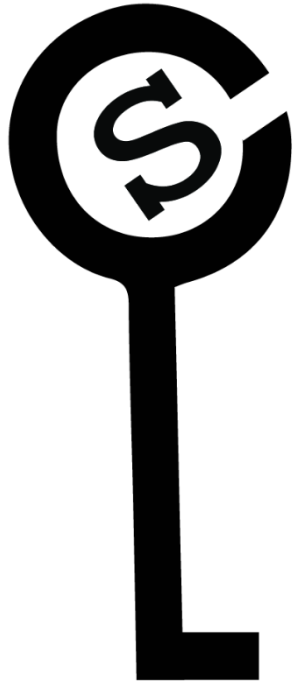# Mitigating Synchronized Hardware Trojan Attacks in Smart Grids

Chenglu Jin, Lingyu Ren, Xubin Liu, Peng Zhang and Marten van Dijk

Secure Computation Laboratory

Department of Electrical & Computer Engineering

University of Connecticut

Email: chenglu.jin@uconn.edu

UCONN

Smart Grid Security

- Current researches are more focused on cyber security issues in smart grids.
- This implicitly assumes that the underlying hardware is trusted.
  - i.e. The hardware is doing and only doing what is supposed to do.

Cyber Security

Hardware / Physical Security

Smart Grid Security

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- This implicitly assumes that the underlying hardware is trusted.
  - i.e. The hardware is doing and only doing what is supposed to do.
- 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
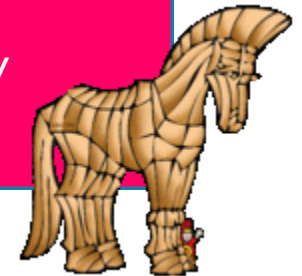
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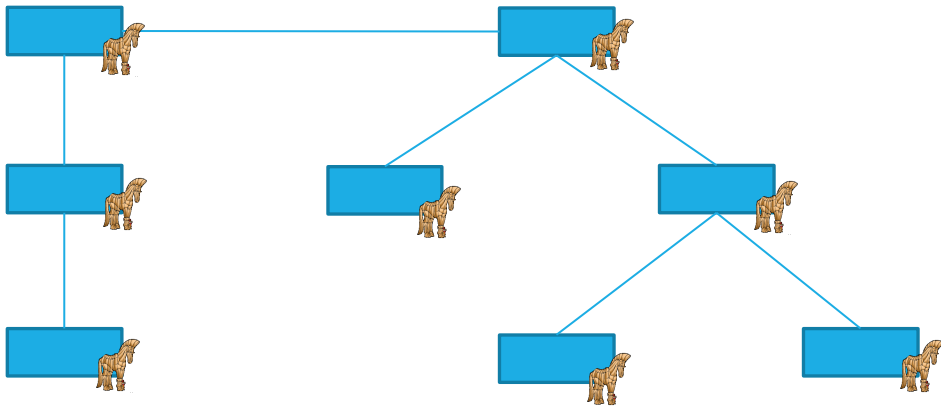
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A hidden 'back door' in a computer chip could allow cyber-criminals a way to override and control computer systems on Boeing 787s

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

http://www.dailymail.co.uk/sciencetech/article-2152284/Could-vulnerable-chip-allow-hackers-Boeing-787-Back-door-allow-cyber-criminals-way-in.html#ixzz28fcdeOdm

4

Hardware Trojans in Smart Grids

Synchronized

VS

Sporadic

Failure in large portion (or every node)
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Sporadic single node failures.
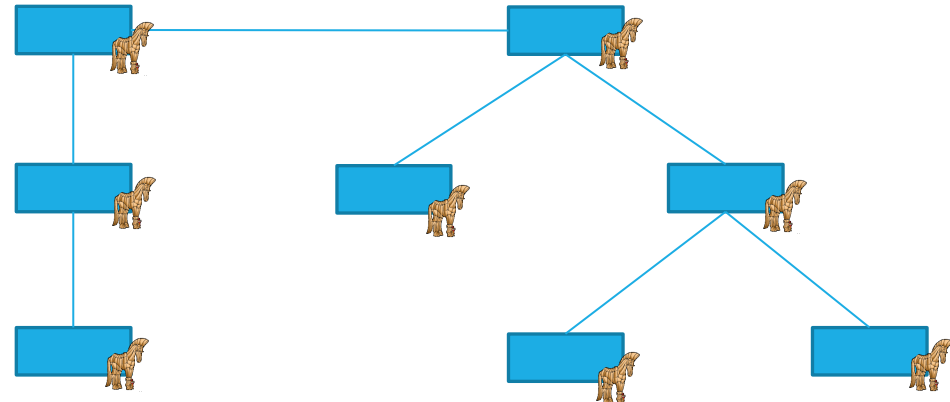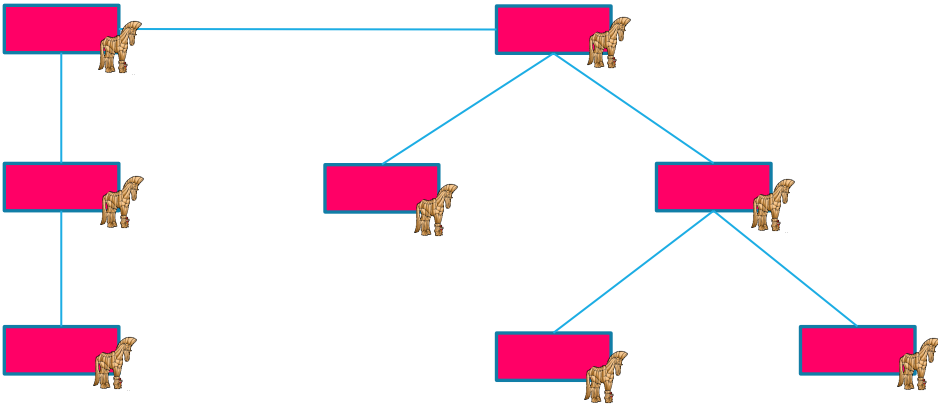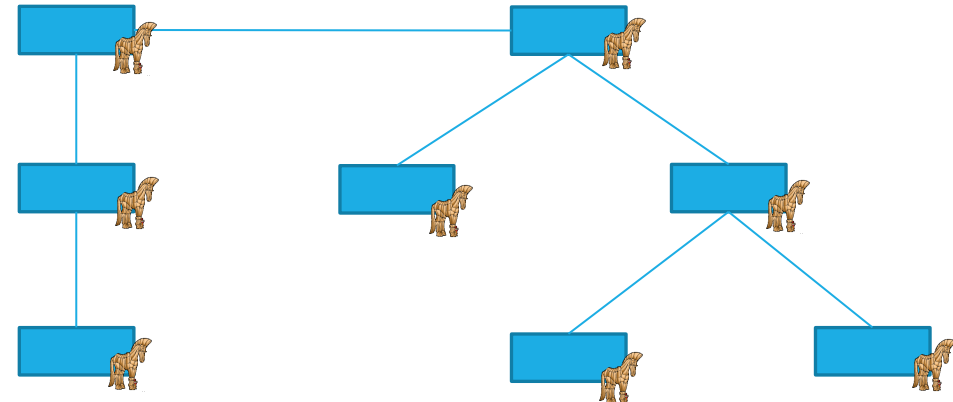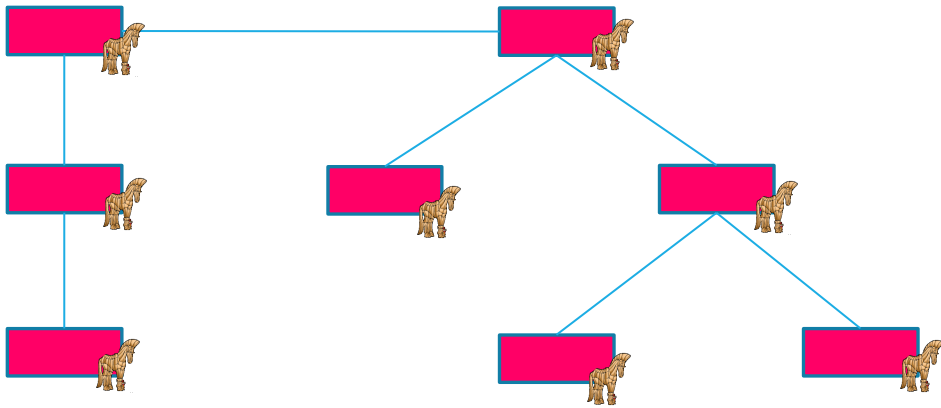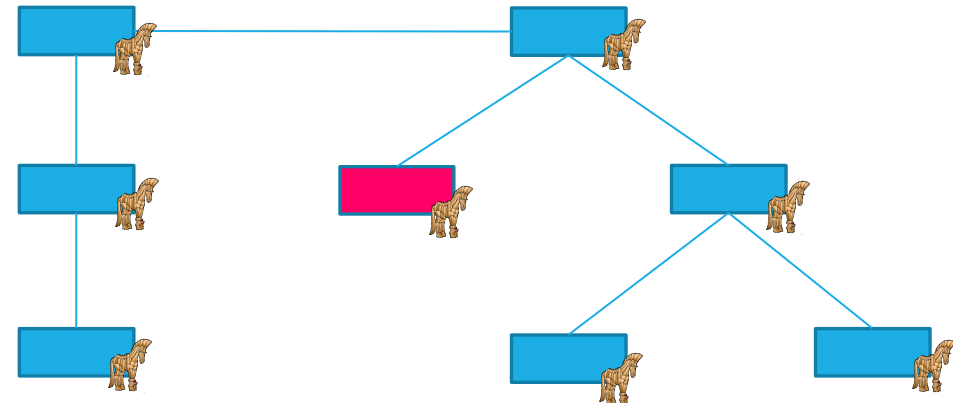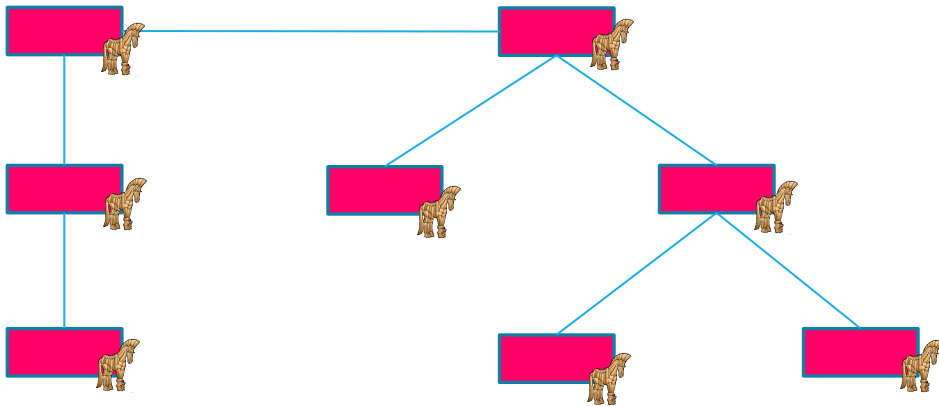
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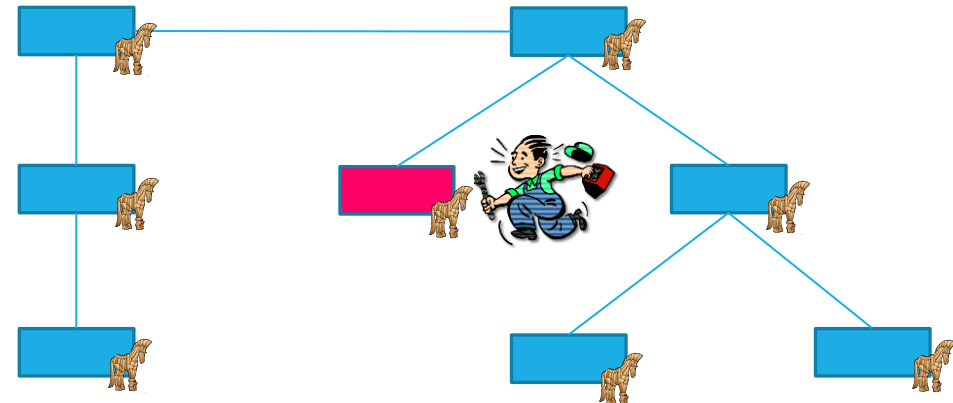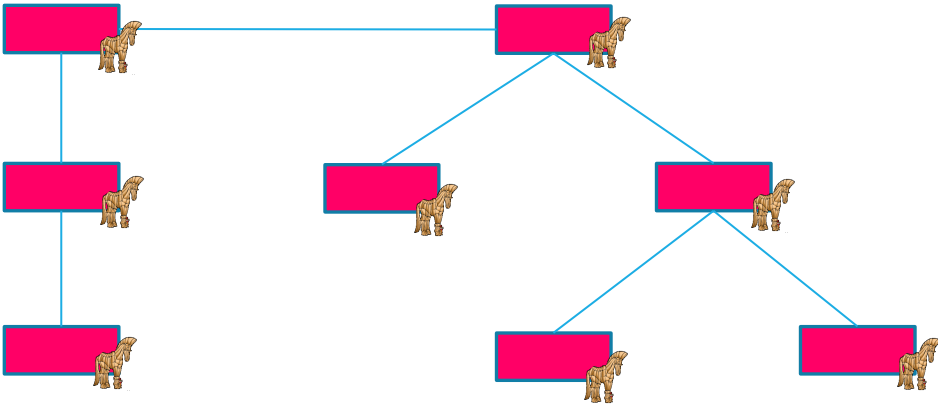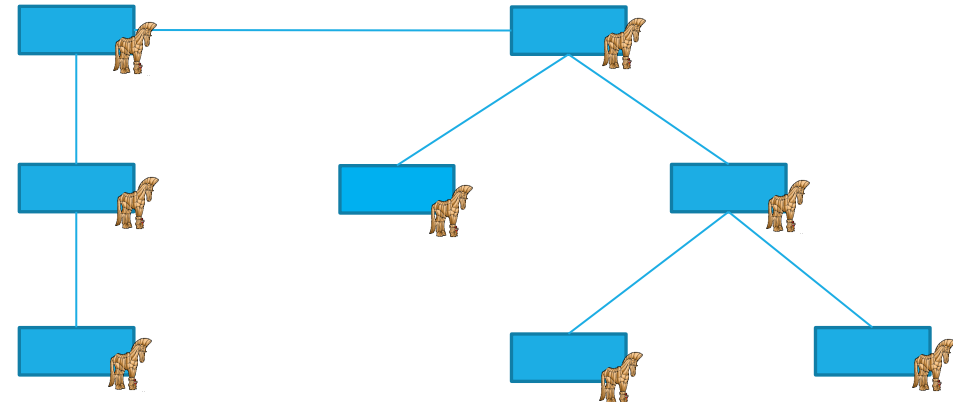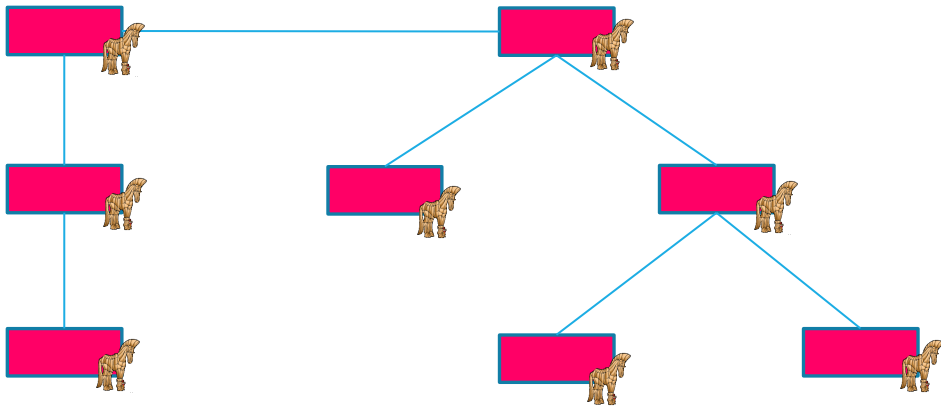
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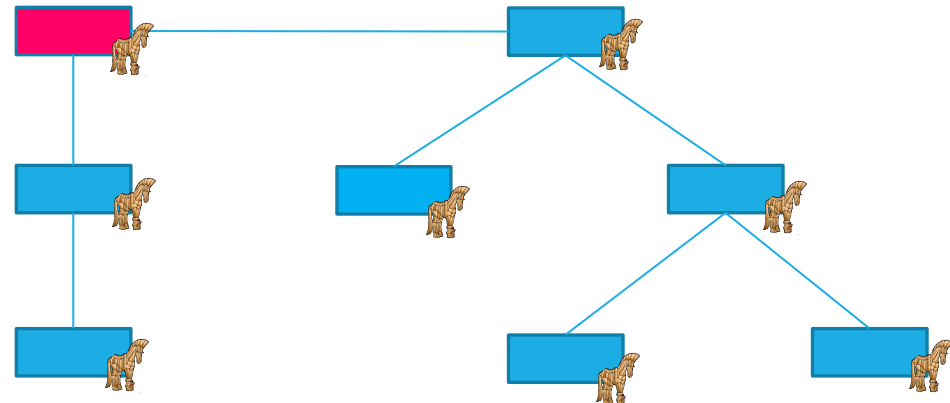
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Sporadic single node failures.

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.
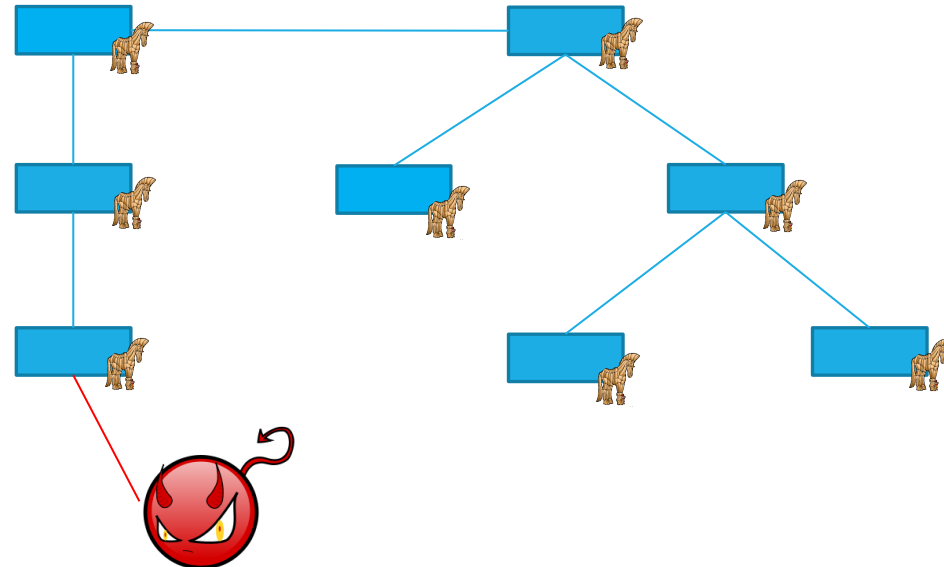
Offline Synchronized Hardware Trojans

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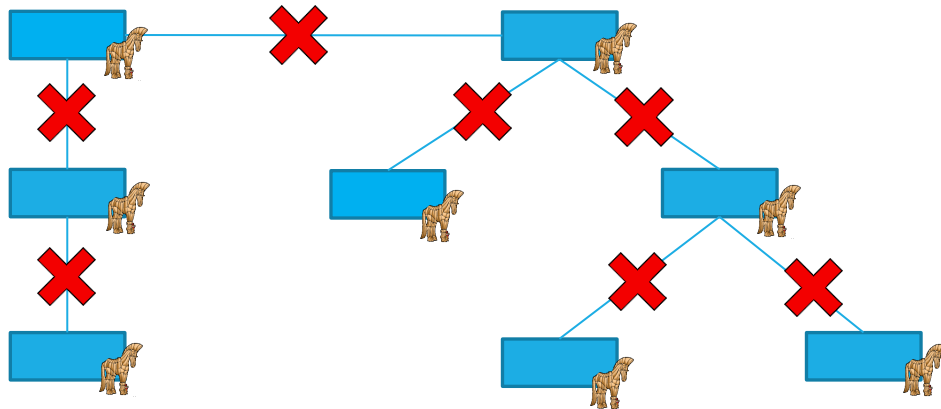
- **Type B: Allow inter-Trojan communications.**
  - Trojans can communicate with one another via network or powerline to synchronize with each other.
  - Open problem, some interesting thoughts.
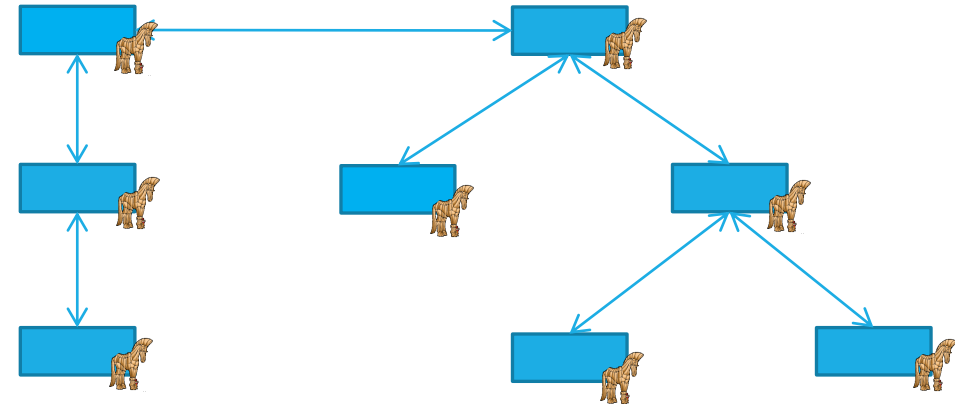
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UCONN

- Type A: No inter-Trojan communications.
  - Attack
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  - Attack
  - Possible Mitigation

- Risk Study

UCONN

- Implemented in a simple killer switch.

Type A Synchronized Attack

- Implemented in a simple killer switch.
- In each critical node of a smart grid, the functional unit (e.g. PMU, RTU) which has a Trojan embedded can check whether the current time information provided by the GPS module is equal to a preset trigger time or not.

Coordinated Universal Time T

GPS
T

Functional Units
Stop working when T = T_{tri}

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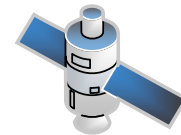- If all the Trojans have the same trigger time, then the entire power grid will shut down at the same time.
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Mitigation for Type A Attack

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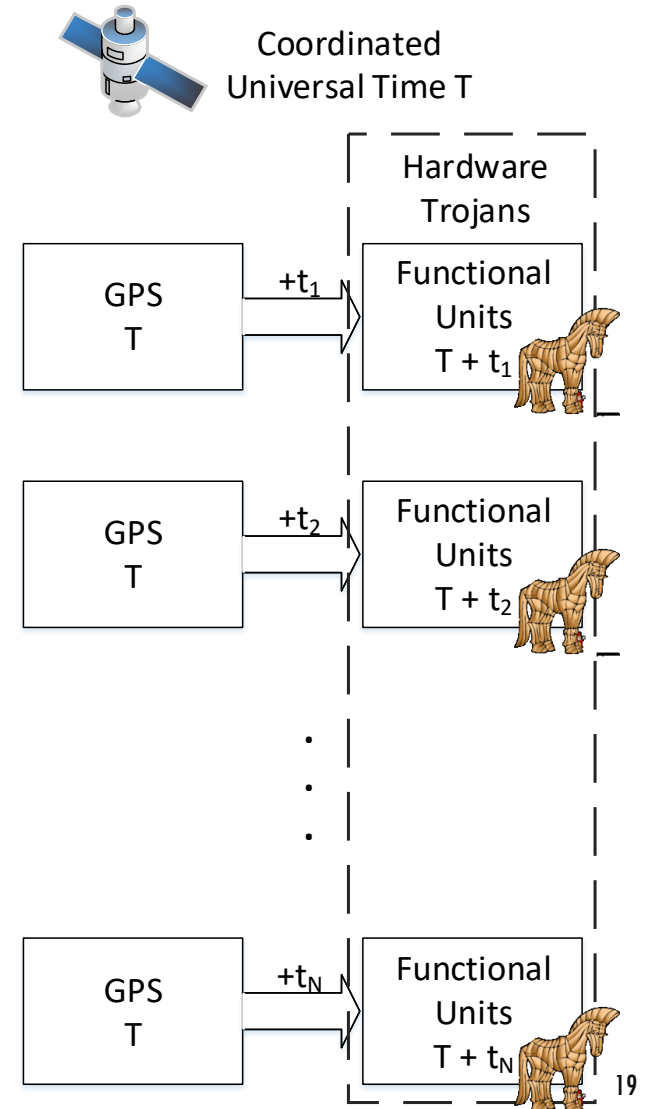GPS T → $+t_2$ → Functional Units $T + t_2$

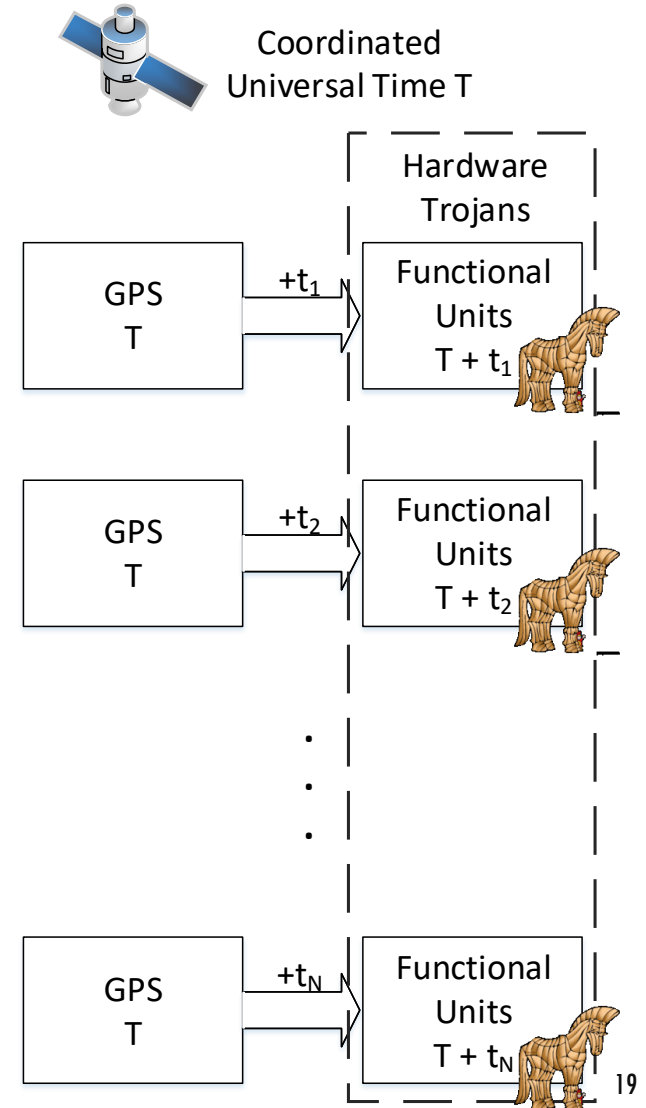GPS T → $+t_N$ → Functional Units $T + t_N$

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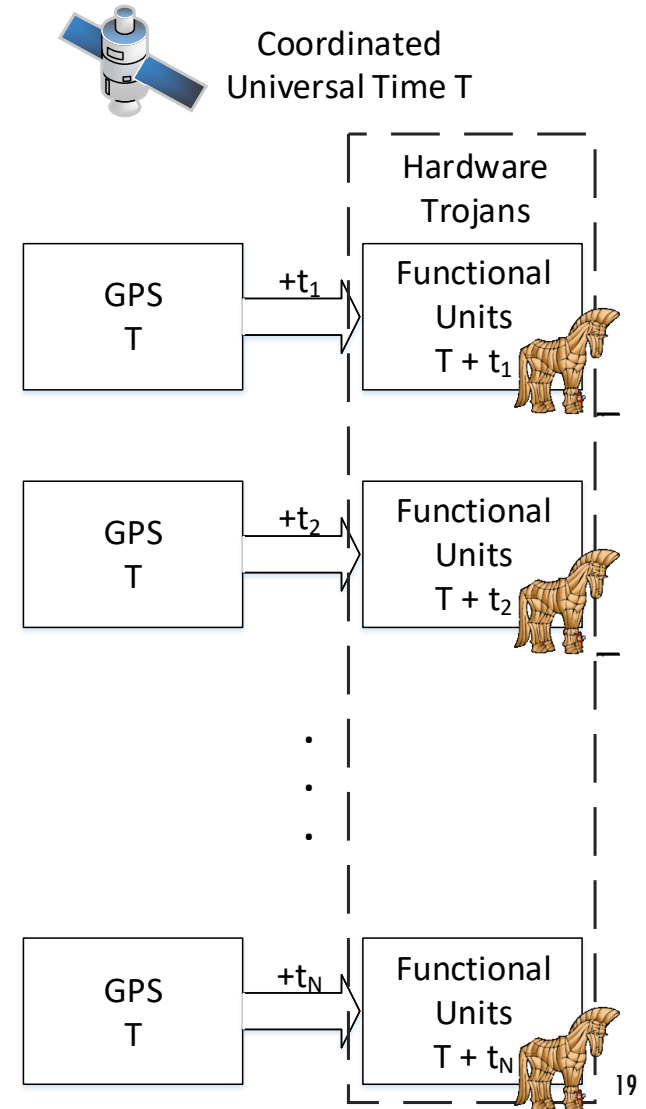GPS T $\longrightarrow$ $+t_N$ $\longrightarrow$ Functional Units $T + t_N$
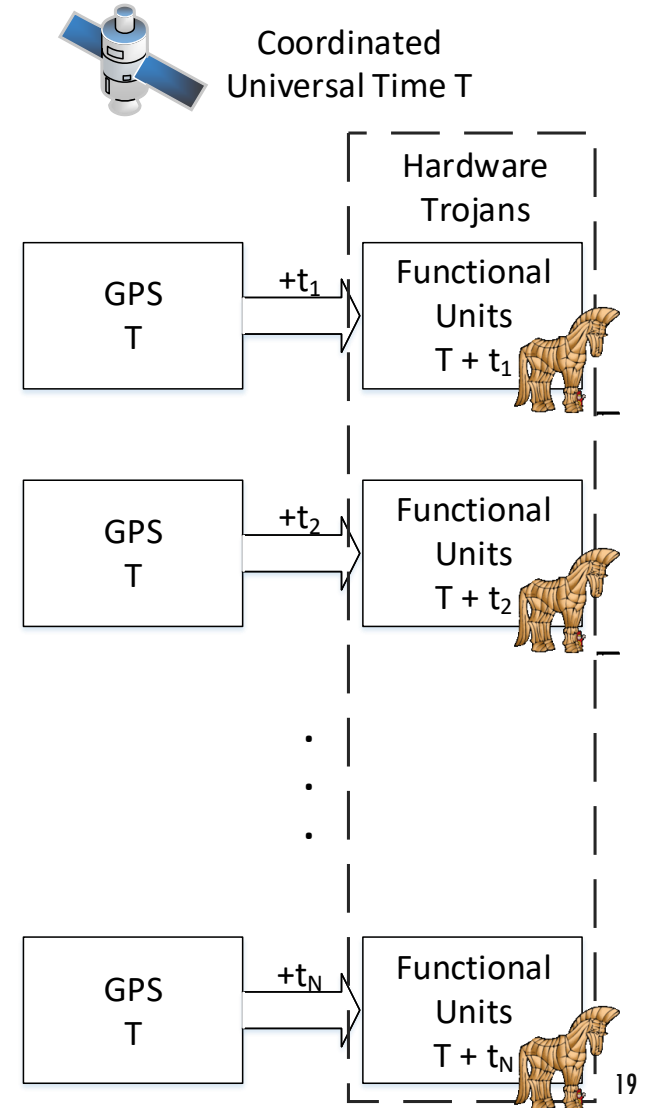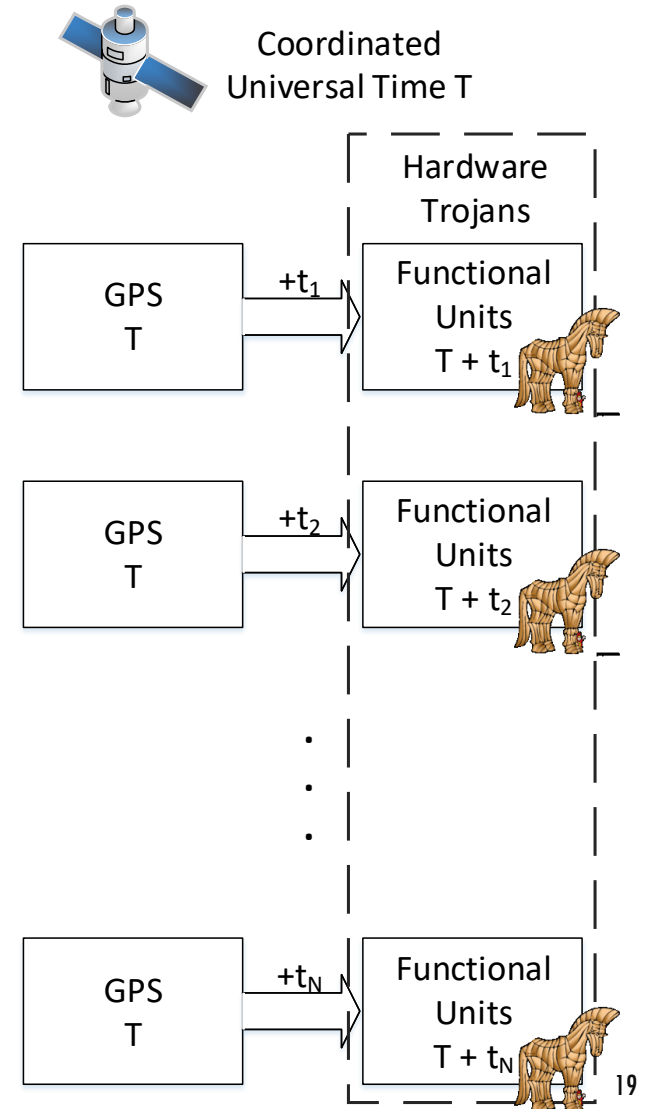
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- Adding an additional interface between the GPS modules and the other functional units.

- 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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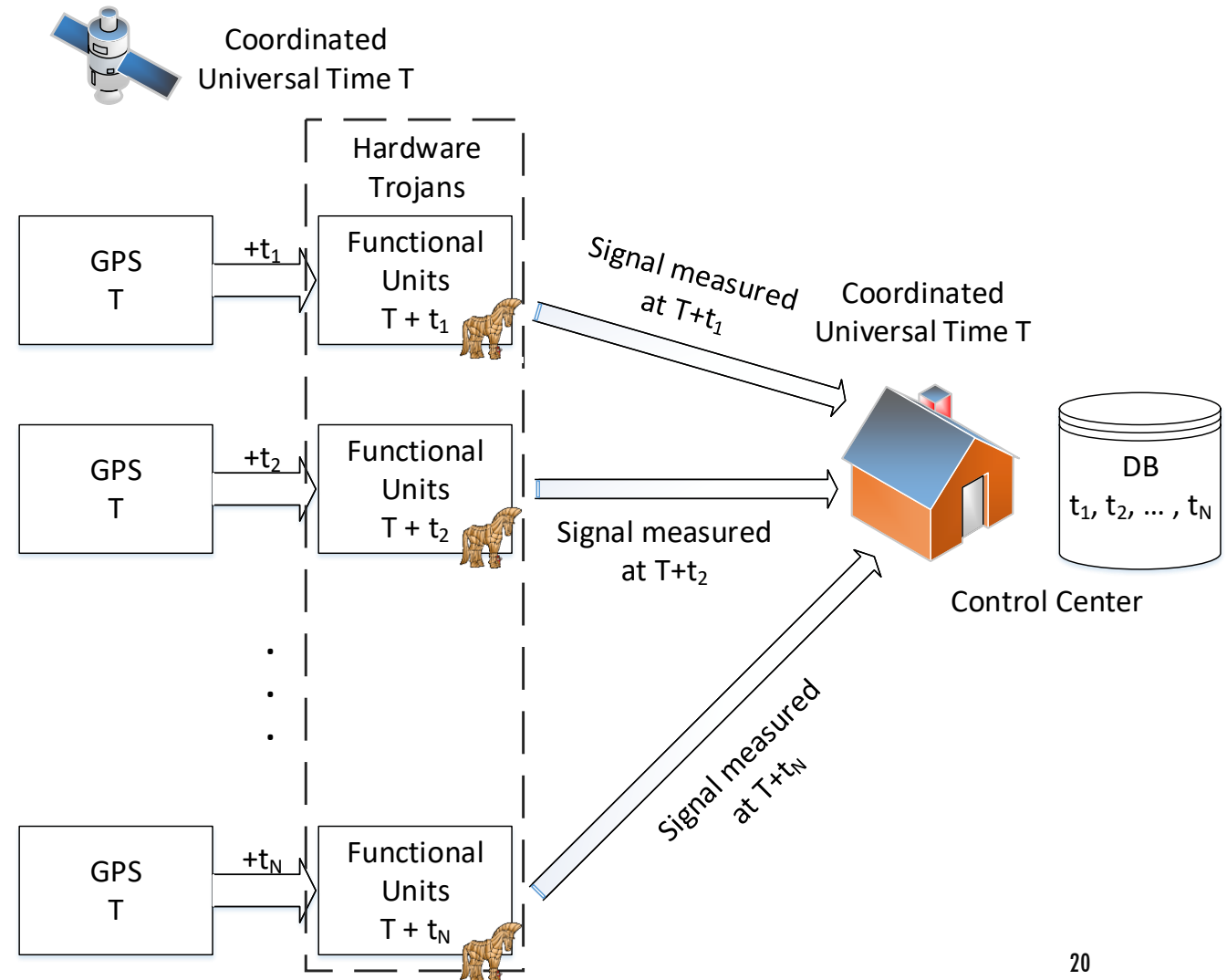
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Coordinated Universal Time T

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Control Center

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20

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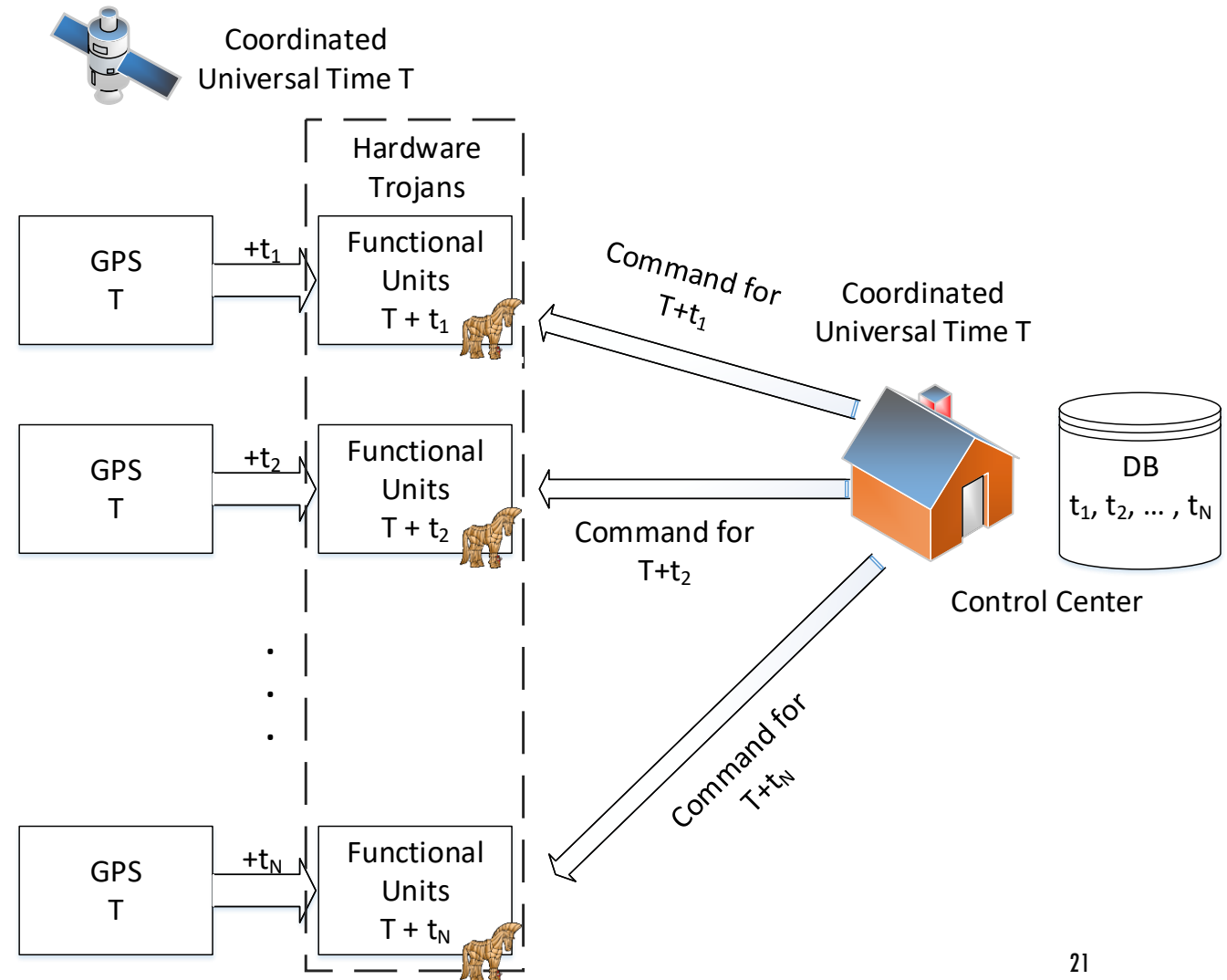 - E.g. PMUs in different nodes need to do measurement using the same time reference.

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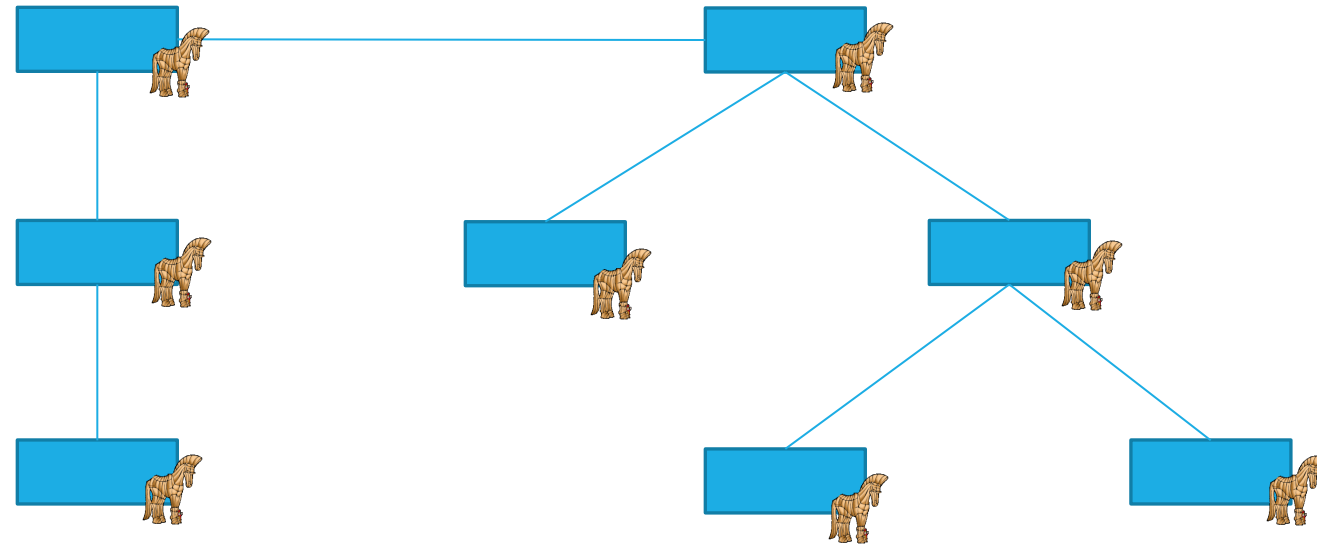Each Trojan has a counter embedded in it to count how long it has been deployed.
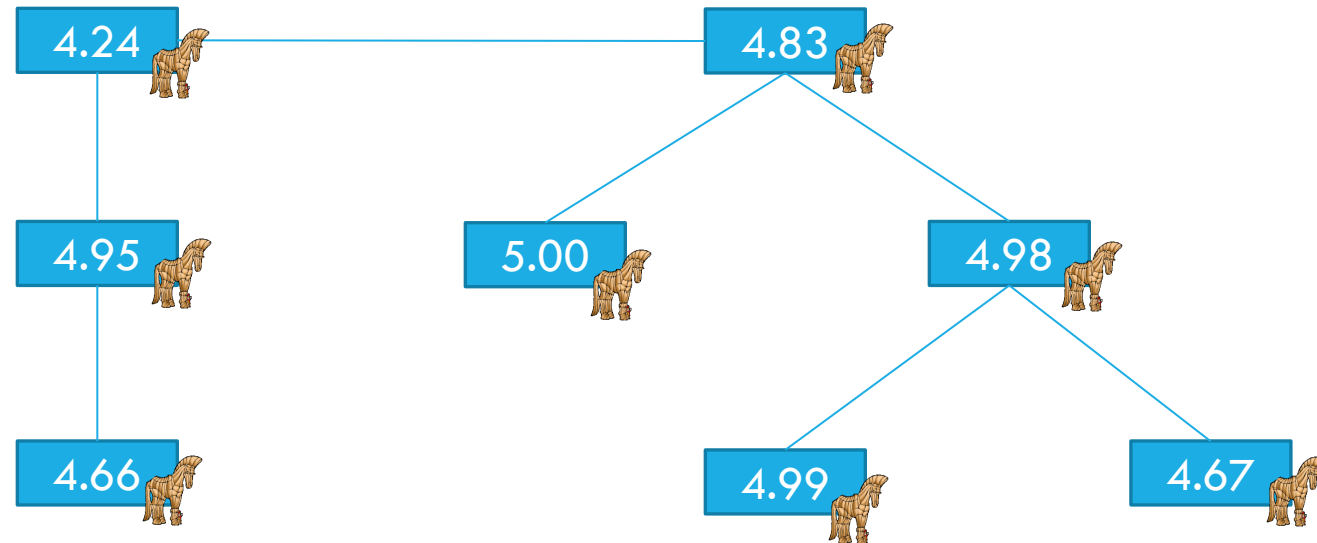
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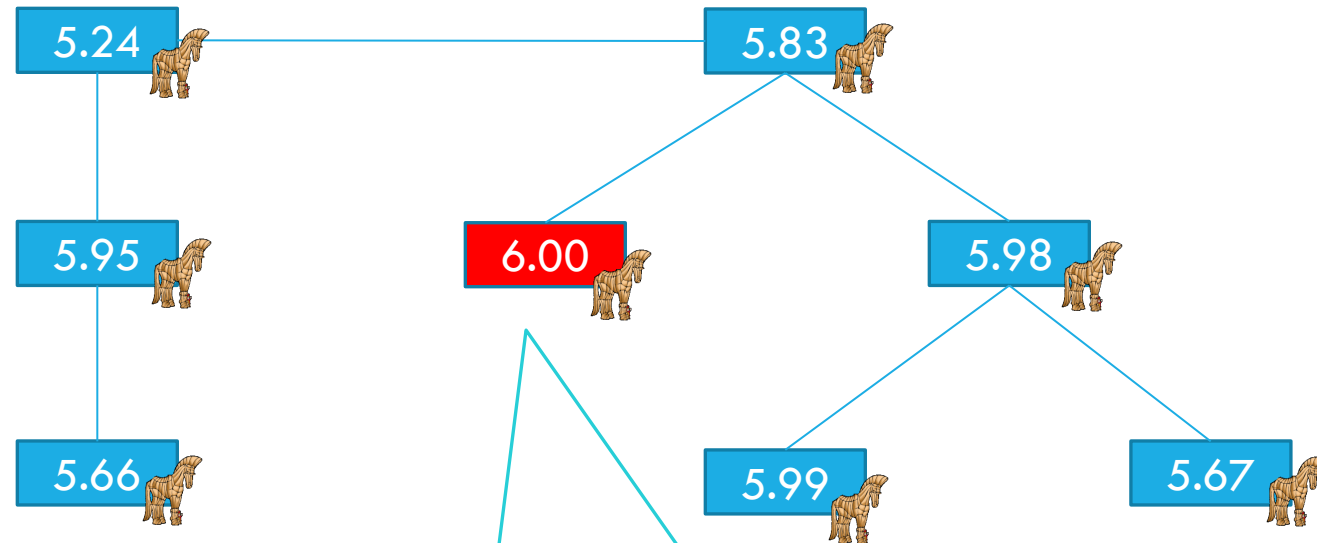
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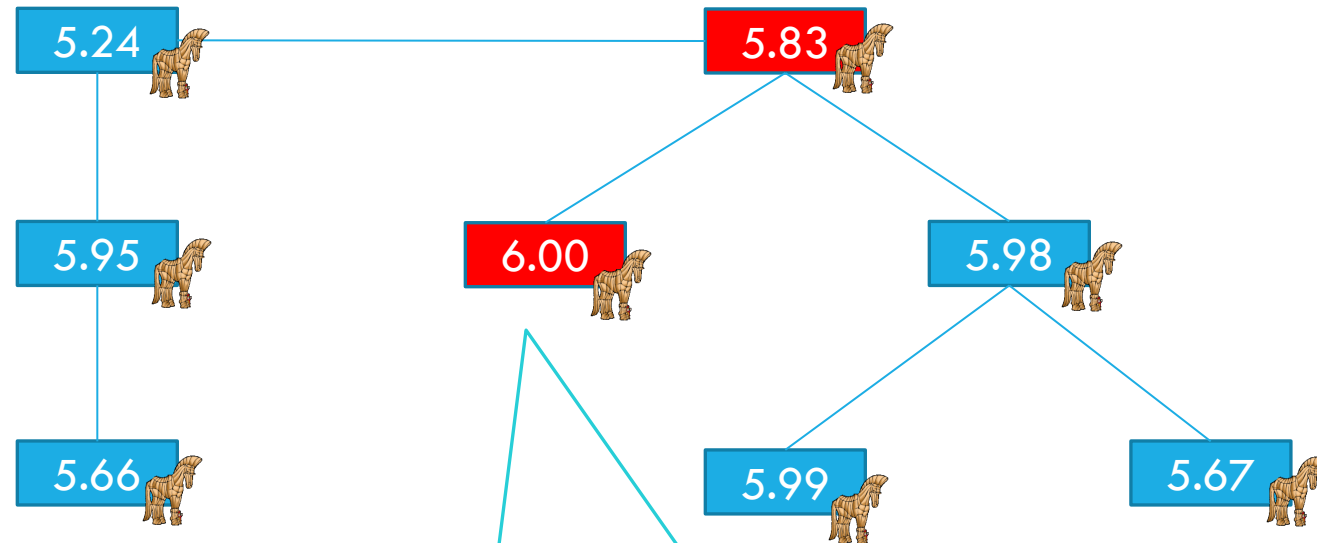Each Trojan has a counter embedded in it to count how long it has been deployed.

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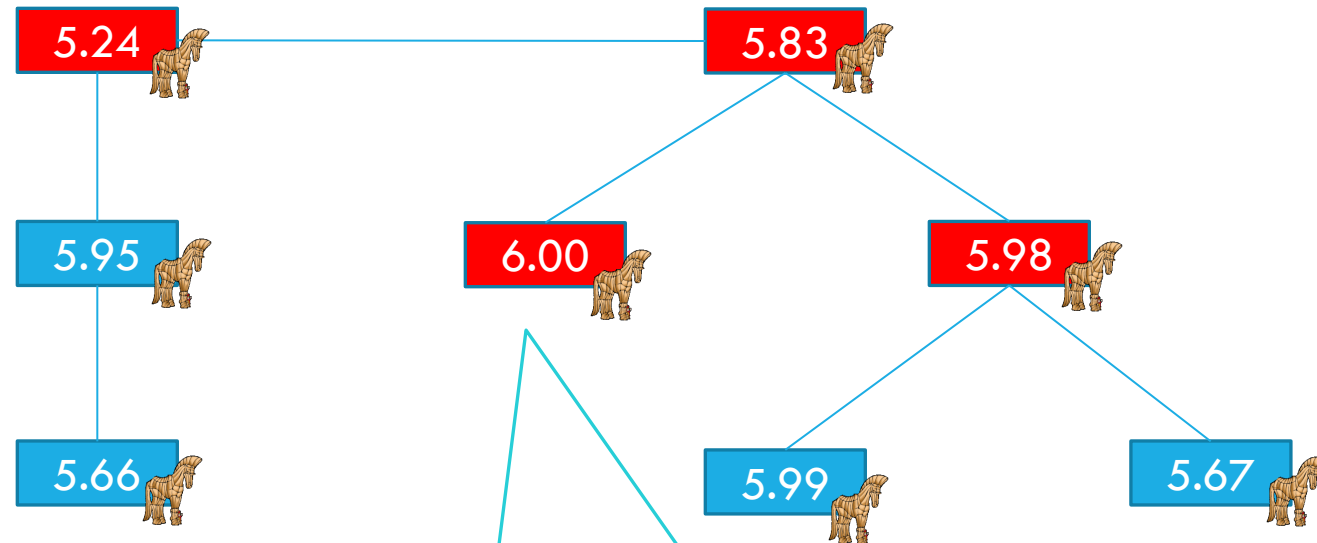Each Trojan has a counter embedded in it to count how long it has been deployed.

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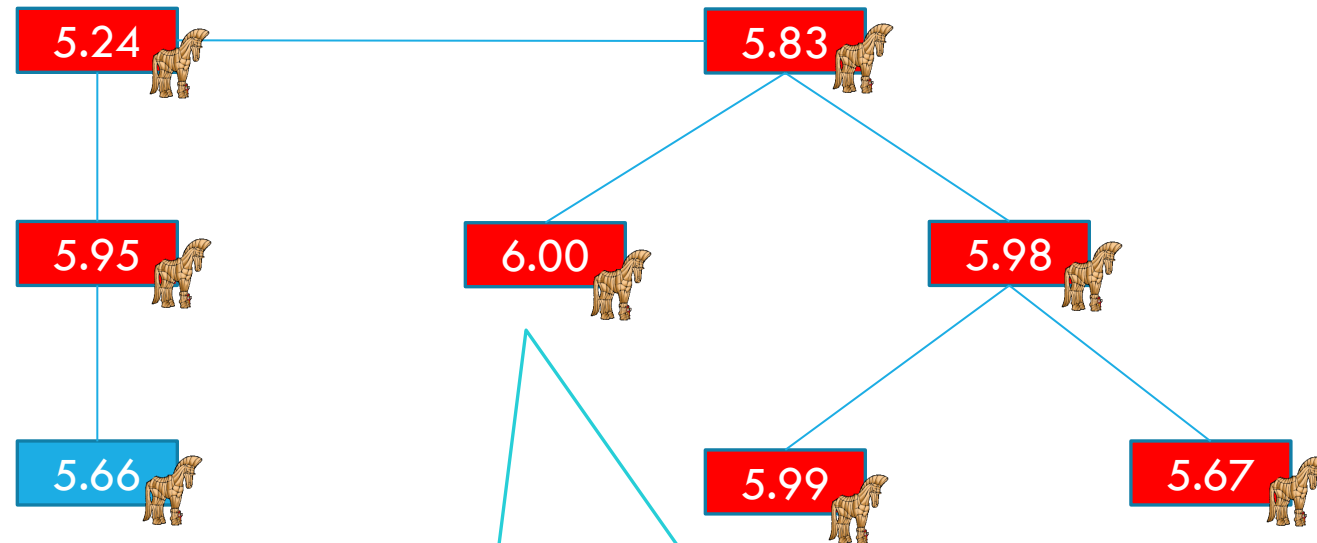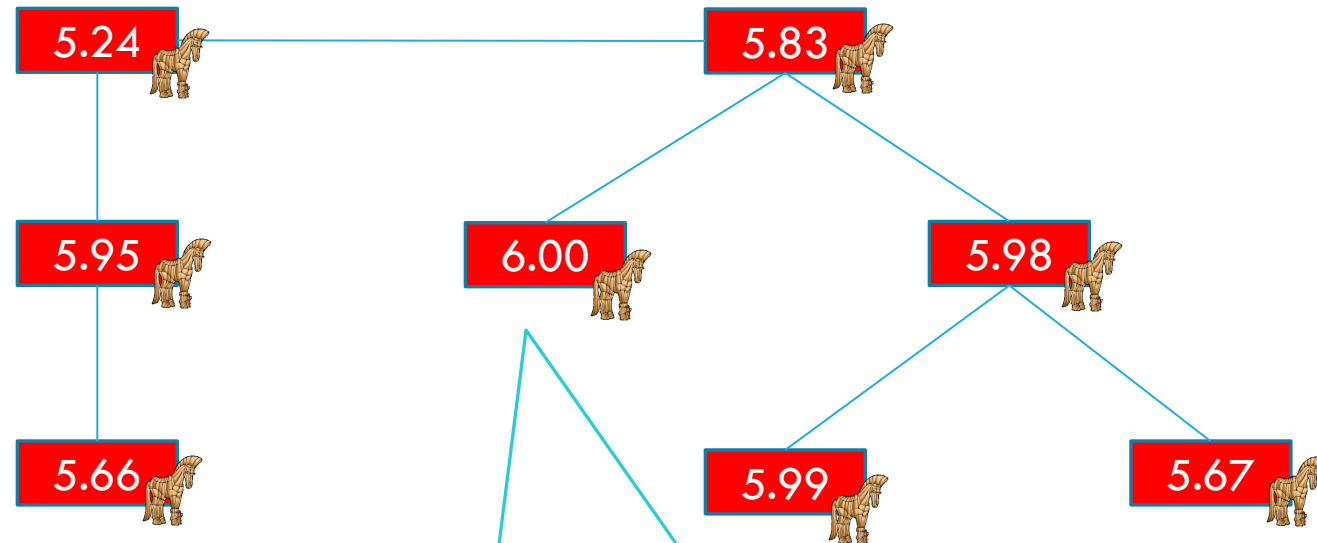

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  - Split manufacturing.
    - Ask two manufacturers to fabricate the communication modules, assuming they do not collude with each other, and they cannot interpret one another's trigger message.
    - Neighboring nodes in the network topology originate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

- Suppose that we have devices from two non-colluding malicious manufacturers A and B.
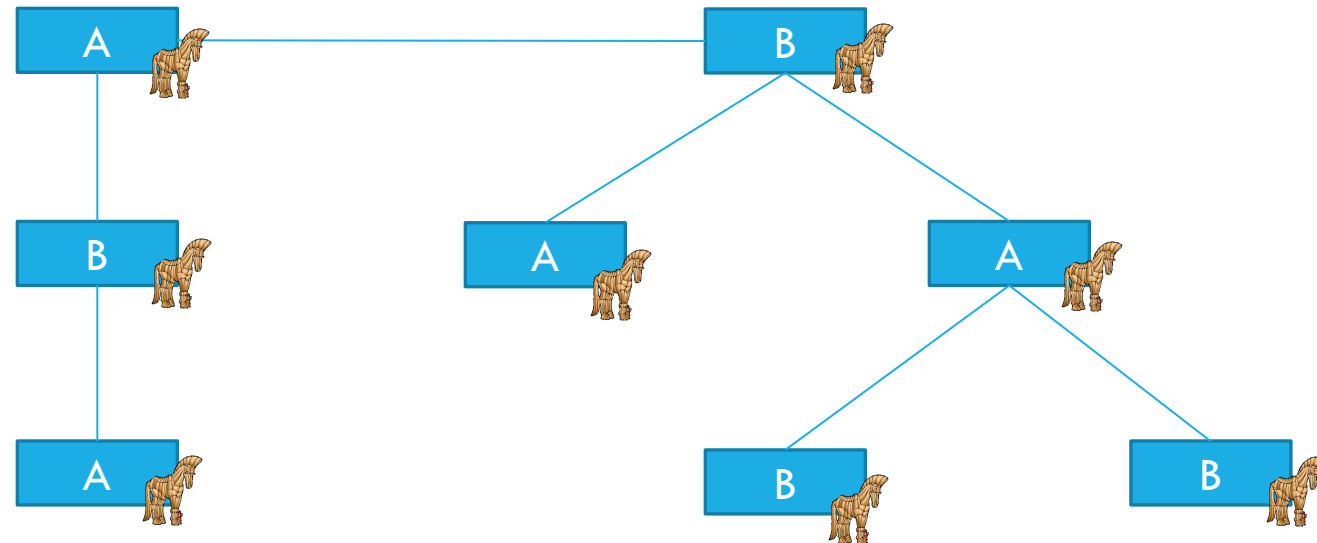
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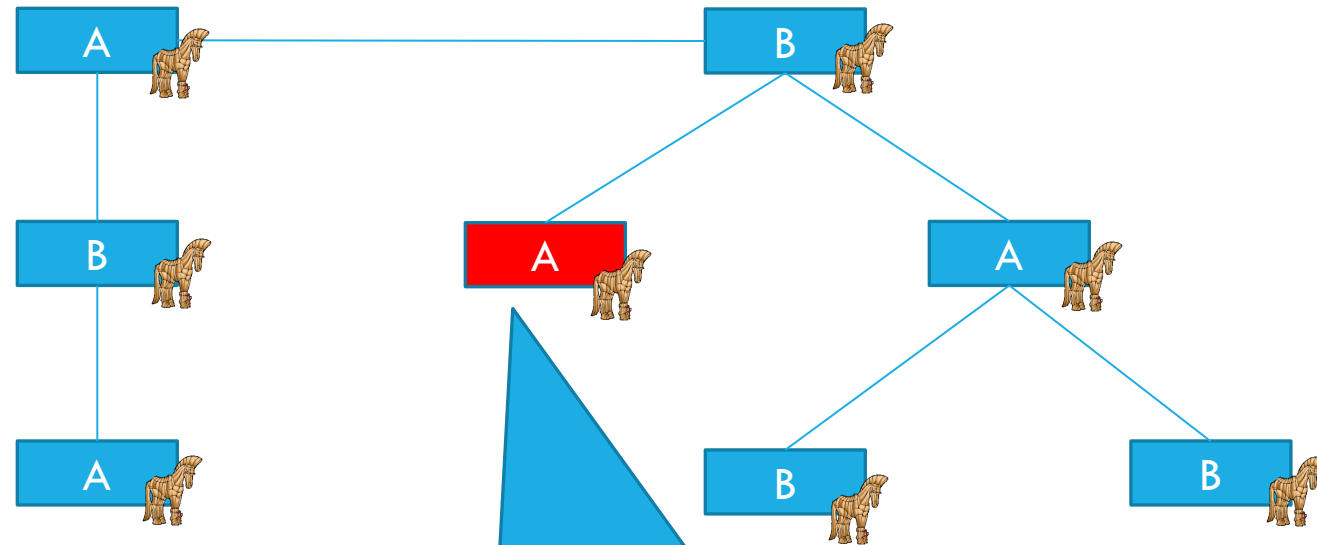
One of the Trojans is activated first, but ideally its broadcasting message cannot be interpreted by the neighboring nodes, so the package is dropped.

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- **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

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  - Possible mitigations: Formally verified communication modules, Split Manufacturing.

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.

- For Type A offline attack:
  - We propose to isolate the time domain of each node to prevent type A offline hardware Trojans from being activated at the same time.
  - 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.

- For Type B offline attack:
  - Open problem.
  - Possible mitigations: Formally verified communication modules, Split Manufacturing.

Thank you!