ICDCS 2021
41st IEEE International Conference on
Distributed Computing Systems

CAD3: Edge-facilitated Real-time **C**ollaborative **A**bnormal **D**riving **D**istributed **D**etection

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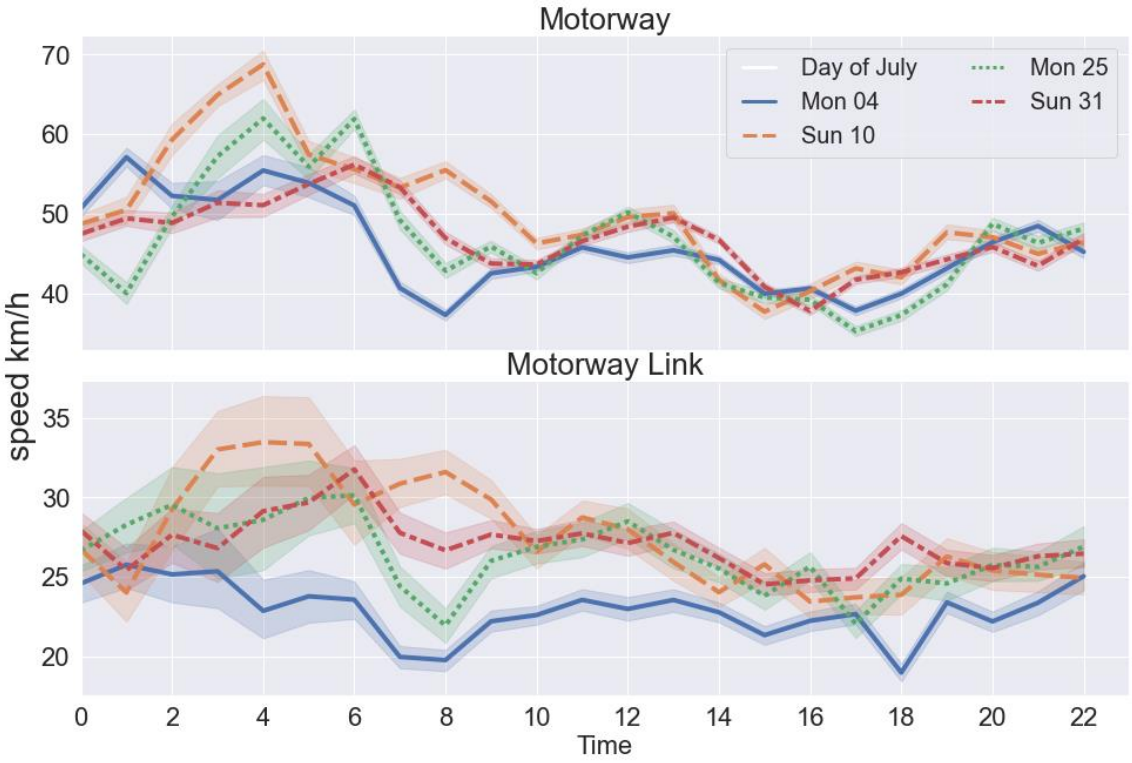
Background

- Anomalous driving patterns increase accidents' risk [1].

- Driving patterns vary depending on temporal & spatial context and the driver's habit.

- **<u>How to detect such patterns and avoid any potential accidents?</u>**



[1] Tian et al, Speed-accident relationship at urban signalized intersections, 2013.

Background -> solutions

1. **Centralized ML:**

   Offload detection to cloud.

   - Lack context-awareness

   - Contextual information and number of vehicles results in a significant network and computational load.

2. On-board solutions:

Use OBU to detect based on other sensors, e.g., *D 3* [2], *Trip recommendation* [3].

- Lack holistic view.

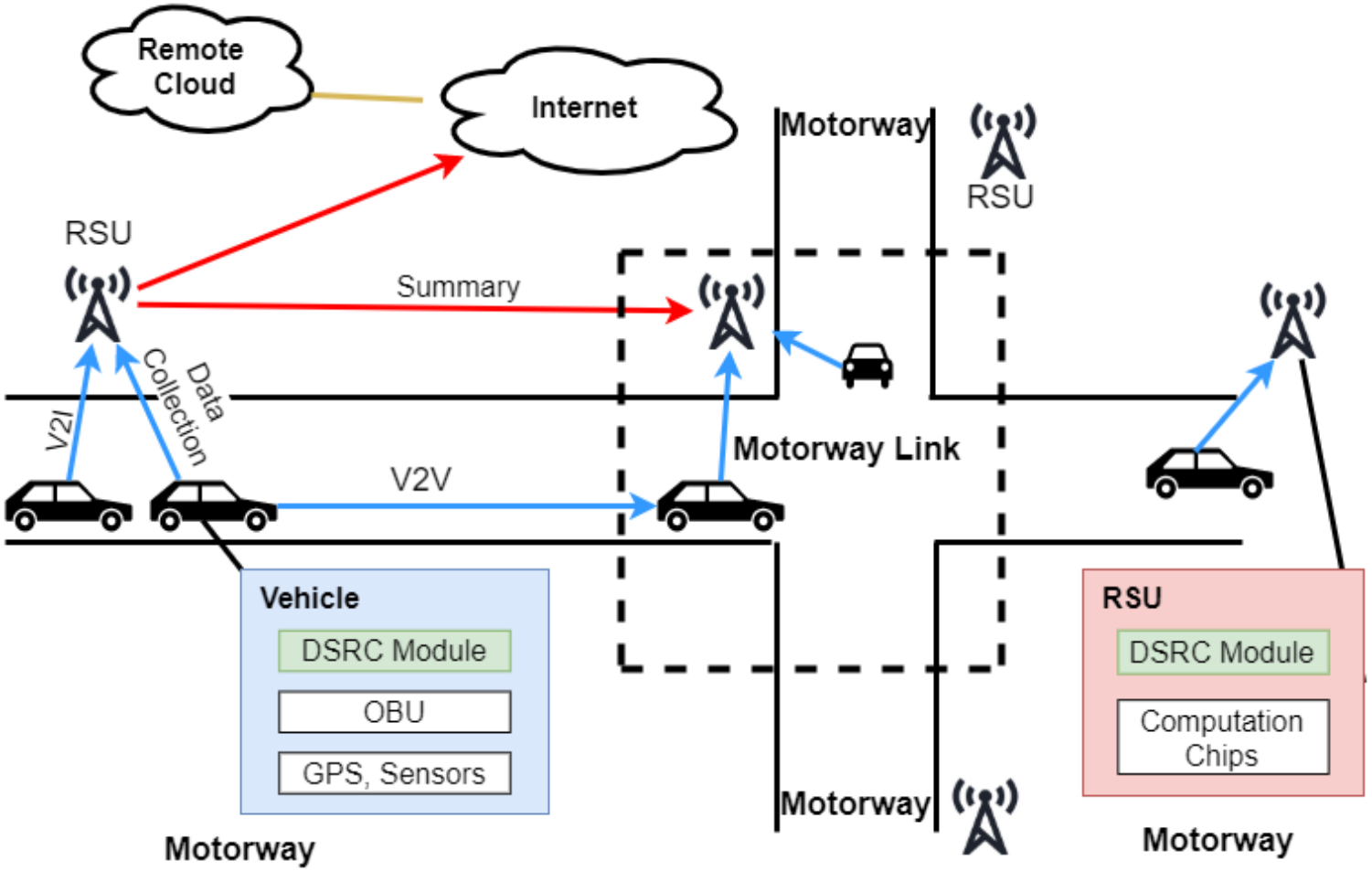
[2] Chen et al, D^3:Abnormal driving behaviors detection and identification using smartphone sensors, 2015.
[3] Verma et al, Avoiding Stress Driving: Trip Recommendation from Driving Prediction, 2019

Research Purpose

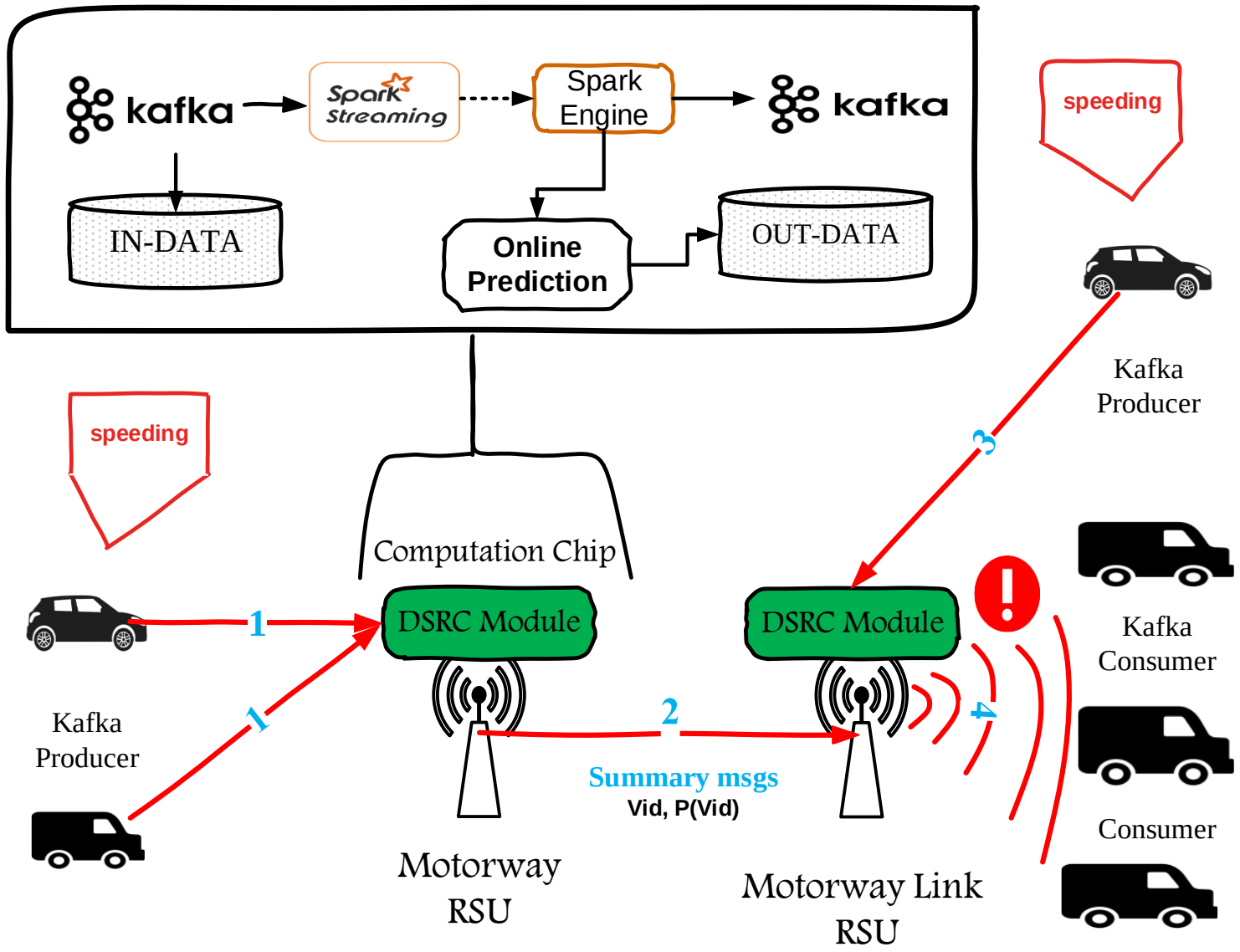
- Detect unsafe driving behaviors and notify the nearby drivers in real-time.
- Driver awareness → Less Accidents

CAD3: An integrated & distributed architecture to recognize normal behaviors and detect any deviations in real-time

CAD3 Architecture

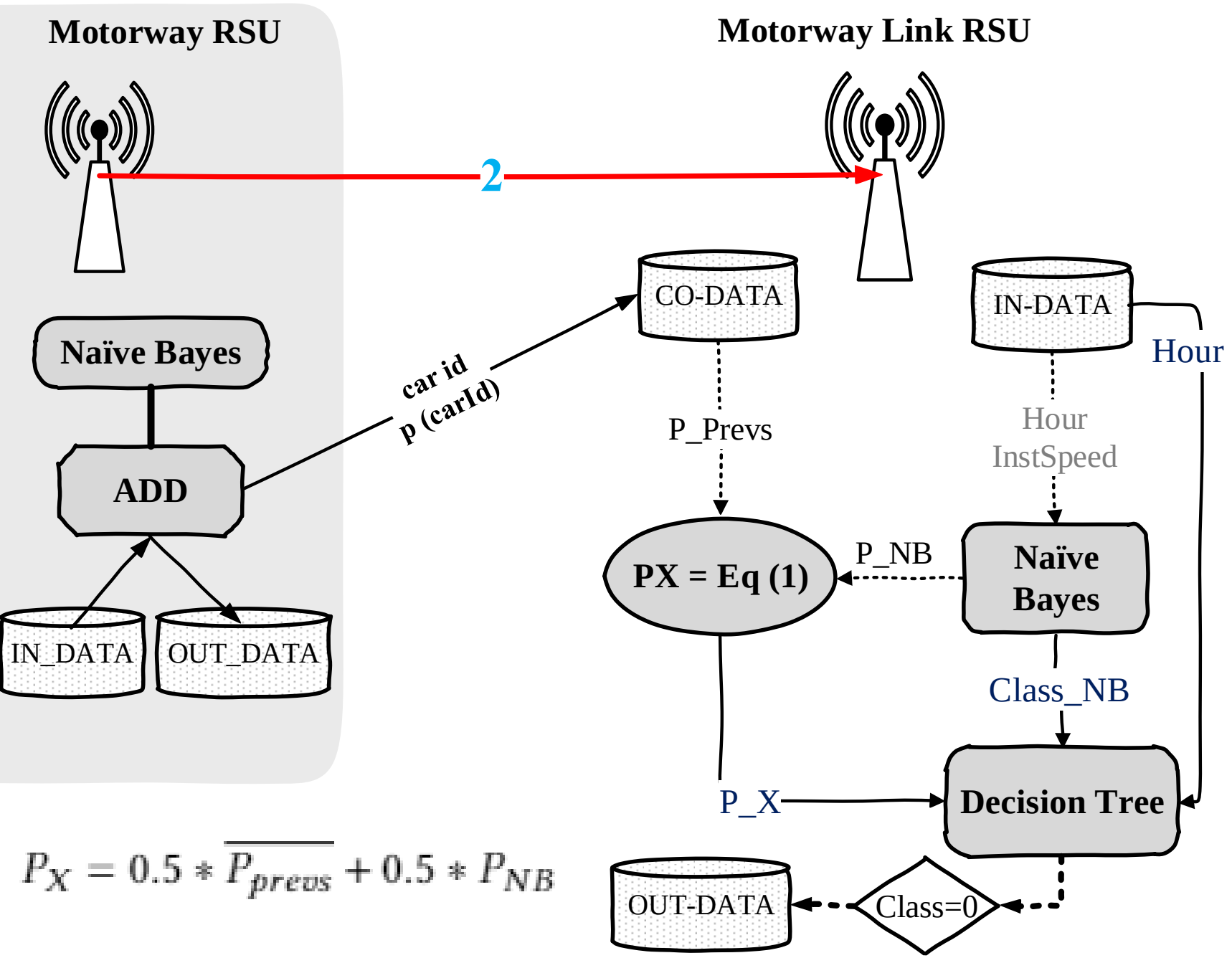


- Onboard Sensors, OBUs, and communication units.
- DSRC communication
- Edge Computing:
  - RSU along the roads
- Inter-RSU communication



CAD3

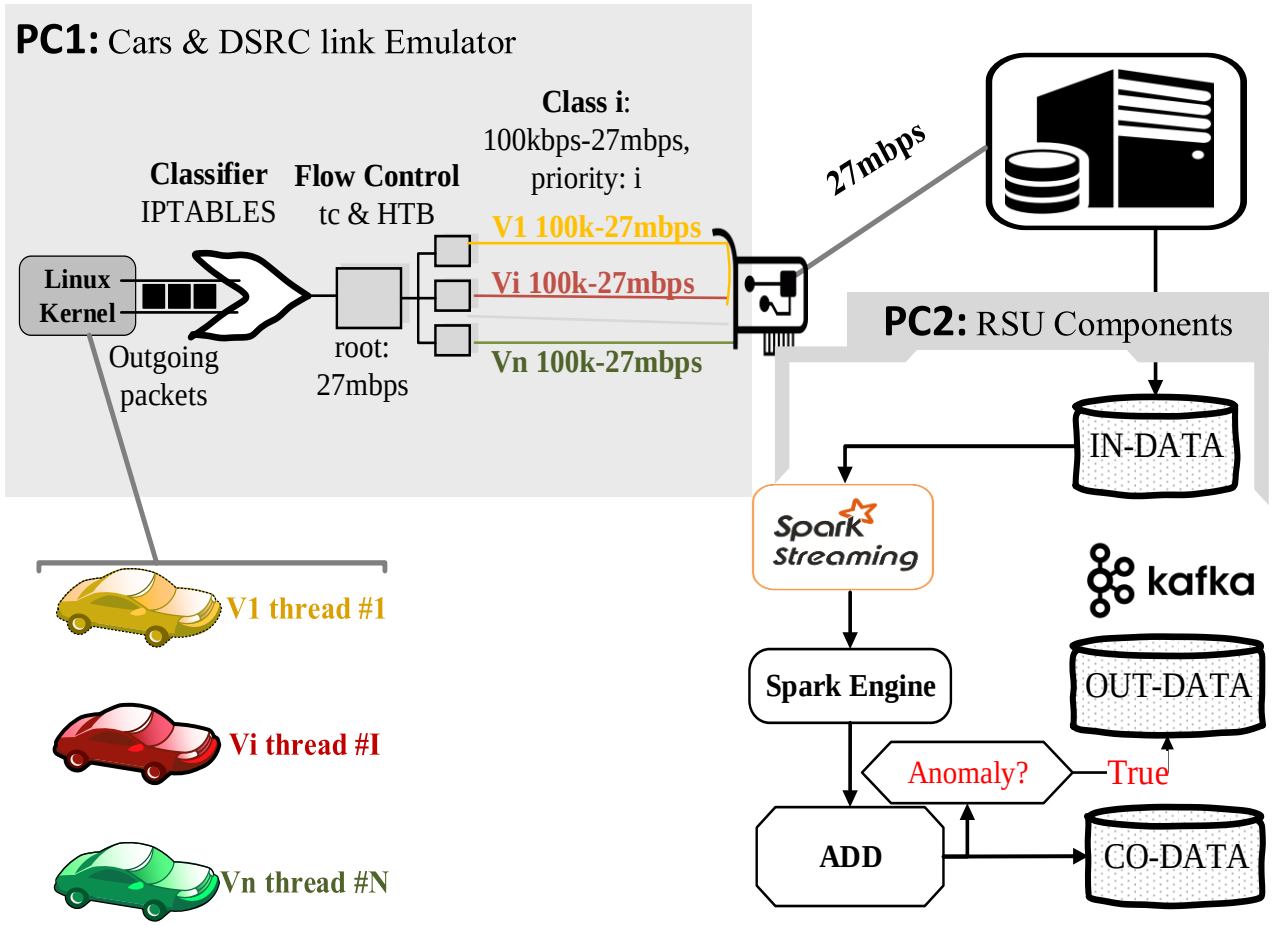
- Pervasive deployment of Edge Computing Nodes (RSUs)
- Realtime Streaming & Processing Framework.
- Inter-edge collaboration.



$$P_X = 0.5 * \overline{P_{prevs}} + 0.5 * P_{NB}$$

- **Inter-edge collaboration.**
- Simple ML Model: Detect anomalous behaviors.

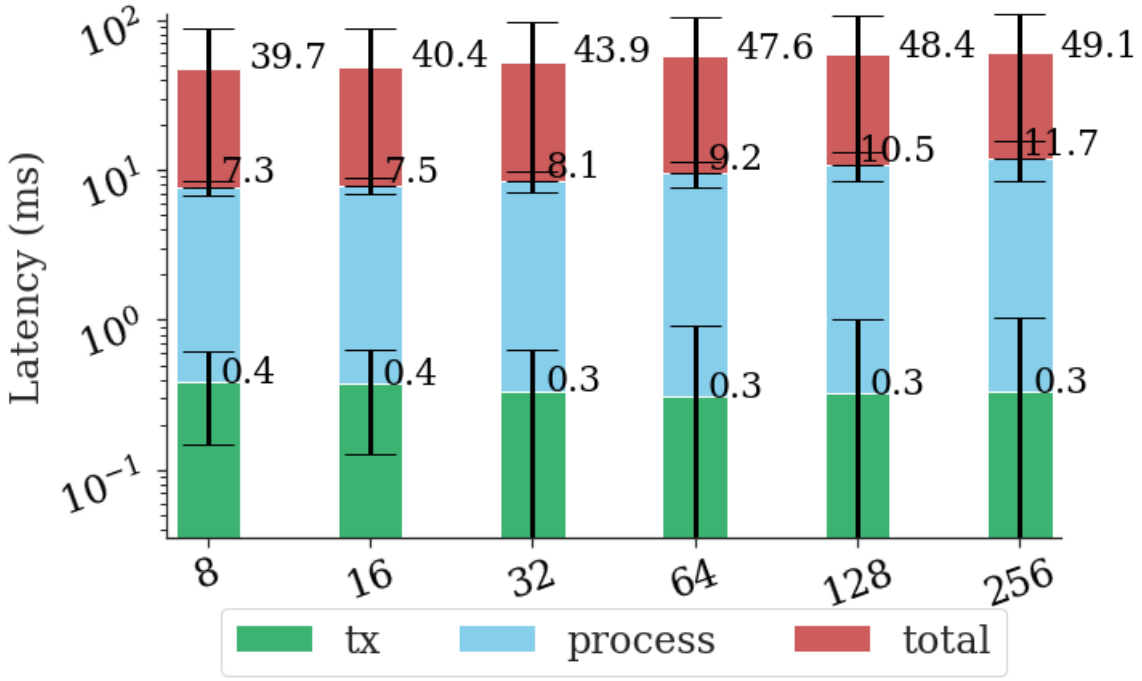
(C)AD3 -Testbed



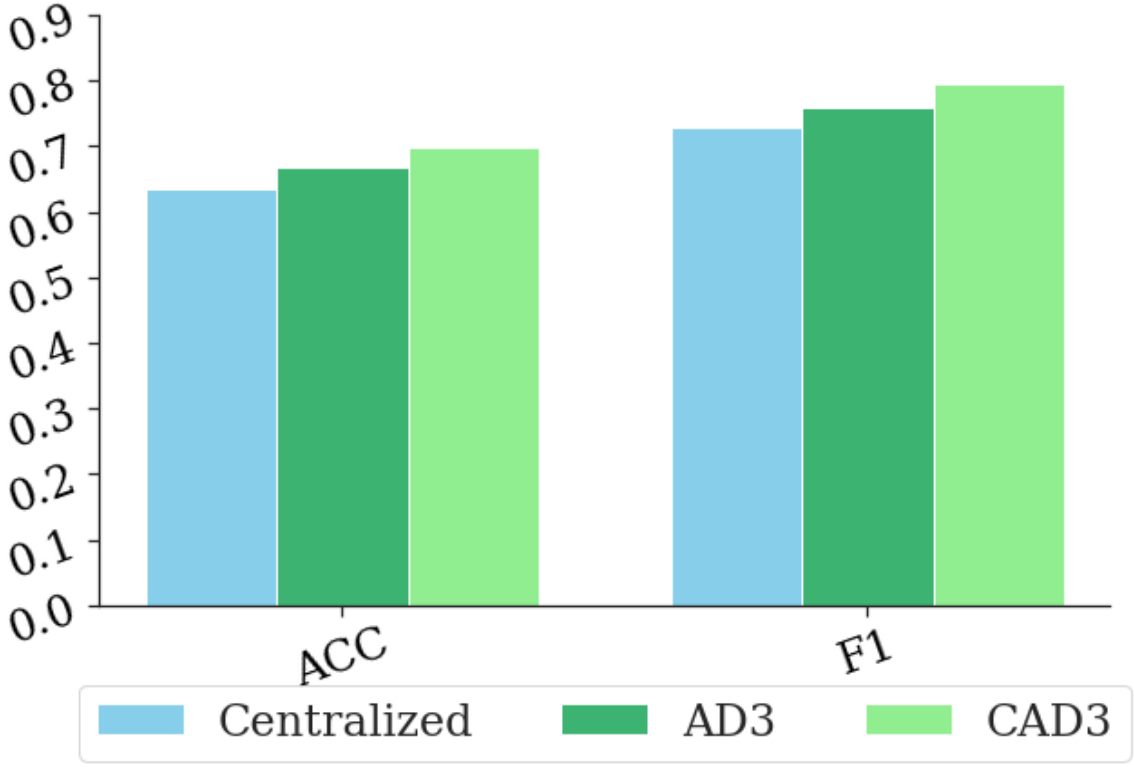
- Use **tc** and **netem** to mimic vehicles and DSRC
- **DSRC** is shared channel between vehicles of up to 27Mb/s
- **Vehicles** are Kafka Producers (Threads) read from Dataset and send to **PC2**

Evaluation

Latency & vehicle increase



Accuracy & F1-score



Evaluation

True positive, false negative rate for 500K measurements

Model	TP Rate	FN Rate	E(A)
Centralized	49.2%	19.9%	9,004
AD3	52.3%	11.8%	1,475
CAD3	**57.9%**	**6.2%**	**371**

Potential Accidents

Based on Nilsson formula[6], we derive:

$$\delta = \begin{cases} 1 - \left(\frac{v_r}{v_r(i)}\right)^2 & \text{if speeding,} \\ 1 - \left(\frac{v_r}{v_r + (v_r - v_r(i))}\right)^2 & \text{if slowing.} \end{cases}$$

$$E(\Lambda) = \sum v_{\vec{FN}} . \vec{v_\delta}$$

[6] Nilsson, Traffic safety dimensions and the power model to describe the effect of speed on safety, 2004

Conclusion

Centralized → Capture Collective anomalies.

AD3 → Capture context anomalies, improves F1- score by **3.52%**, drops FN by **2/3**, and #potential accidents **8 X**.

CAD3→ Capture context & collective anomalies, improves F1- score by **6.44%**, drops FN by **1/3**, and #potential accidents **24 X**.

Thank you