Car Reservation Software Model

Lab STICC/P4S

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Context

- A model of the software implemented in a embedded computer was created based on the scenarios
- The source code of the embedded system was also inspected
- The prototype was confirmed with the creators of the system
- For Lab STICC: How can formal models ease the cybersecurity analysis of connected vehicles?

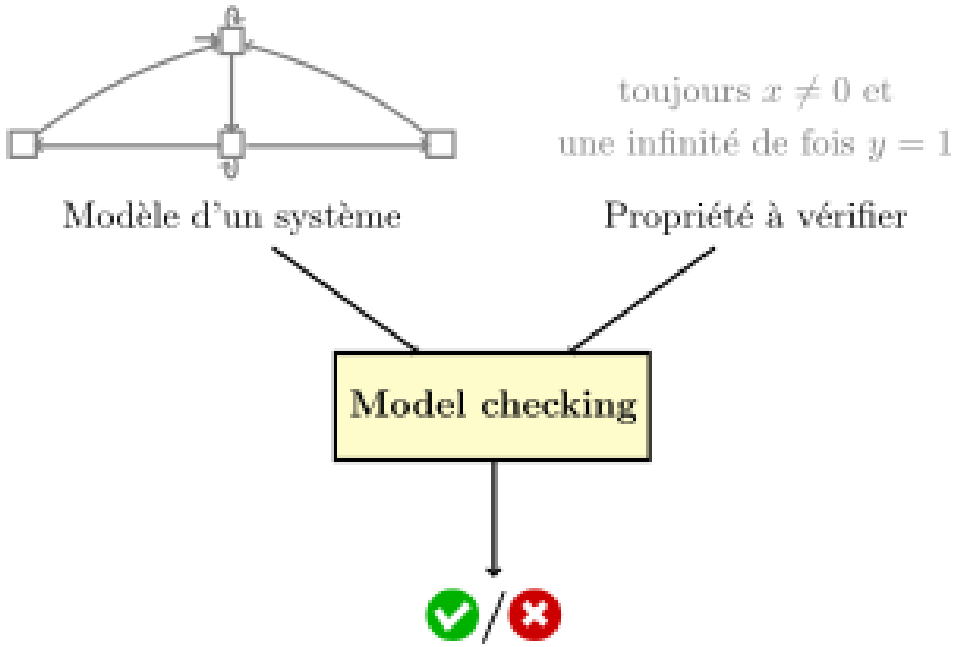
Formal Verification & Model Checking

- Formal verification is the act of proving or disproving the correctness of a system with respect to a certain formal specification regarding system properties.

- Model Checking:
  - automatic verification technique
  - input:
    - a model of a system
    - a logical formula which describes the desired properties
  - model checking algorithm (output): checks if the model satisfies the formula if the property is not satisfied, a counterexample is produced

Formal Verification & Model Checking

- Natural language to formal specification (model and properties in formal logic)



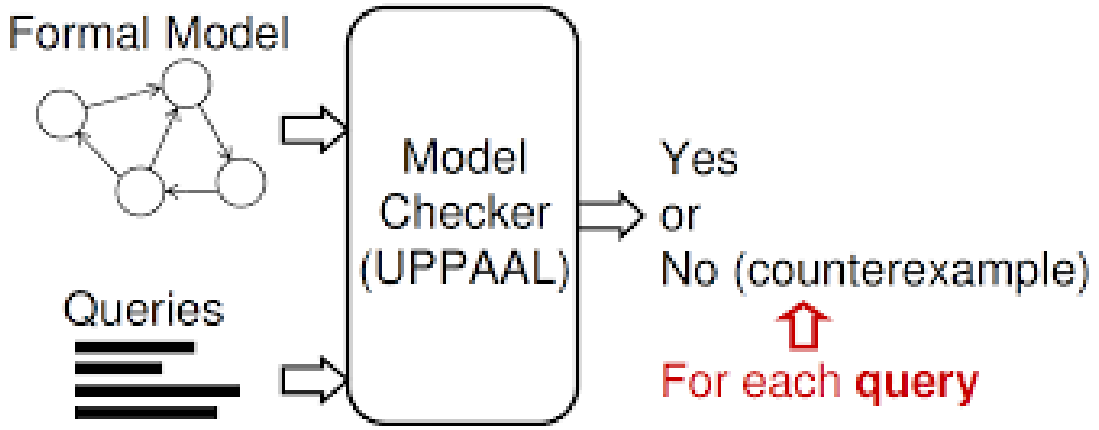
Related works

- Some work has been done on model-checking of cybersecurity
  - Finding vulnerabilities [1]
  - Checking network protocols (access to the system)[2]
  - Not focusing on properties[1] [2] [3]

- Our work
  - Assumes that the attacker already has access
  - Studies the risks on the system(Risk Analysis)
  - Focuses on defining properties

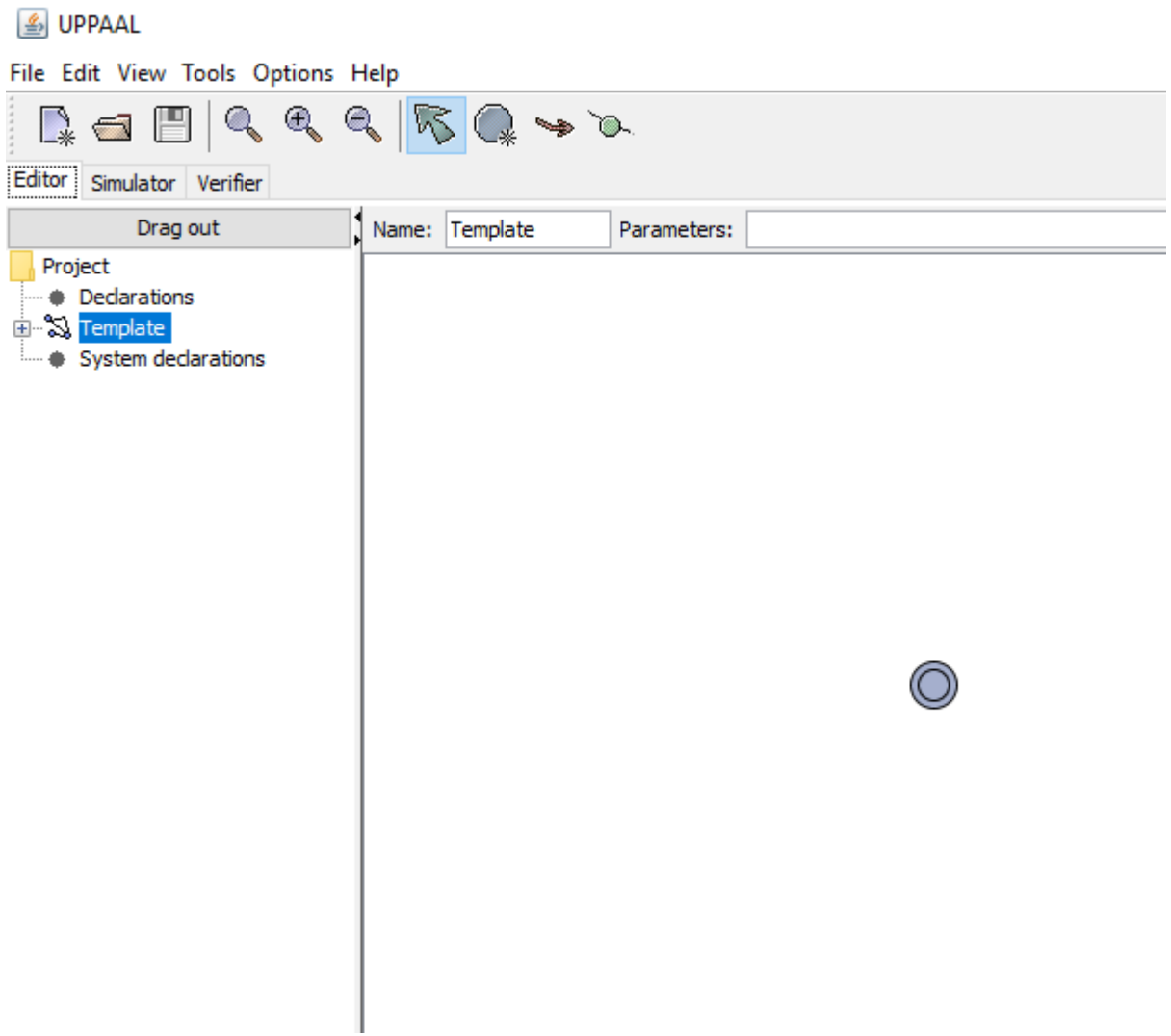
Tool Used - UPPAAL

- Uppaal is an integrated tool environment for modeling, validation and verification of real-time systems



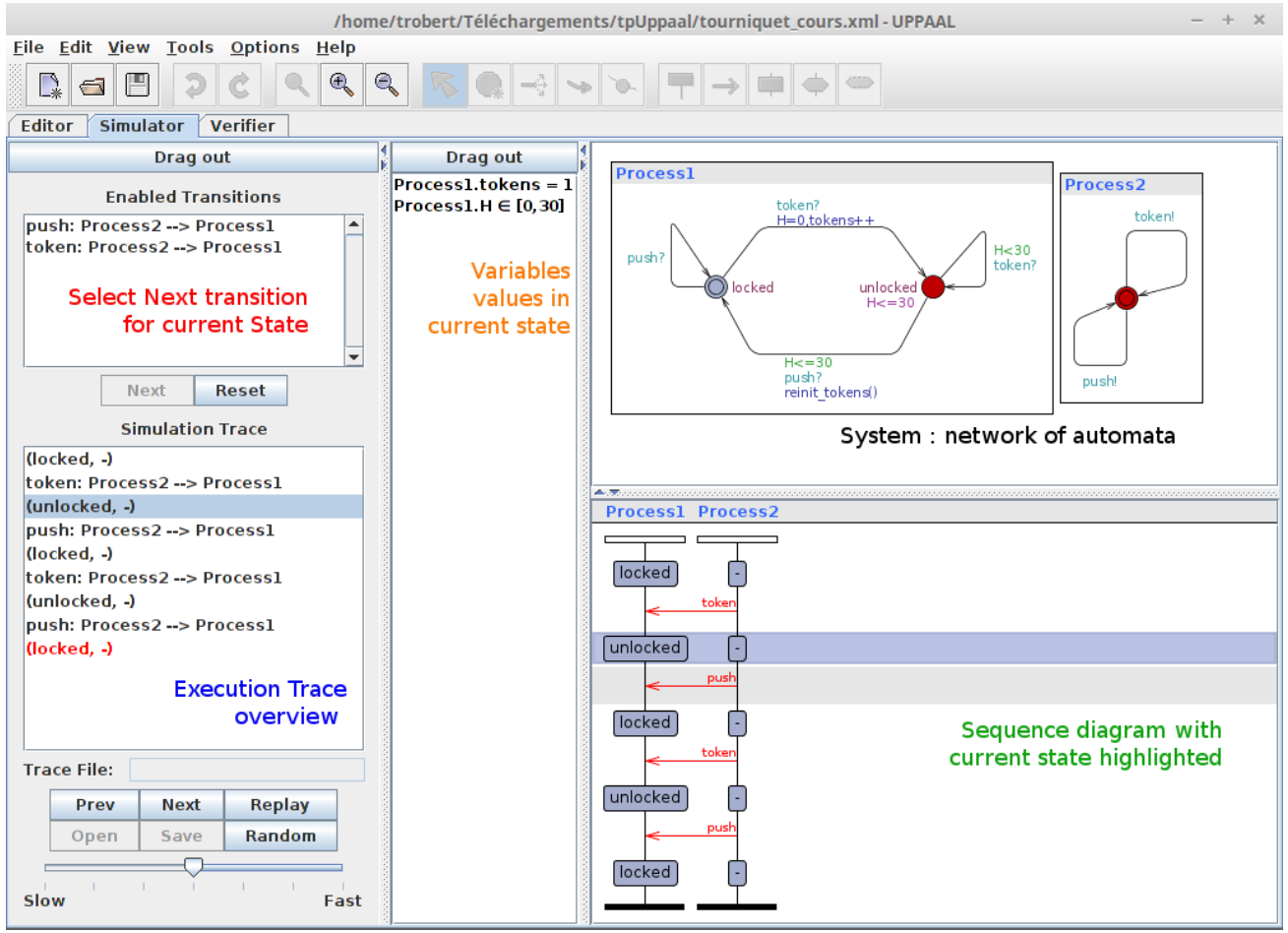
UPPAAL Editor

- To create the templates of the different components and define the system, functions, and variables



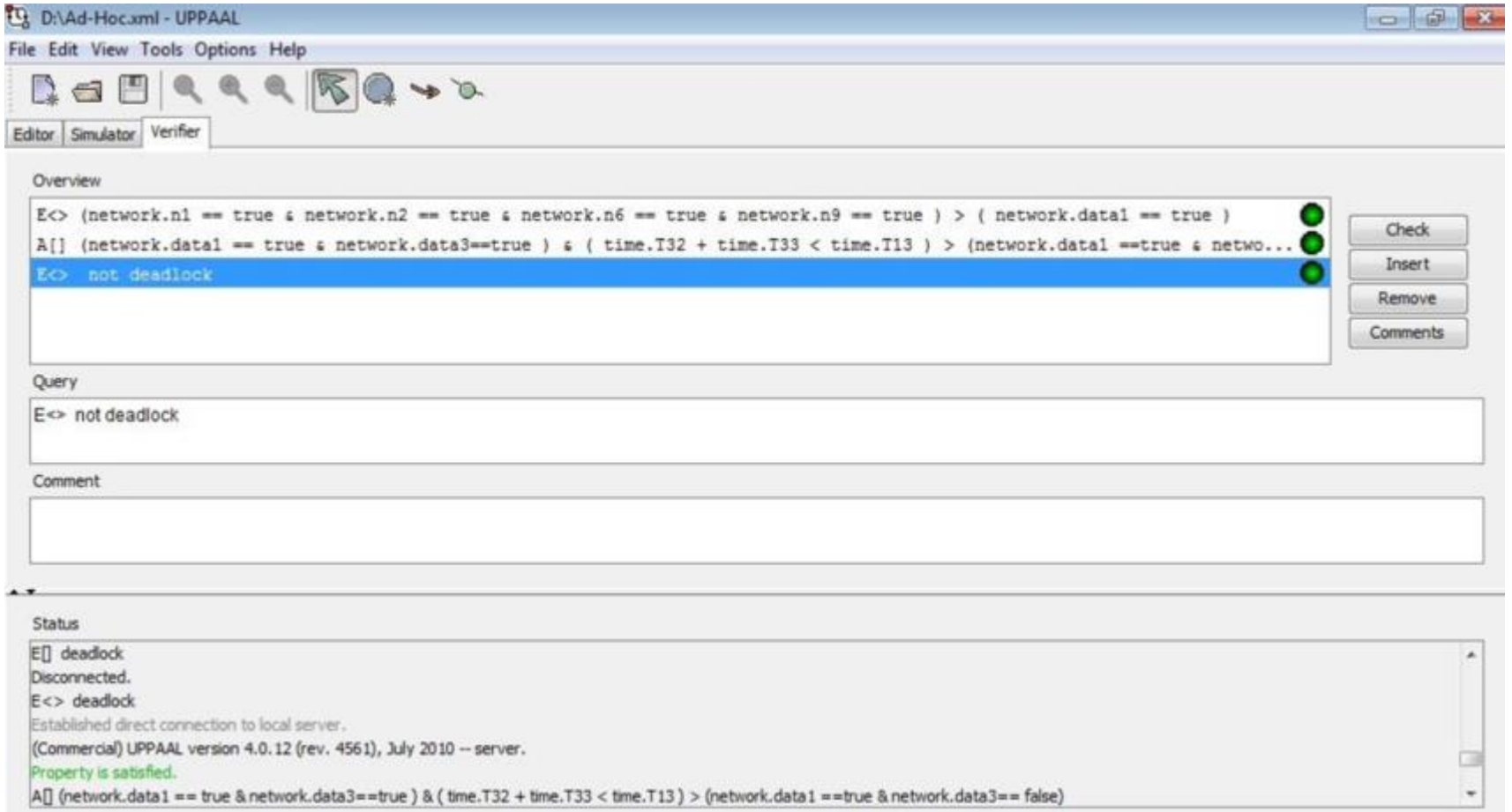
UPPAAL Simulator

- To simulate a specific or random scenario while observing the variables, the components, and the sequence diagram



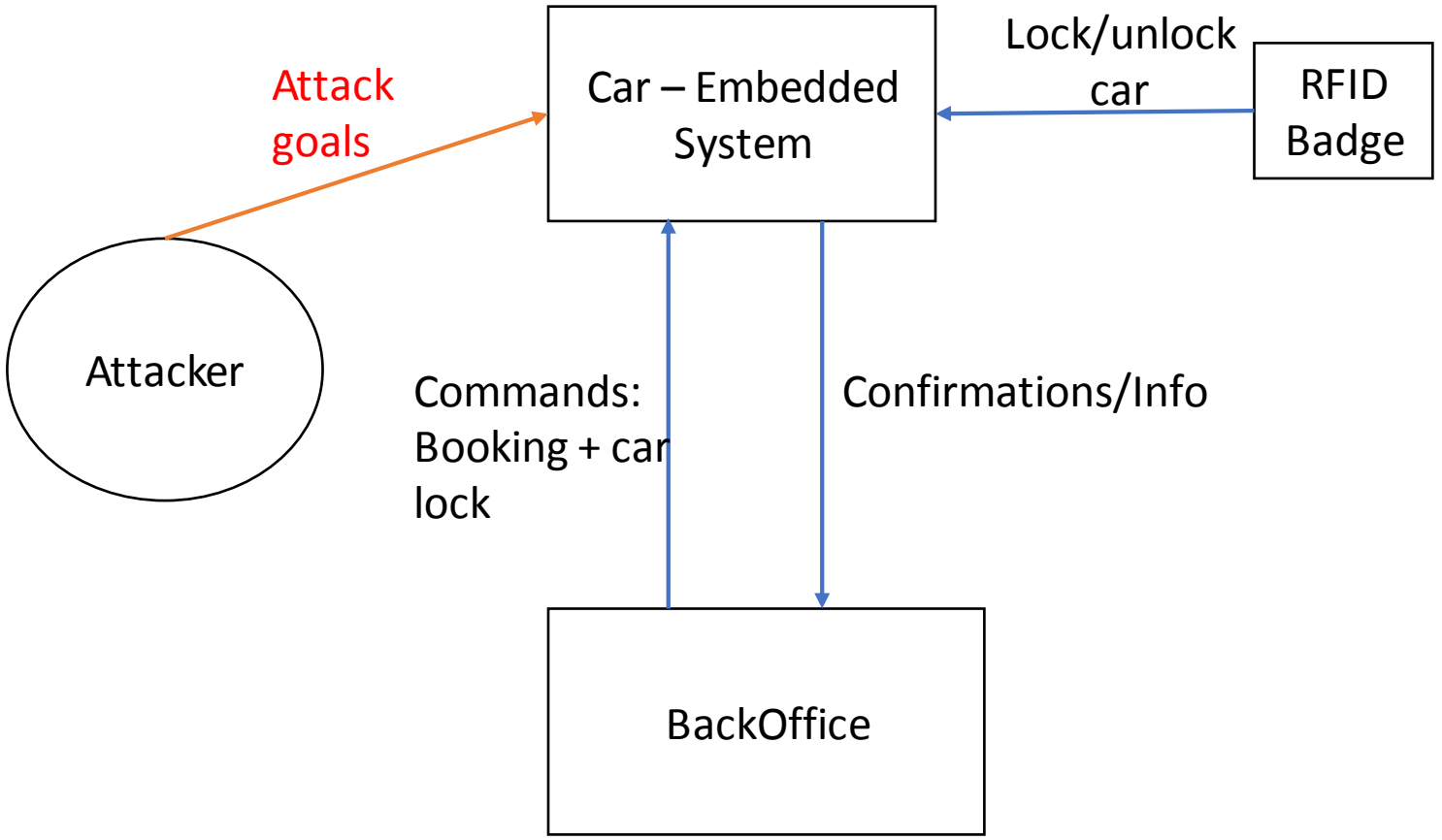
UPPAAL Verifier

- To verify the system properties or specifications written in the form of queries



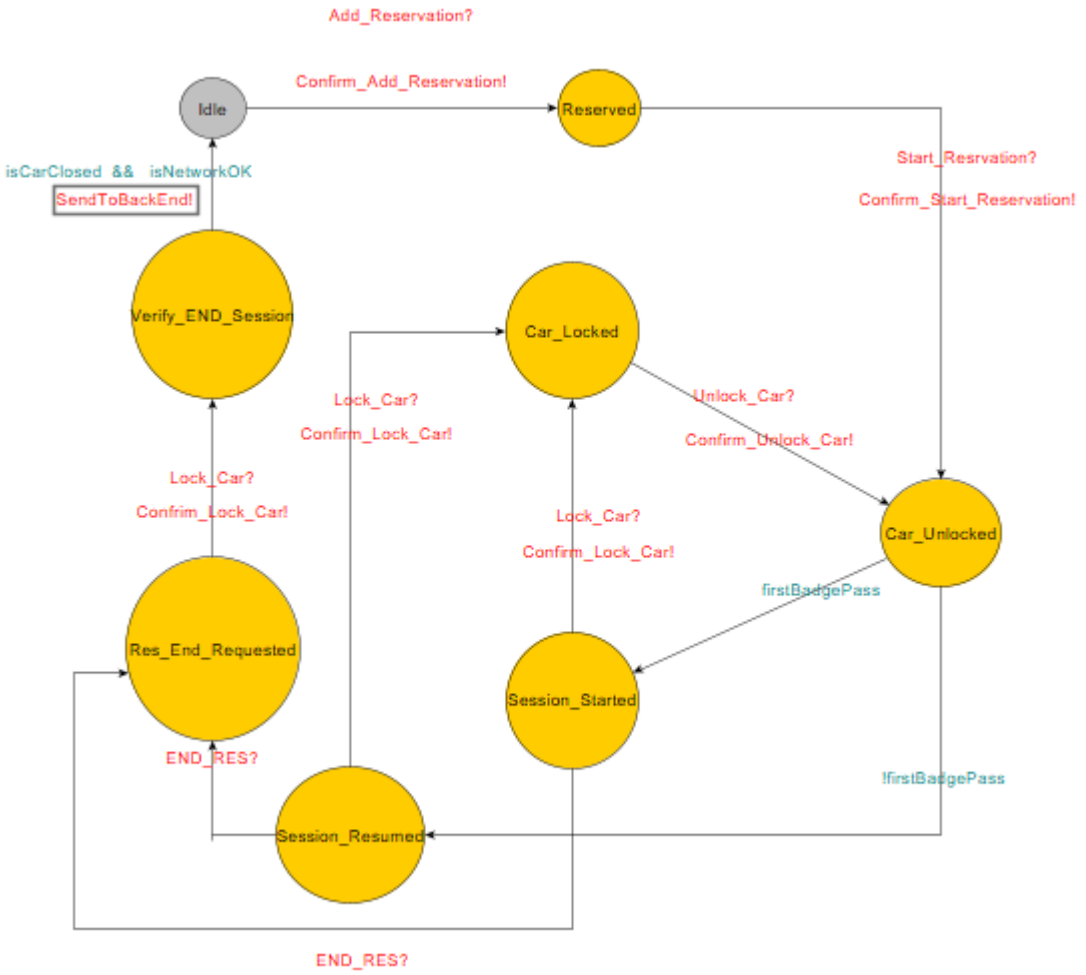
System Architecture

- Car
- BO
- RFID
- Attacker

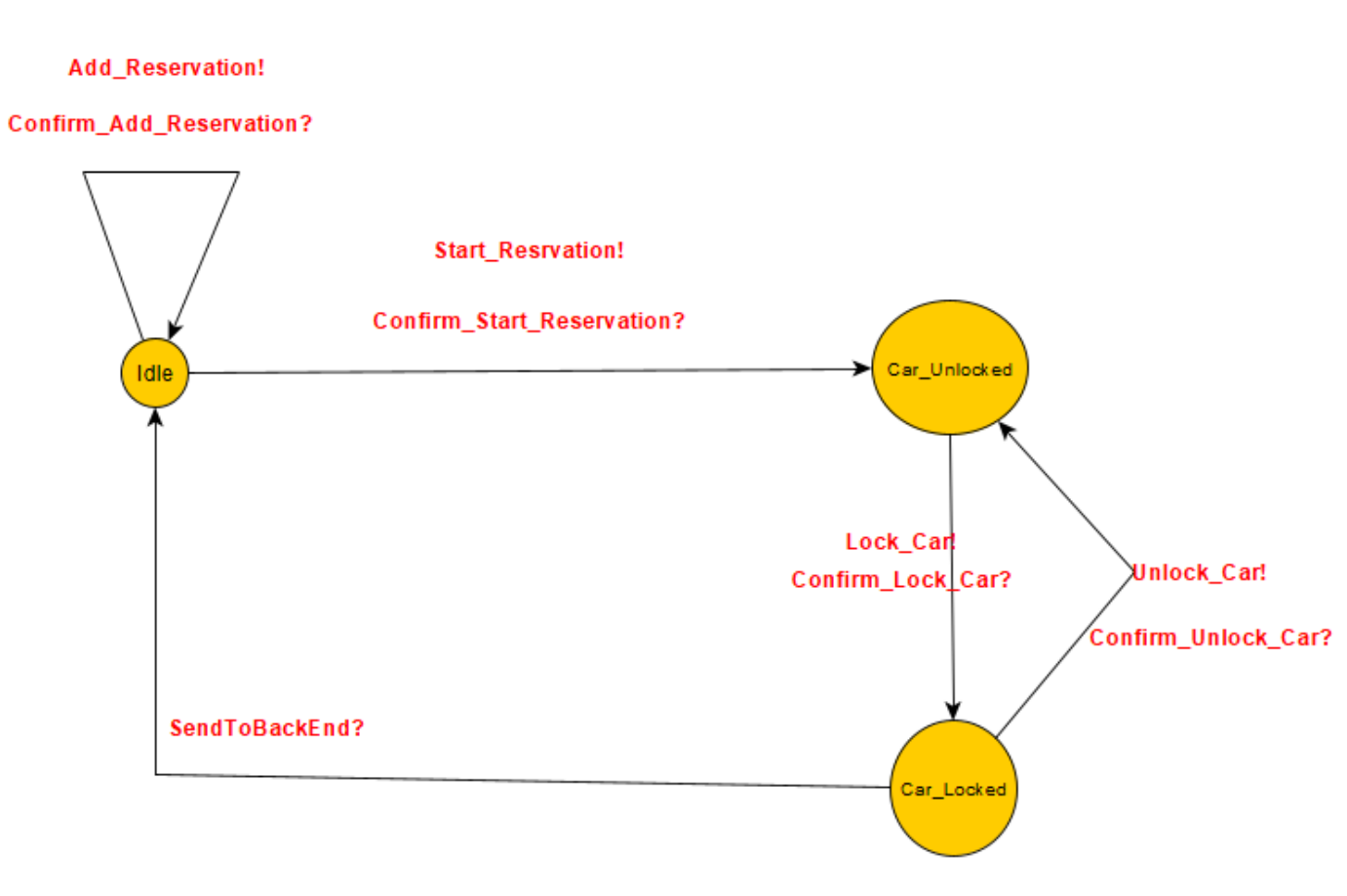


System Abstract Model

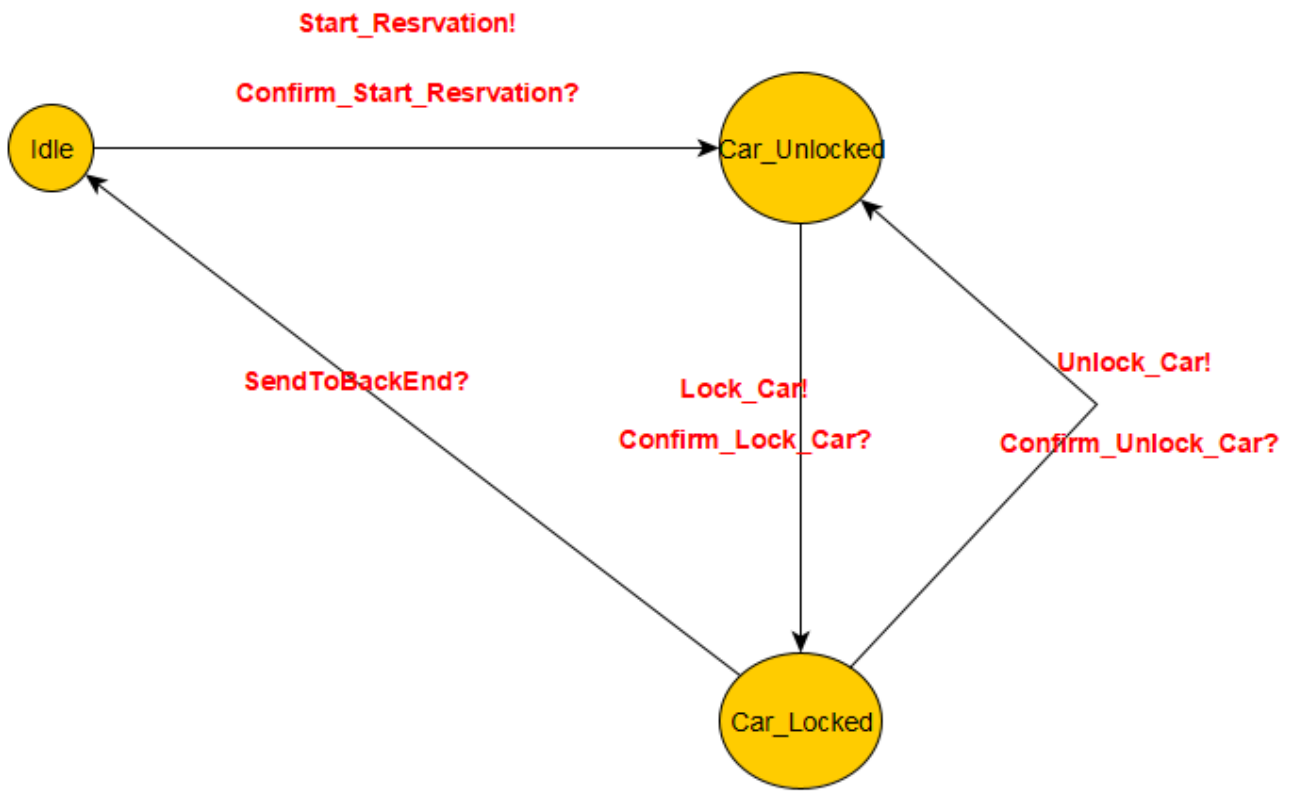
- Behavior:
- The system is idle at first
- The booking is added
- The booking is started
- The car in locked
  (intermediate stop)
- The session is continued
- The session is ended
- Car locked



Back Office Model



RFID Model


Start_Resrvation!
Confirm_Start_Resrvation?
Idle
Car_Unlocked
SendToBackEnd?
Lock_Car!
Confirm_Lock_Car?
Unlock_Car!
Confirm_Unlock_Car?
Car_Locked

Risk Analysis

- Risk analysis is the process of identifying and analyzing potential issues that could negatively impact key business initiatives or projects.
- Identify states and behaviors of the system that can be targets for the attacker
- Example:
  - States carLocked and carUnlocked
- Some of the targets are present in:
  - The car door lock
  - The booking state

Translate goals into properties

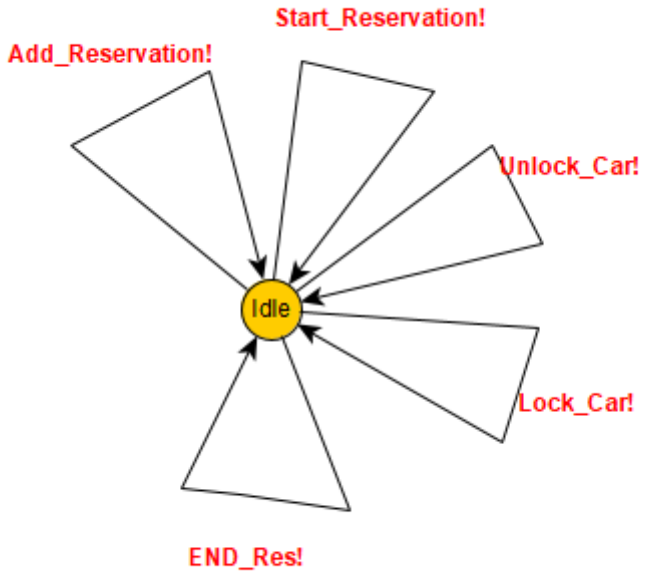
- The attacks or the goals of the attackers are translated into UPPAAL properties.
- There are two ways to define properties：
  - From the system’s point of view - to verify that the system functions well
  - From the attacker’s point of view – to verify that the attack was successful
- We used the system point of view
  - Make sure the system is resilient to the attacks

Translate goals into properties

- The properties are checked in the UPPAAL simulator
  - If the verification is successful → The attack failed
  - If the verification fails →The system is faulty or the attack was successful
    - A counter example is given

How to capture the attacker

- An automaton is added to the model to represent an attacker
- The attacker can use all capabilities at anytime.
- It can interfere in a scenario and cause it to block or to act in an unexpected way.



Results

- In some cases, the attacker is able to keep the vehicle open or closed and blocks the system
  - Service Availability
    - Once the car is unlocked, at some point in the future, the system goes back to idle and the car can be booked again.
    - If the car is locked, it will eventually be unlocked

Conclusion

- Reading the source code and the scenarios
- Agreeing on a representation
- Risk analysis feedback
  - We were able to detect some risks on the system
    - Car still open after the session ends
    - Car is locked and can not be unlocked
- UPPAAL was used only for feasibility analysis and prototyping
- Further work:
  - Another language or tool is to be provided due to UPPAAL limitations

References

[1] Dean C. Wardell et al. “A Method for Revealing and Addressing SecurityVulnerabilities in Cyber-physical Systems by Modeling Malicious AgentInteractions with Formal Verification”. In:Procedia Computer Science95 (2016). Complex Adaptive Systems Los Angeles, CA November 2-4,2016, pp. 24–31.issn: 1877-0509.doi:https://doi.org/10.1016/j.procs.2016.09.289.url:http://www.sciencedirect.com/science/article/pii/S1877050916324619

[2] J. C. Mitchell and J. Bau. “Security Modeling and Analysis”. In:IEEESecurity & Privacy9.03 (May 2011), pp. 18–25.issn: 1558-4046.doi:10.1109/MSP.2011.2.

[3] W. Yu et al. “Modeling and Verification of Online Shopping BusinessProcesses by Considering Malicious Behavior Patterns”. In:IEEE Trans-actions on Automation Science and Engineering13.2 (2016), pp. 647–662