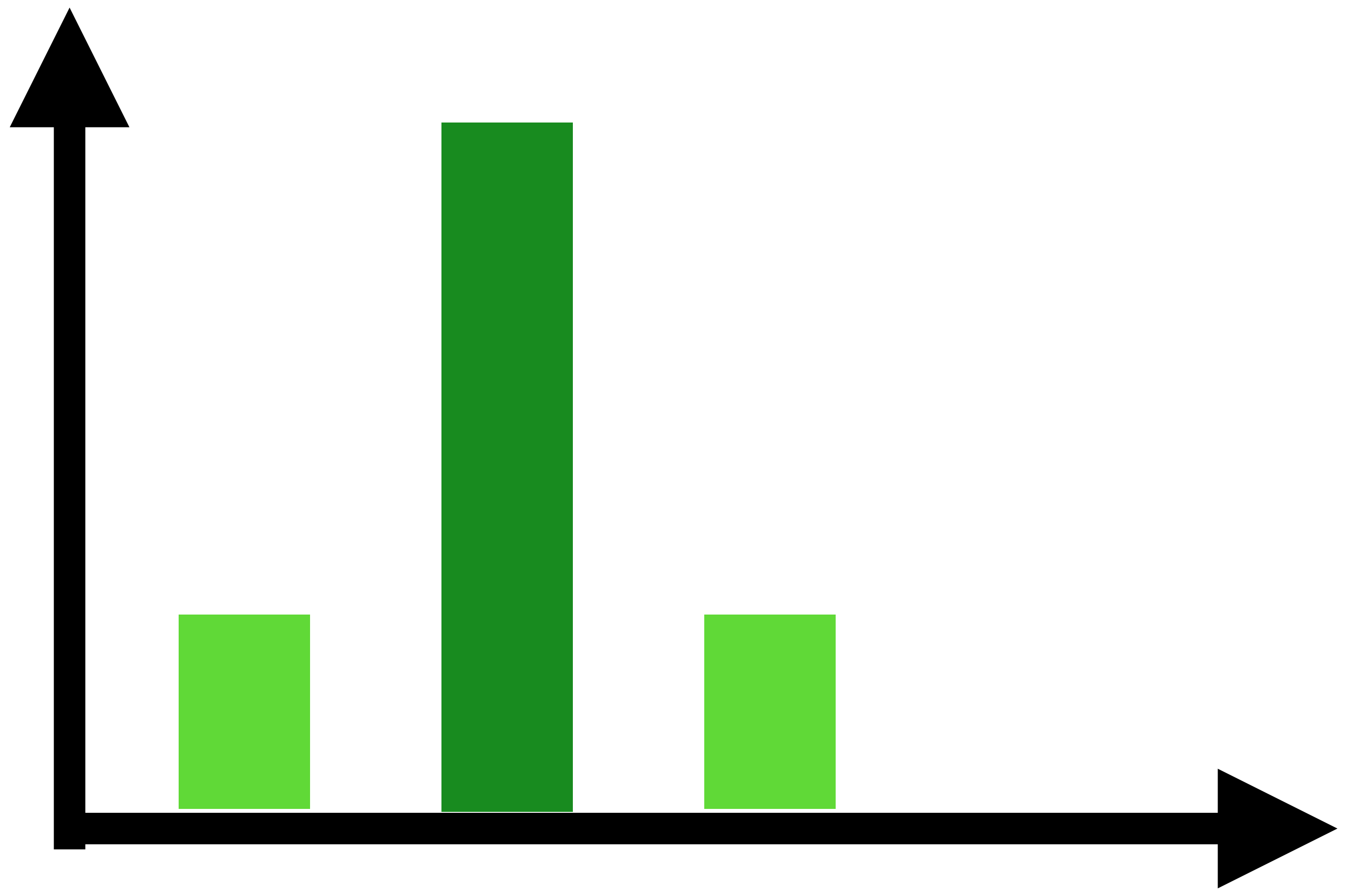
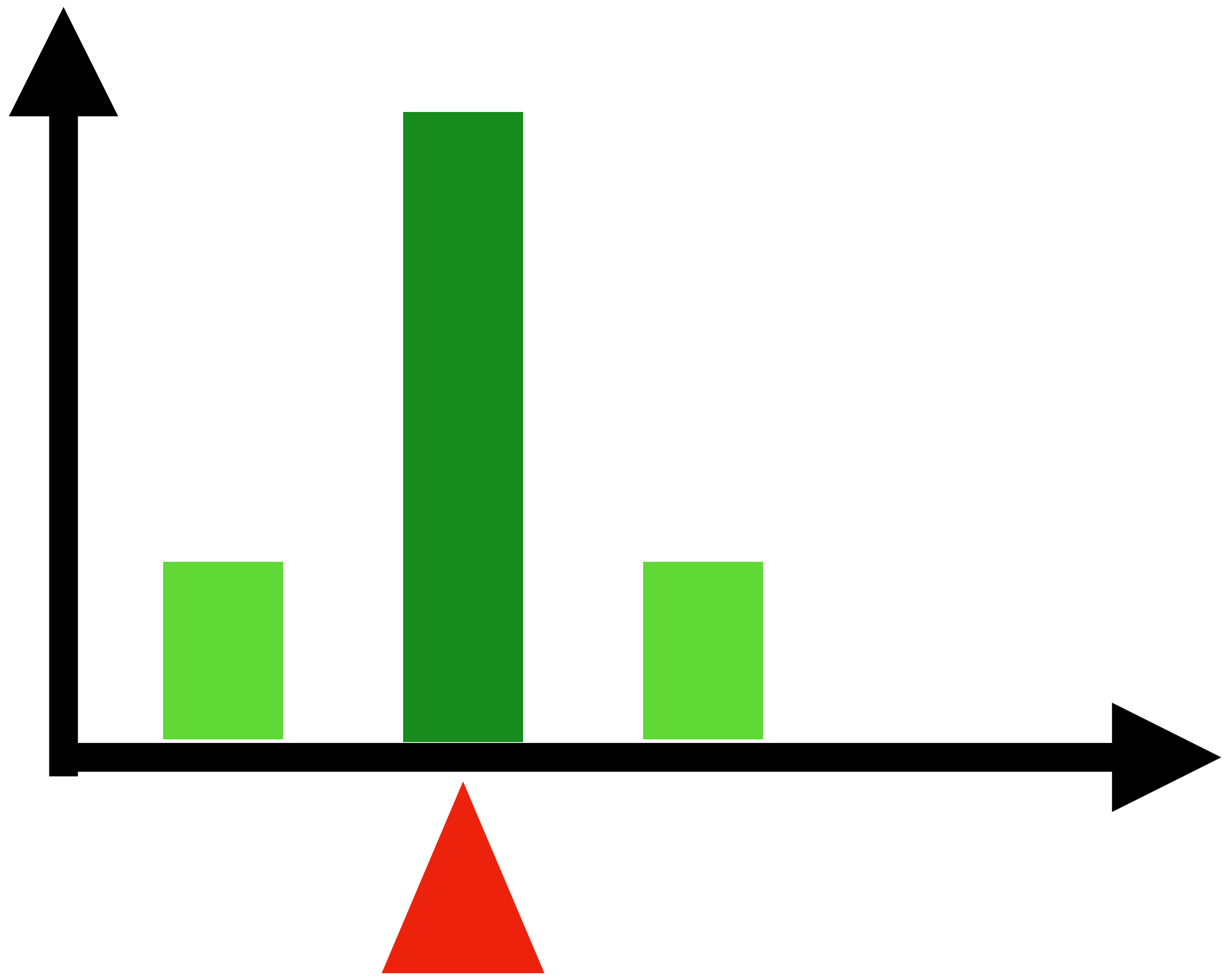


Why are the data leaked?

- Attacker knows when victim is active!



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while True:
    AccessData( )
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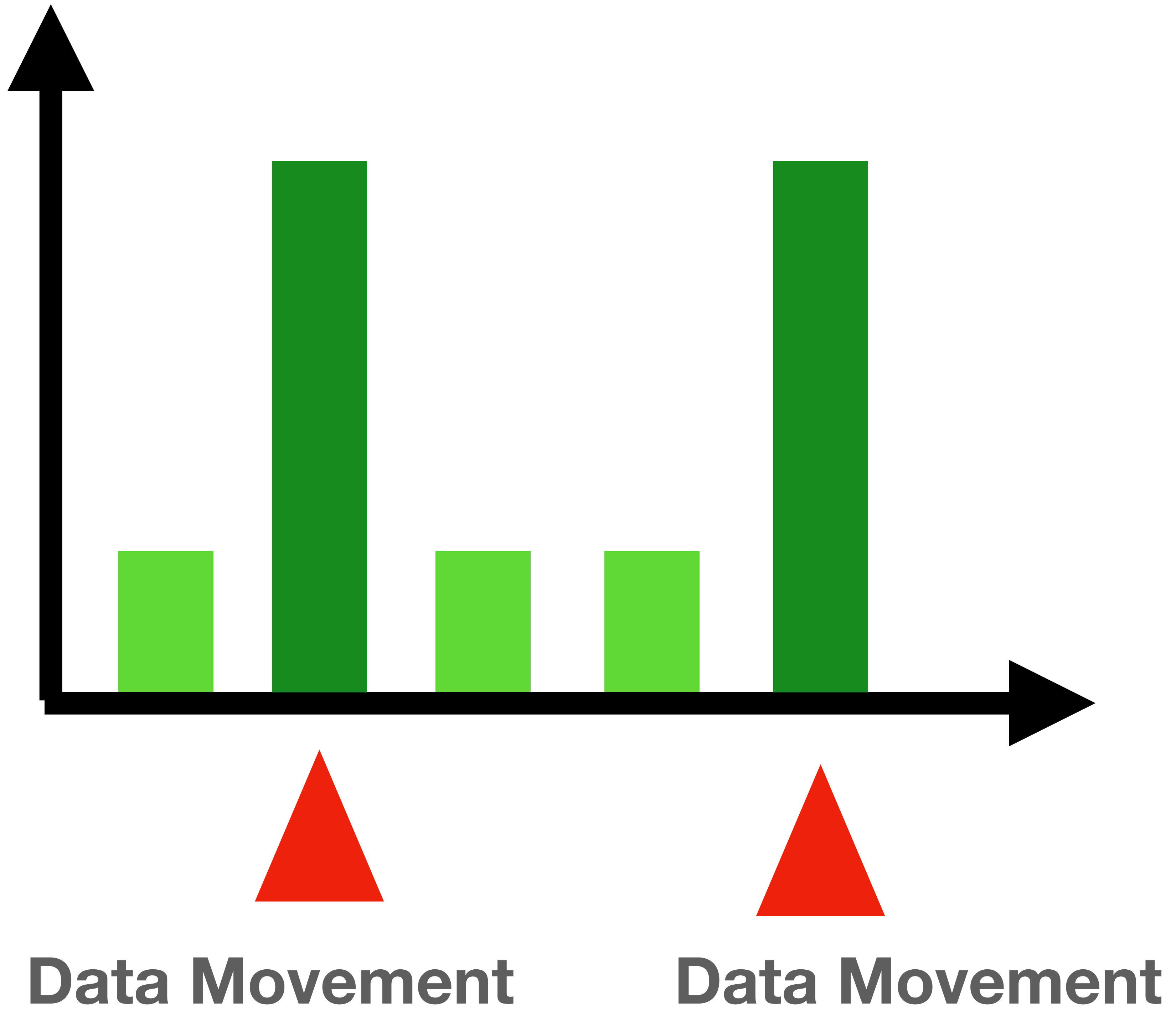
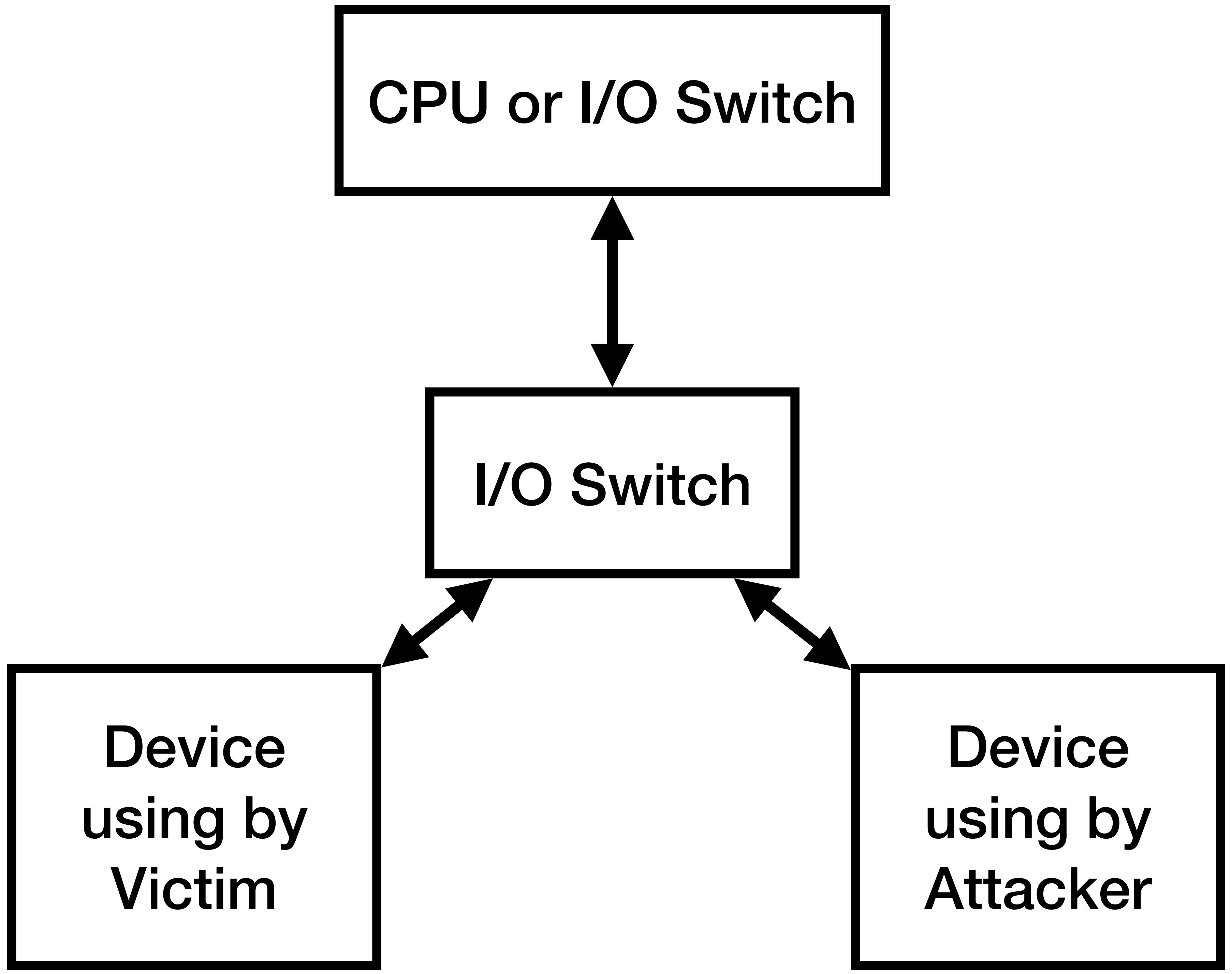
- A higher latency means data is transmitting



What information can we infer?



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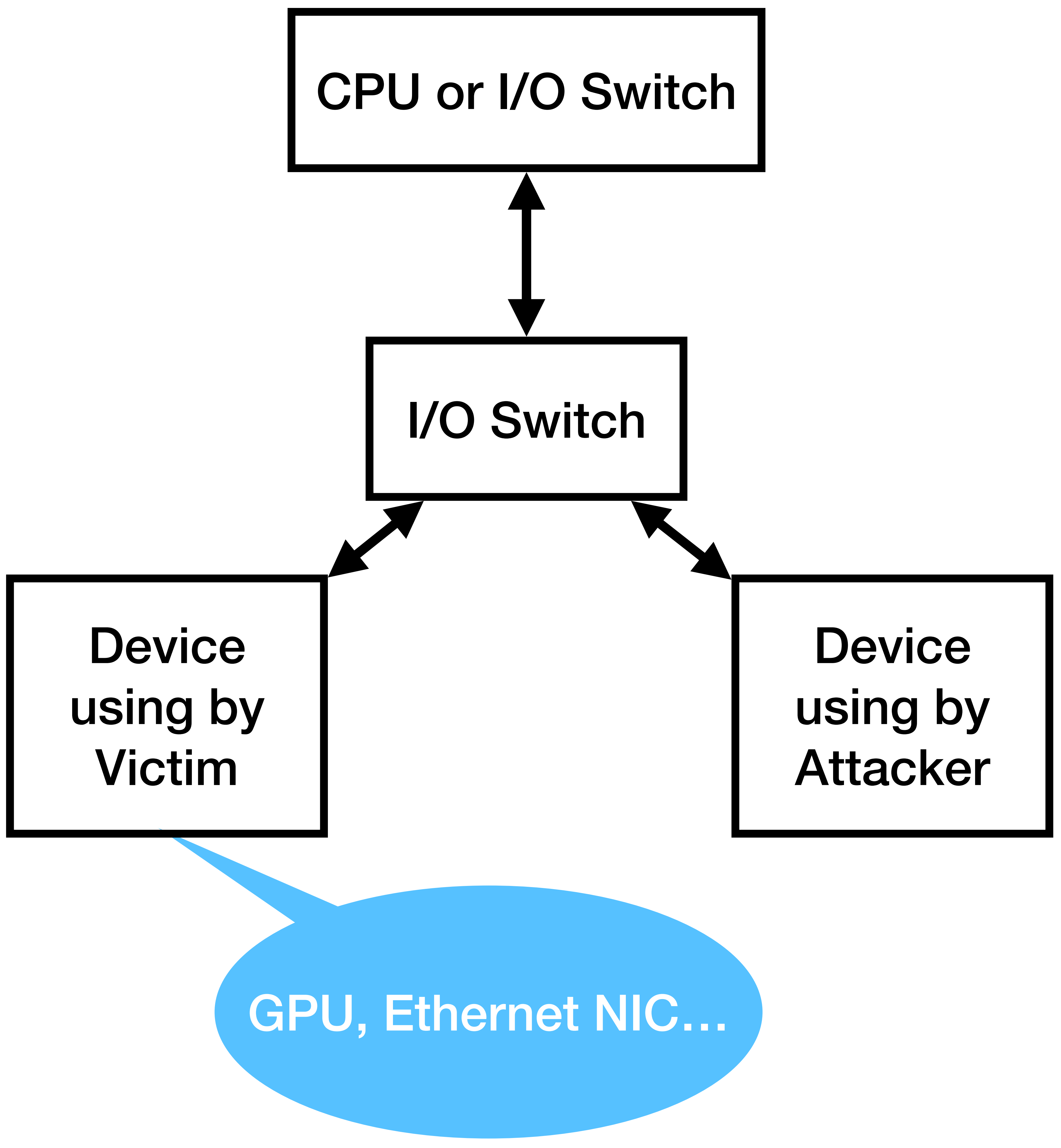

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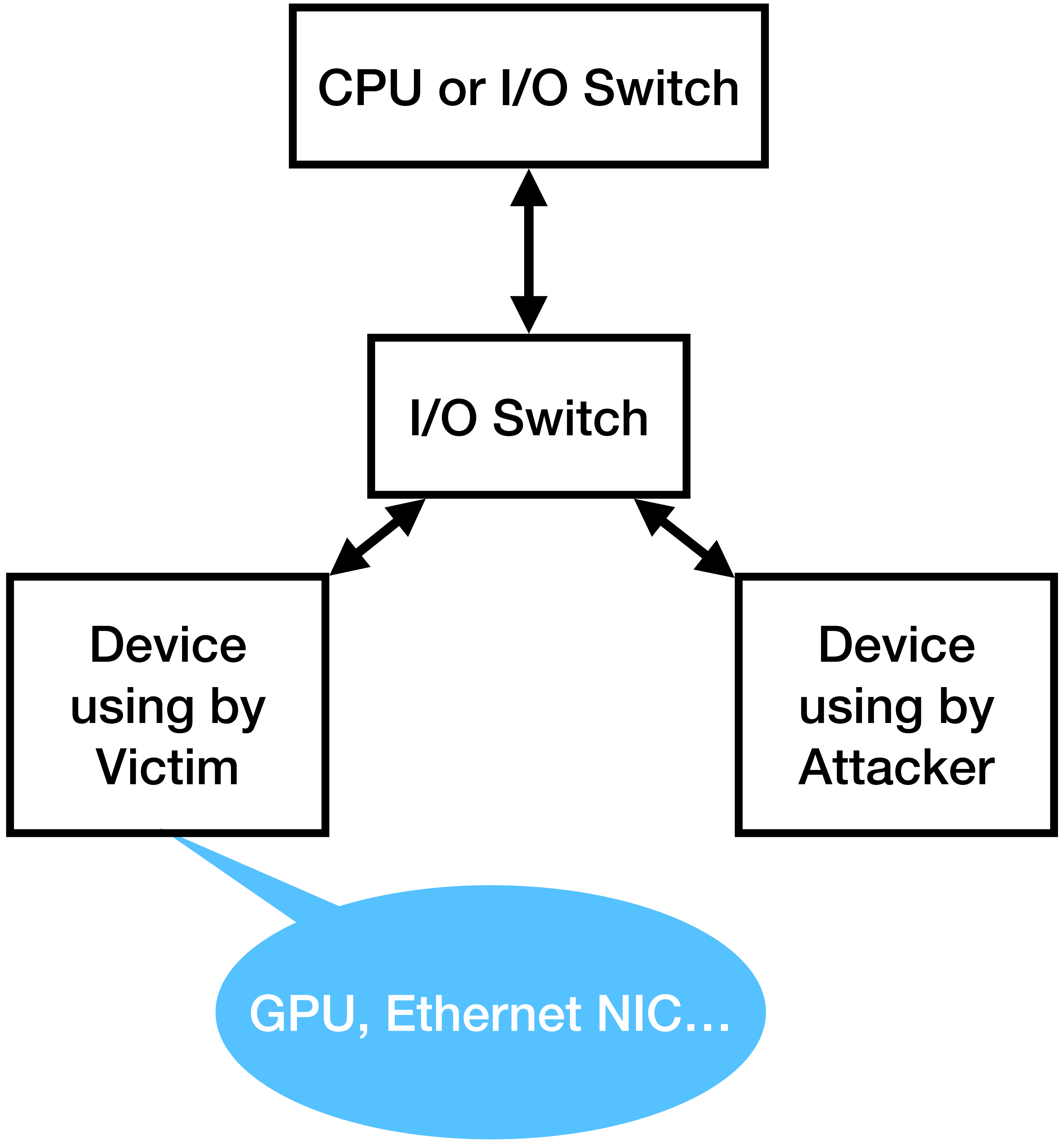

- GPU
  - password input in monitor
  - render webpages
  - machine Learning models trained

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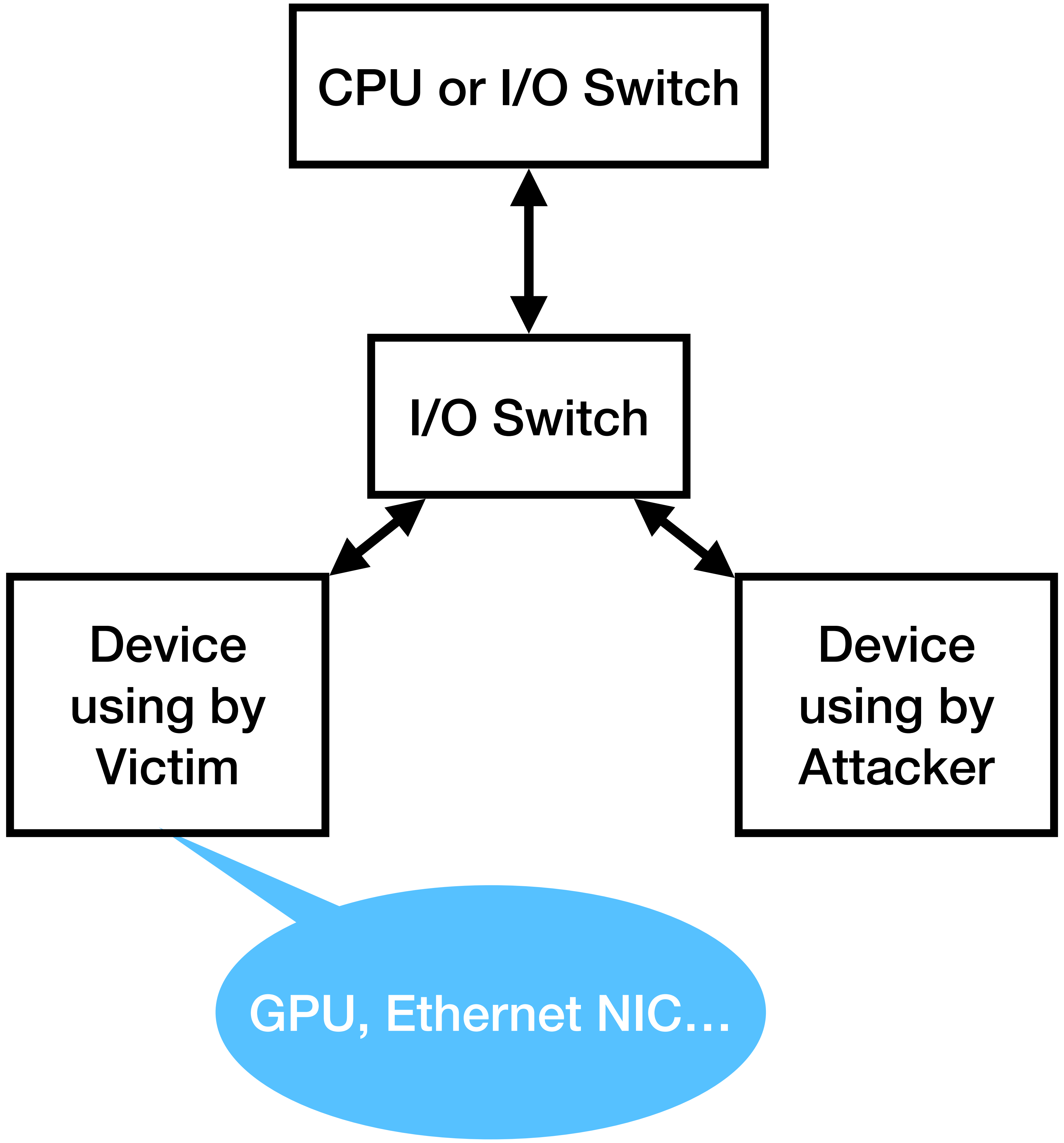
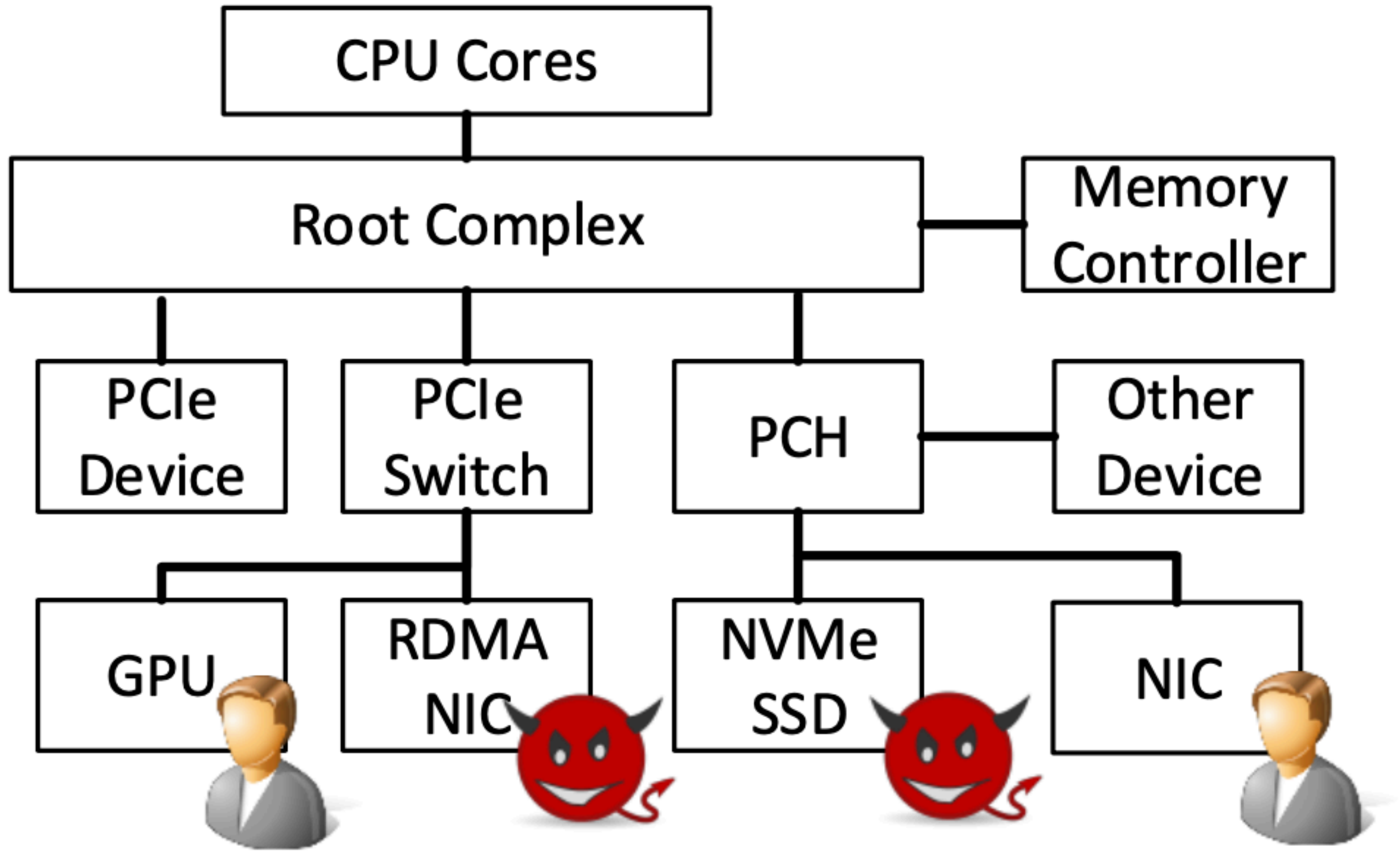


- GPU
  - password input in monitor
  - render webpages
  - machine Learning models trained
- Ethernet NIC
  - transmit webpages packets
  - SSH passwords or texts

Attack scenarios and victim tasks



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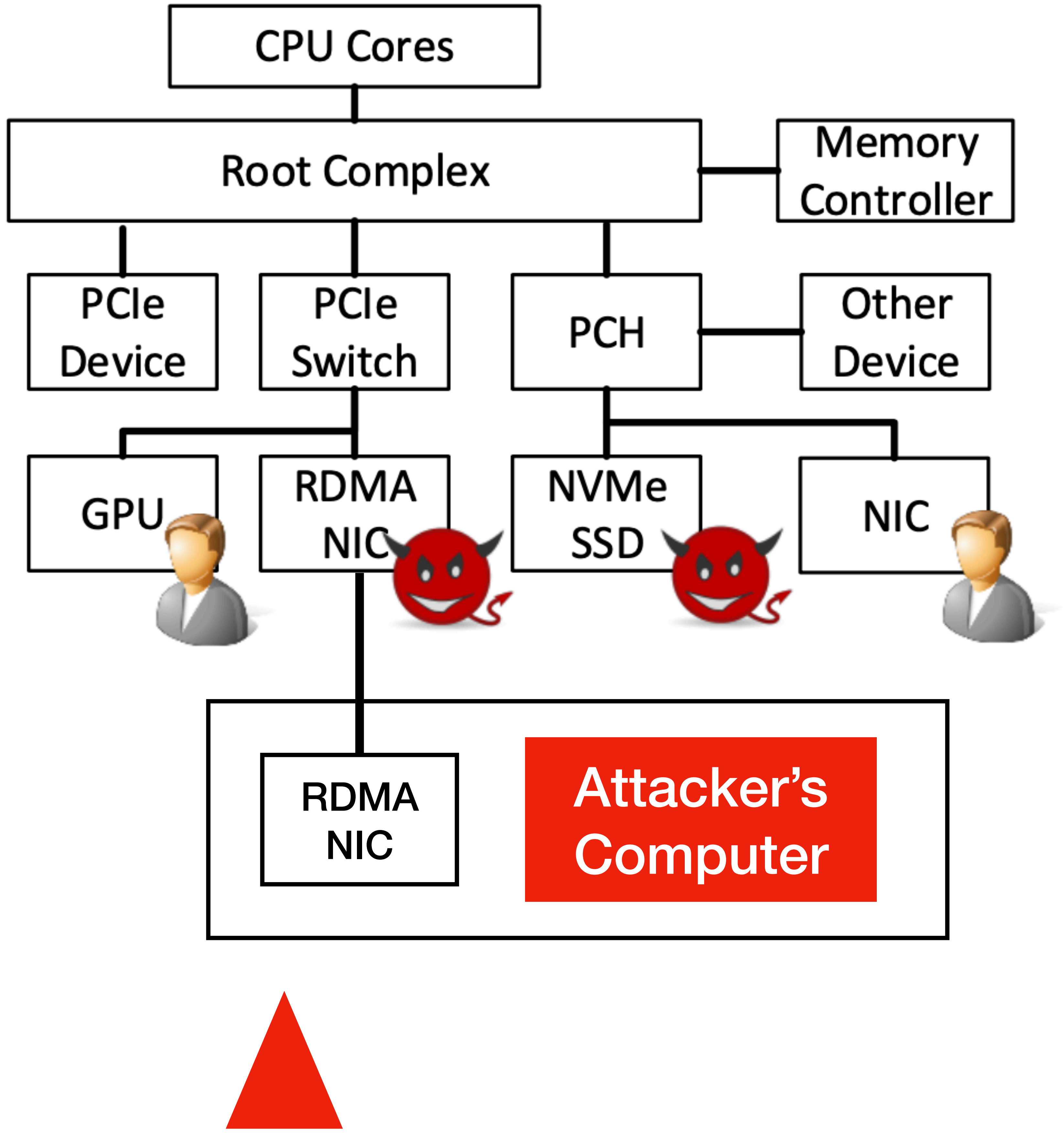
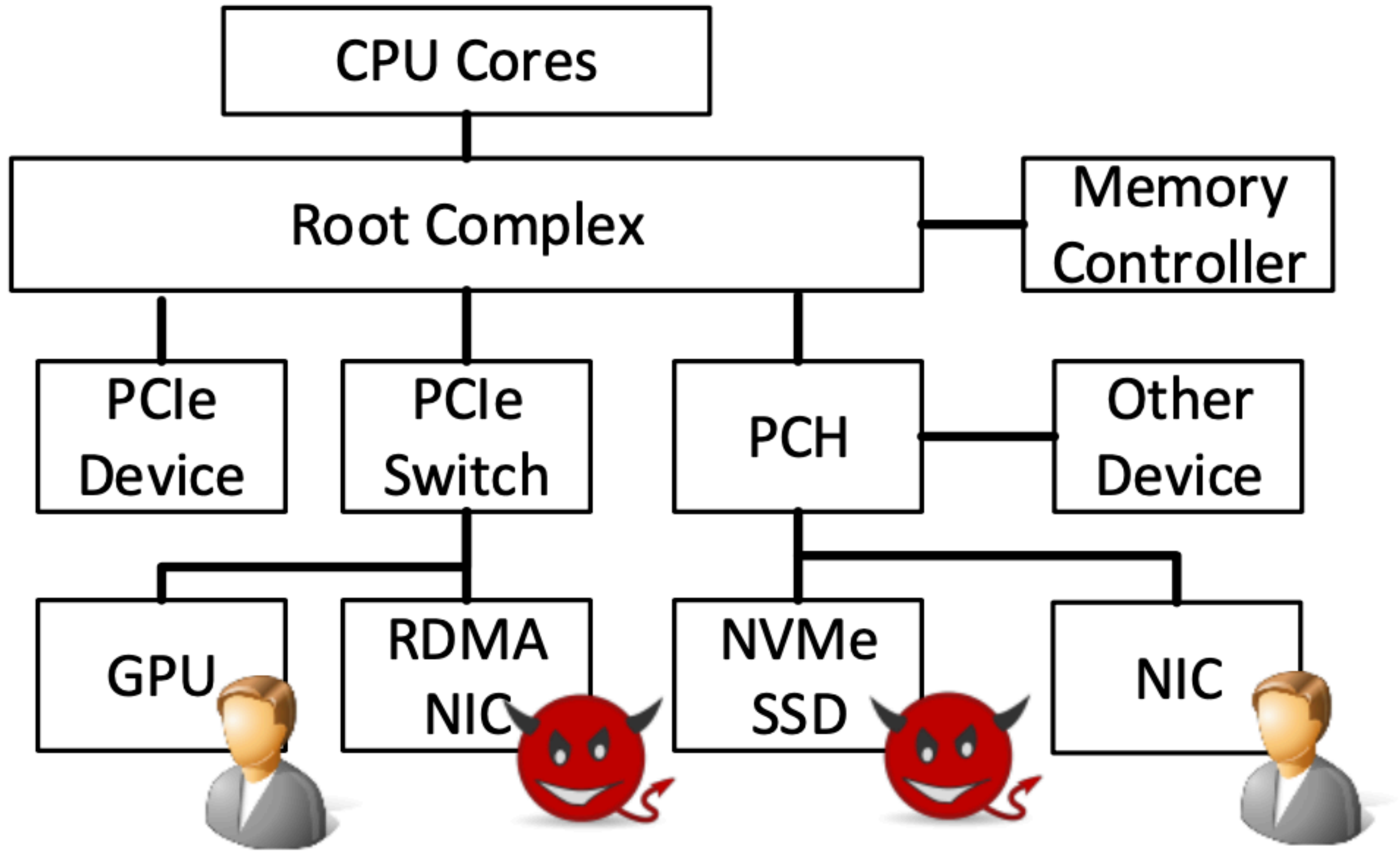


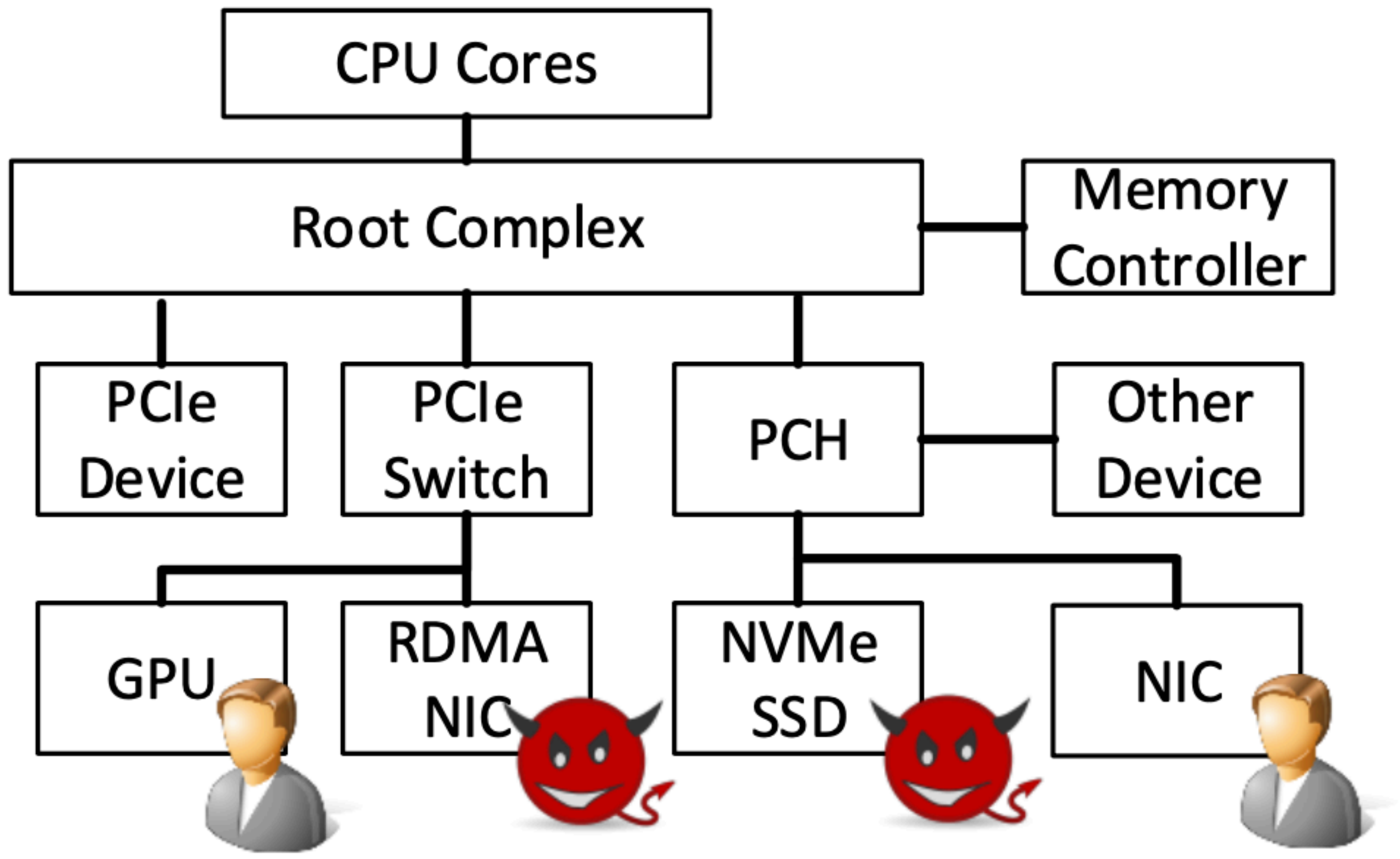
S1 Control RDMA NIC to attack GPU

Attack scenarios and victim tasks



S2 Control NVMe SSD to attack Ethernet NIC

Attack scenarios and victim tasks



- T1 User-input Inference
- T2 Webpage Inference
- T3 Machine-learning Model Inference

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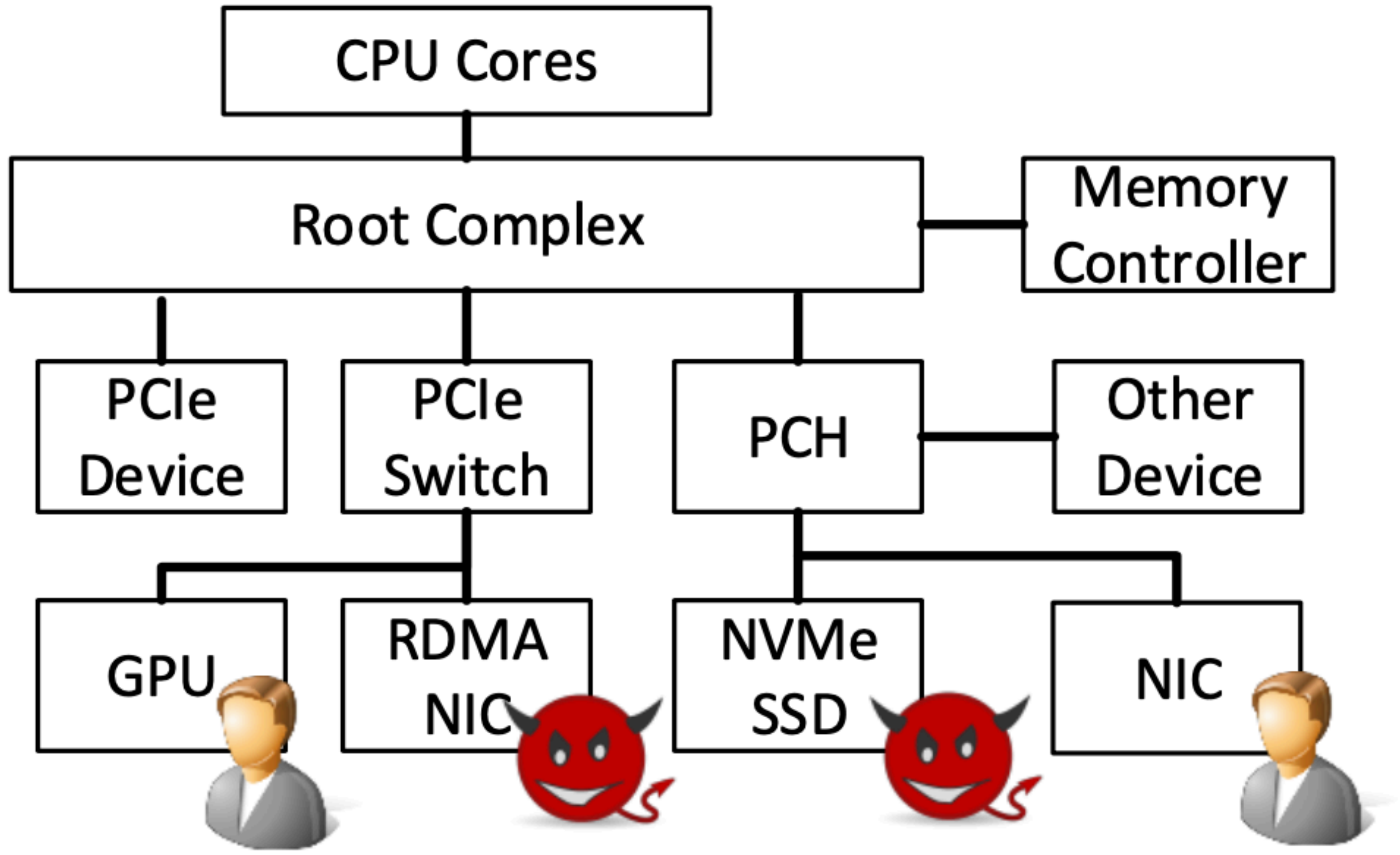

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	T1	T2	T3
S1	✓	✓	✓
S2		✓	

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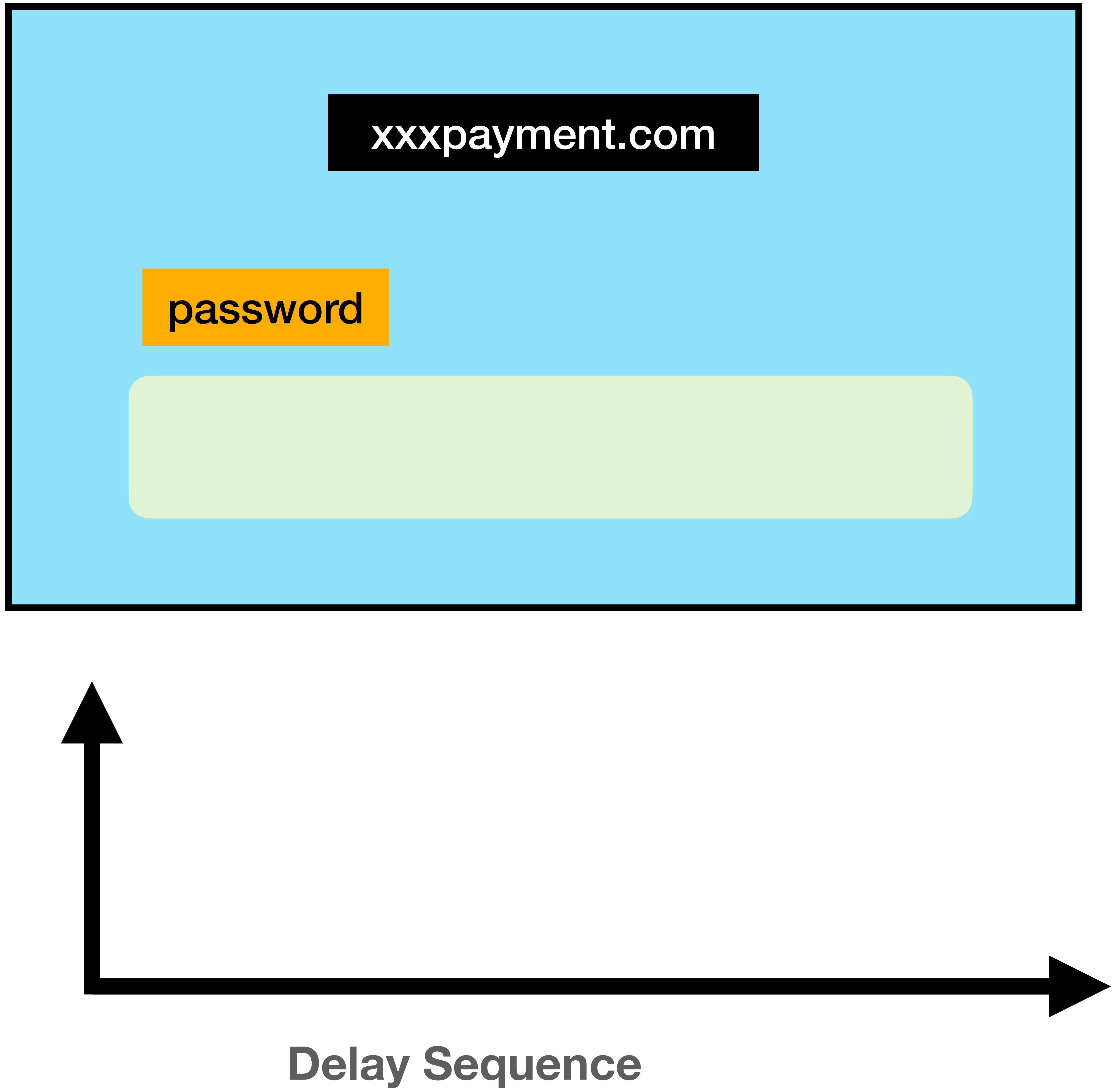

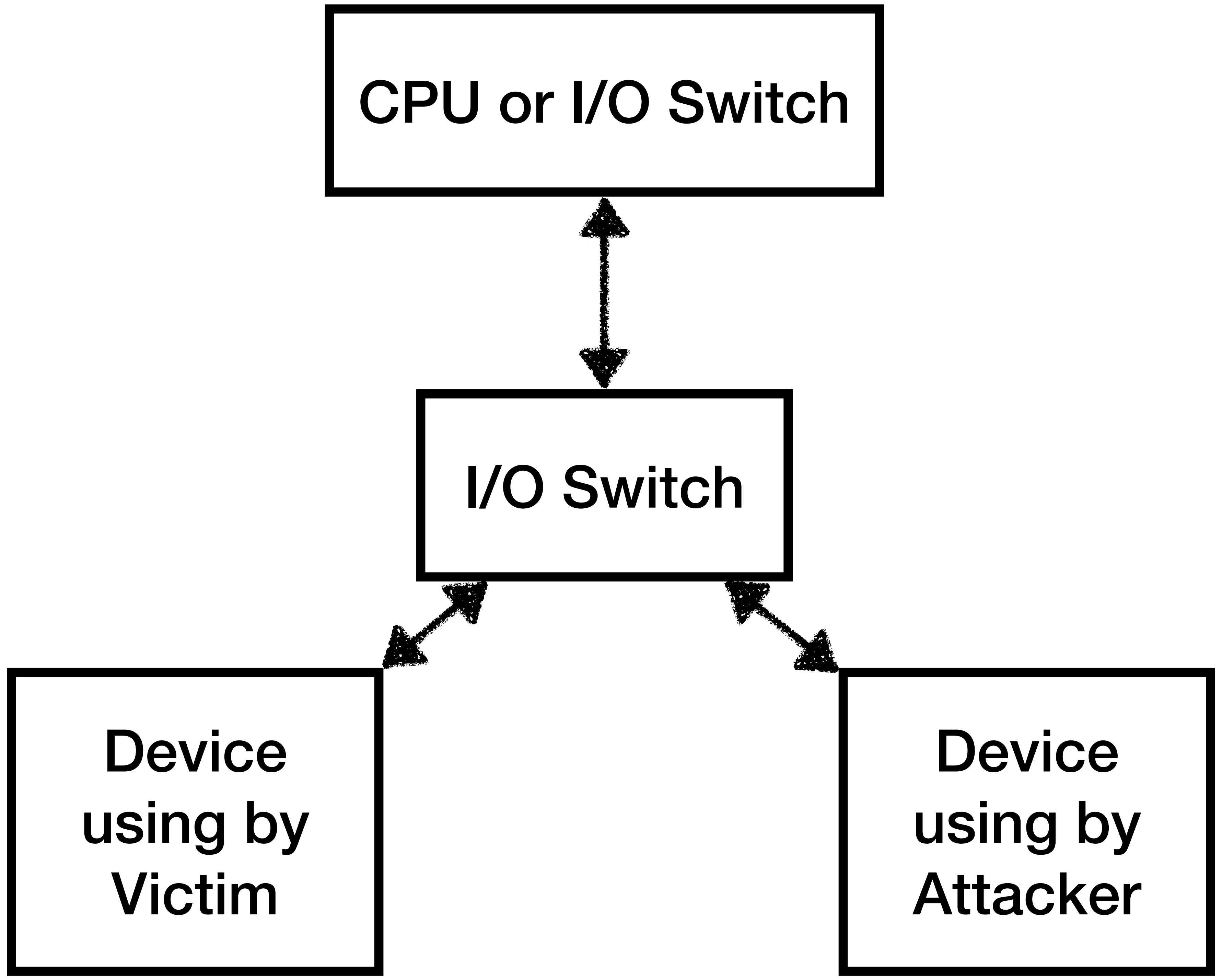

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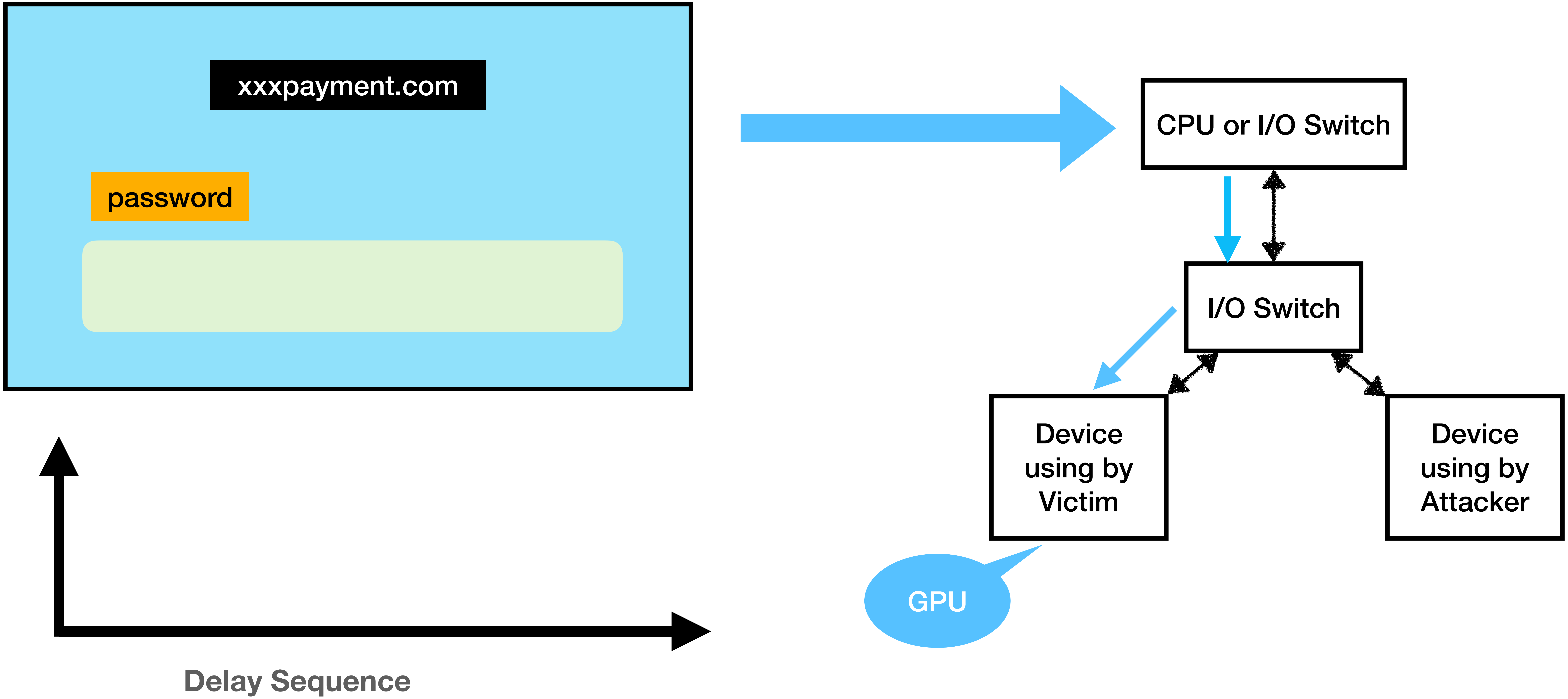

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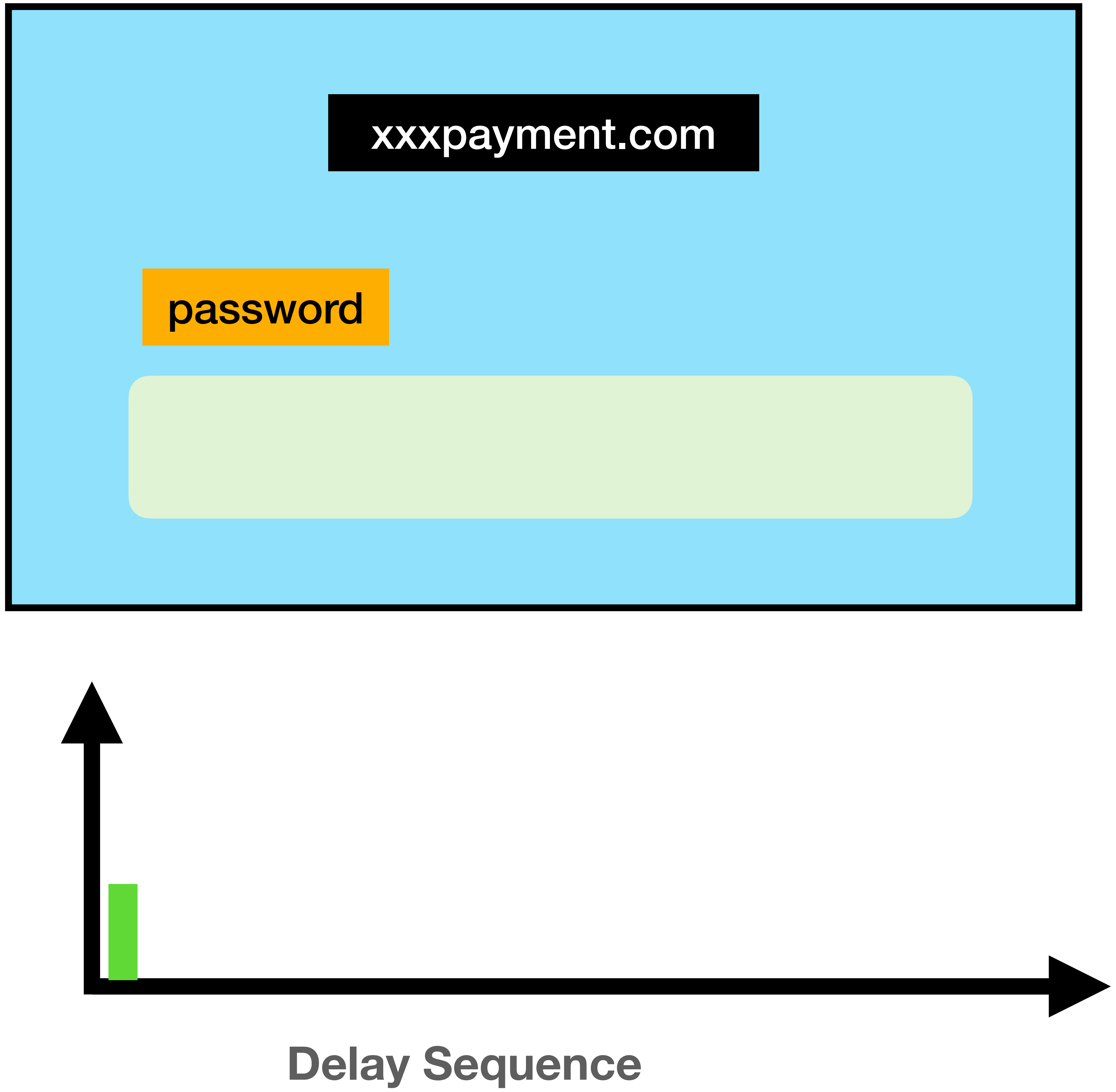

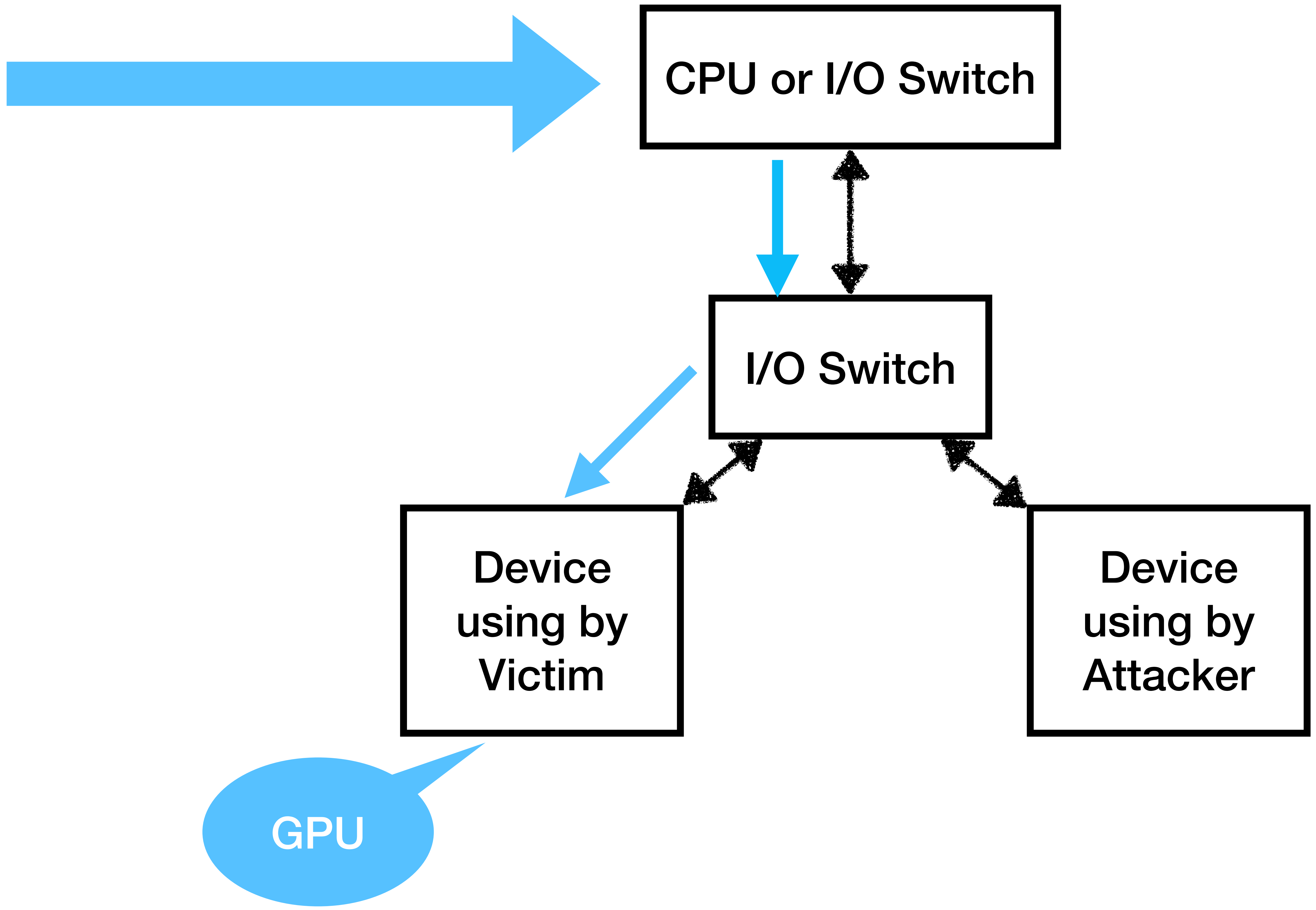

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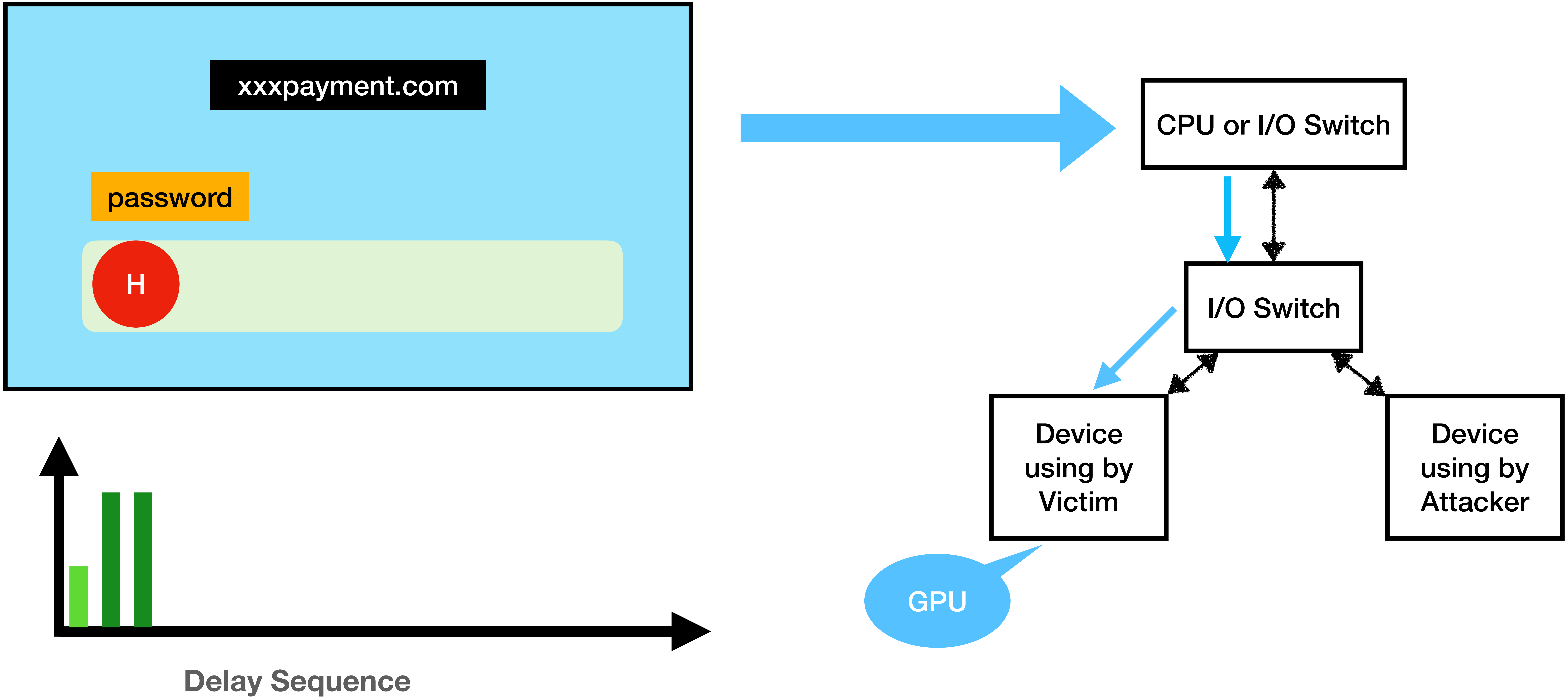

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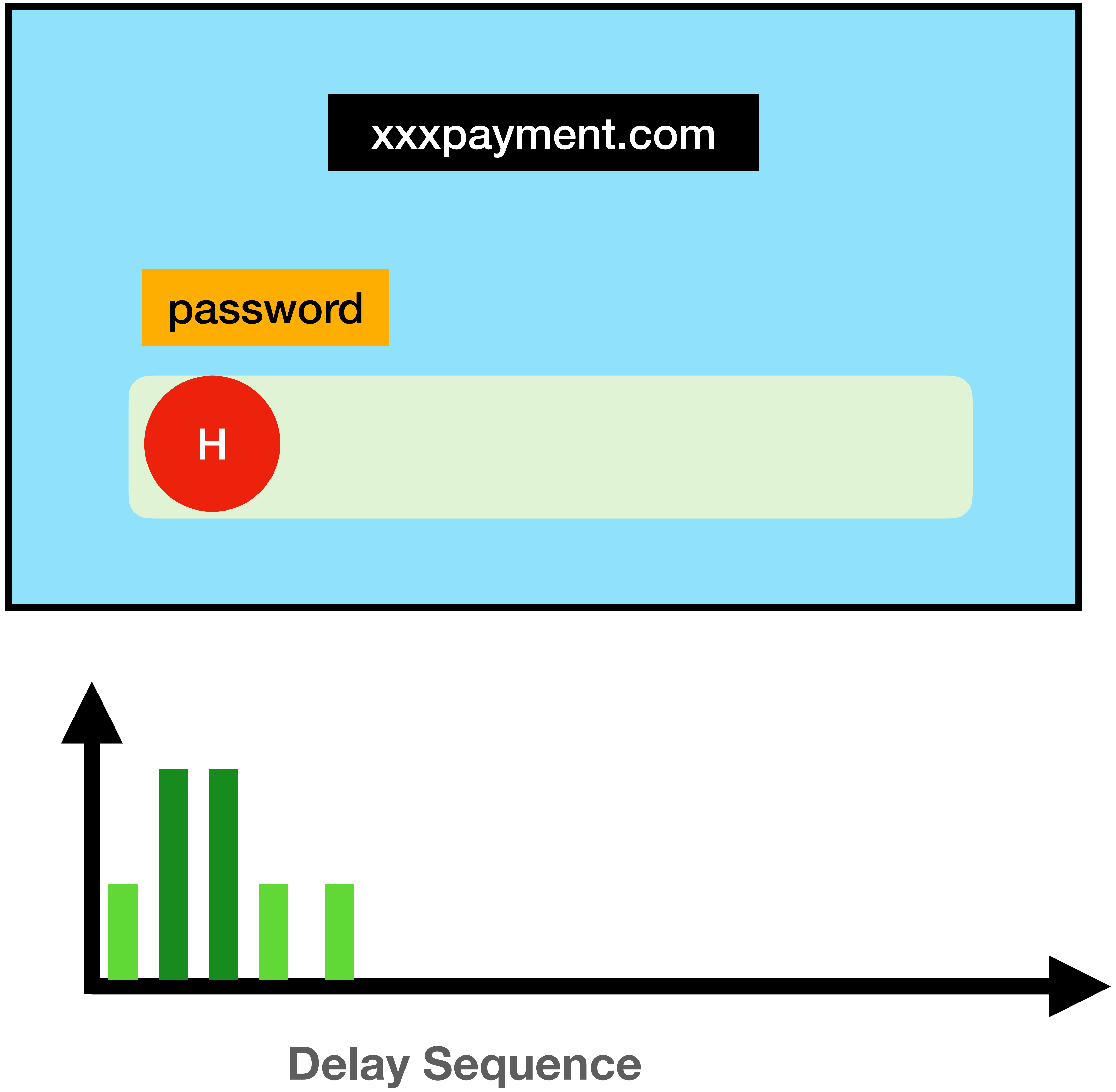

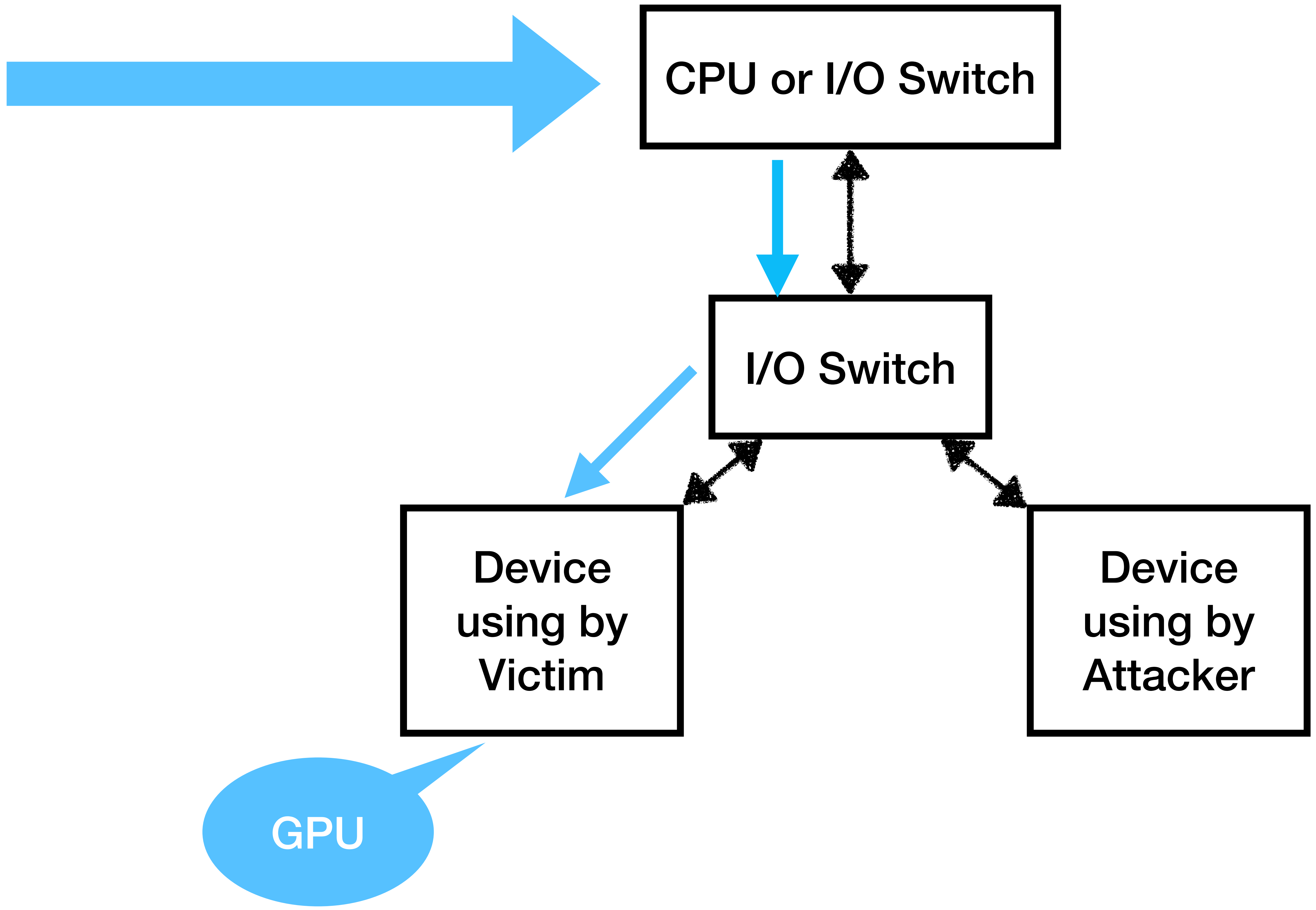

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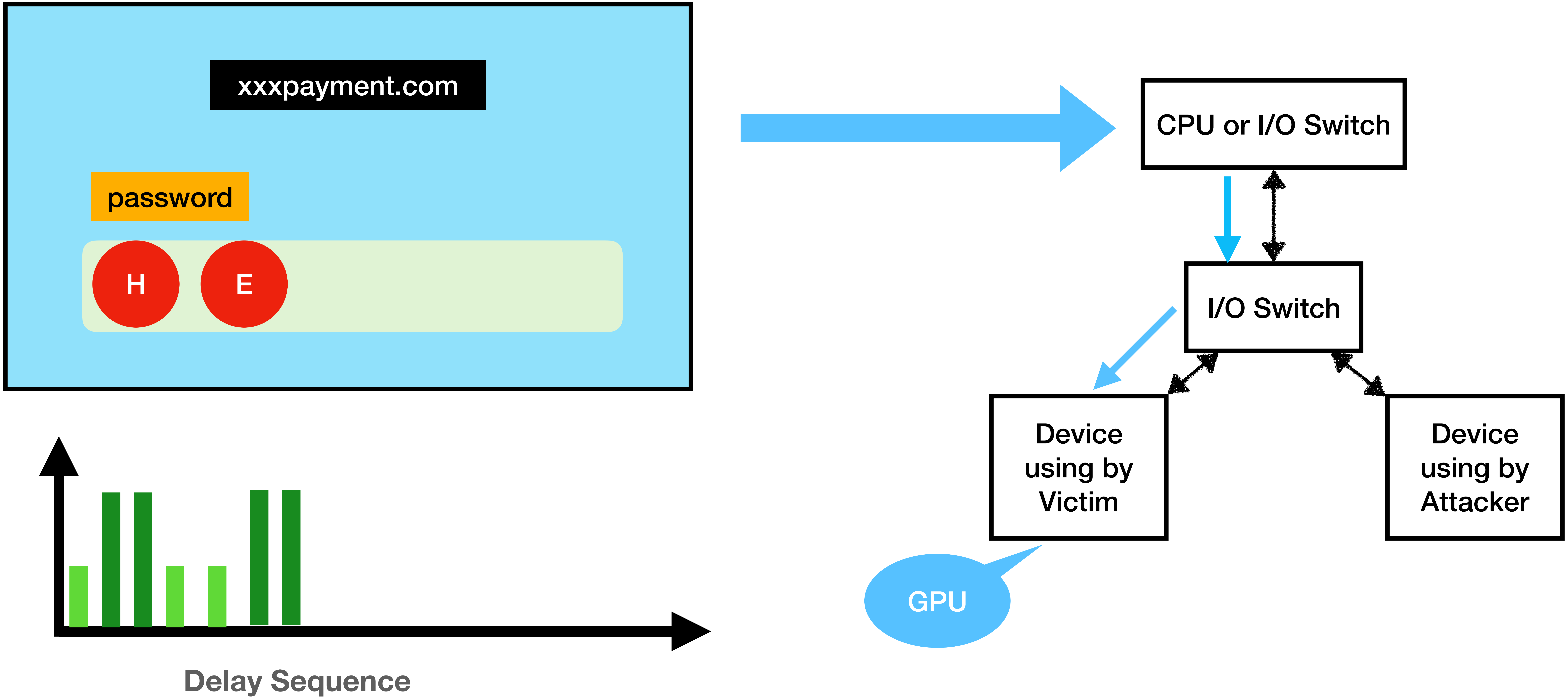

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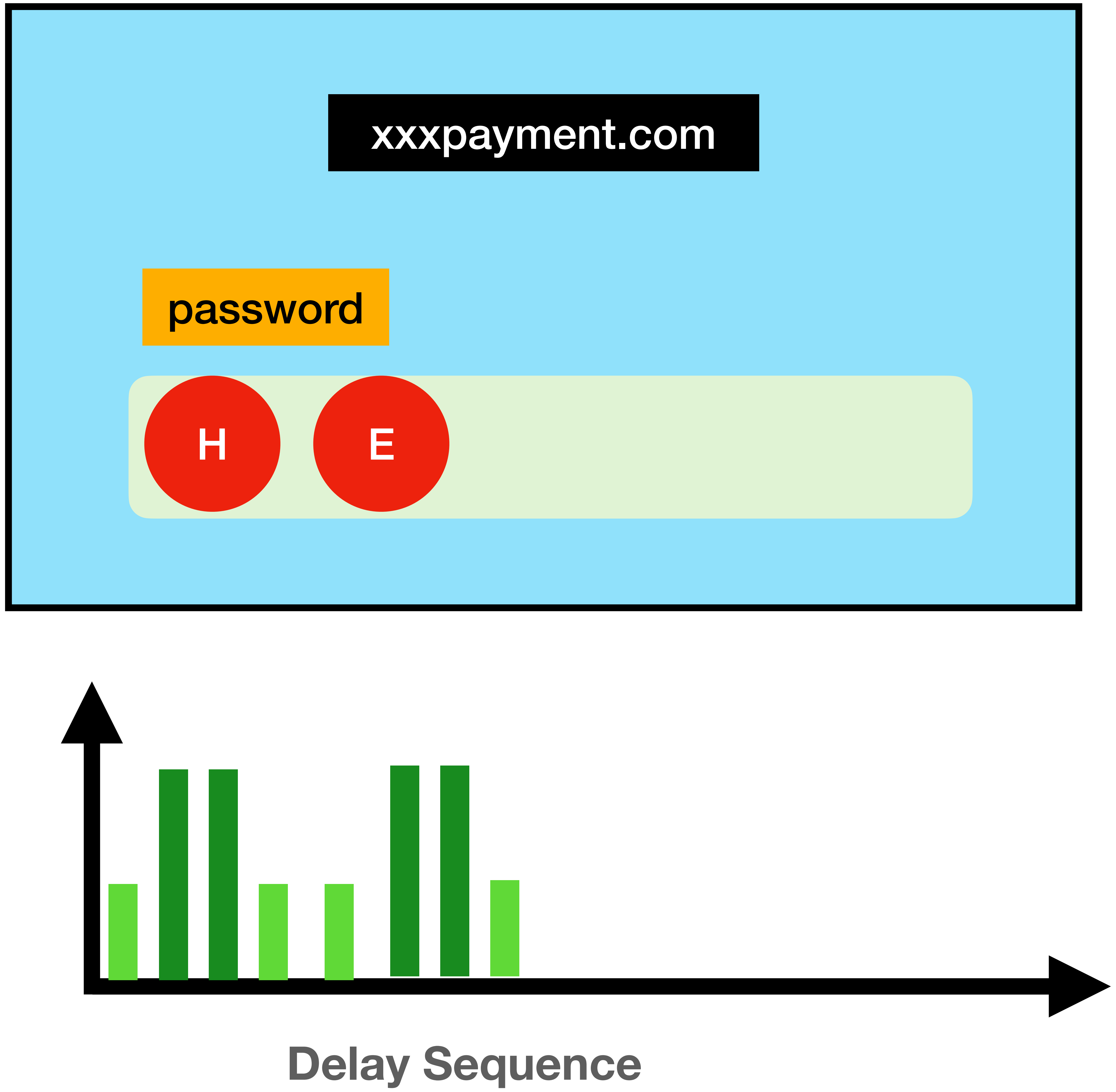

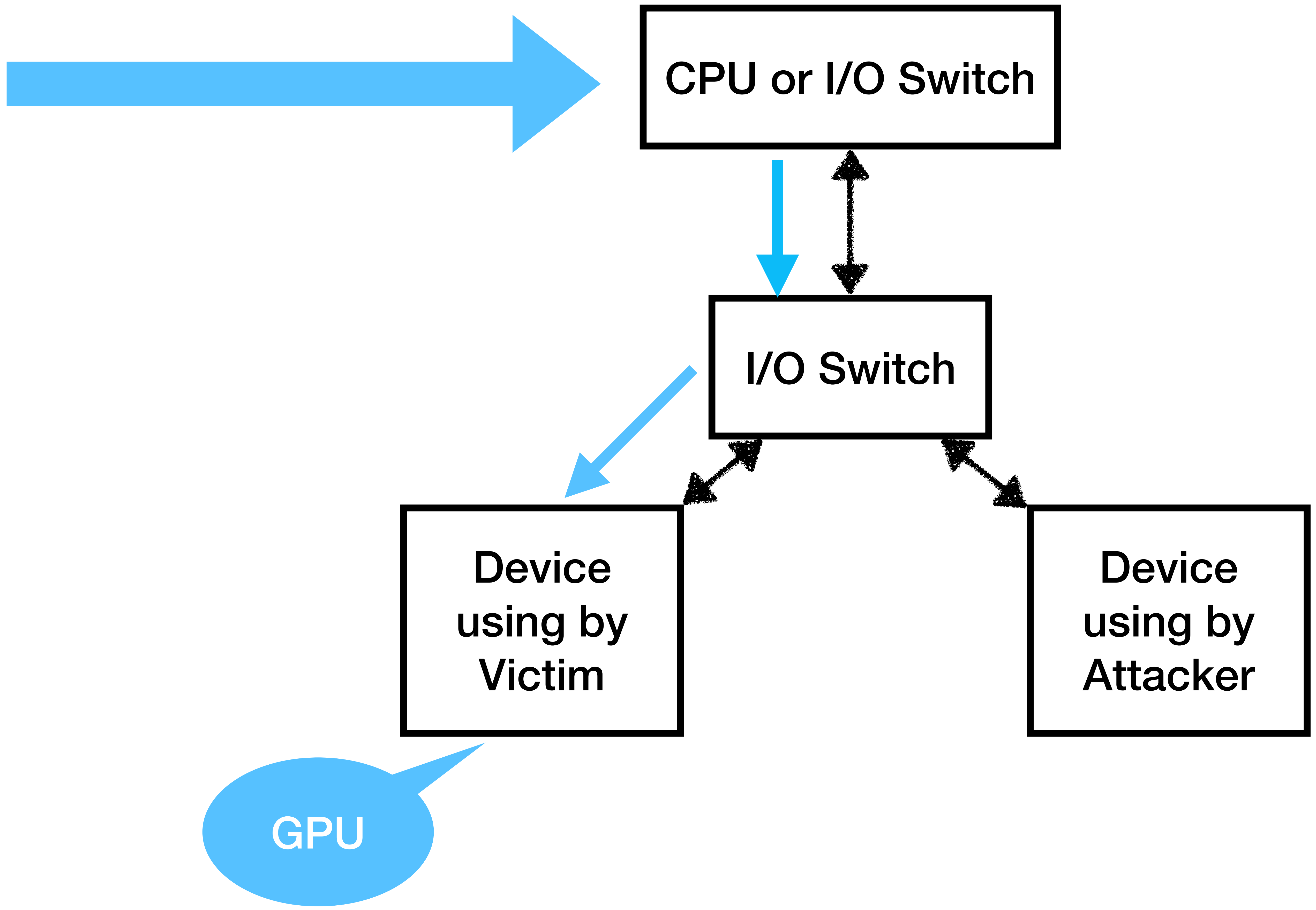

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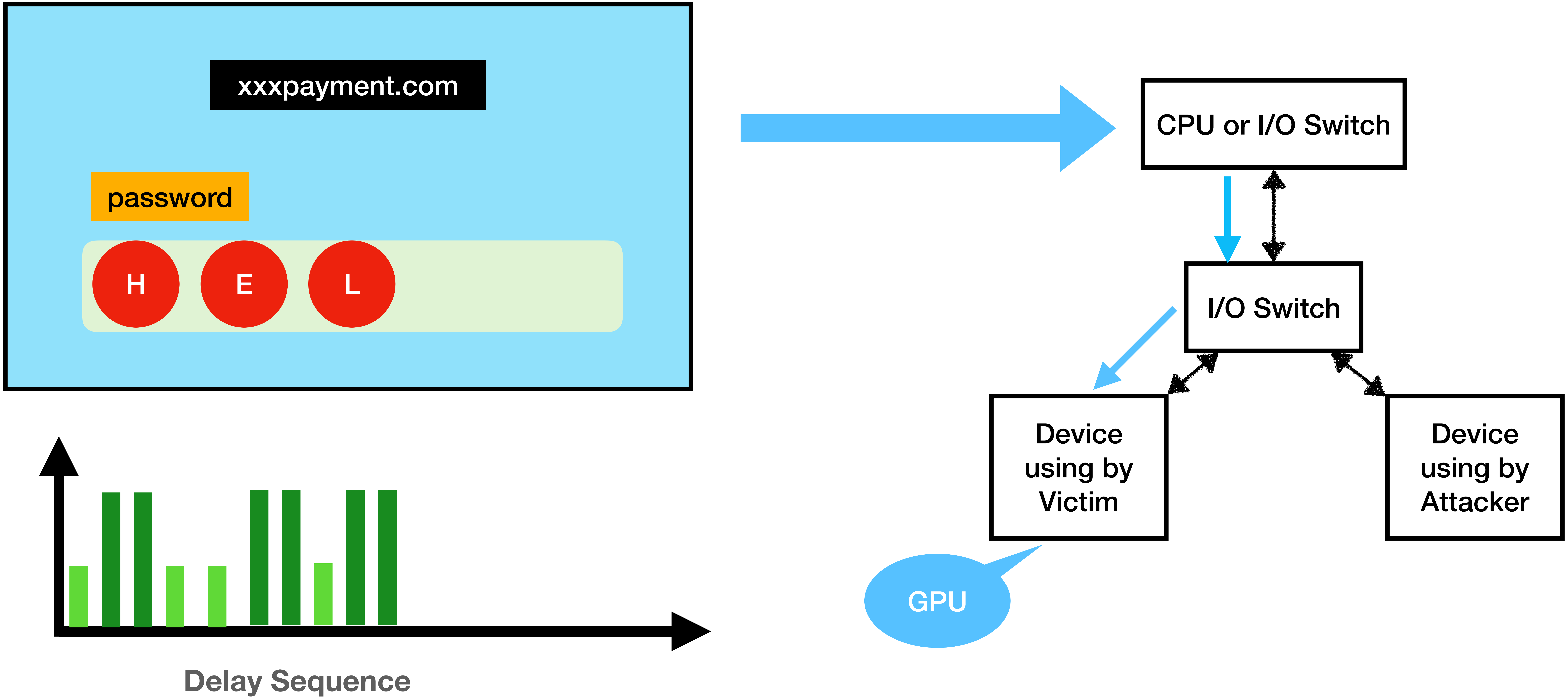

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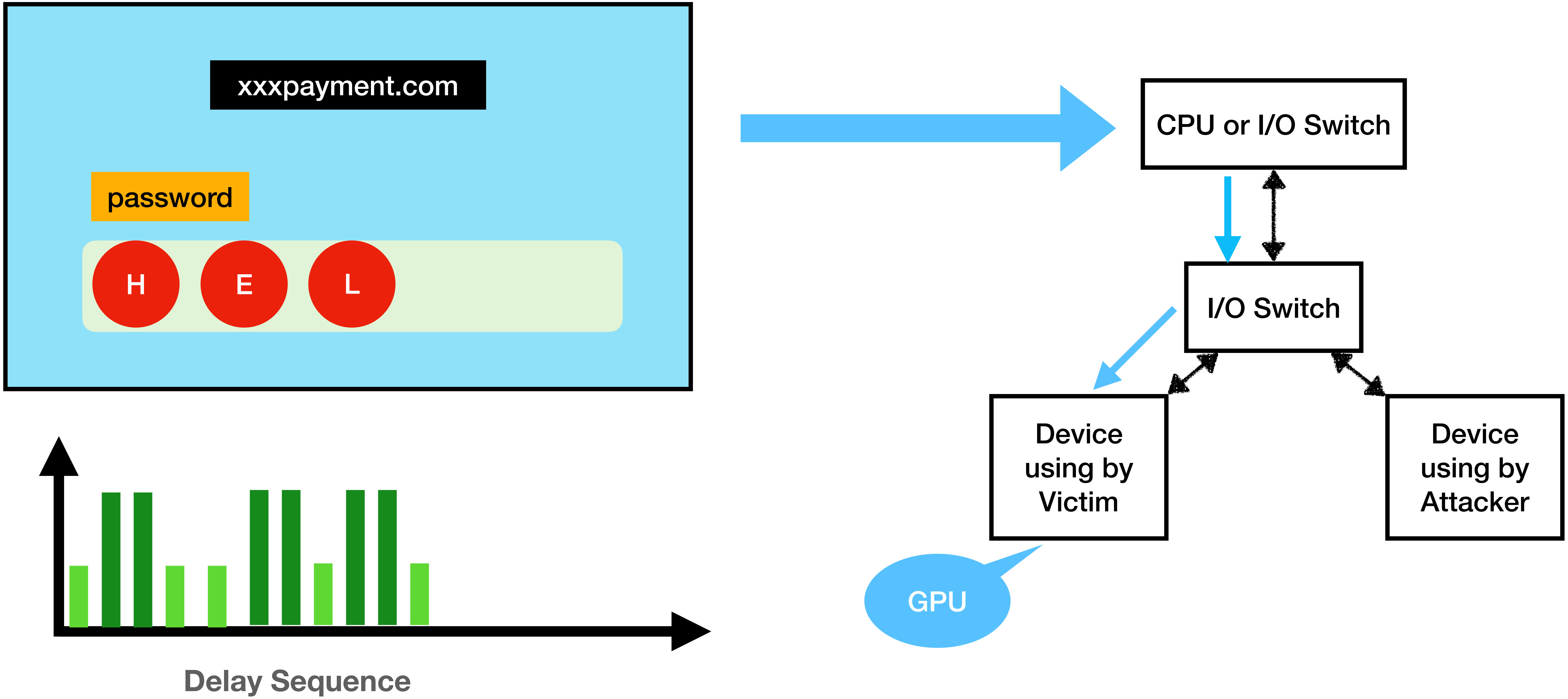

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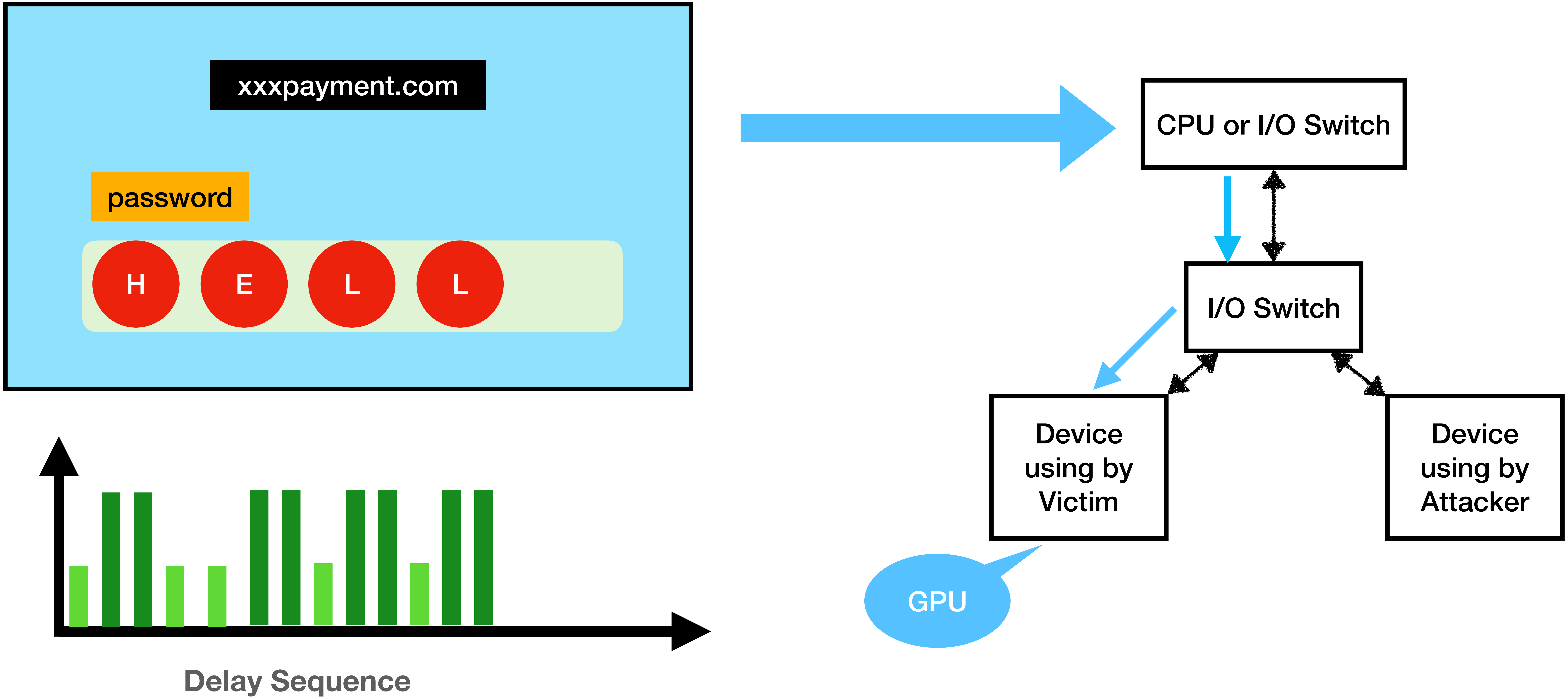

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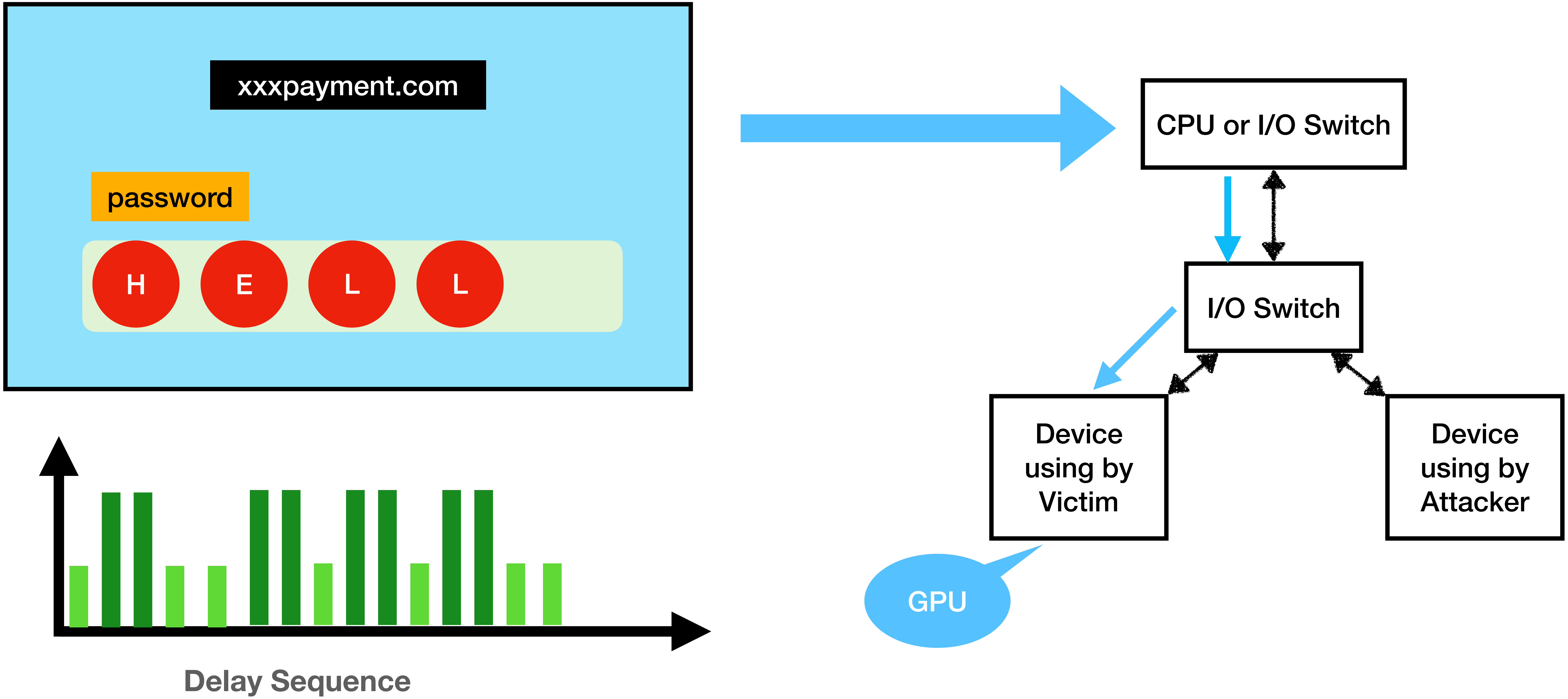

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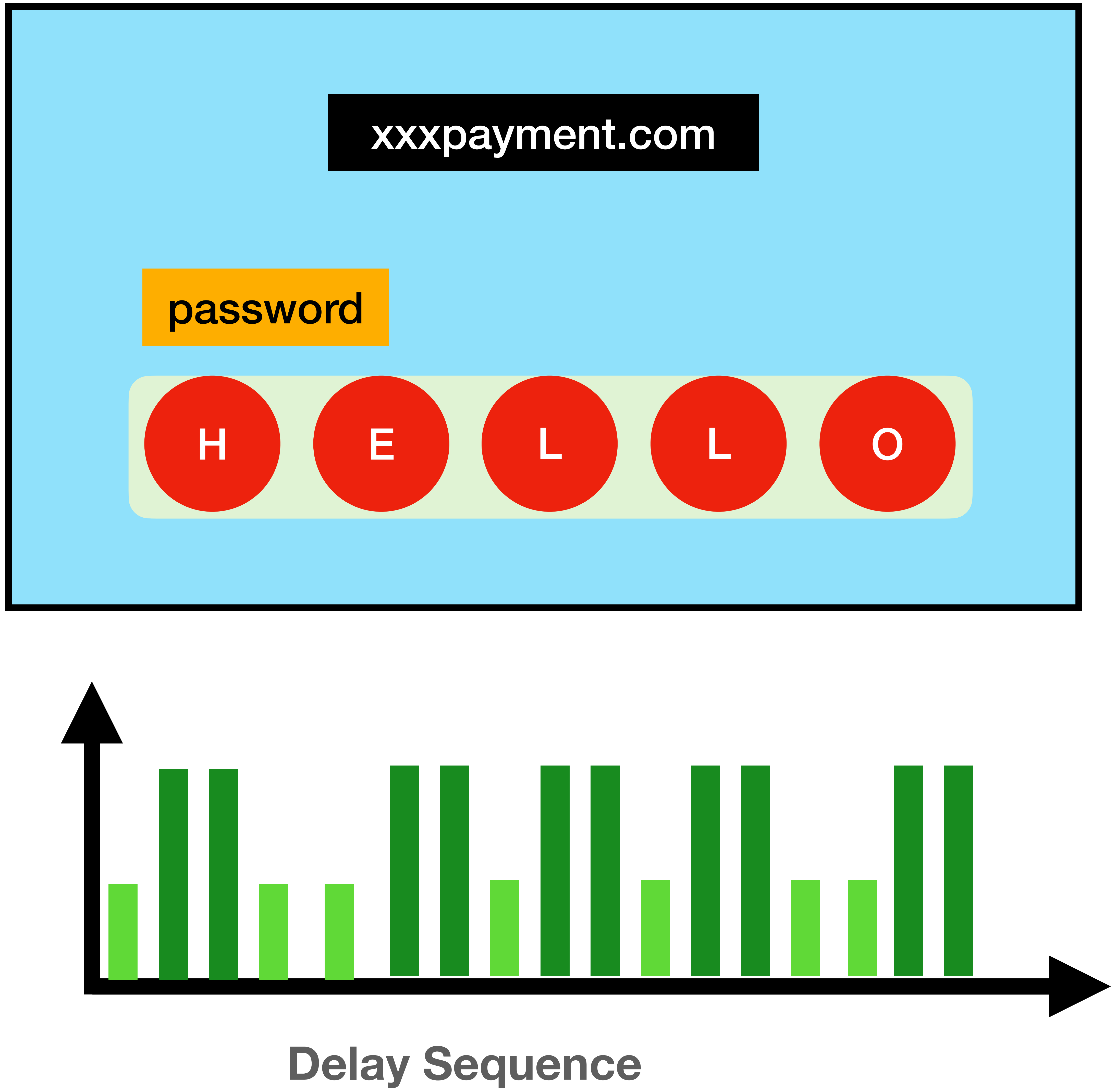

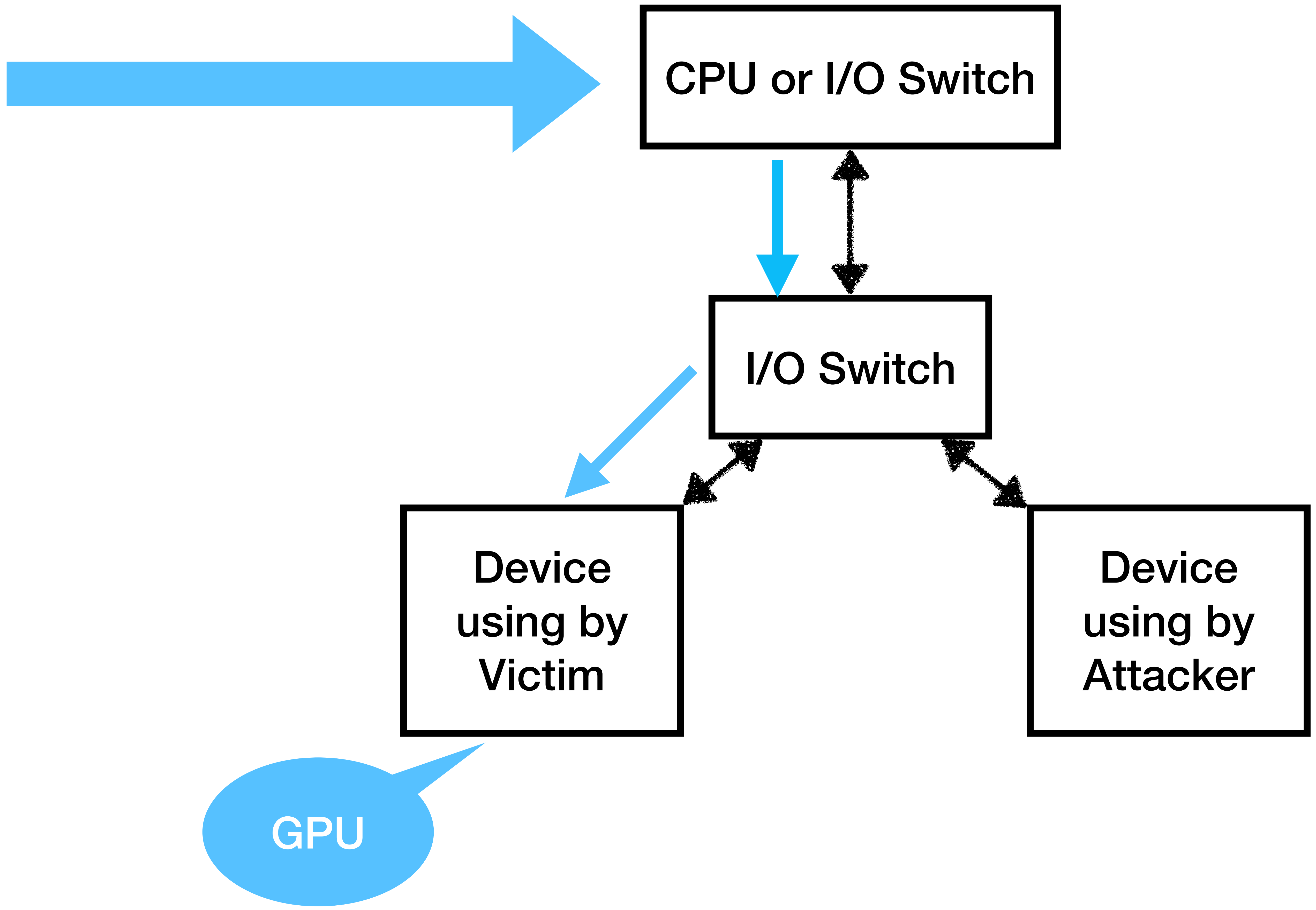

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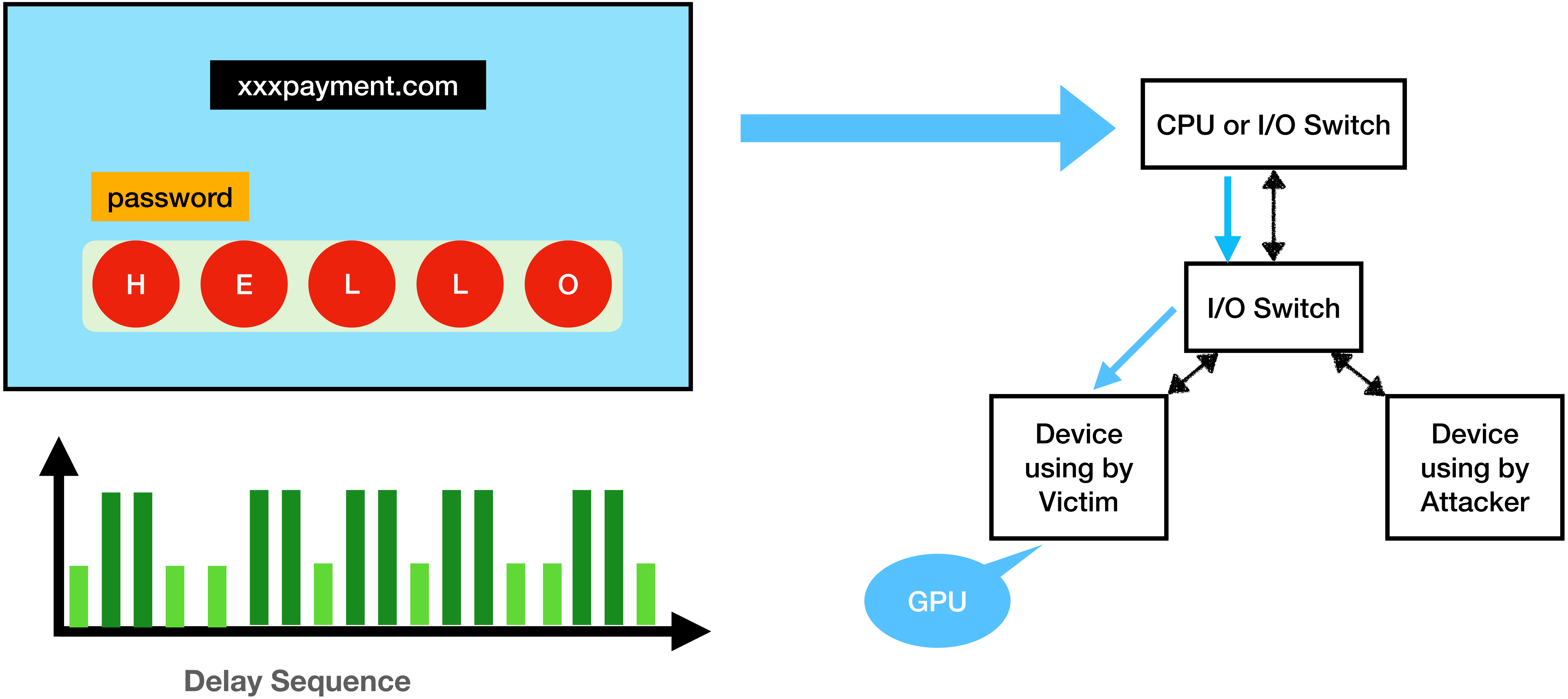

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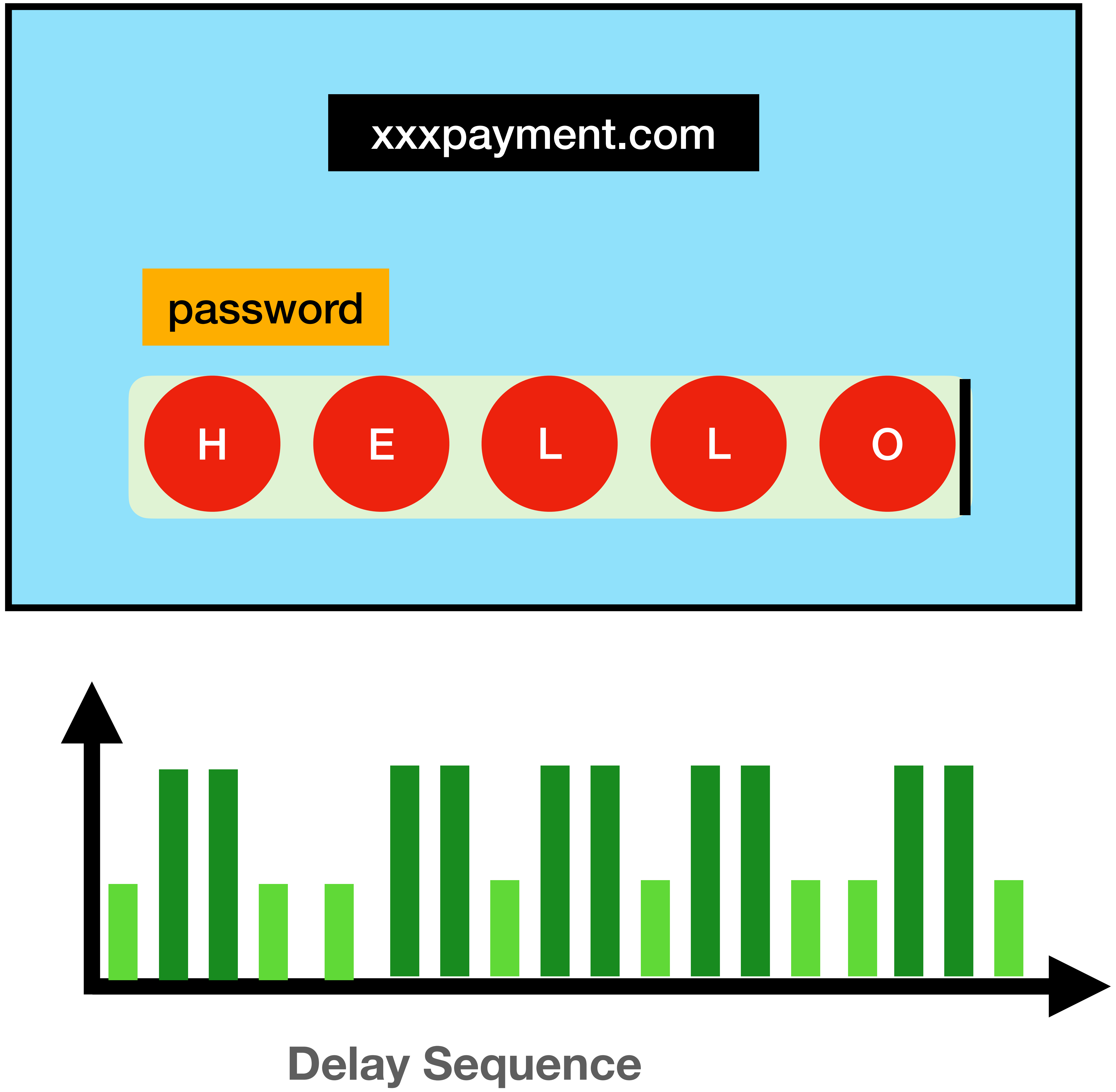

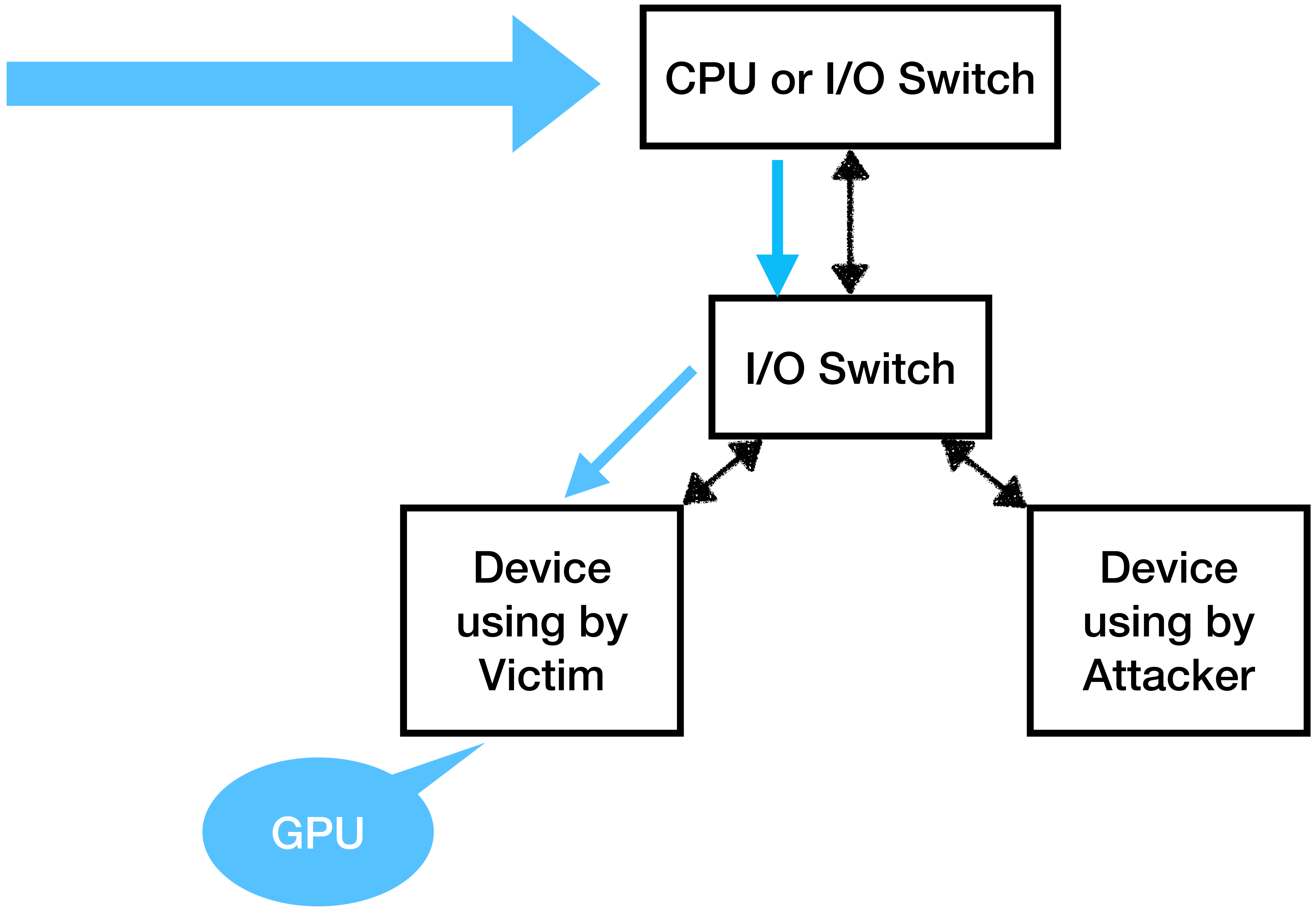

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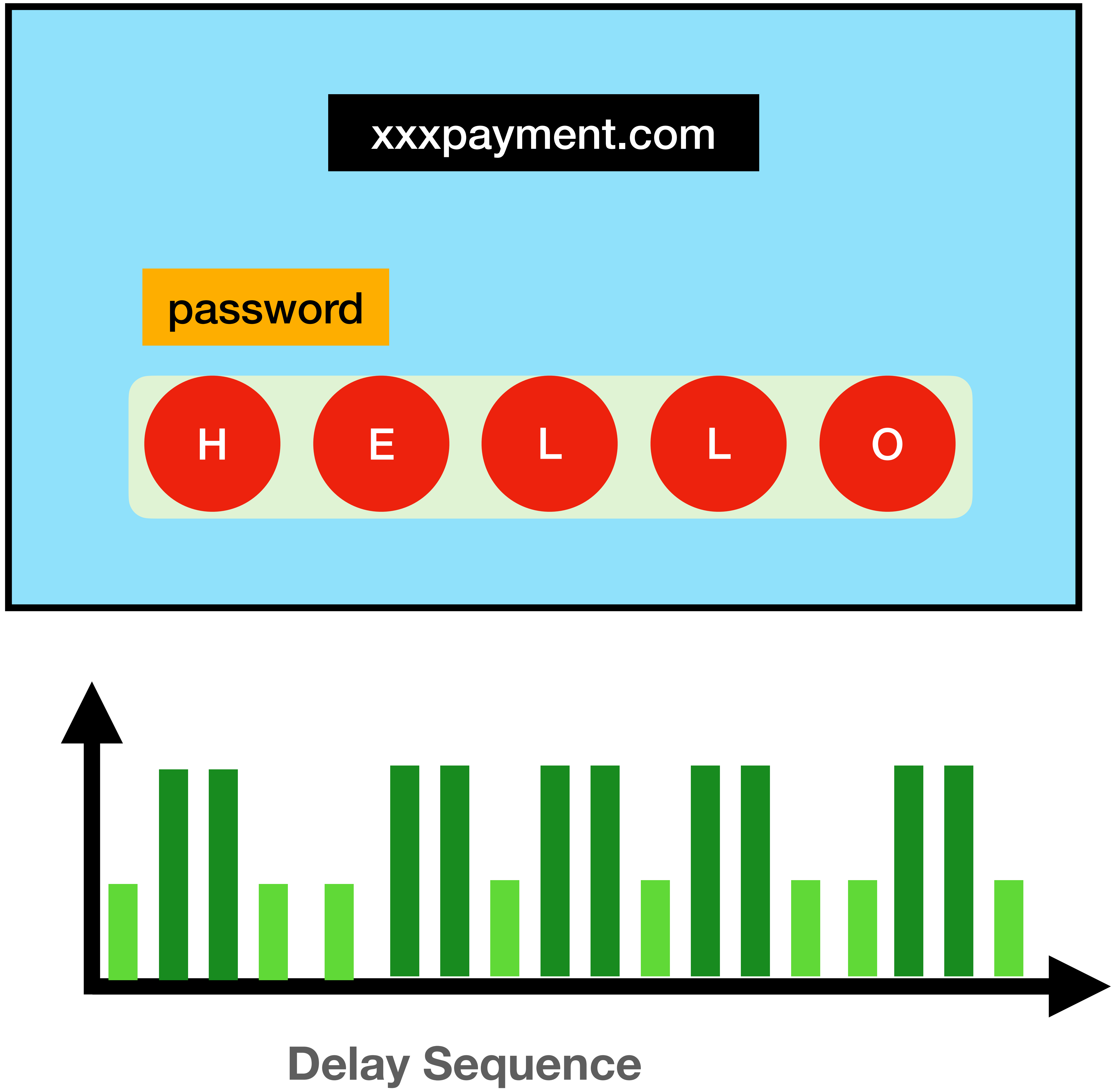

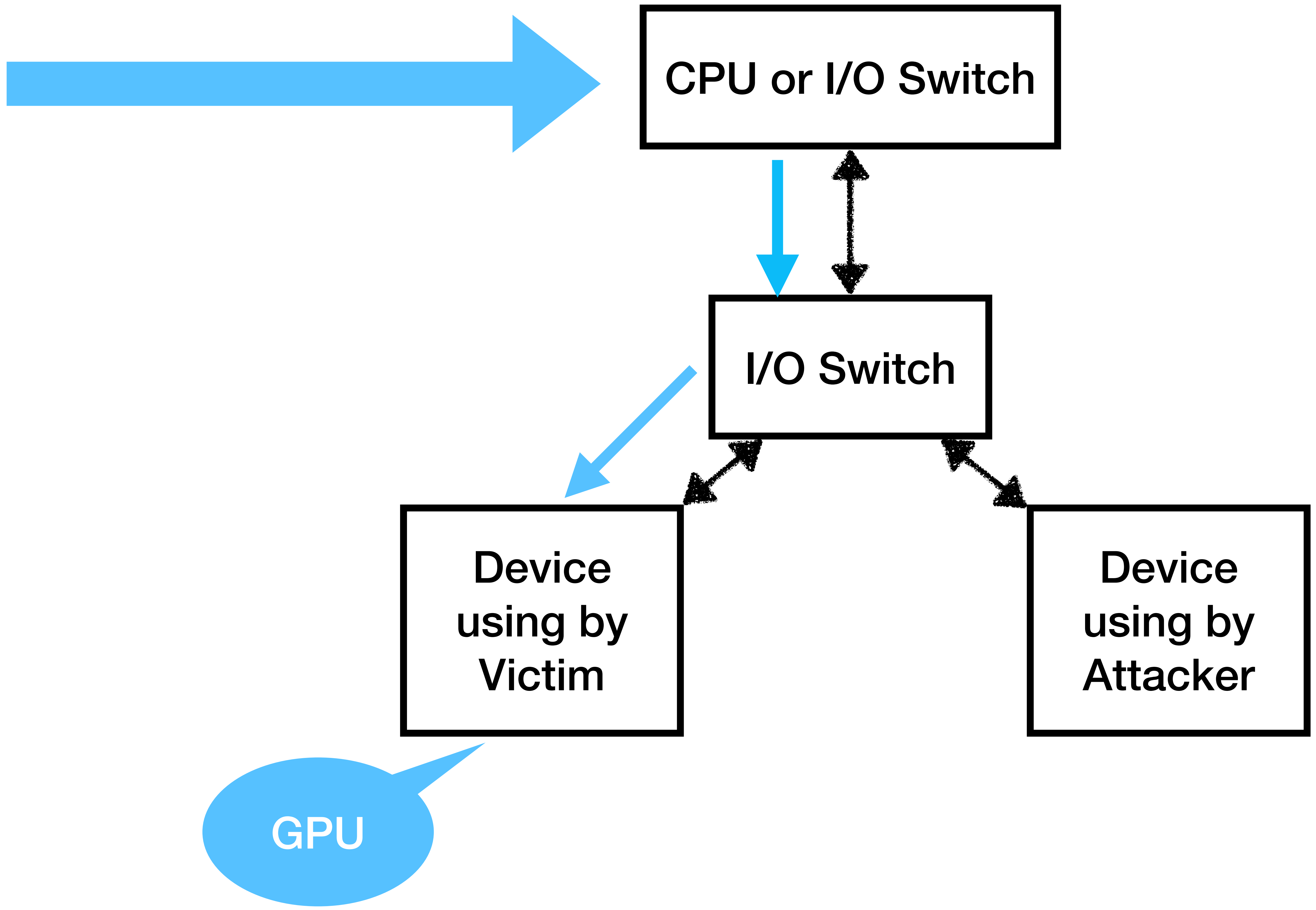

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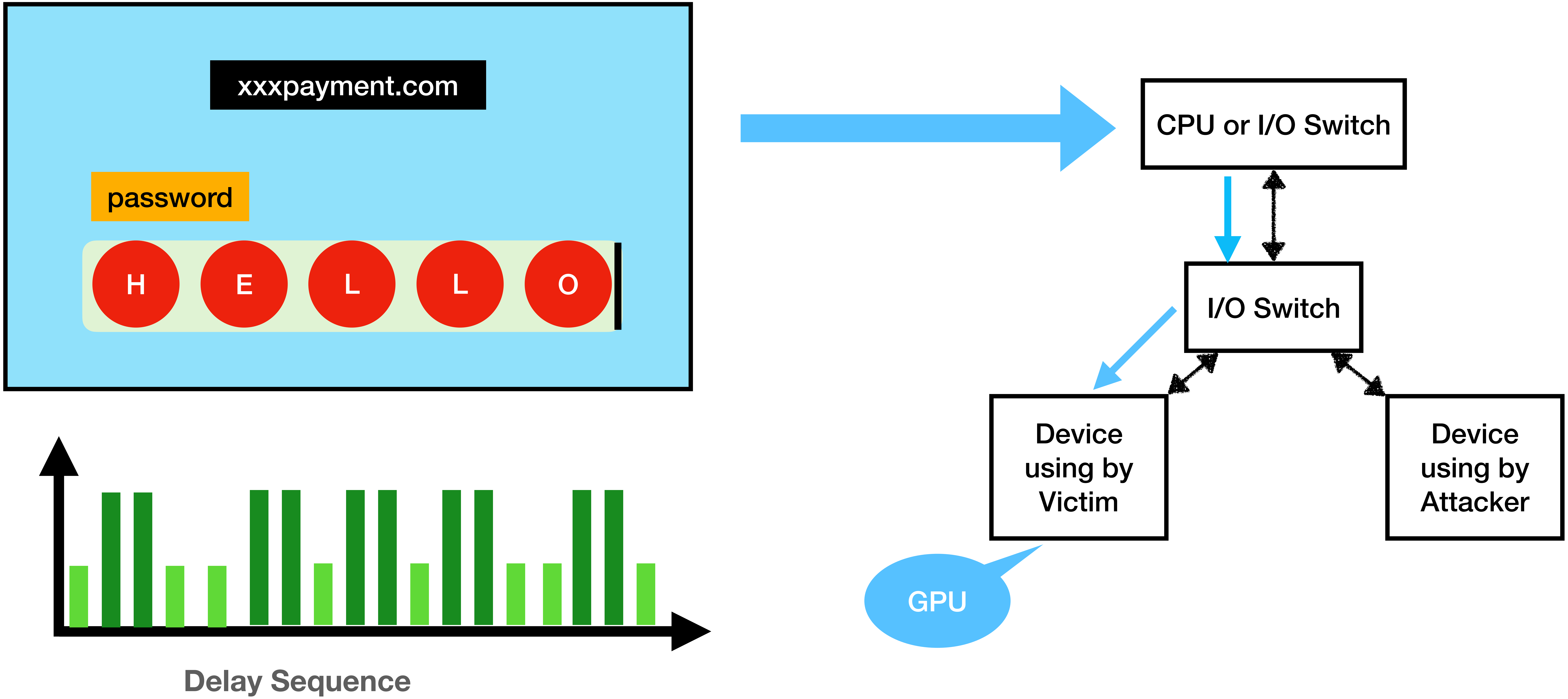

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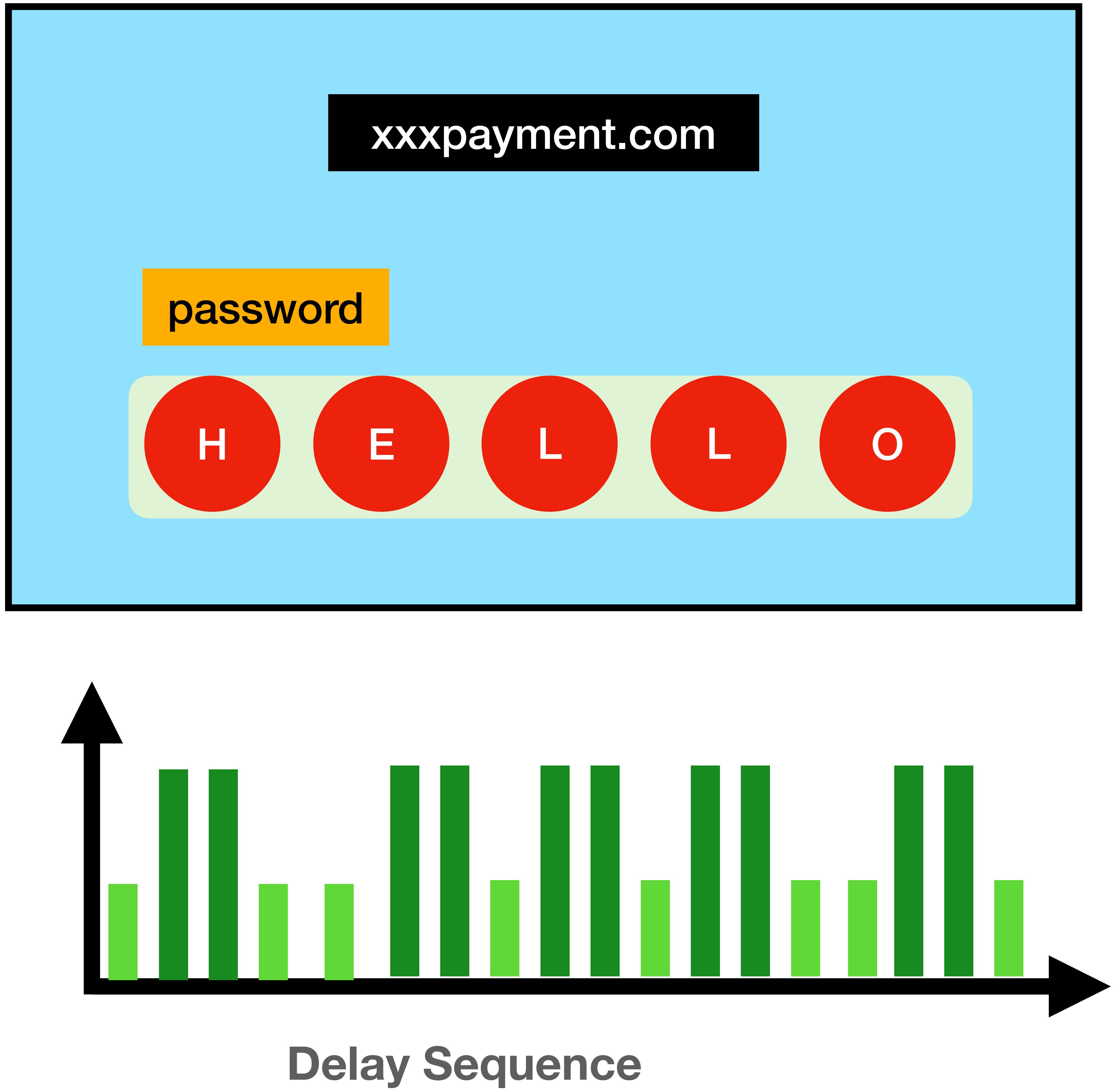
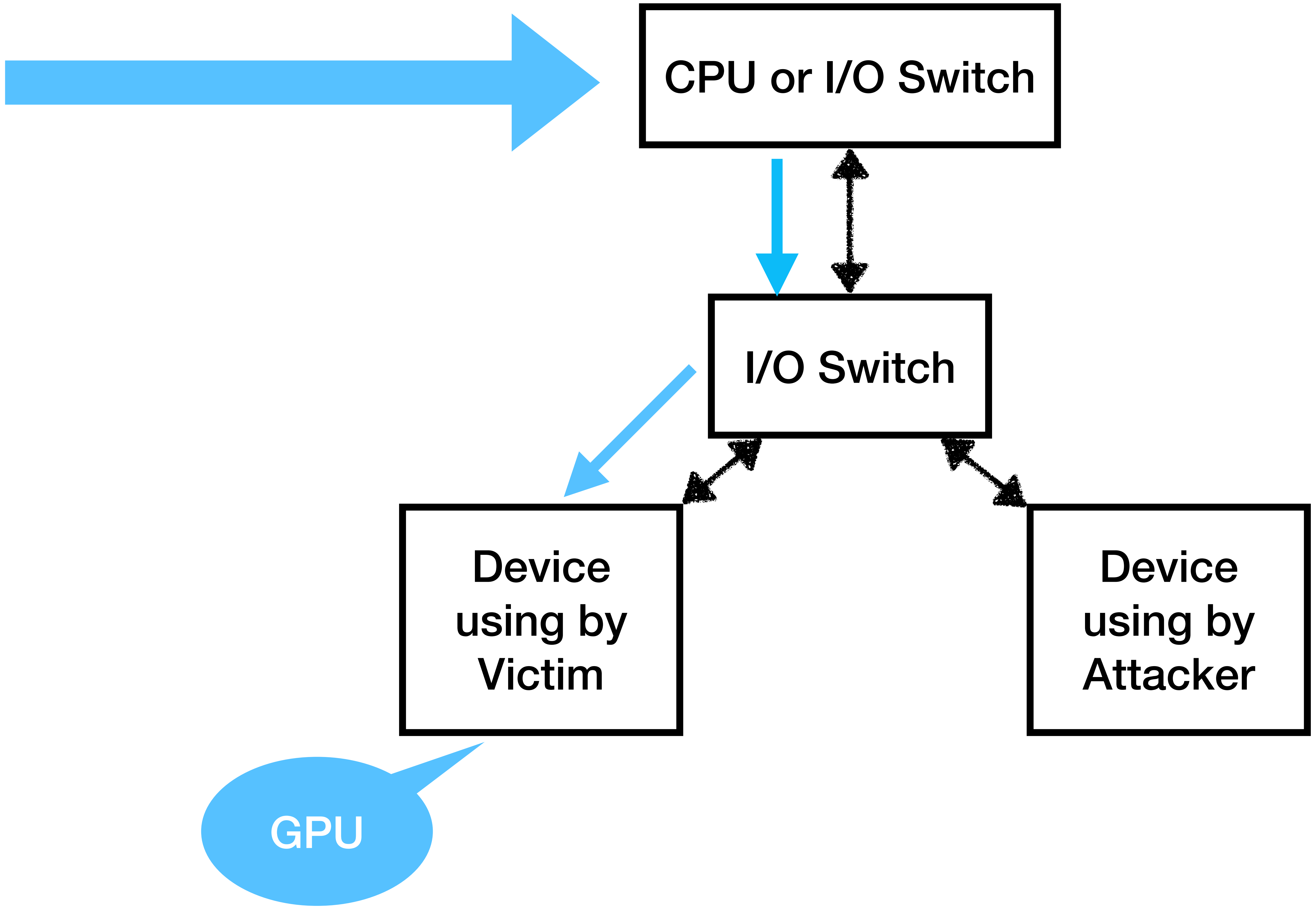
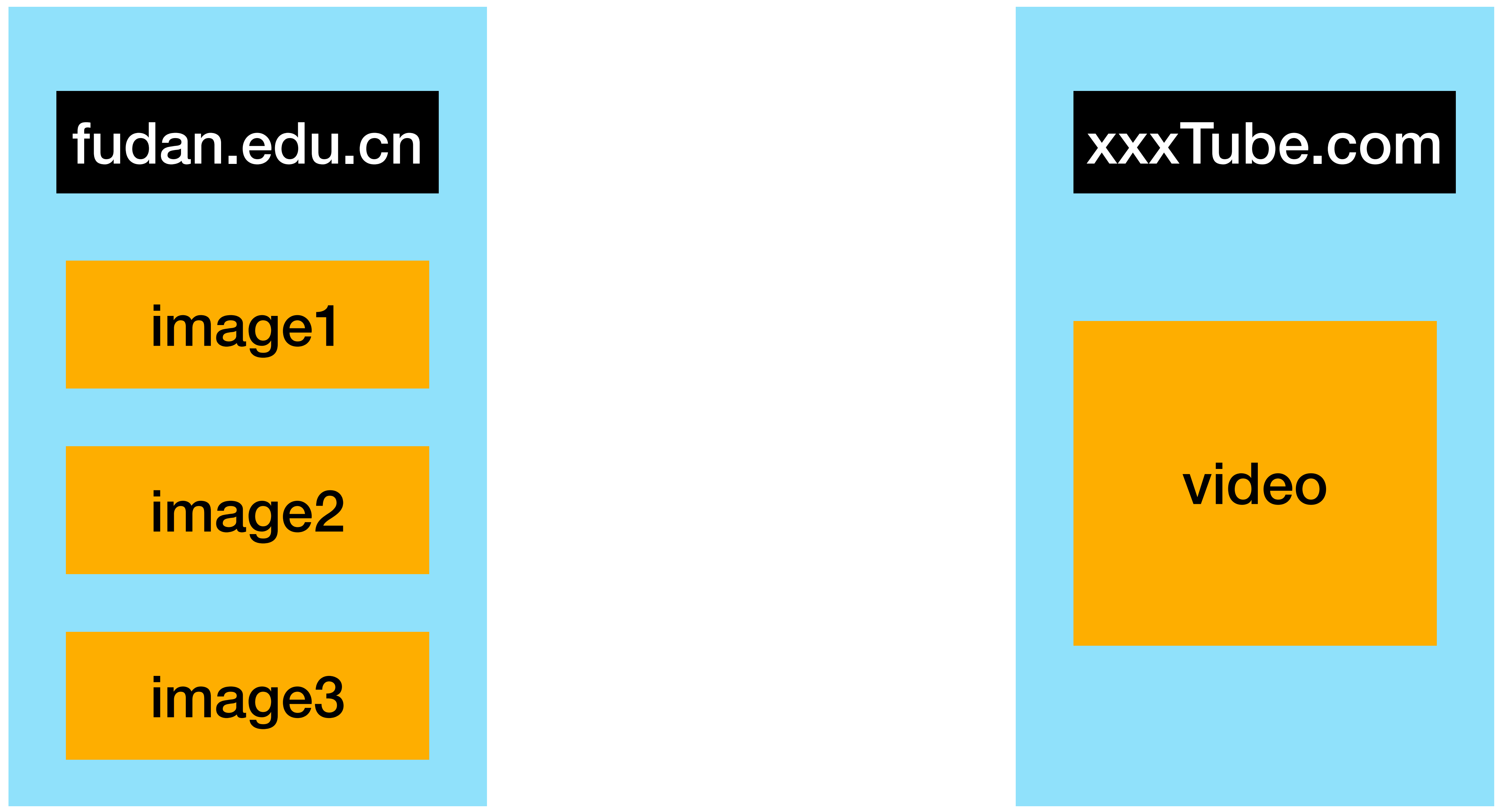
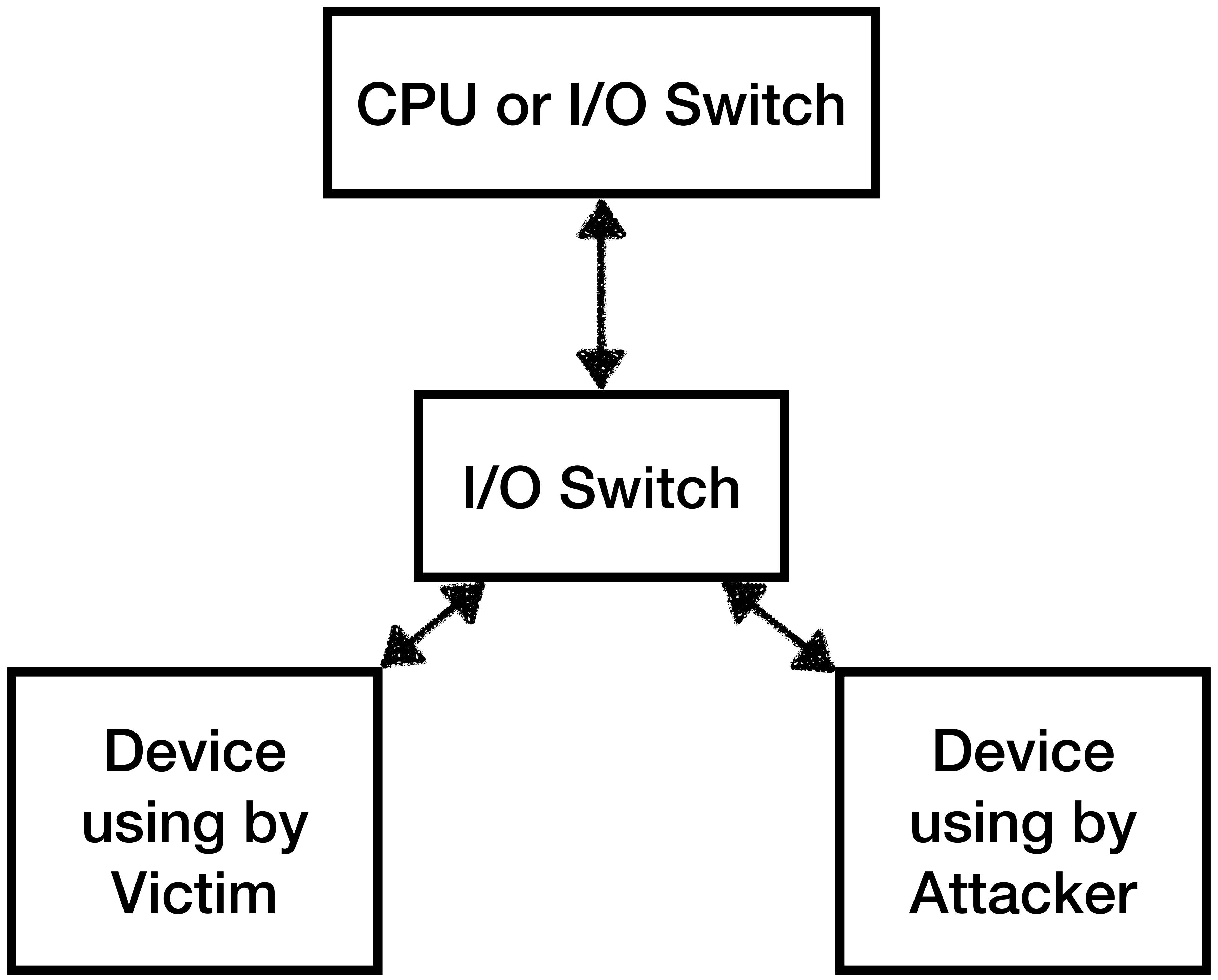




Webpage Inference





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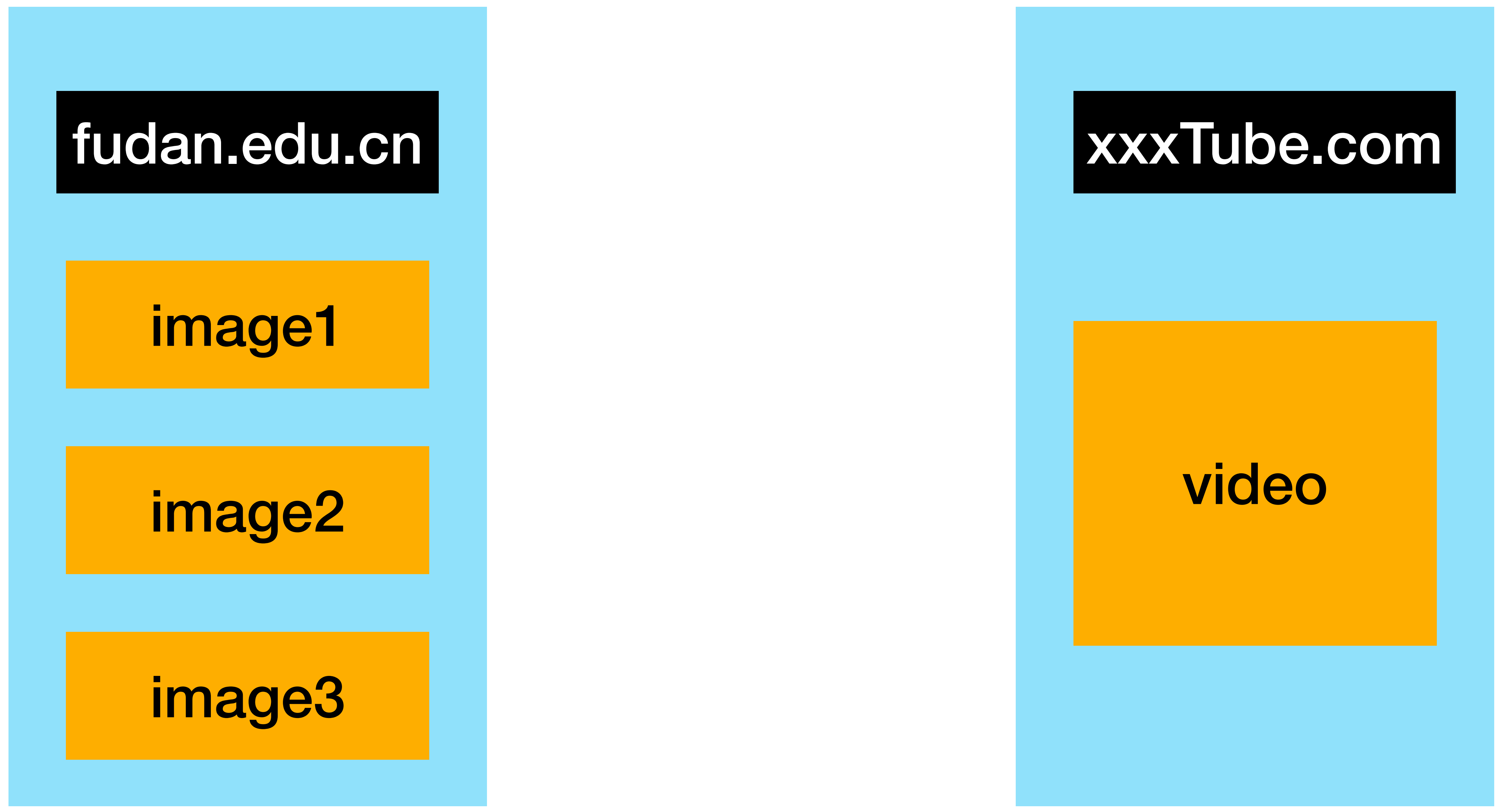

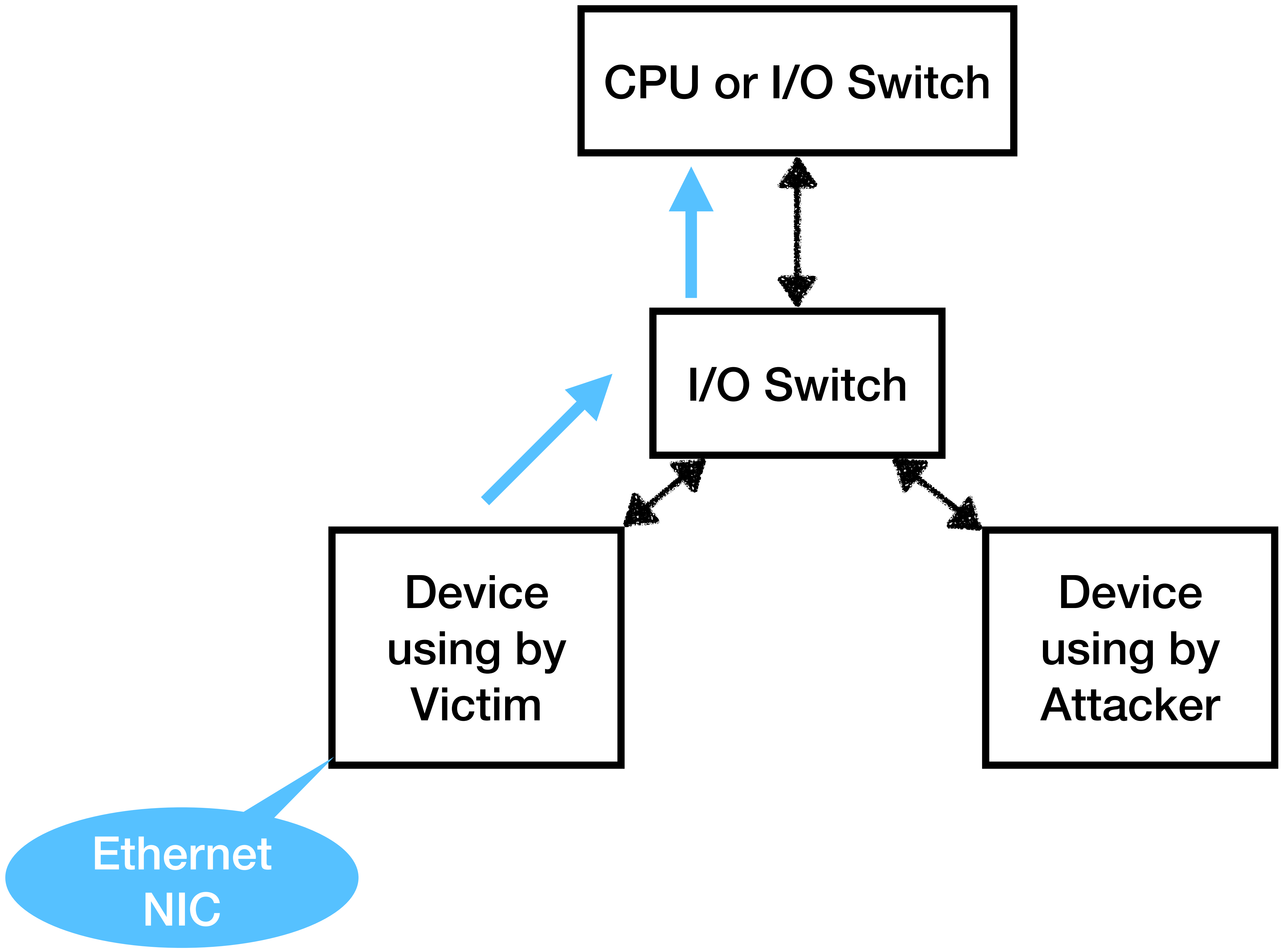

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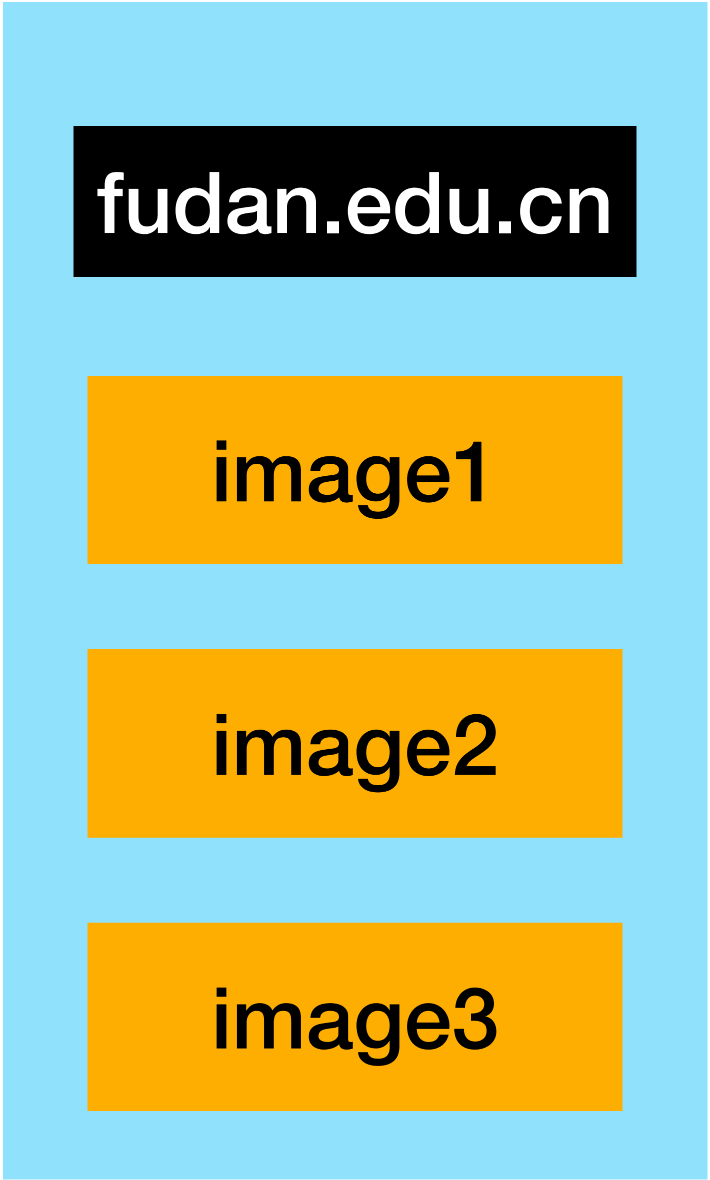

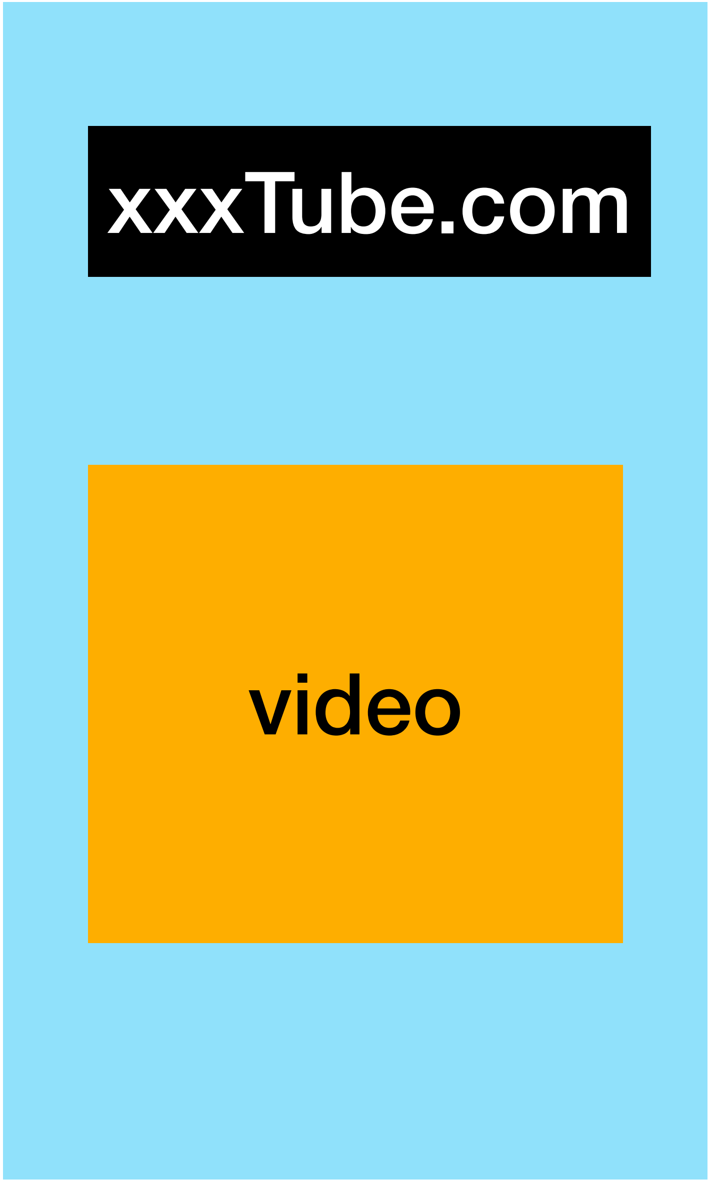

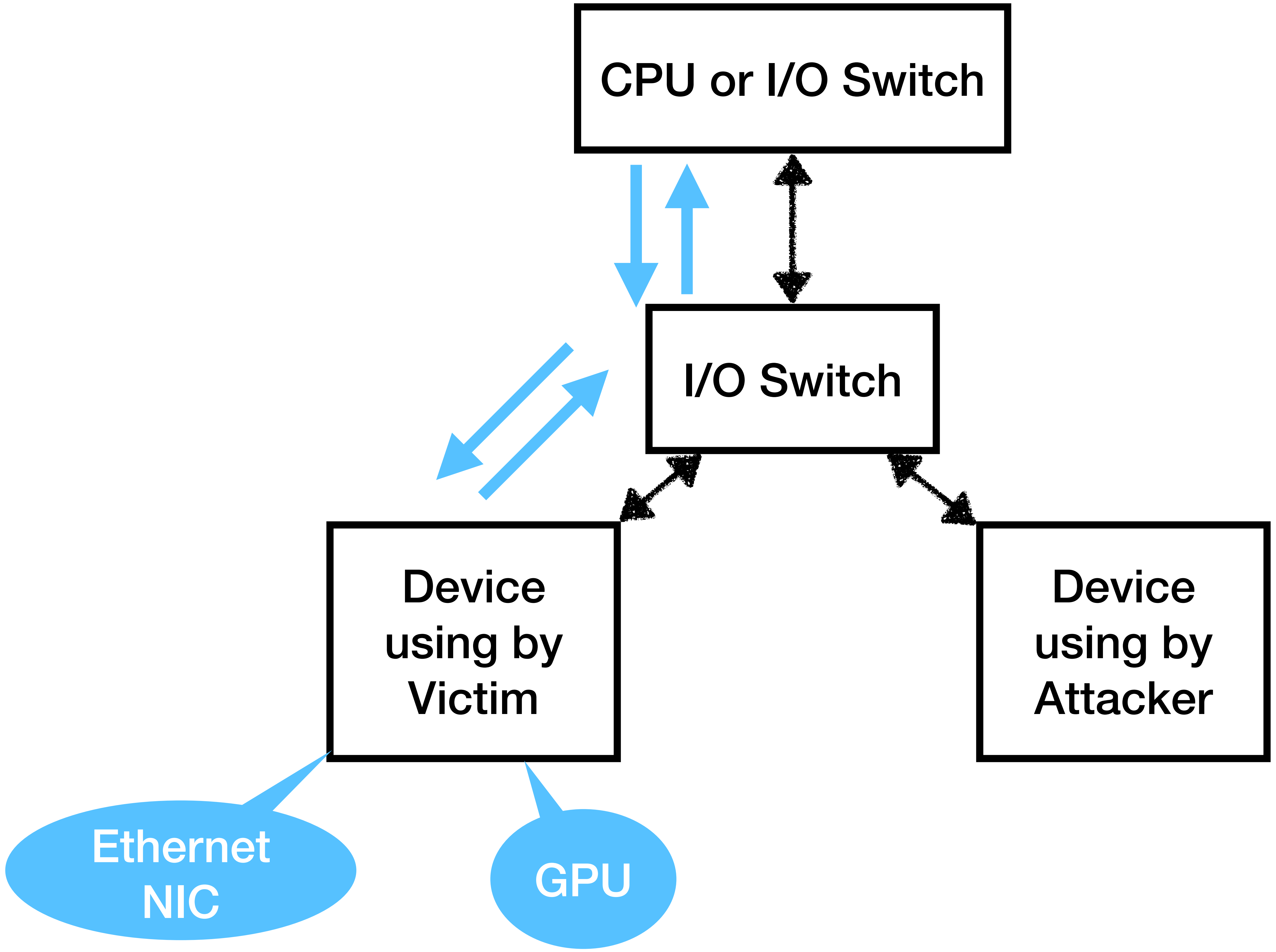

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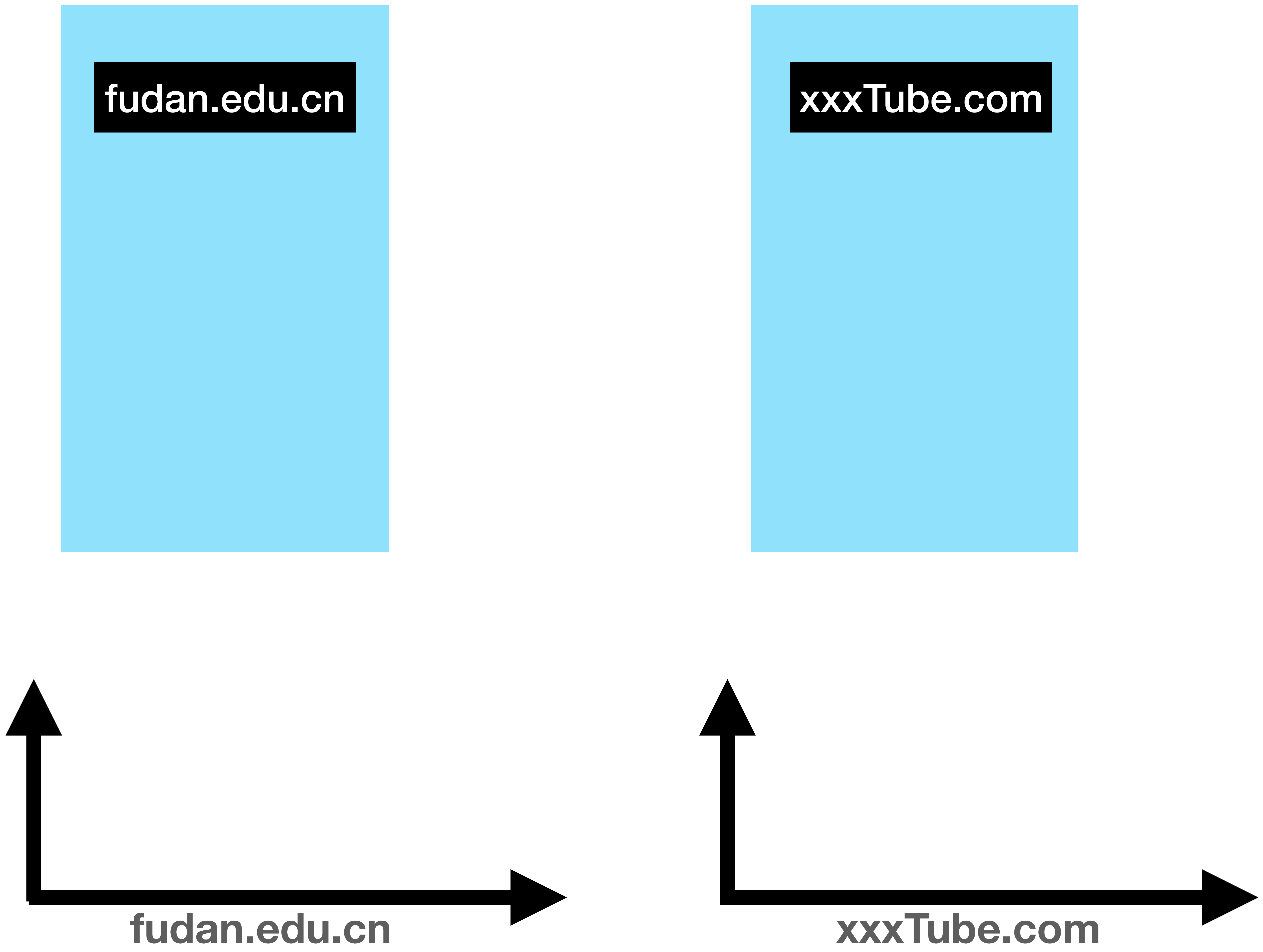

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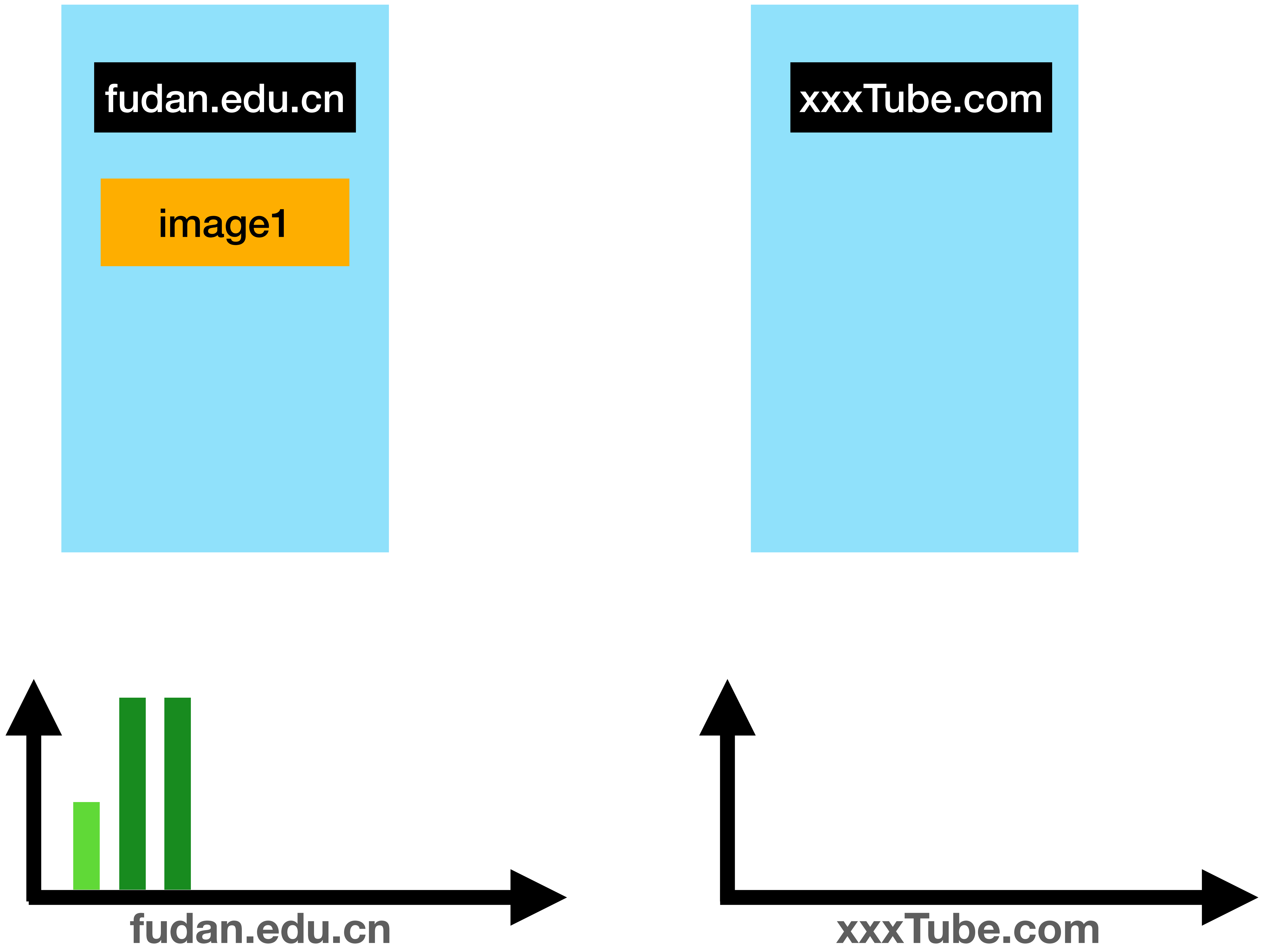

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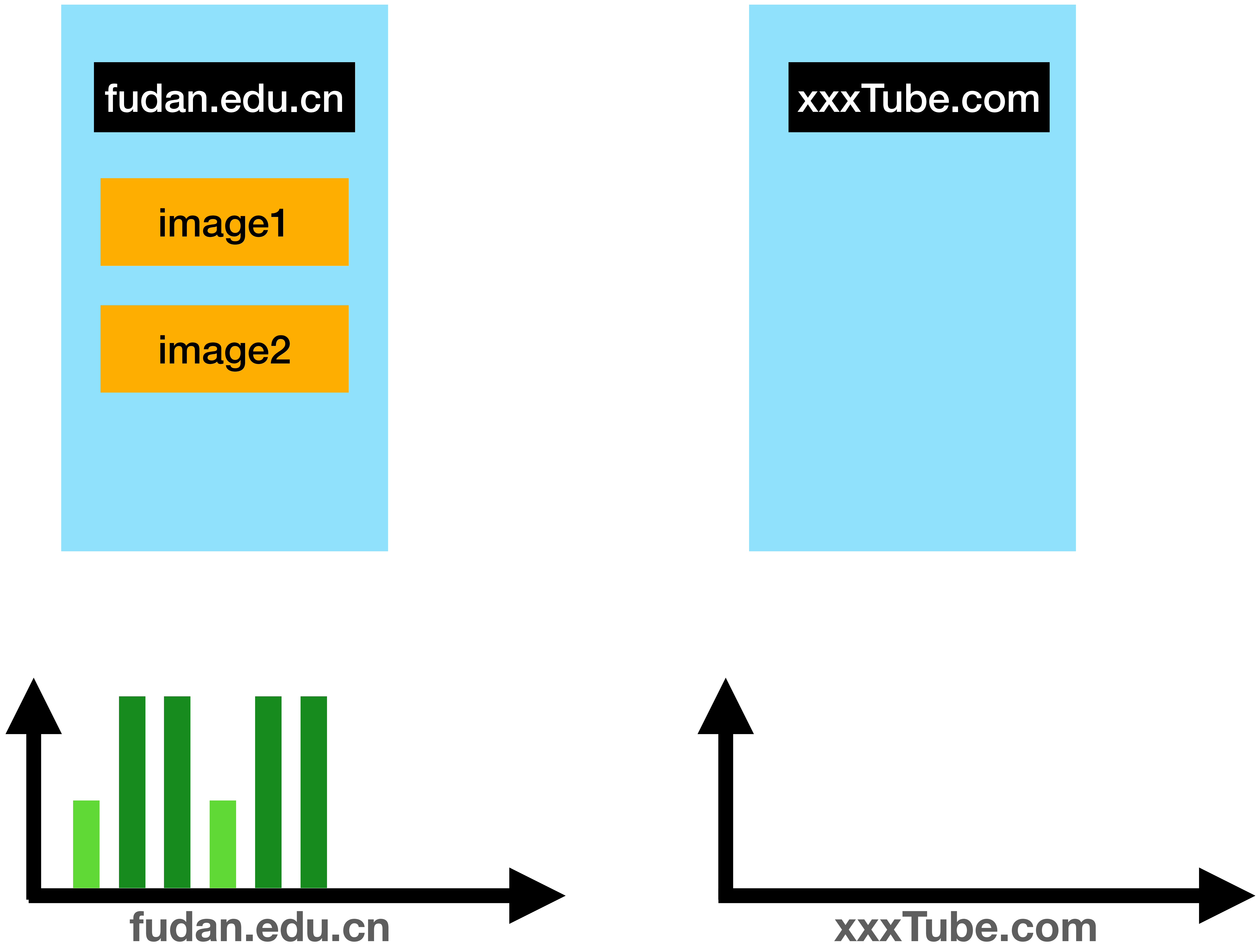

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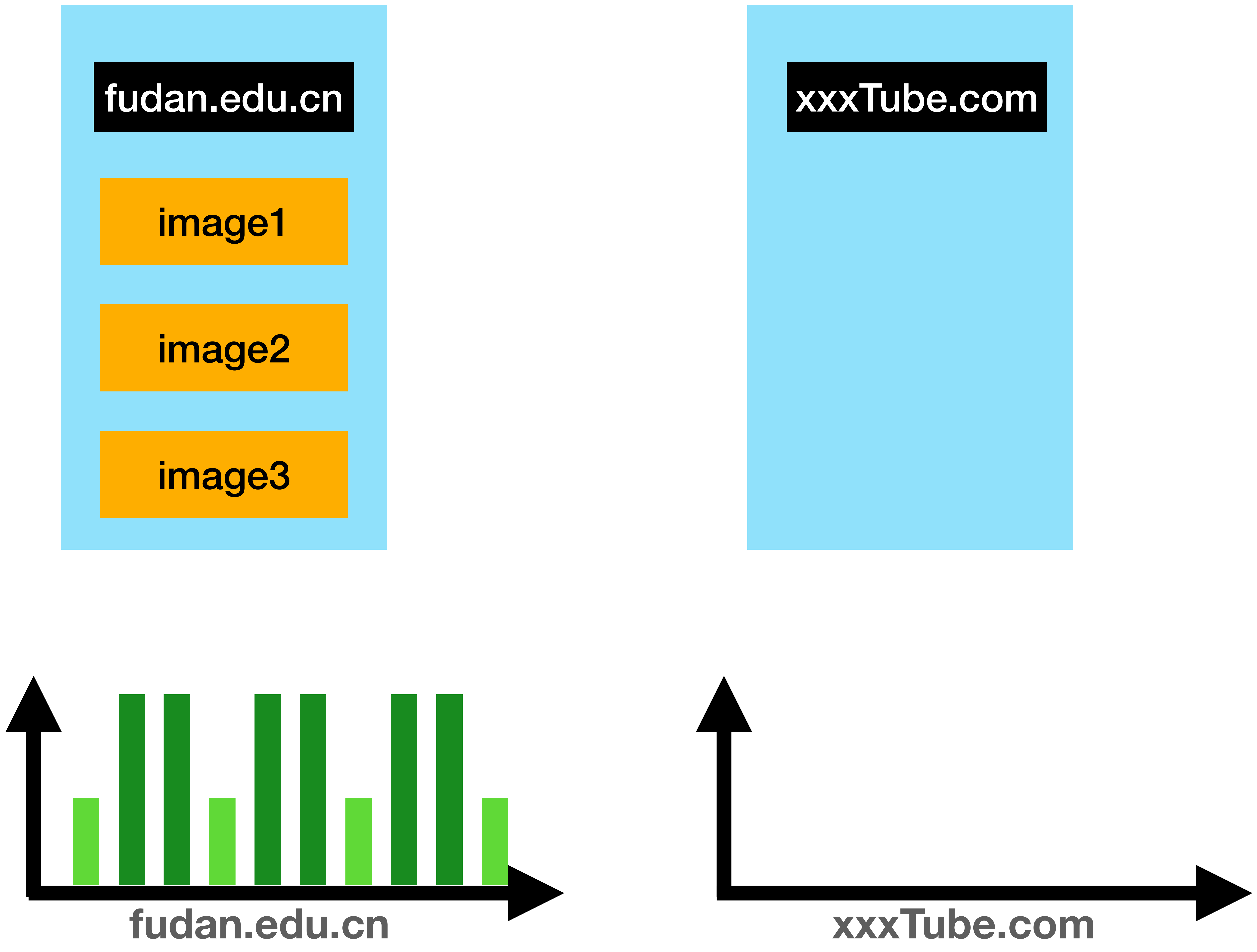

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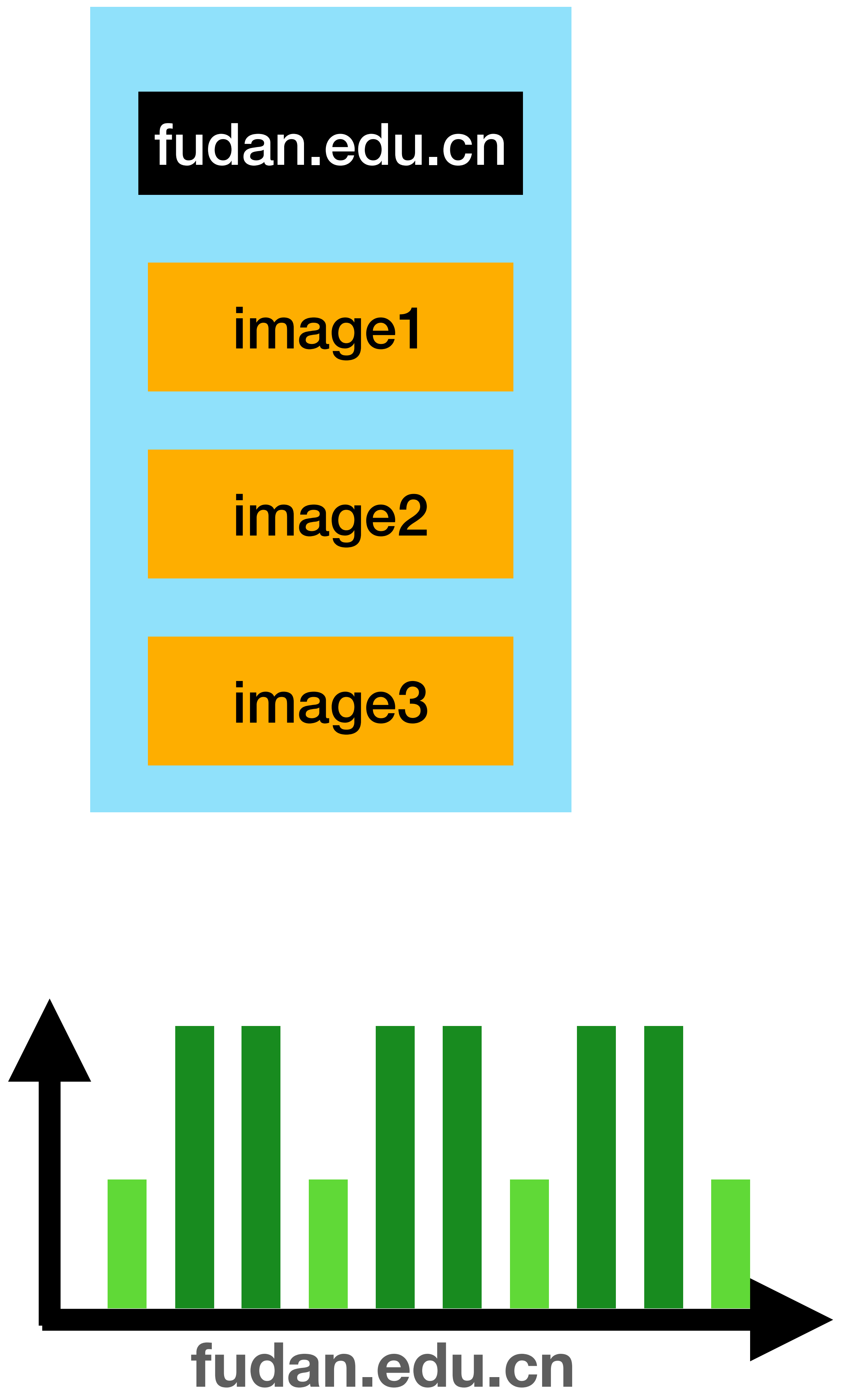

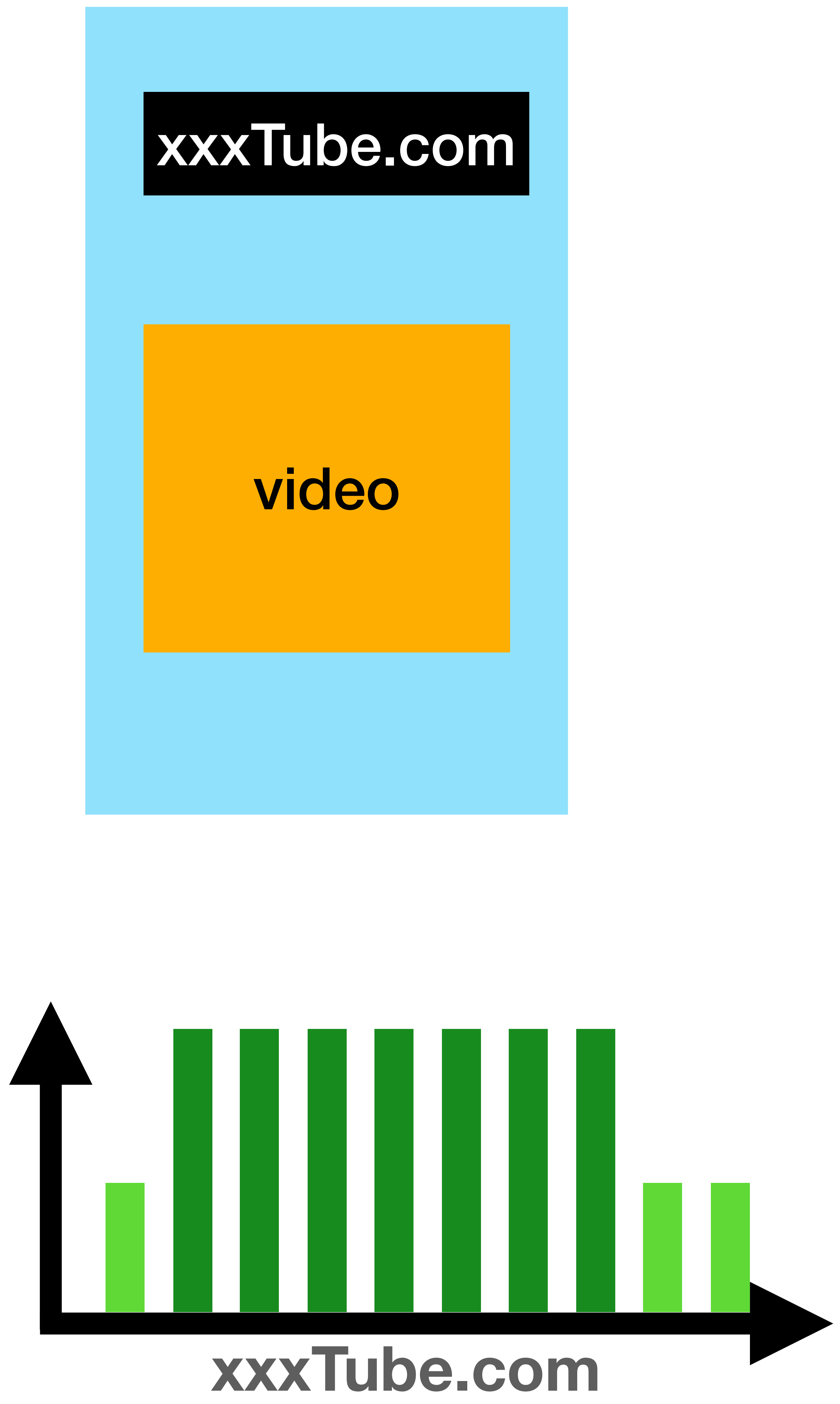

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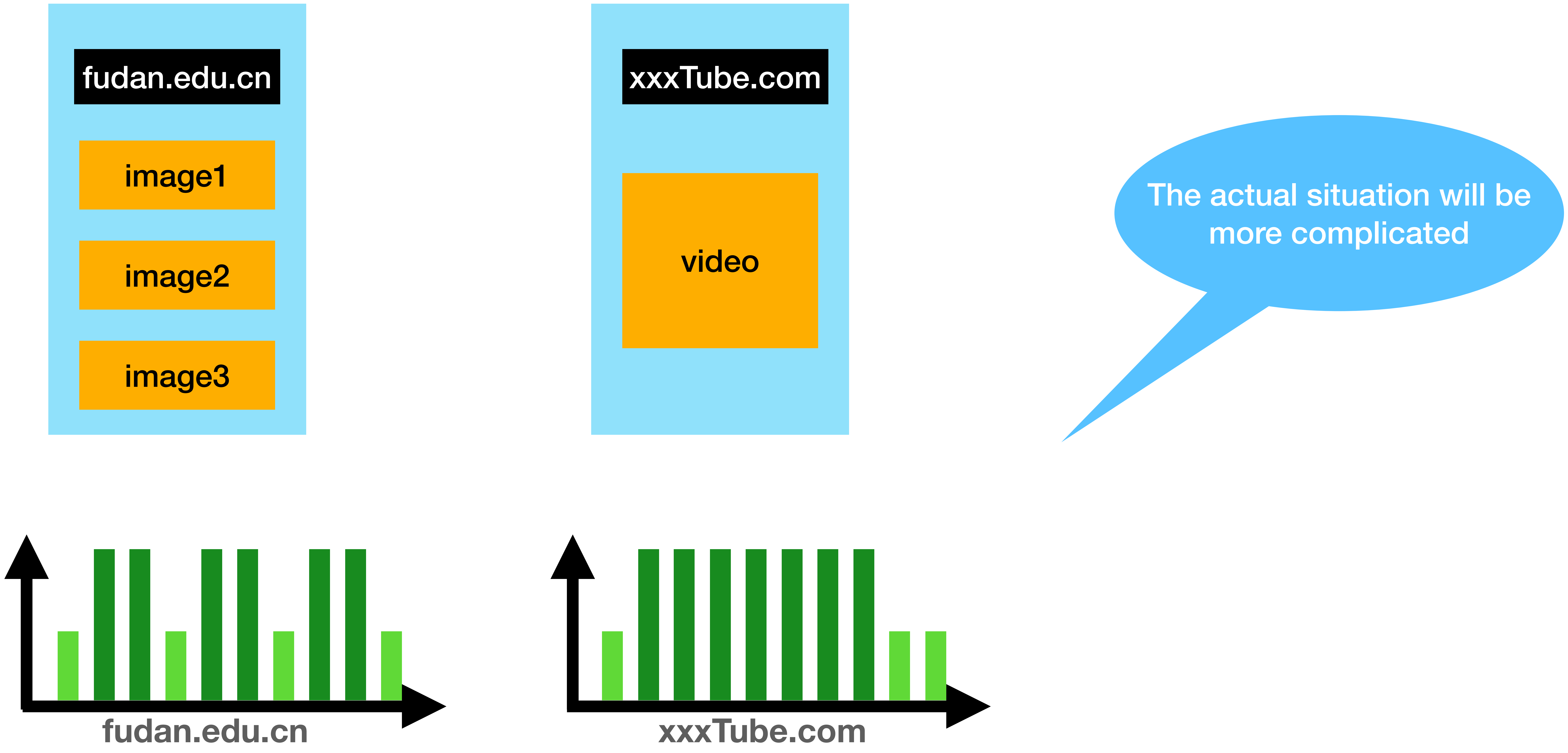
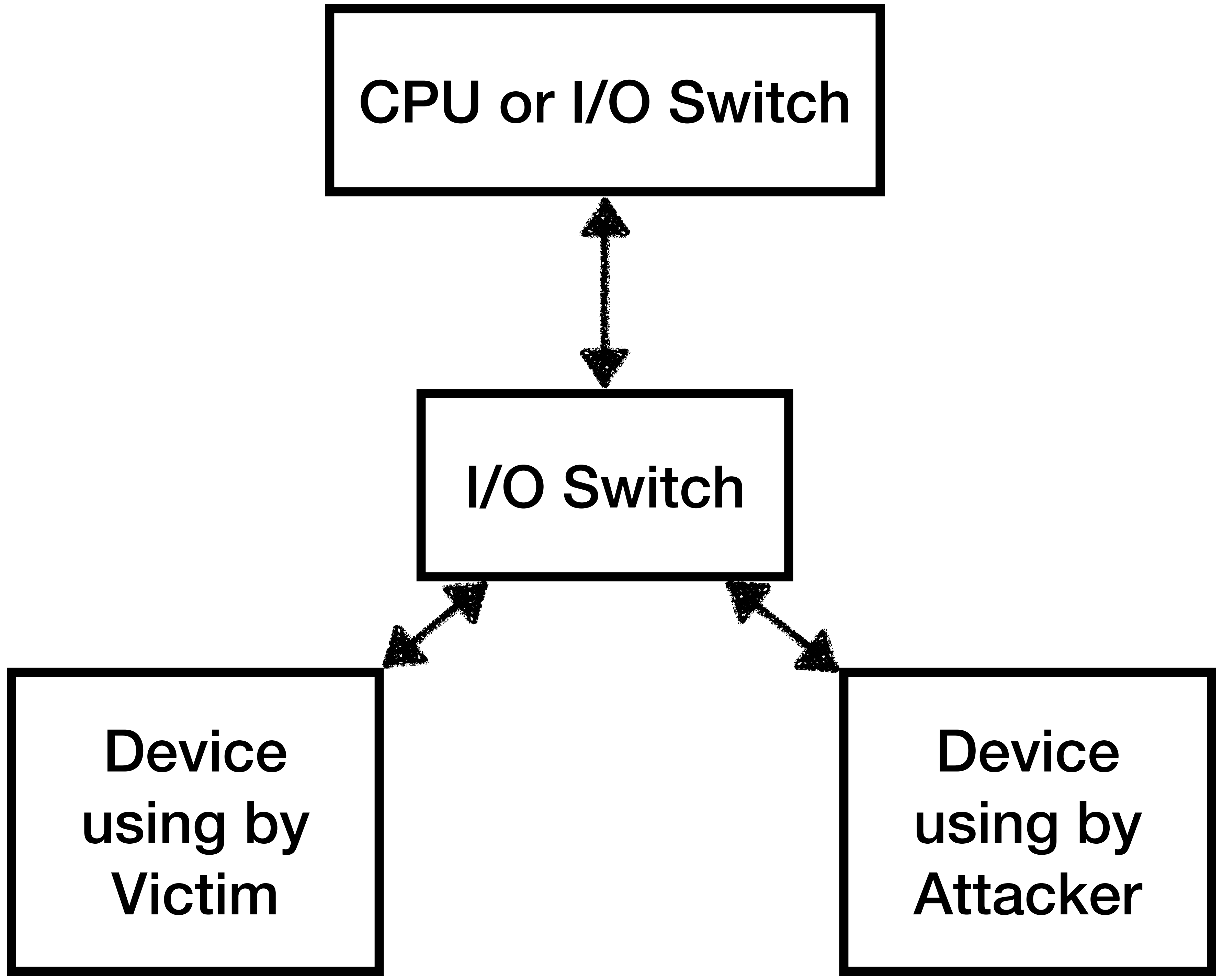
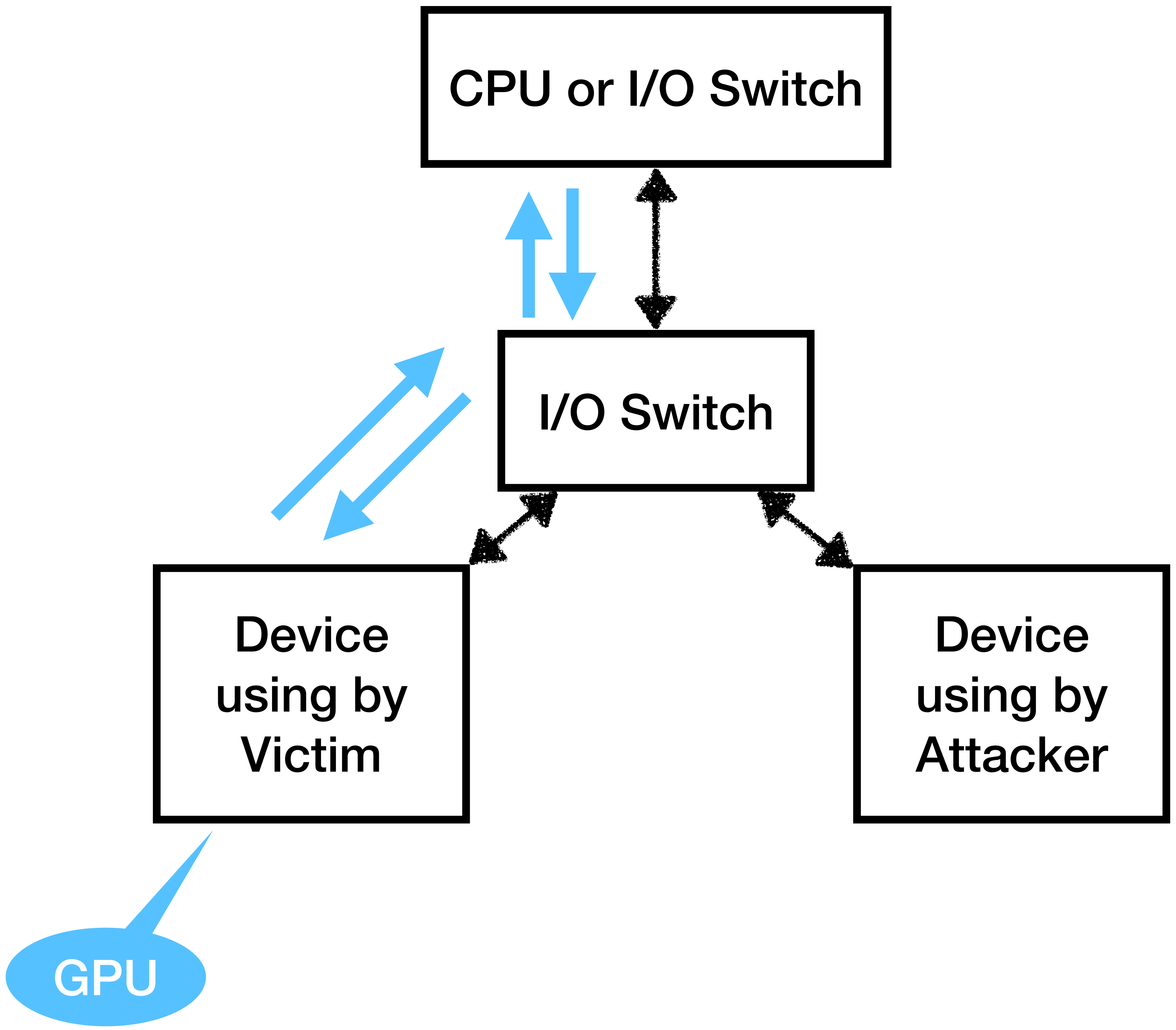


Machine-learning Model Inference



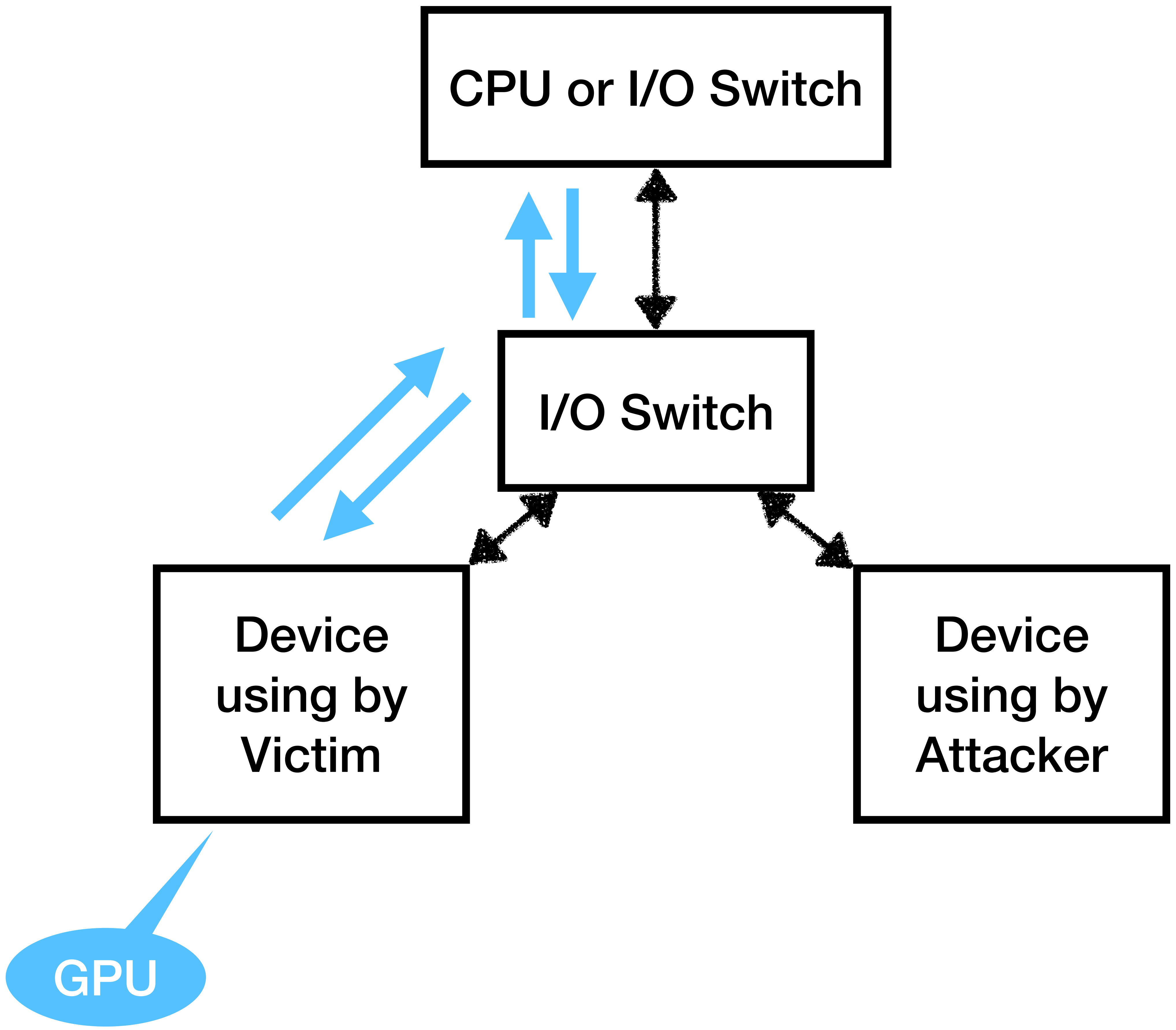
Machine-learning Model Inference

- Data transferred in and out of the GPU



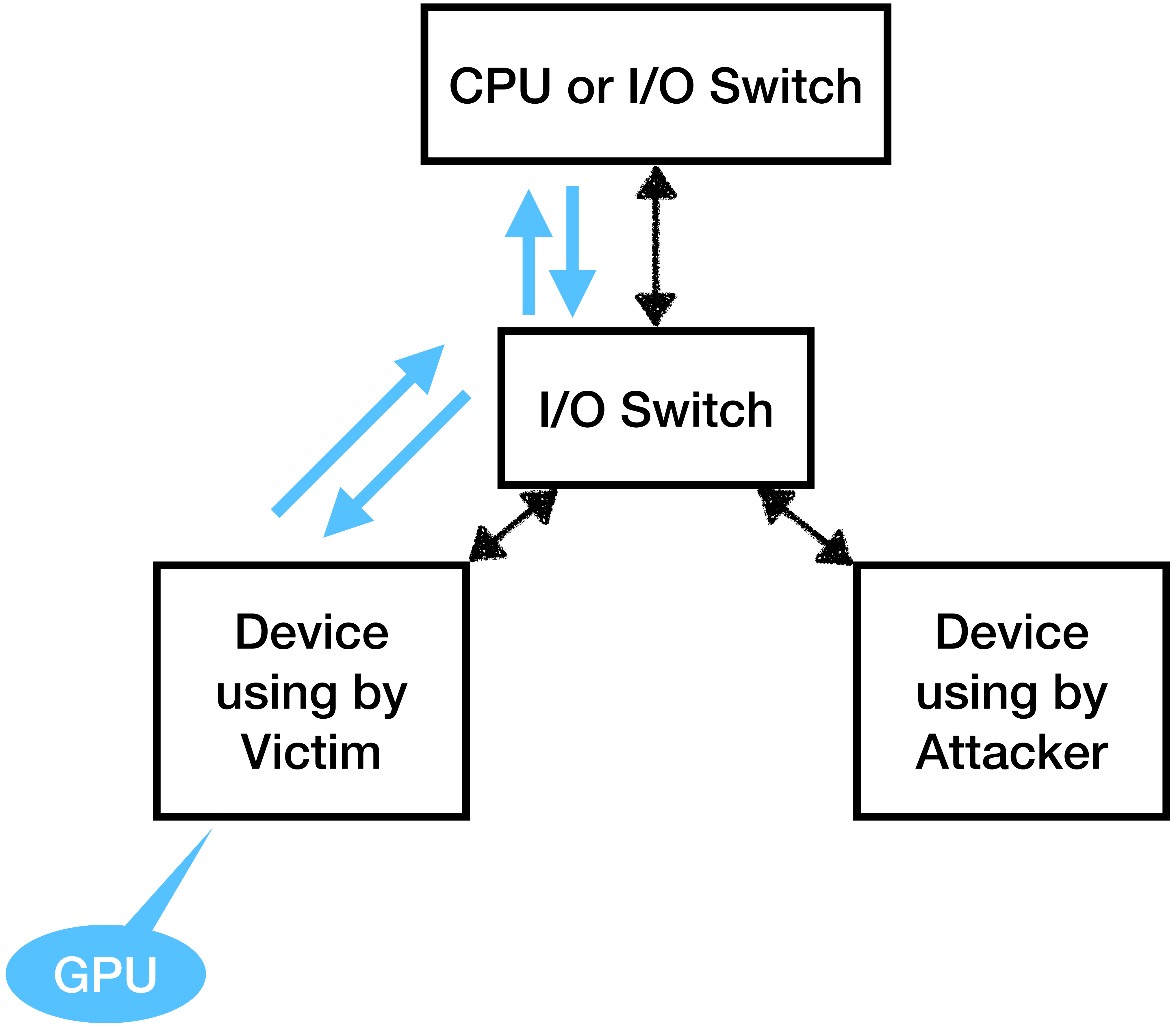
Machine-learning Model Inference

- Data transferred in and out of the GPU
- Different layers transfer different size of data at different frequency



Machine-learning Model Inference

- Data transferred in and out of the GPU
- Different layers transfer different size of data at different frequency
- Delay sequences of models significantly different



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  - Probe 100 webpages, collect delay sequence, and train a classifer (AttBLSTM[2])
  - Accuracy: above 96% in S1, above 93% in S2
- Machine-learning Model Inference
  - Probe 10 machine-learning models, collect delay sequence, and train the same classifer
  - All the models are correctly classified

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- Develop two attack strategies:
  - using RDMA NIC to attack GPU
  - using NVMe SSD to attack Ethernet NIC
- Evaluate them under three tasks:
  - keystroke typing
  - webpage browsing
  - training machine-learning model

Thank you for listening!

Questions?

References

[1] D.X.Song,D.A.Wagner,and X.Tian,“Timing analysis of keystrokes and timing attacks on ssh.” in USENIX Security Symposium, vol. 2001, 2001.

[2] P. Zhou, W. Shi, J. Tian, Z. Qi, B. Li, H. Hao, and B. Xu, “Attention- based bidirectional long short-term memory networks for relation classification,” in Proceedings of the 54th annual meeting of the association for computational linguistics (volume 2: Short papers), 2016, pp. 207–212.

[3] https://hakk.me/windows-secure-boot-process-enumeration-detailed-mechanism-and-overview-a156b57f4f98