Mitigating Synchronized Hardware Trojan Attacks in Smart Grids

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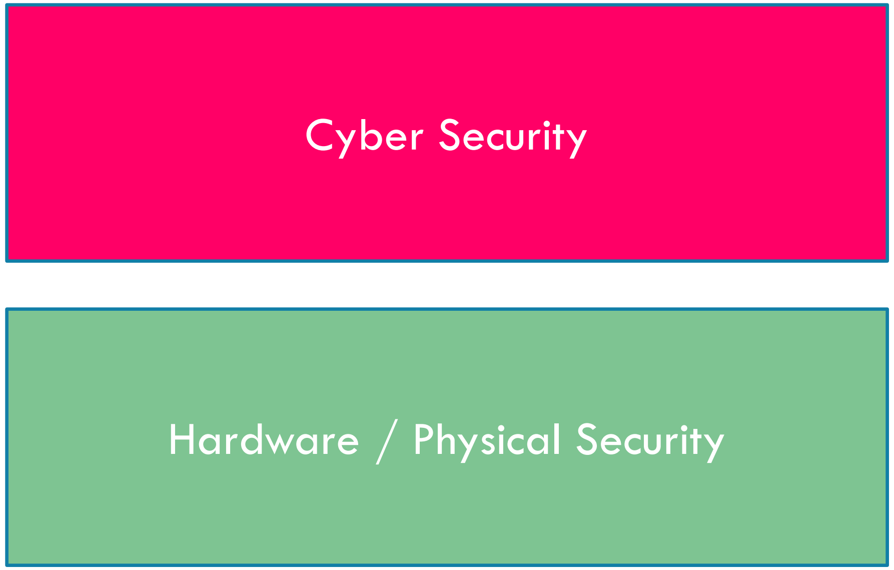

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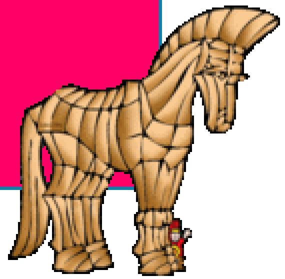
- But this may not the case in the real life.
- Malicious hardware manufacturers can introduce malicious modifications, so called hardware Trojans, into their designs.
- We have to start questioning trustworthiness of the underlying hardware.

Cyber Security

Hardware / Physical Security



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- It is still very hard to completely eliminate/ detect hardware Trojans in a large chip.
- Instead, we minimize the damage of a hardware Trojan.

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Synchronized

VS

Sporadic

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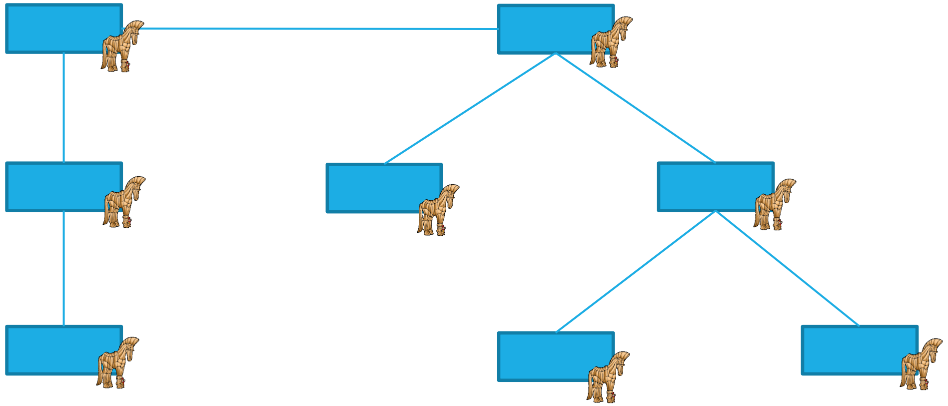

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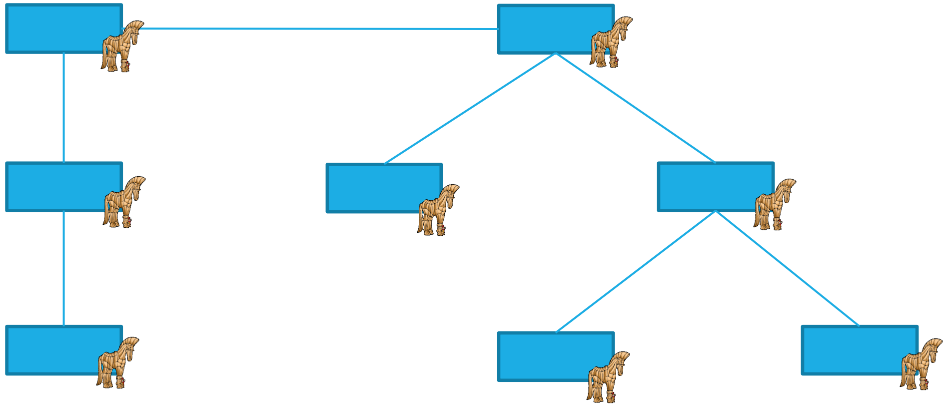

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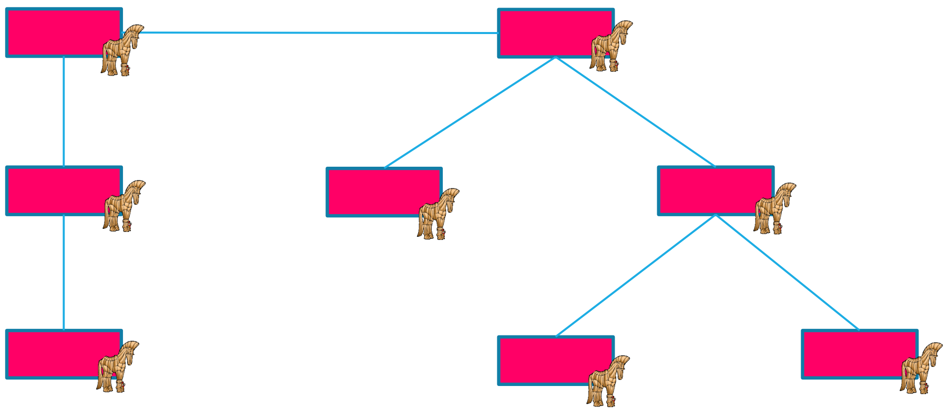

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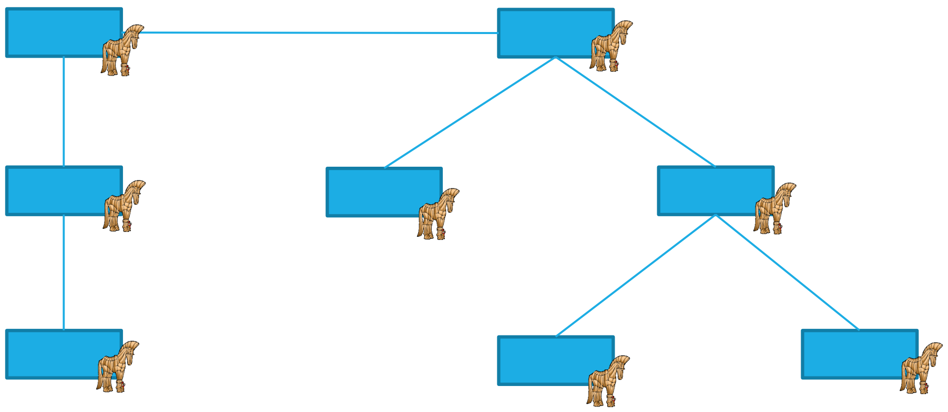

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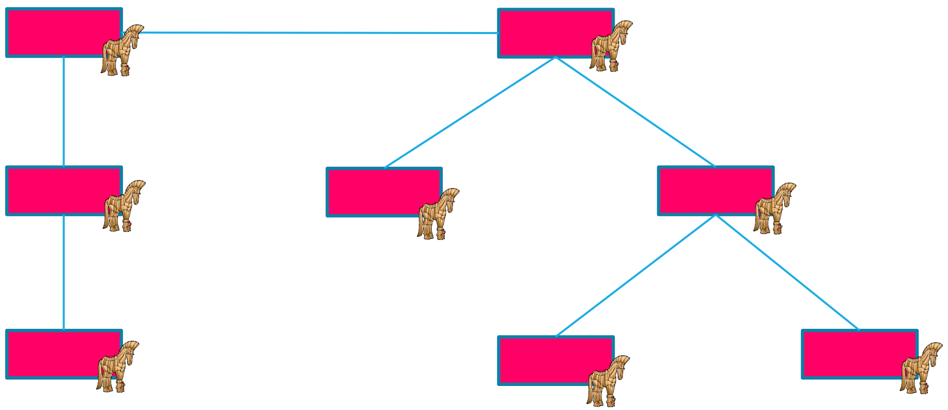

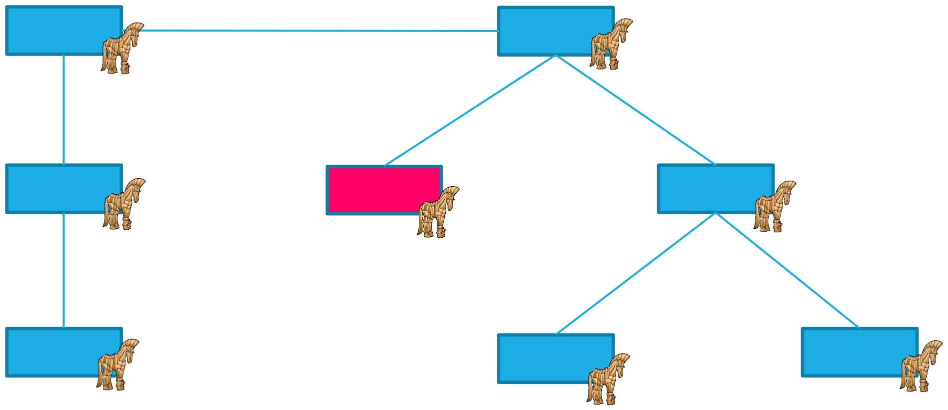

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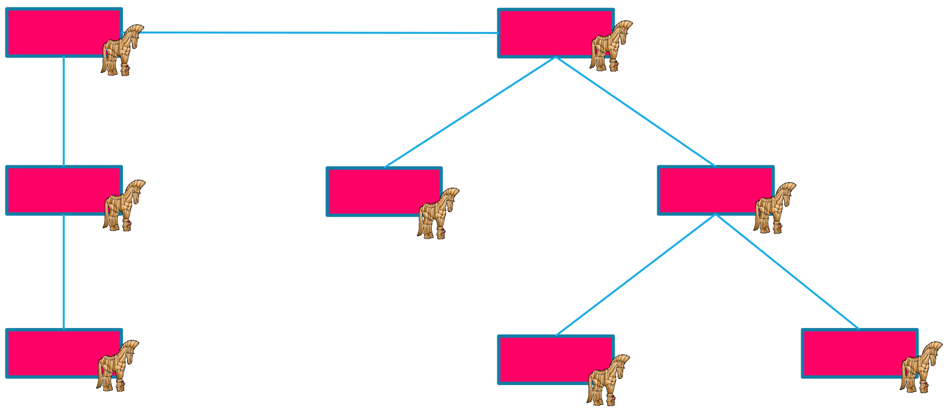

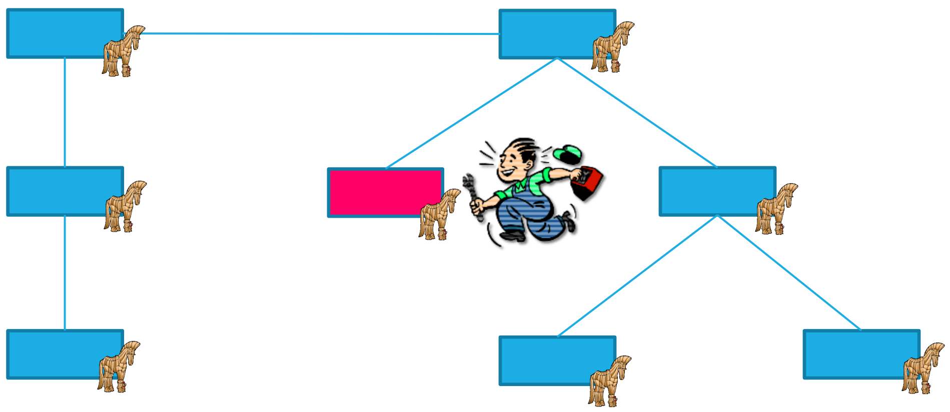

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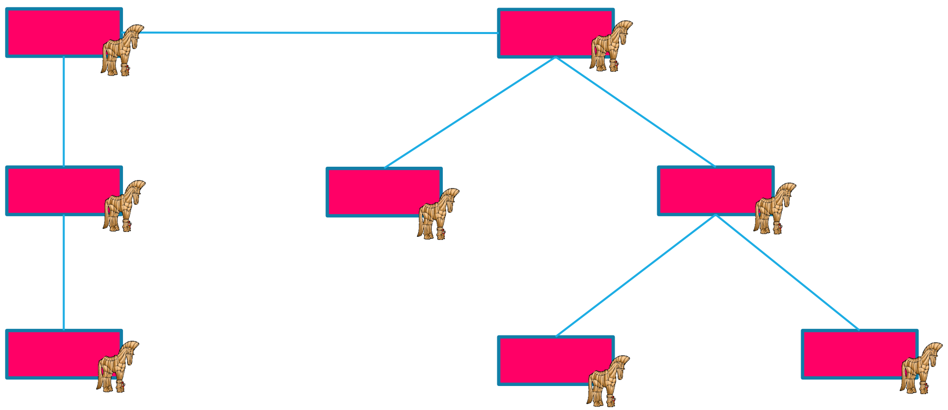

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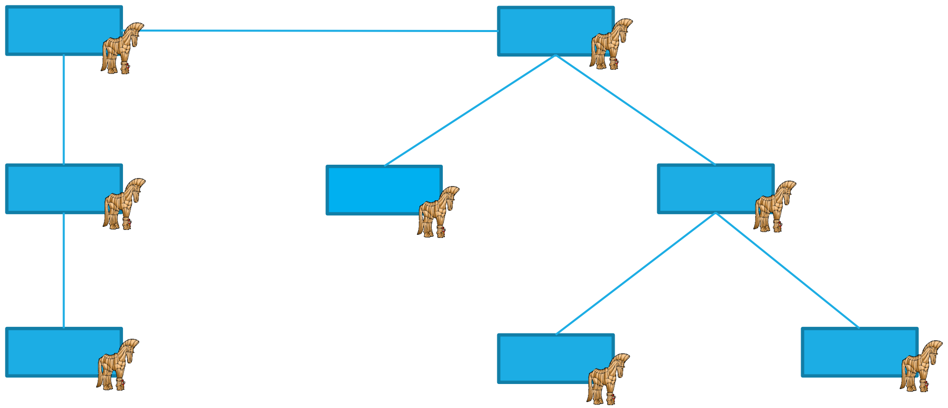

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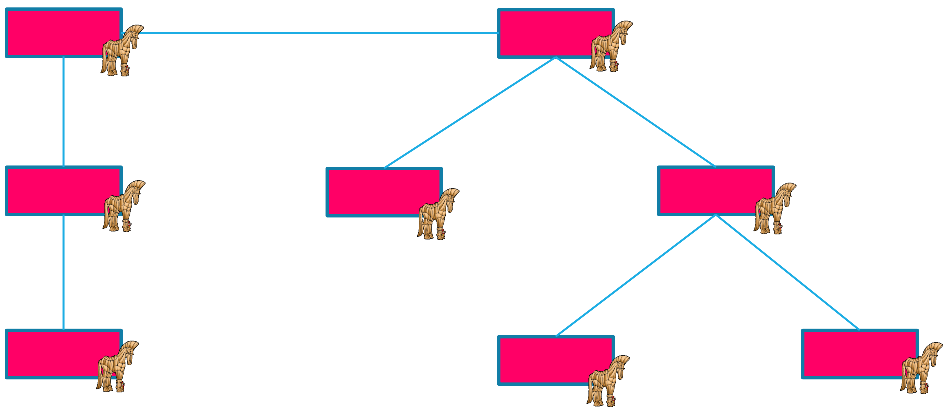

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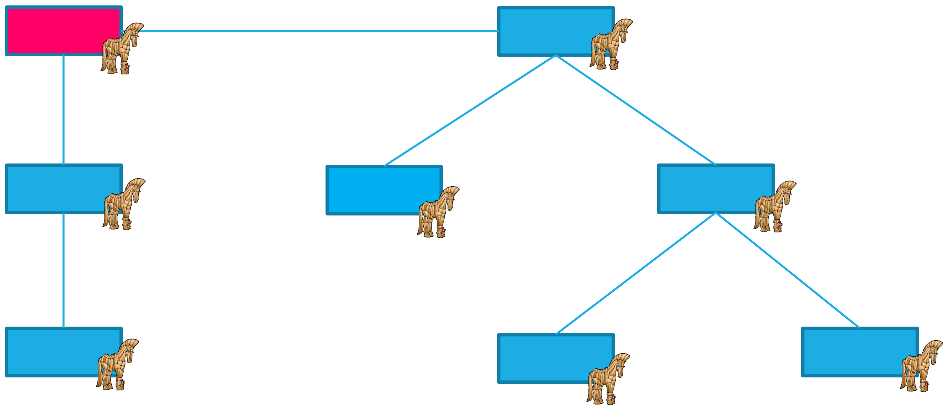

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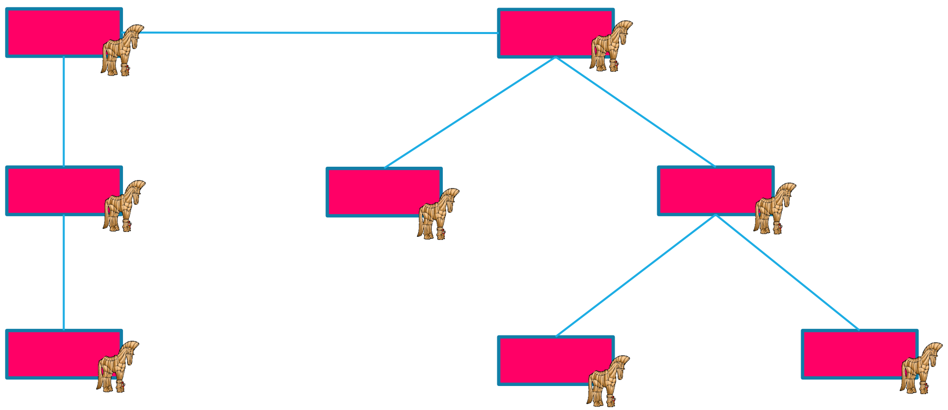

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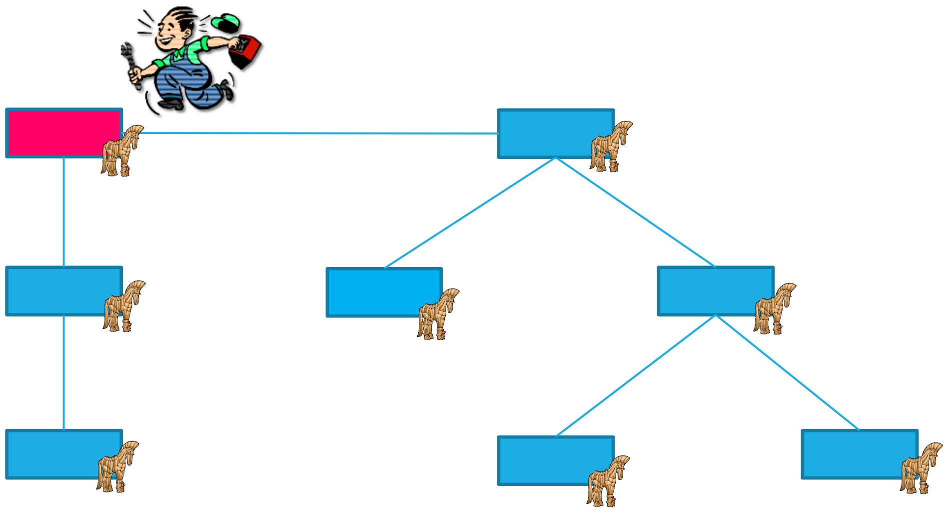

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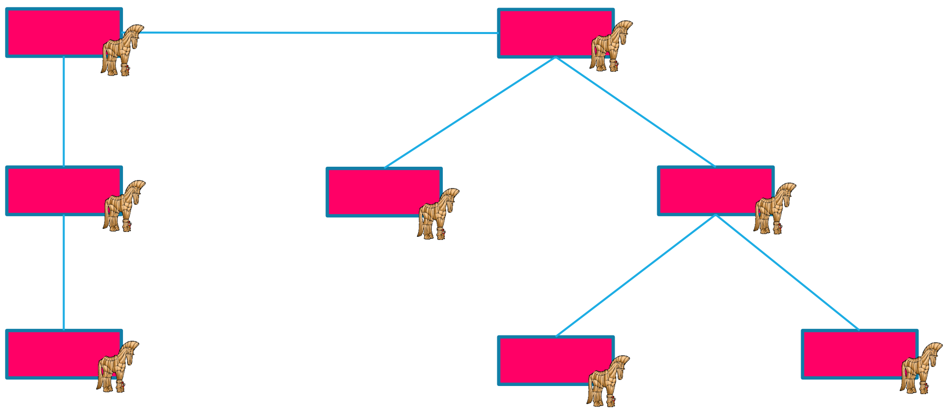

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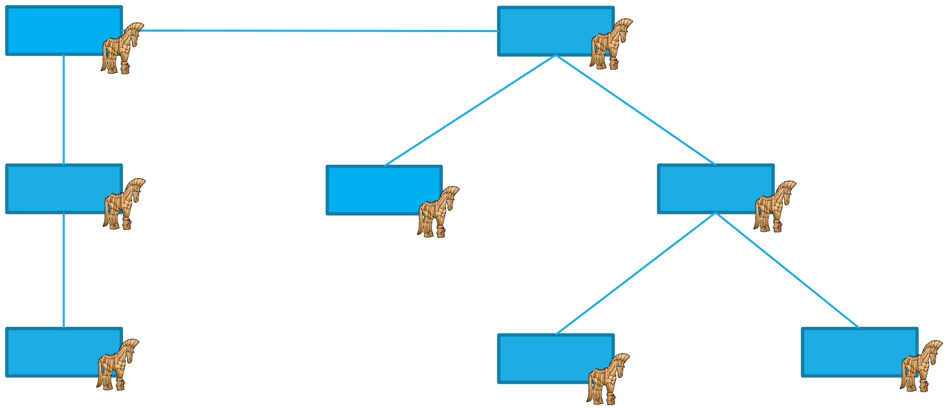
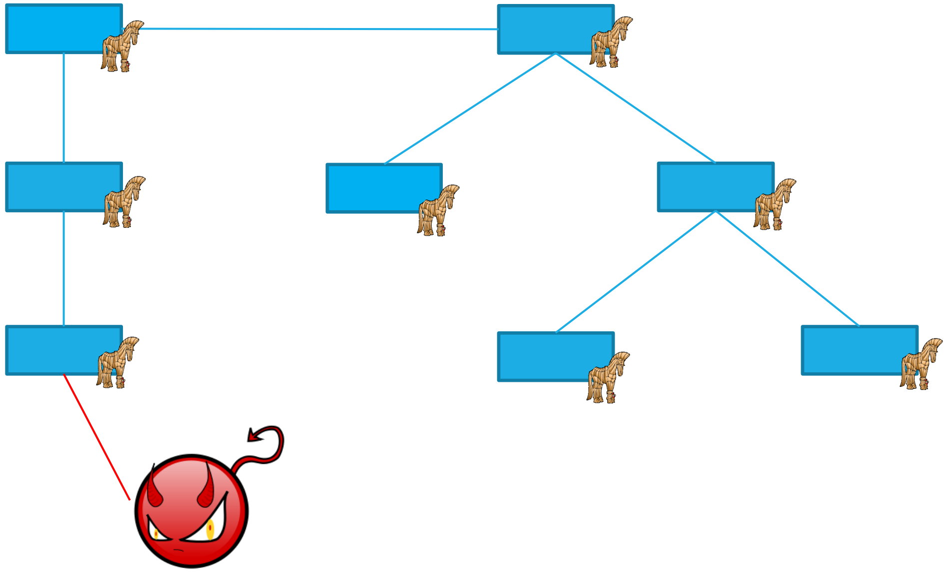


Our mitigation strategy is to converte a synchronized hardware Trojan attack into sporadic single node failures.

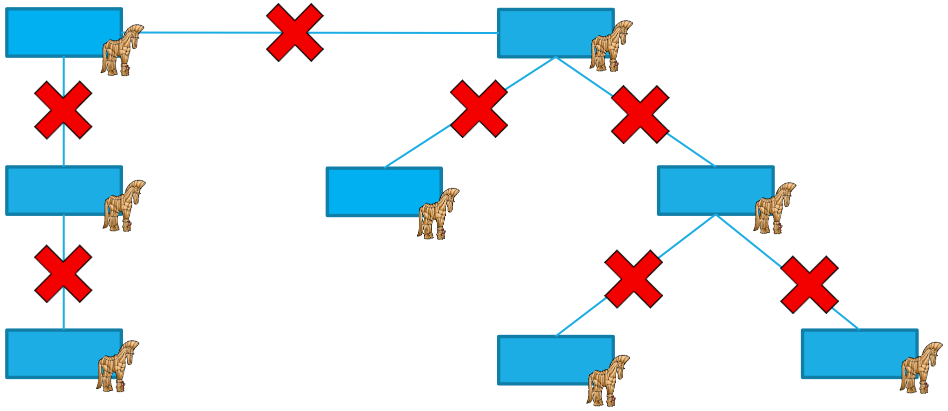
Online vs Offline Trojans

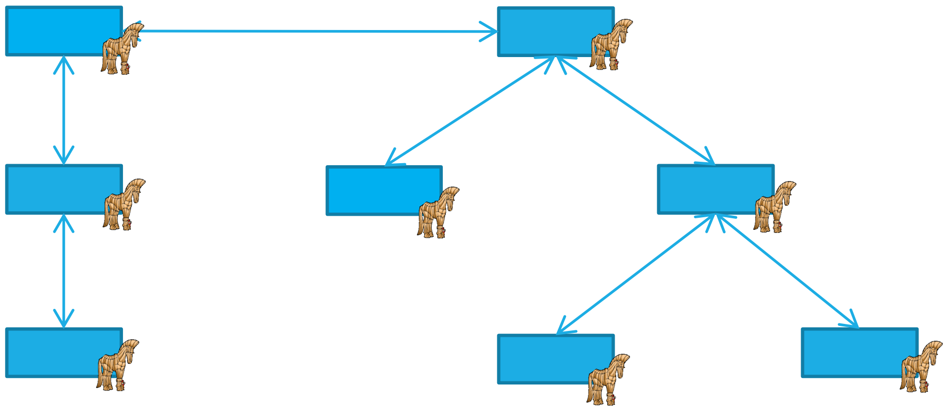
- Online Hardware Trojans:
- The attackers have connection and controllability of the chips (Trojans) after they are deployed.
- It also requires the attackers to first penetrate the network of smart grids to communicate with the Trojans and trigger the payloads.
- Needs to exploit software/ network vulnerabilities.
- Can be solved by software solutions.
- Open problem.



Offline Synchronized Hardware Trojans

- Type A: No inter-Trojan communications.
  - UTC provided by GPS module is a perfect way to synchronize each Trojan with one another.
- Type B: Allow inter-Trojan communications.
  - Trojans can communicate with one another via network or powerline to synchronize with each other.
  - Open problem, some interesting thoughts.





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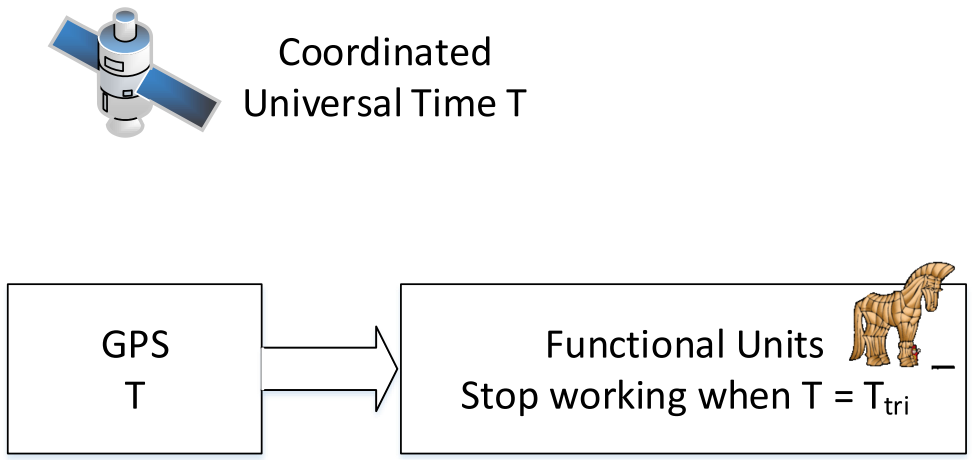

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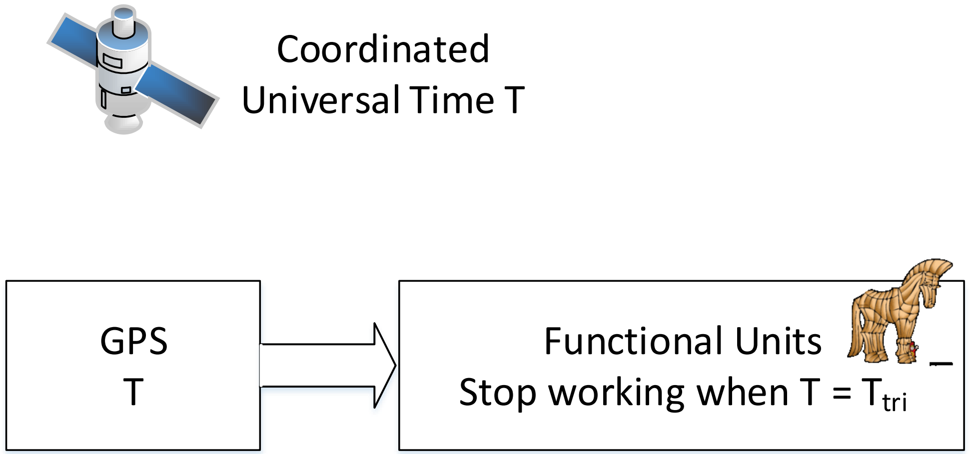

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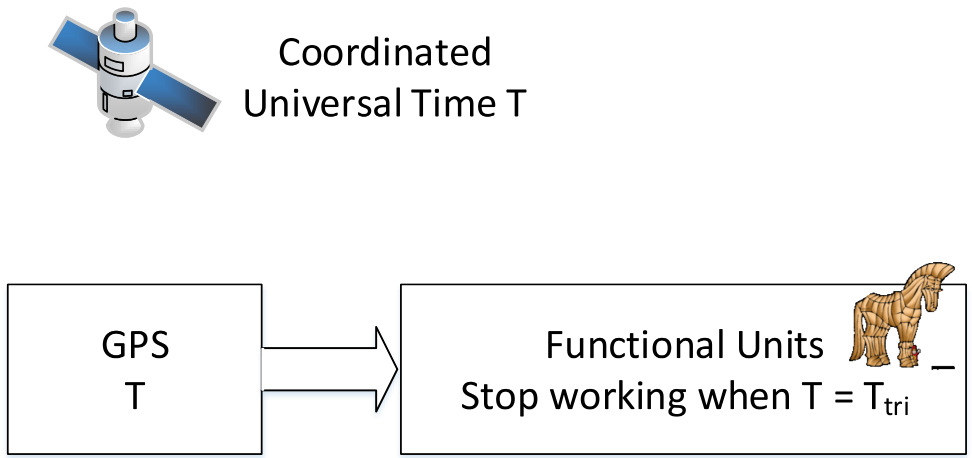

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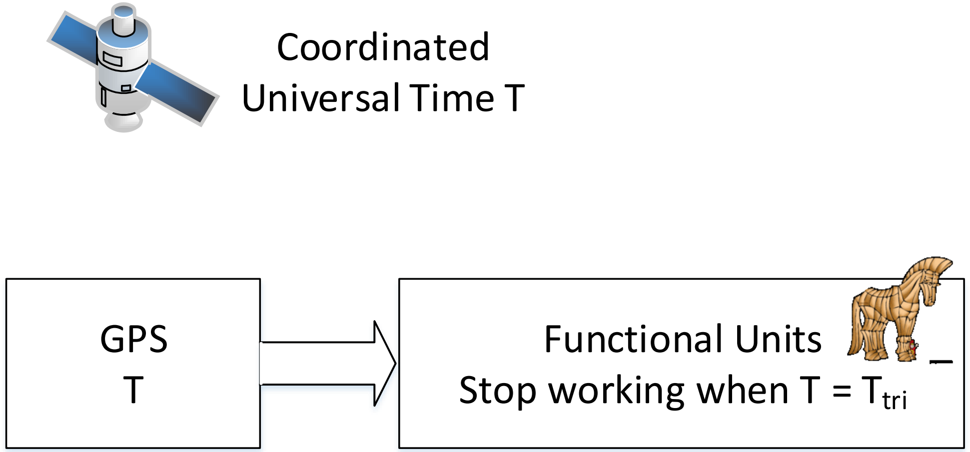

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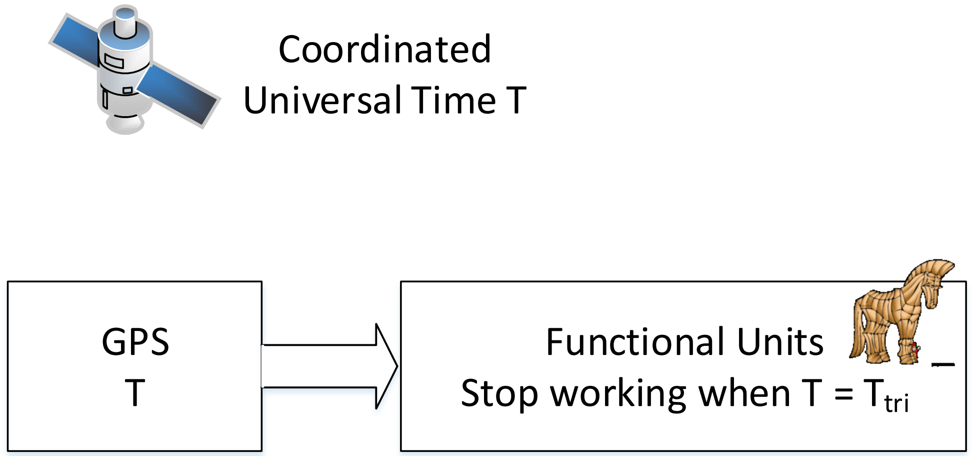

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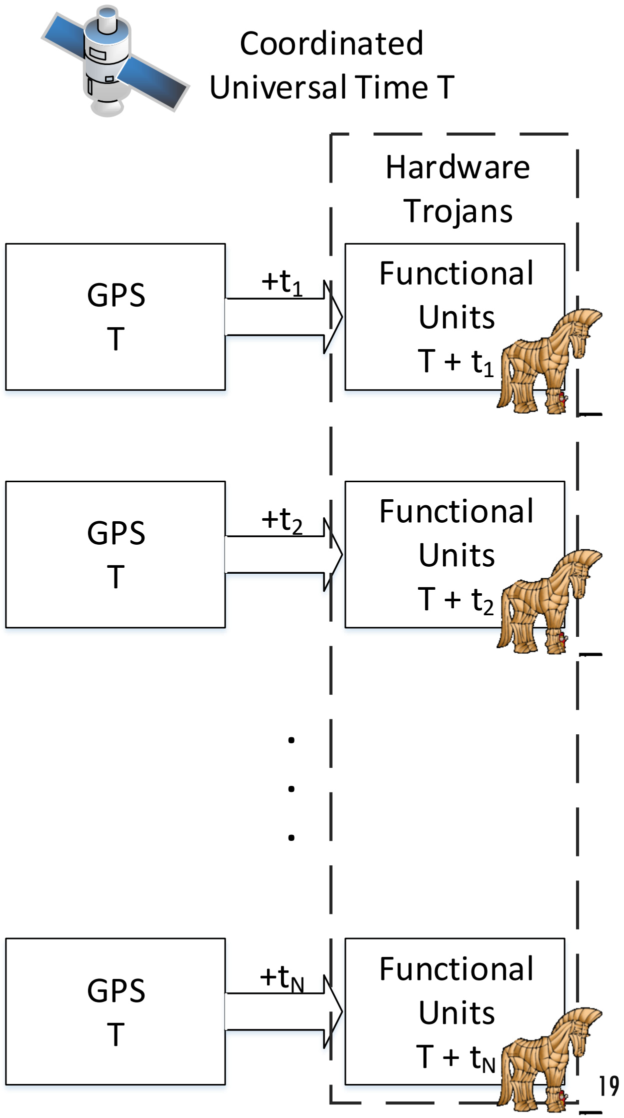

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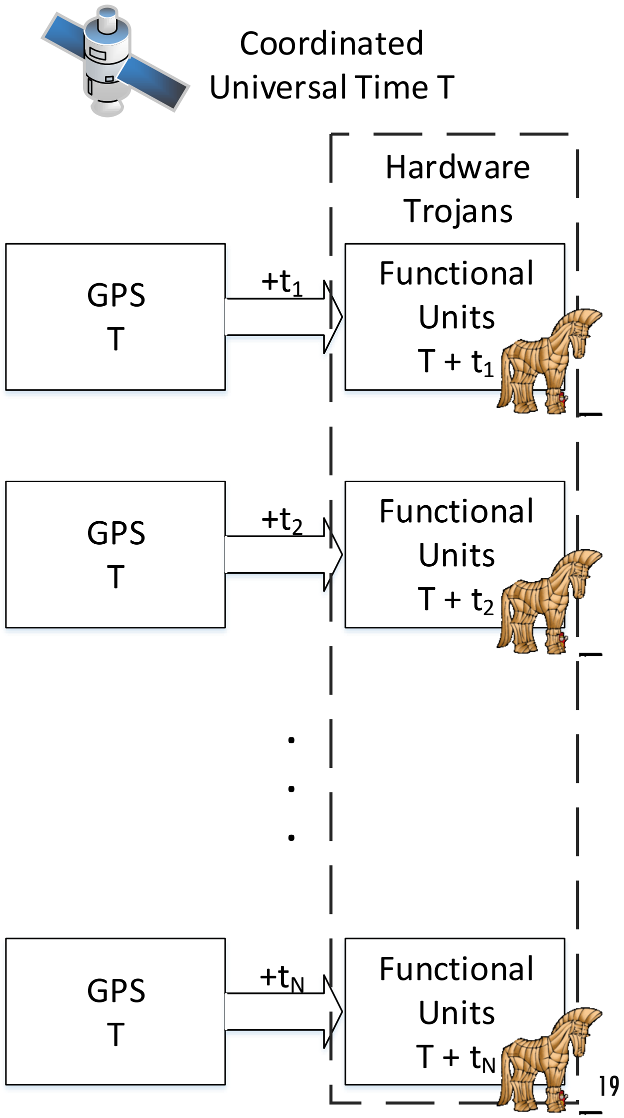

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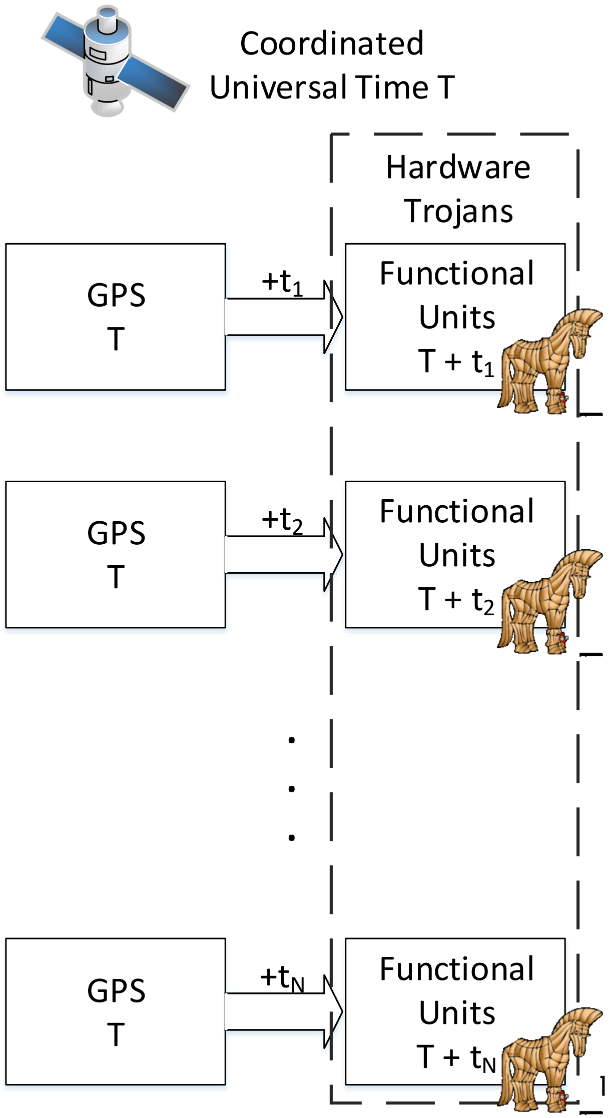

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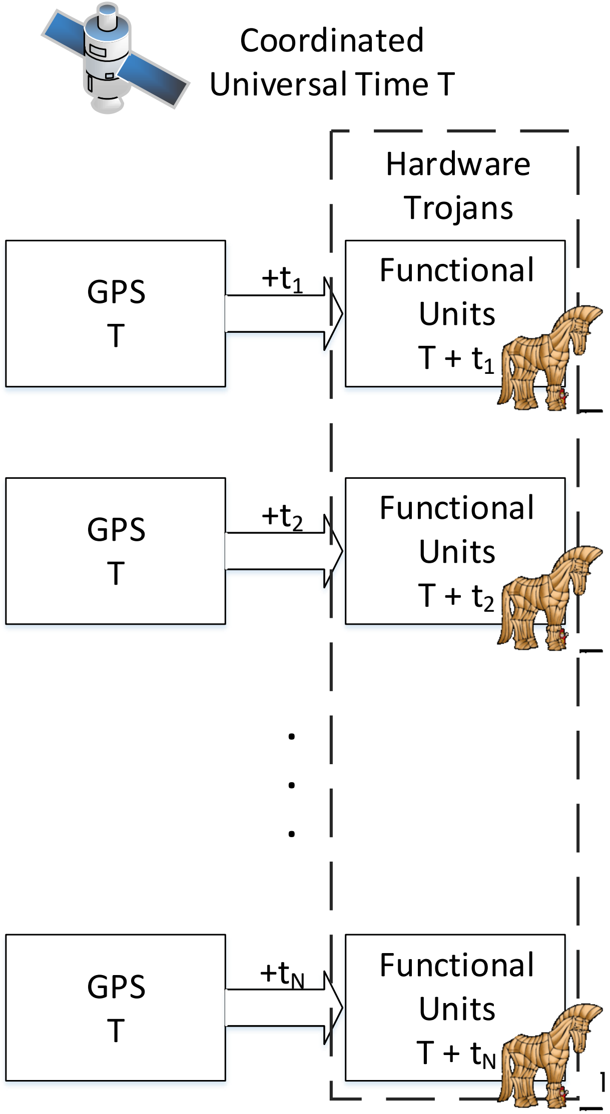

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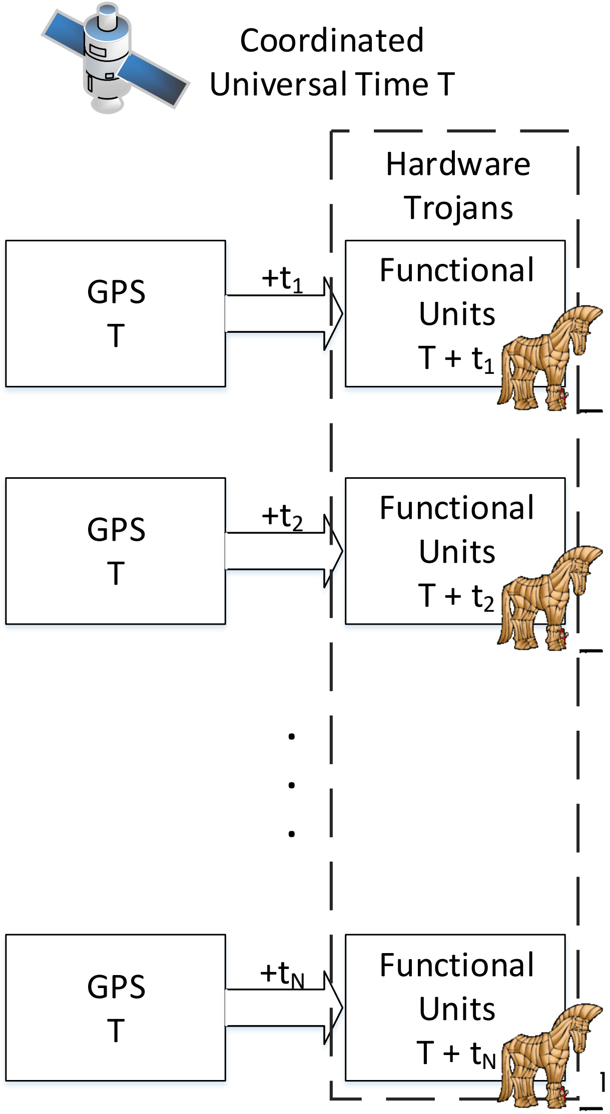
- Adding an additional interface between the GPS modules and the other functional units.
- We **reduce** the Trusted Computing Base (TCB) from all the modules in one node to **a trusted GPS module and a trusted additional interface.**



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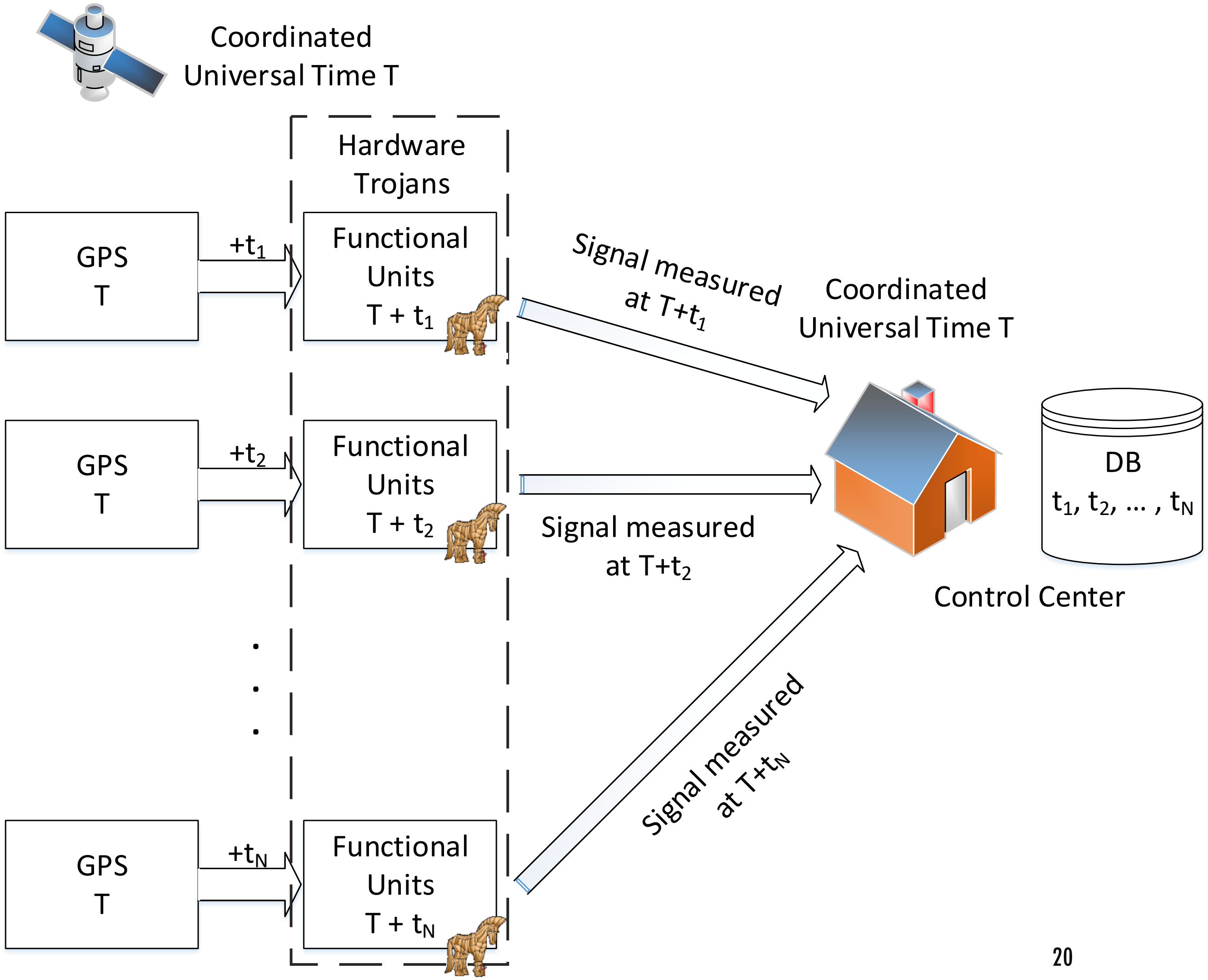

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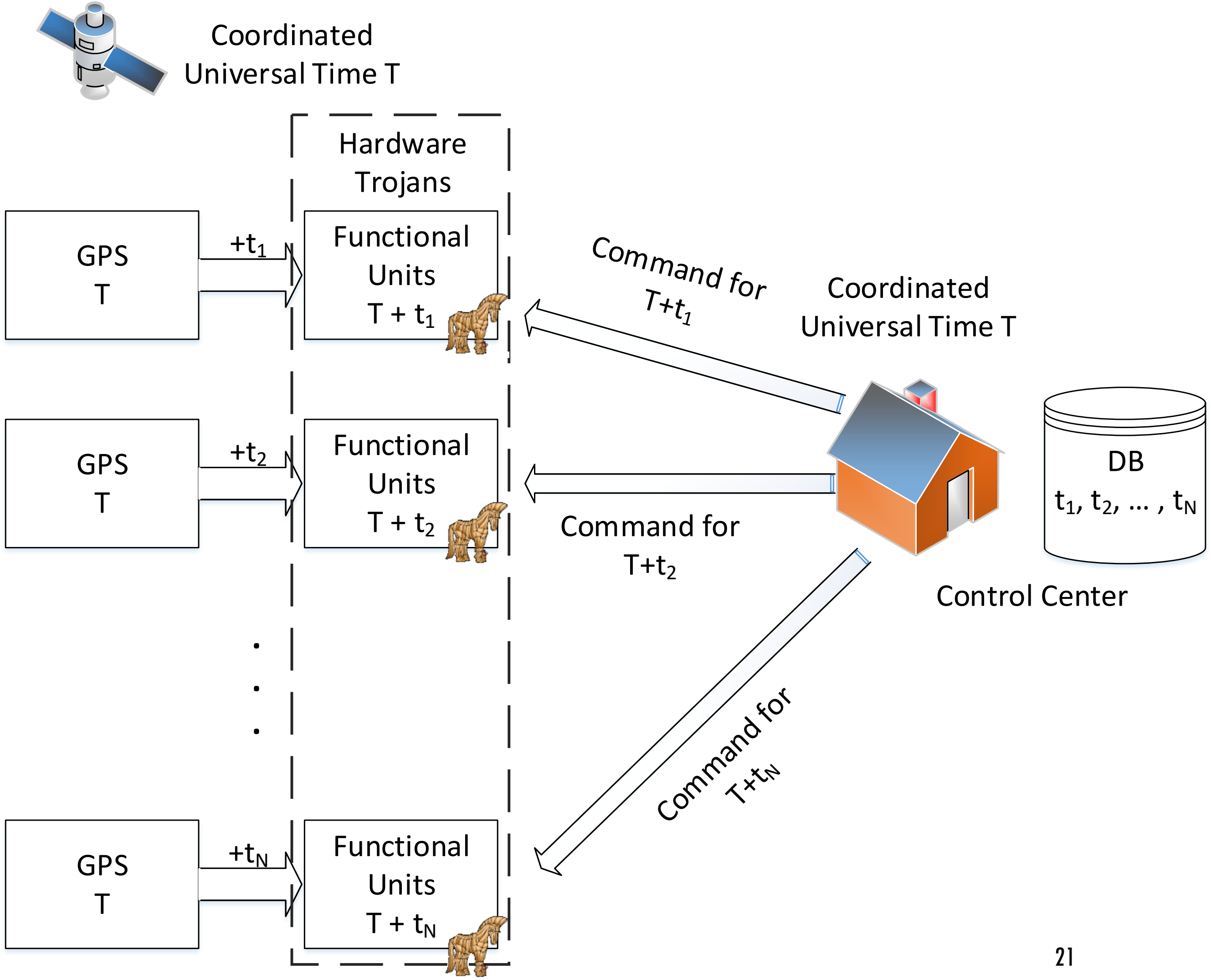

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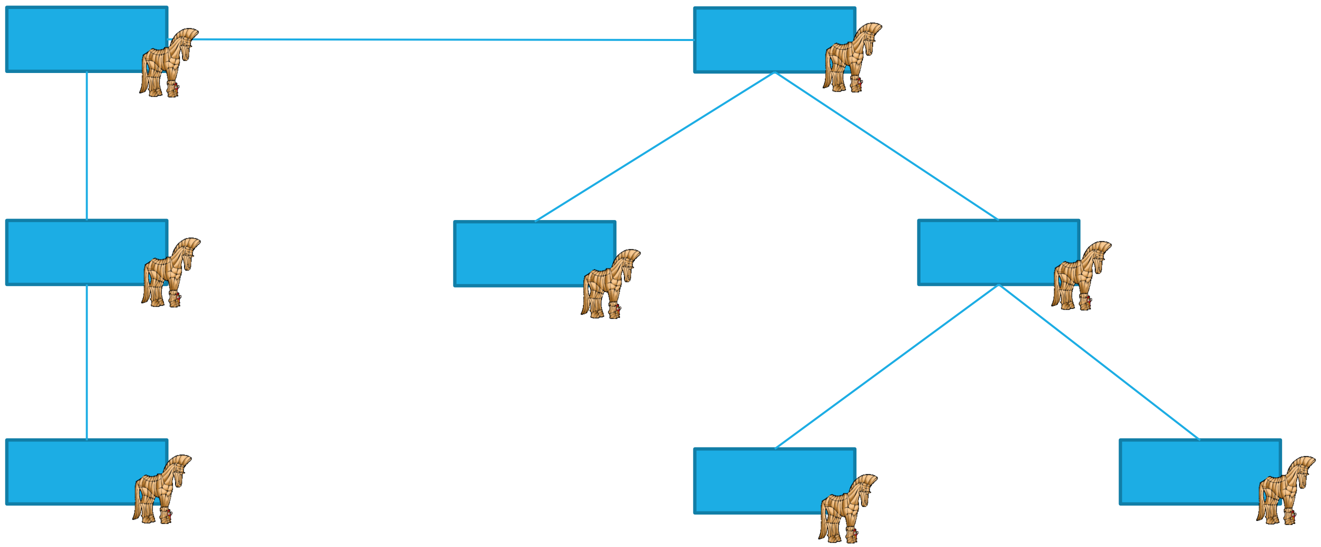

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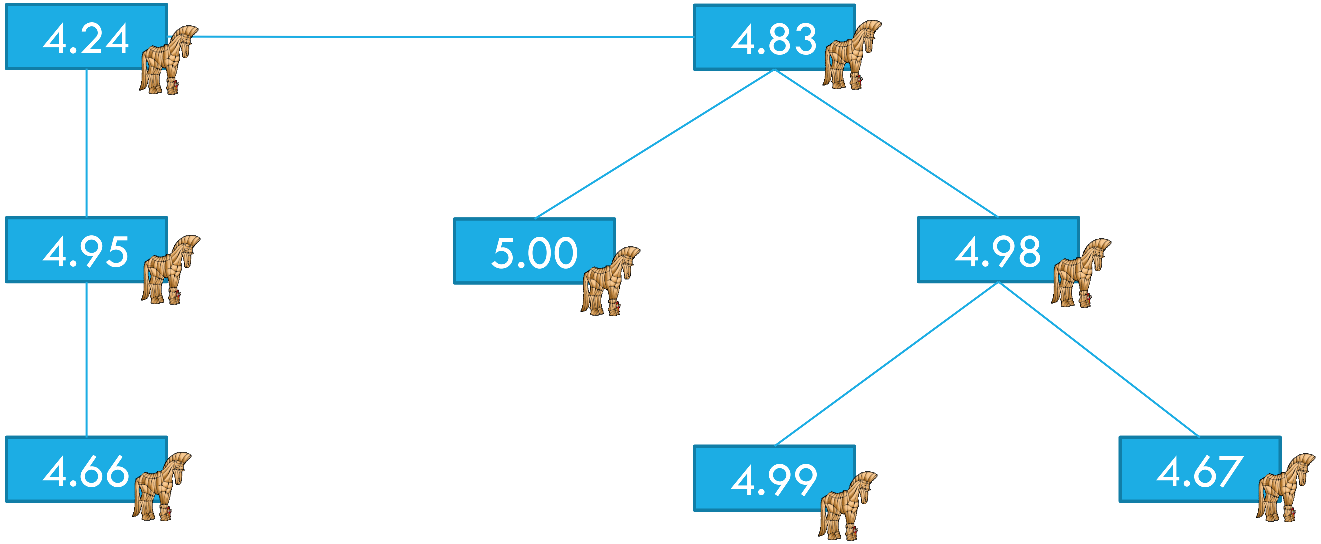

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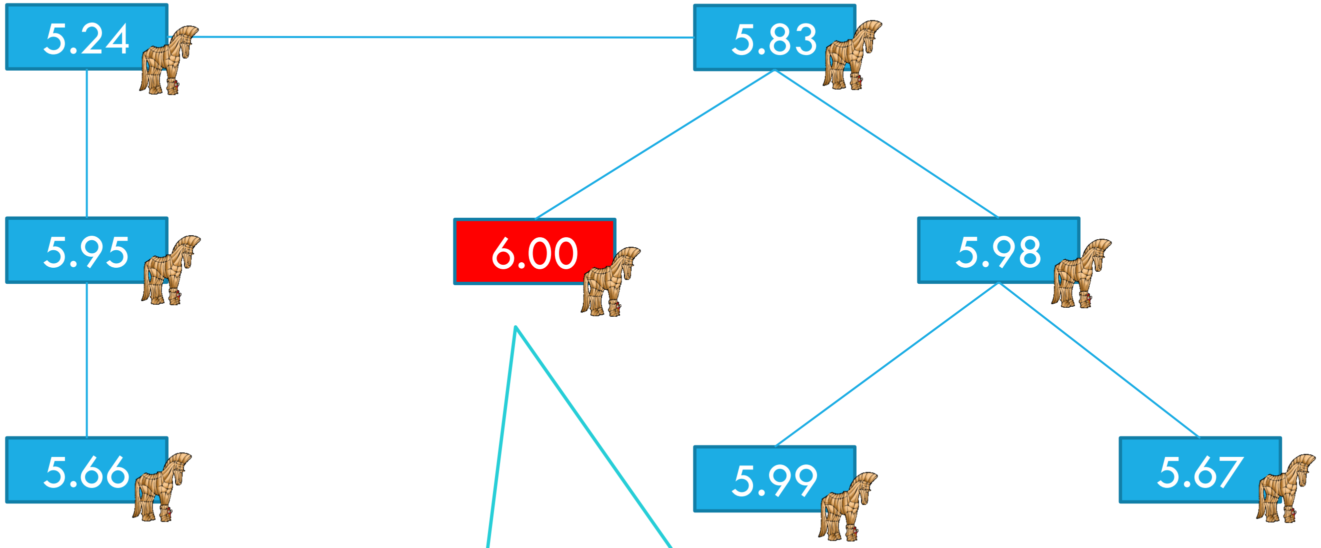

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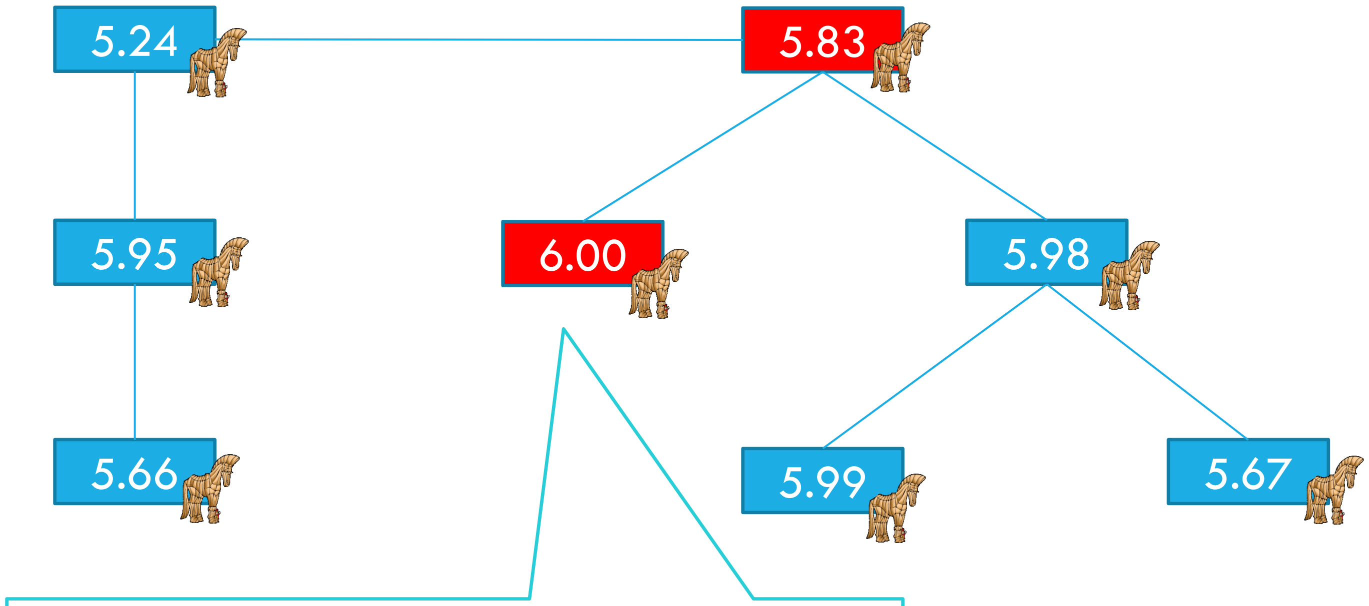

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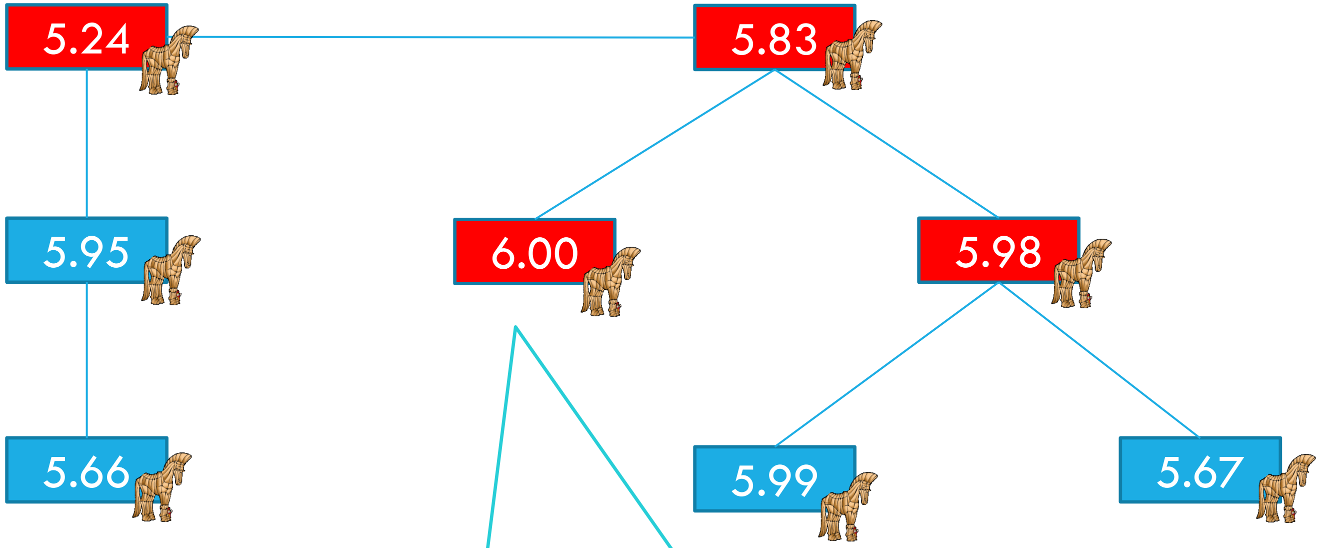

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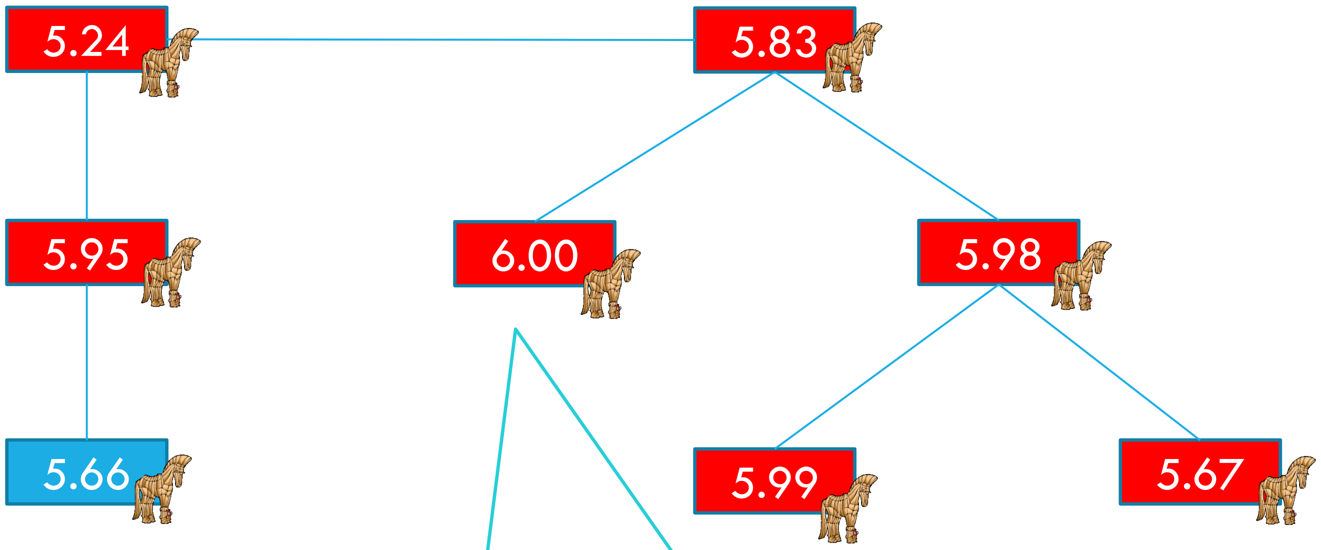

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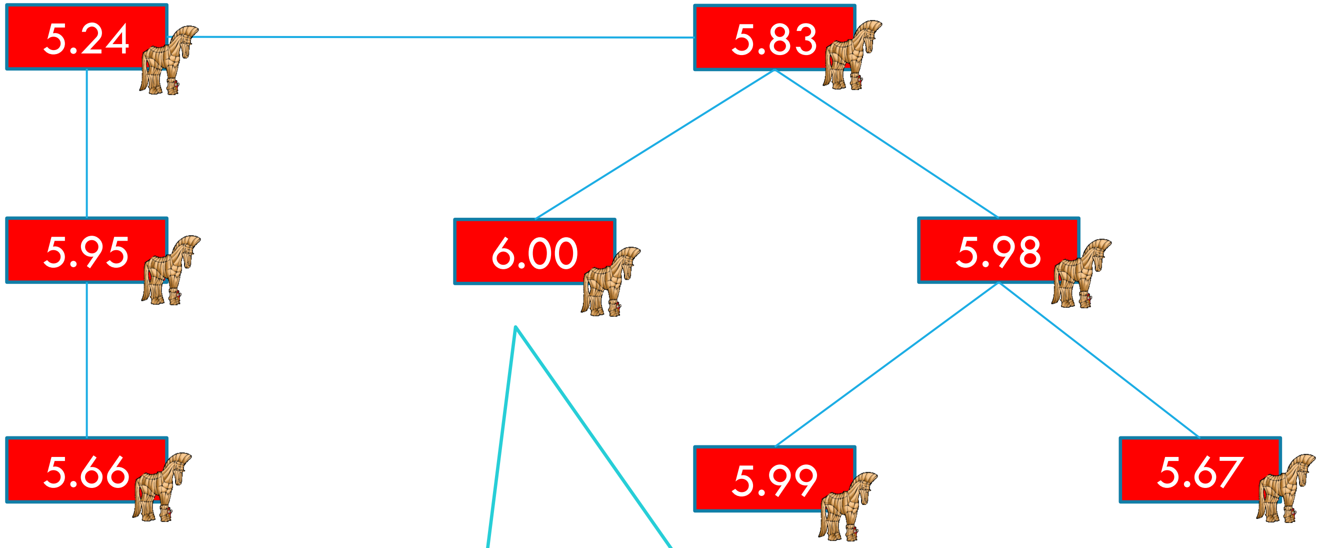

E.g. If one of the counters reaches 6 years, then this Trojan becomes master and broadcasts one special message to trigger all the other Trojans in the network.

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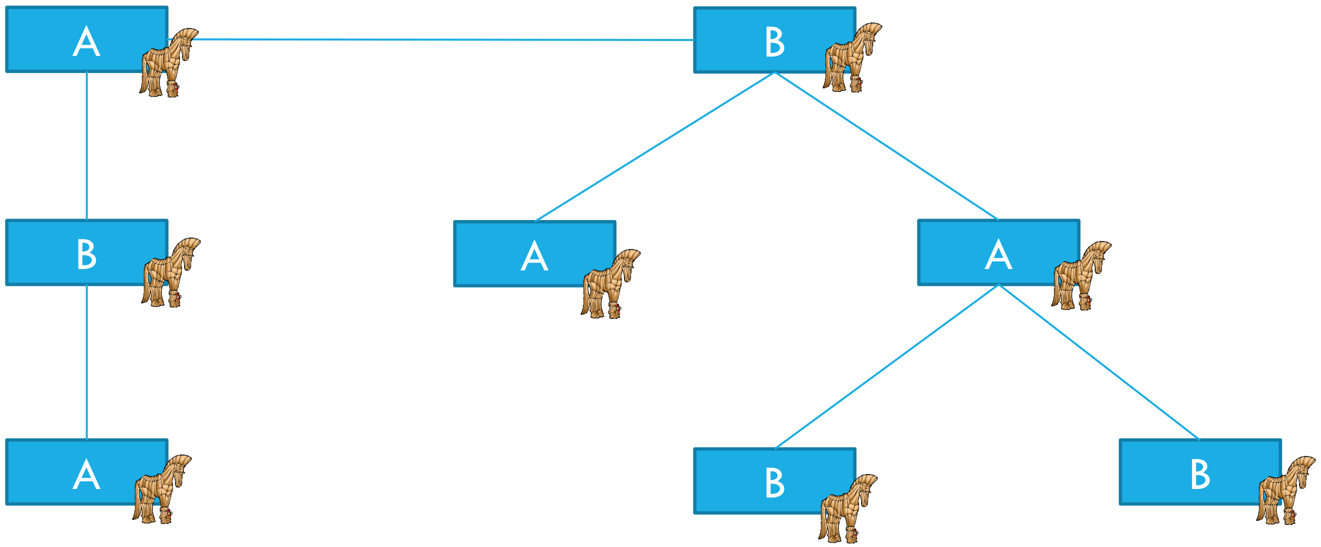
  - Split manufacturing.
    - Ask two manufacturers to fabricate the communication modules, assuming they do not collude with each other, and they cannot interpret one another's trigger message.
    - Neighboring nodes in the network topology originate from the different manufacturers.

Mitigation for Type B Attack

- Suppose that we have devices from two non-colluding malicious manufacturers A and B.



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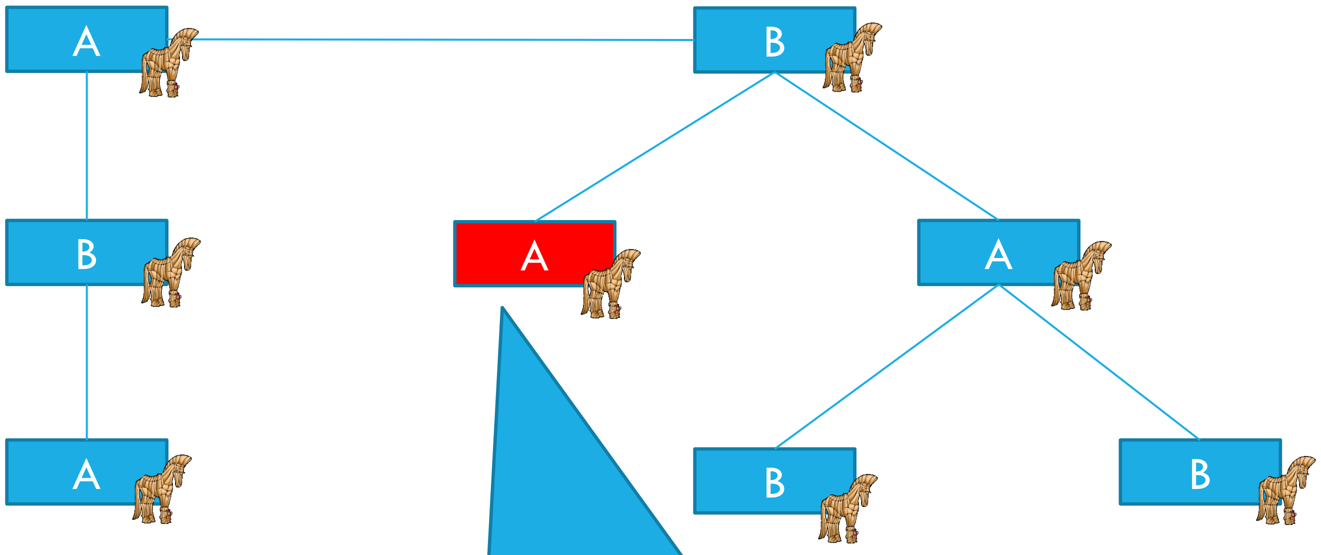

One of the Trojans is activated first, but ideally its broadcasting message cannot be interpreted by the neighboring nodes, so the package is dropped.

Outline

- Type A: No inter-Trojan communications.
  - Attack
  - Mitigation
- Type B: Allow inter-Trojan communications.
  - Attack
  - Possible Mitigation
- Risk Study

Risk Study

- Both online and offline hardware Trojan attacks are valid and possible in theory.
- In practice, a software attack is more likely to happen, because a large scale hardware attack is harder to prepare and launch.
- Hardware Trojans can be used to support software attacks, and the malicious behavior is controlled/ triggered by software.

Conclusion

- We studied the feasibility and risk of synchronized hardware Trojan attacks in smart grids. We conclude that hardware Trojan attacks are more difficult to launch a damaging attack in smart grids than software attacks.

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- For Type A offline attack:
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  - It converts a failure of the entire power grid to sporadic single node failures.
  - Our solution reduces the TCB to a GPS module with a small additional interface in each node.
  - Applicable to the current power grid infrastructure.

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Thank you!