A Generalized Stochastic Petri Net for Survivability and Security Analysis of Intelligent Transportation Systems

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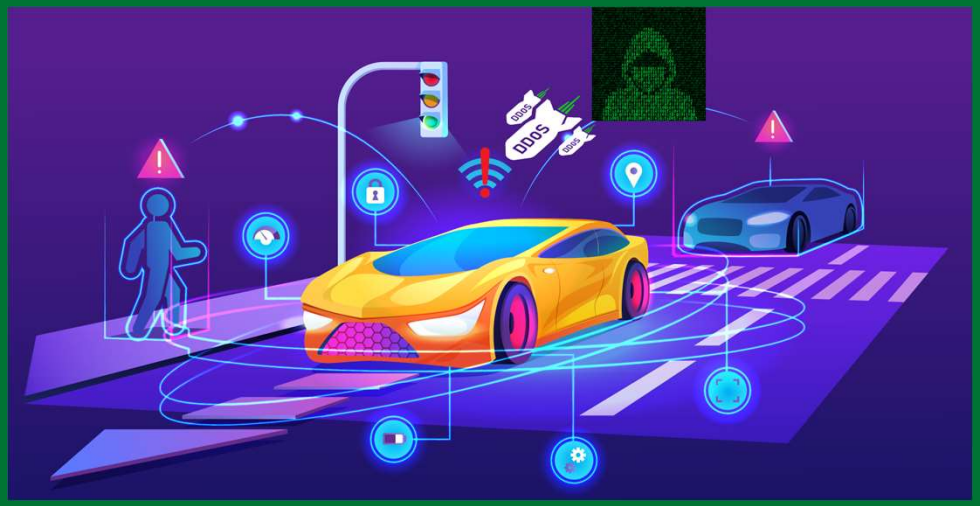
MOTIVATION

- Connectivity and autonomy increase exposure to cyber attacks
- **Denial-of-service (DoS) attacks** are still a very relevant threat vector to connected autonomous vehicles and the infrastructure of intelligent transportation systems (ITSs)
- **Unavailability of communication, especially in critical windows can affect vehicle survivability**
- Attacks can have **ripple effects** on other vehicles, as well as components connected to intelligent transportation systems
- **Predicting and quantifying the effect of these attacks can guide efforts to fortify communication infrastructure**

METHODS

- We considered the effect of DoS attacks on **802.11p wireless communication** in an ITS
- **More sophisticated attacks exploit the prioritization enabled by Enhanced Distributed Channel Access (EDCA)** to increase the priority of attack messages, resulting in greater harm to legitimate communication
- We used a **generalized stochastic Petri net** to model vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication and predict the effects of these DoS attacks



Denial-of-service attacks against the wireless network can block communication with and by vehicles. Our work **predicts and quantifies** the effect of such attacks on **communication availability** and message failure in an intelligent transportation system.

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SIMULATION ENVIRONMENT

- Used to investigate and quantify the effects of attacks, and to **validate the communication failure rates predicted by the model**
- Specific simulators used:
  - **Great SPN**: Discrete-event simulation for Petri net model
  - Vehicles In Network Simulation (**VEINS 5.2**): Customizable simulation model for vehicular networking
  - Simulation of Urban Mobility (**SUMO 1.11.0**): Road traffic simulator; vehicles, maps, pedestrians
  - Objective Modular Network Testbed in C++ (**OMNet++ 5.7**): Event-based network simulator; GUI for information provided by SUMO; data collection alongside VEINS

RESULTS

- We validated our PN model against two different simulation environments, using four types of DoS attacks
- **Our model was 99.9% accurate for "naïve" DoS attacks, and 97% accurate for more sophisticated DoS attacks that exploit prioritized communication**
- A single attacker can block broadcast messages from the roadside unit
- **Communication availability can fall below the 90% threshold** required by IEEE 1609 (Standards for Wireless
- Access in a Vehicular
- Environments (WAVE)
- **Sophisticated attacks can lower communication availability during the critical application window to 0.03%**
- Increasing the number of vehicles or the distance between them exacerbates the effects of DoS attacks against broadcasts
- Future work on this project will investigate the effect of man-in-the-middle attacks on V2V and V2I communication

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