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ConnRAD – Connectivity and Resilience for Automated Driving

ConnRAD
Connectivity & Resilience for automated Driving Functions in Germany

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Subjective Logic-based Trust Assessment Framework

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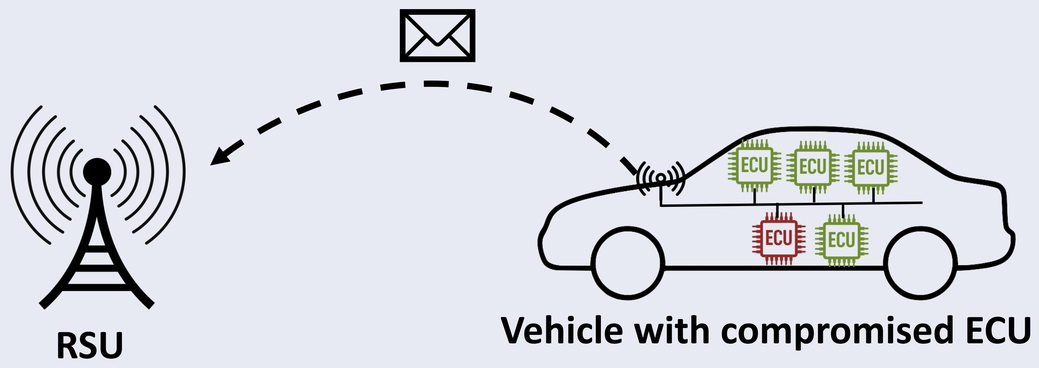
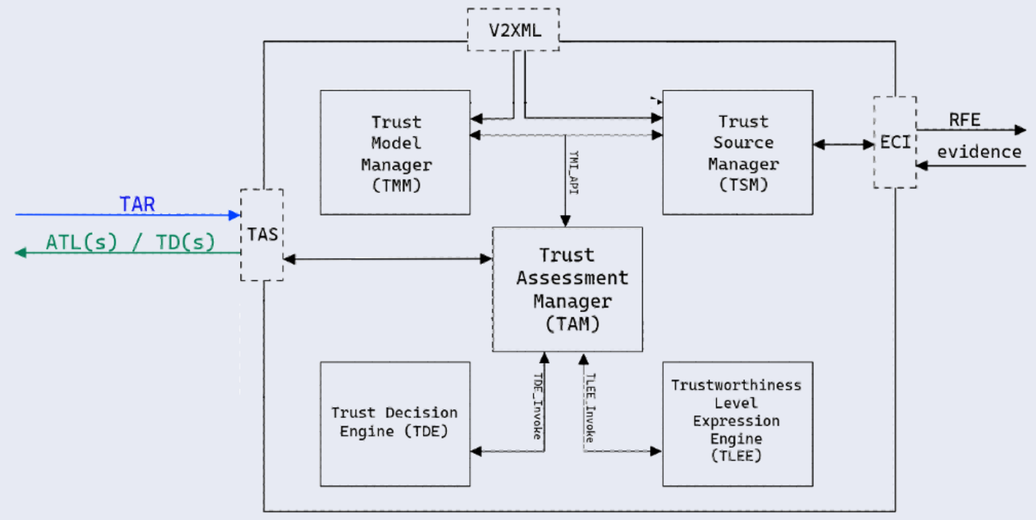
Motivation for Trust Assessment

- Vehicles rely on diverse data sources from different systems for safety-critical applications. Malicious data manipulation can compromise security and safety, potentially leading to accidents.
- Current security mechanisms cannot fully assess the impact of attacks on system integrity in complex Systems-of-Systems (SoS). For example, a misbehaviour detection system running in a Road Side Unit cannot detect a compromised ECU in a vehicle.
- A Trust Assessment Framework (TAF) helps to assess trustworthiness in cooperative systems, contributing to safer autonomous vehicles. The TAF assesses the trustworthiness of received V2X data by integrating evidence from multiple trust sources. It utilizes subjective logic, a probabilistic framework consisting of a belief, disbelief and uncertainty value that allows reasoning with incomplete or unreliable information.

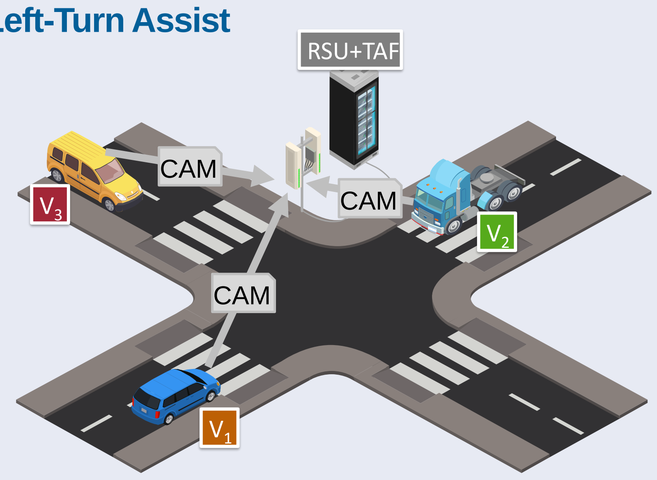


Implementation of Trust Assessment Framework



- Trust Model Manager (TMM): Selects appropriate trust models based on a TAR.
- Trust Sources Manager (TSM): Collects evidence from all available trust sources to derive atomic trust opinions.
- Trustworthiness Level Expression Engine (TLEE): Enables reasoning over trust models and input from the TSM to produce an Actual Trustworthiness Levels (ATL).
- Trust Decision Engine (TDE): Compares the ATL with a Required Trustworthiness Level (RTL) to take trust decisions.
- The Trust Assessment Framework was implemented and open sourced under https://github.com/vs-uulm/go-taf

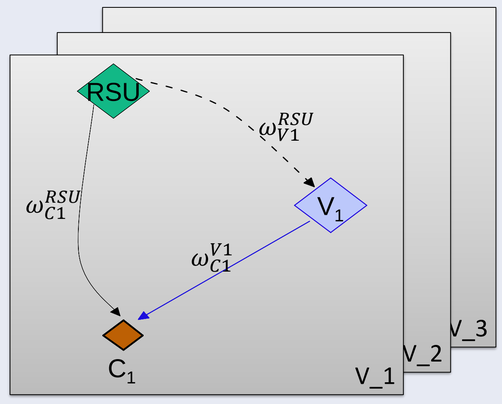
Left-Turn Assist



- Vehicles send CAMs to the Road Side Unit (RSU).
- The RSU uses the CAMs to provide different kinds of services (e.g. fuse the CAMs to create CPMs)
- We have evaluated the TAF in the context of a smart traffic lights system.

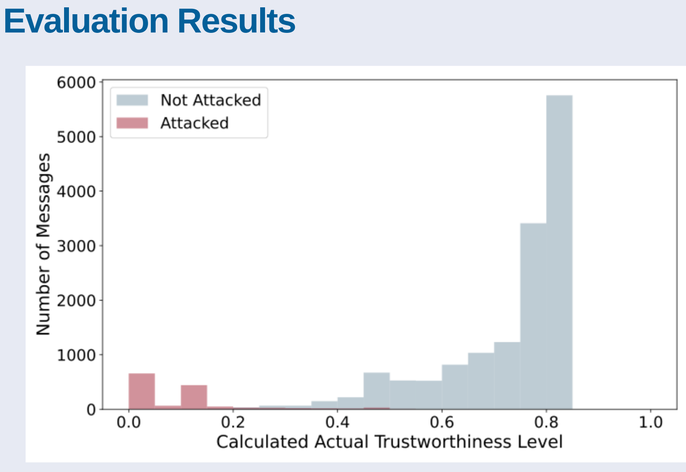
- Hermann, A., Trkulja, N., Wachter, P., Erb, B. and Kargl, F., "Quantification Methods for Trust in Cooperative Driving", VCN 2025
- Hermann, A., Trkulja, N., Eisermann, D., Erb, B. and Kargl, F., "Hyperparameter Optimization-Based Trust Quantification for Misbehavior Detection Systems", ITSC 2025
- Hermann, A., Trkulja, N., de Lucena, A.R.F., Kiening, A., Petrovska, A. and Kargl, F., "WIP: A Trust Assessment Method for In-Vehicular Networks using Vehicle Risk Assessment", VehicleSec 2024

Trust Model and Trust Sources



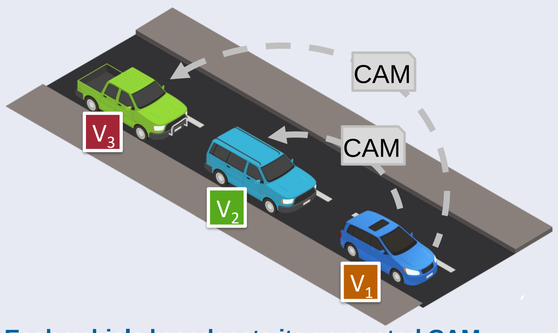
- The ω values are subjective logic trust opinions, consisting of a belief, disbelief and uncertainty value.
- ω_{C1}^{RSU} : Calculated based on a misbehaviour detection system
- ω_{V1}^{RSU}: Calculated based on a security report
- ω_{C1}^{V1}: Calculated based on self assessment

Evaluation Results



- Four different attack types were simulated.
- Around 16,000 messages were evaluated.
- Evaluation results:
  - Precision: 0.98
  - Recall: 0.89
  - Accuracy: 0.99
  - F1-Score: 0.93

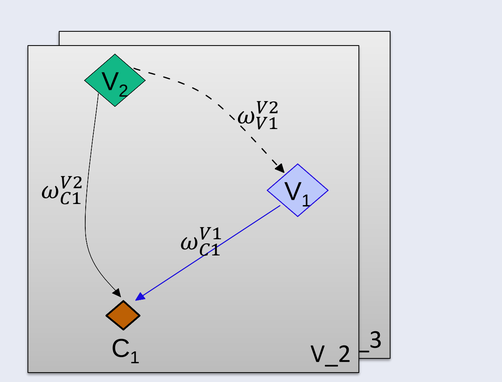
Platooning



- Each vehicle broadcasts its generated CAM.
- Based on the CAMs, the vehicles adjust their velocity to achieve shorter distances between them.
- For each CAM received, the vehicles checks whether the CAM is trustworthy.

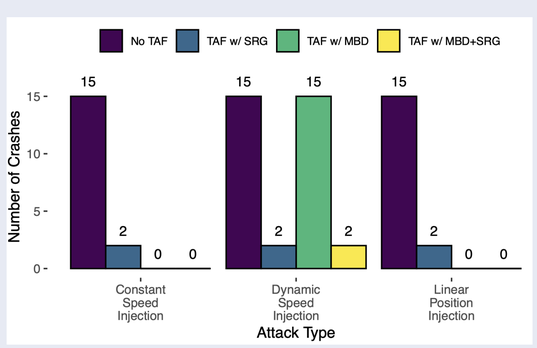
- Trkulja, N., Hermann, A., Meißner E., Erb, B. and Kargl, F., "Vehicle-to-Everything Trust: Enabling Autonomous Trust Assessment of V2X Data by Vehicles", CSCS 2025

Trust Model and Trust Sources



- ω_{C1}^{V2}: Calculated based on misbehaviour detection
- ω_{V1}^{V2}: Calculated based on a security report
- ω_{C1}^{V1}: Static trust value

Evaluation Results



- Three different attack types were simulated.
- Evaluations were conducted without the TAF, with one trust source, and with two trust sources.

Run-Time Performance & Scalability

- Based on a workload generator, the scalability of the TAF was evaluated.
- Two different scenarios were evaluated:
  - TAF in an RSU (high computing power)
  - TAF in a vehicle (low computing power)

TAF in Vehicle

	Proc. Times (ms)		Resource Usage	
Setup	p_{50}	p_{99}	CPU Util.	Mem (kB)
16 × 1/s	1.854	2.612	1.50%	21,504
16 × 10/s	1.439	2.304	12.75%	22,548
64 × 1/s	1.746	2.218	5.75%	23,400
64 × 10/s	1.317	9.730	36,75%	24,360
256 × 1/s	1.127	4.737	16.50%	29,580
256 × 10/s	1,385.2	1,681.6	78.75%	45,756

TAF in RSU

	Proc. Times (ms)		Resource Usage	
Setup	p_{50}	p_{99}	CPU Util.	Mem (kB)
64 × 1/s	0.185	0.279	0.08%	36,480
64 × 10/s	0.093	0.187	0.48%	39,456
256 × 1/s	0.186	0.269	0.29%	40,692
256 × 10/s	0.106	0.276	1.81%	42,164
1024 × 1/s	0.156	0.309	0.96%	43,776
1024 × 10/s	0.949	95.944	5.10%	52,448