5G Edge Cloud Application

RUTGERS
WINLAB | Wireless Information Network Laboratory

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verizon

Human vs Autonomous Driving

- 0 • No Automation
- 1 • Driver Assistance
- 2 • Partial Automation
- 3 • Conditional Automation
- 4 • High Automation
- 5 • Full Automation

A fully integrated Level 5 autonomous driving system would reduce car accidents by between **50 to 90** percent.[1]

These systems **will** require intervehicle communication.

Improving Transportation Systems

- Current autonomous vehicles (AVs) use only their own sensors to navigate the world.
- By implementing **V2N** (vehicle-to-network) communication, AVs will be able to make **more informed decisions**, allowing safer and more efficient transportation.

Our Lifesaving Motives

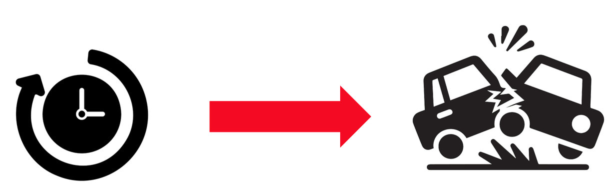

Figure 1: Safety critical algorithms will be highly sensitive to network latency

Figure 2: Near-term applications focus on notifying users with emergency vehicles, traffic, and weather alerts

- **Network latency** can be the difference between life and death
- There are no **open-source** tools to test intelligent transportation systems on 5G wireless networks
- Autonomous vehicles will require the **low latency** of edge computers and **wide coverage** of 5G networks

Minimizing Network Delay

- MQTT protocol allows devices to **subscribe** and **publish**
- Fan-in and fan-out promotes scalable systems
- Quality of service promotes flexibility

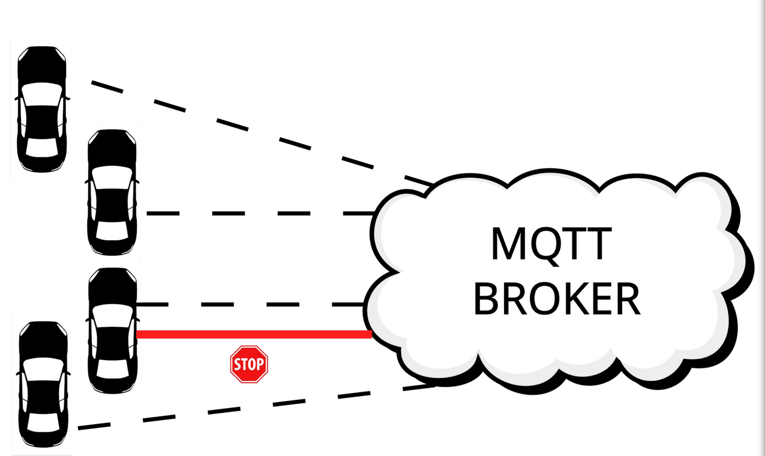

Figure 3: Example of many cars (fan-in) communicating with only one response

How is the system connected?

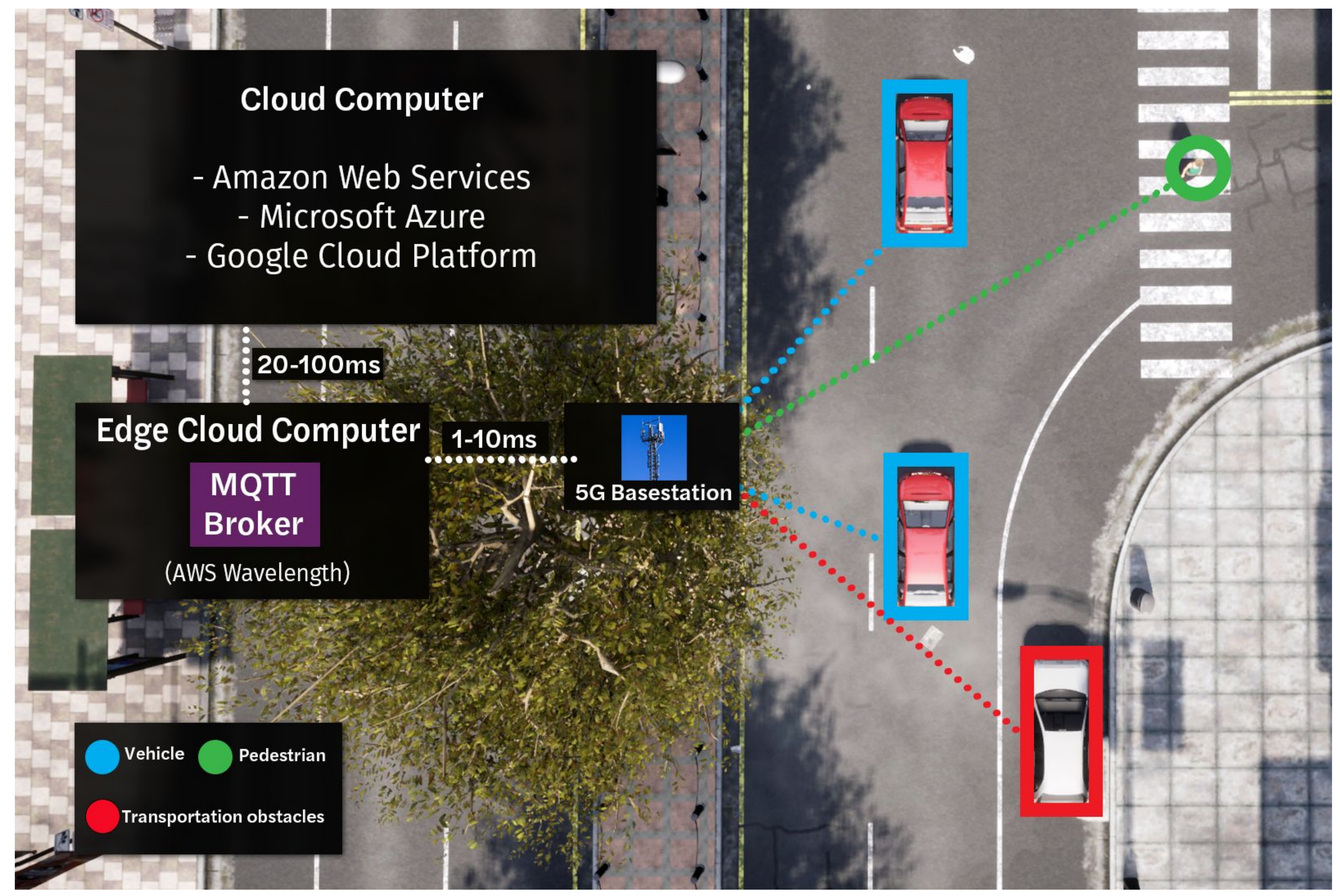

Figure 4: System diagram of how a 5G base station relays information to be processed

Vehicles transmit **GPS coordinates**, **speed**, **acceleration** and an edge computer close to the 5G base station processes this information. Cloud computing is used as a final resort for high intensity scenarios.

What does the edge computer look for?

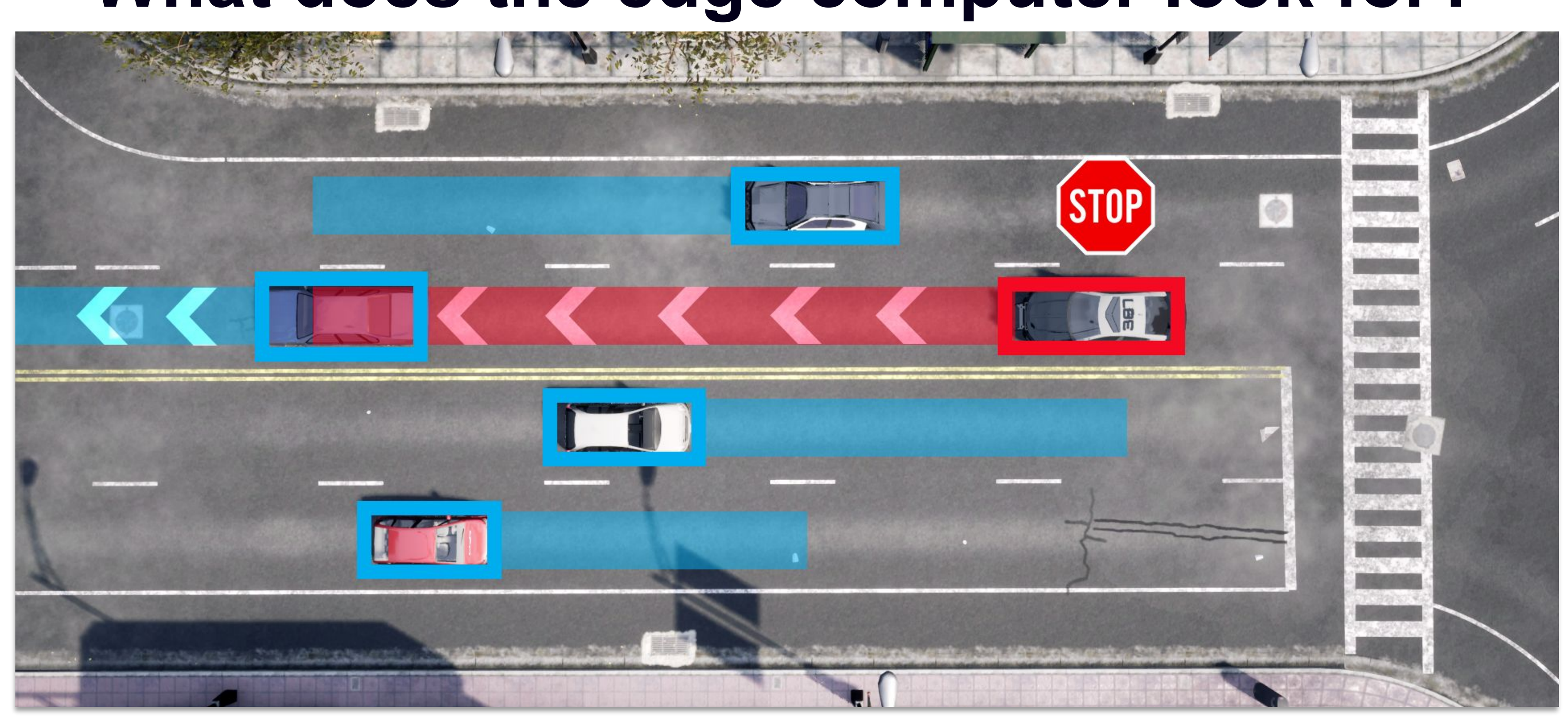

Figure 5: Scenario showing a car being warned to slow down

We implemented a simple algorithm that **looks 2 seconds ahead** of each car's trajectory and send out emergency break warnings for imminent collisions

docker SUMO CARLA

Real-time Data Experiment

A Raspberry Pi connected to an onboard diagnostic emulator (OBD-II) streams **real-time** data.

We profiled latency in our network using PTP

Figure 6: OBD-II Emulator

Importance and Scaling

- Developed a method to test **end-to-end V2N** latencies with open-source software
- Allow exploration of how **latency** affects edge applications
- High density scenarios propose additional issues with **GPS reliability** and **network interference**
- Network traffic will have to balance prioritizing **high-density** scenarios versus **high-risk** scenarios

Future Work

- Transition from a kinematical to a **reinforcement learning** (RL) algorithm to better predict collisions.
- Design an edge-case robust safety system
- Scale up current system so that it can support a much greater number of vehicles.

Acknowledgements

We would like to thank our advisors Anthony Megnan, Ivan Seskar, and Jenny Shane as well as the team at Verizon for their support, guidance, and coordination throughout this project.

References

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[2] SAE International Technical Standard, V2X Communications Message Set Dictionary, SAE Standard J2735_202007, Revised July 2020, Issued December 2006, https://doi.org/10.4271/J2735_202007.

[3] B. Coll-Perales et al., "End-to-End V2X Latency Modeling and Analysis in 5G Networks," in IEEE Transactions on Vehicular Technology, vol. 72, no. 4, pp. 5094-5109, April 2023, doi: 10.1109/TVT.2022.3224614.