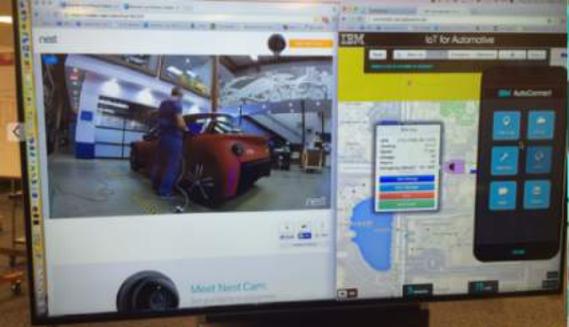


200mph Autonomy

Open Source Racecars Speed Us to Safety





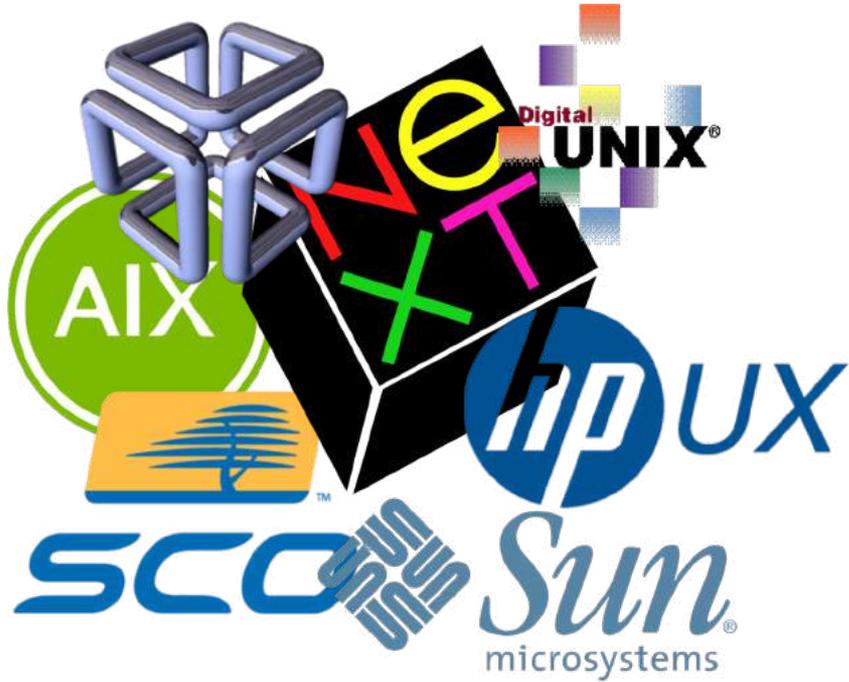


Joe Speed – Field CTO

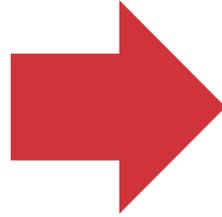
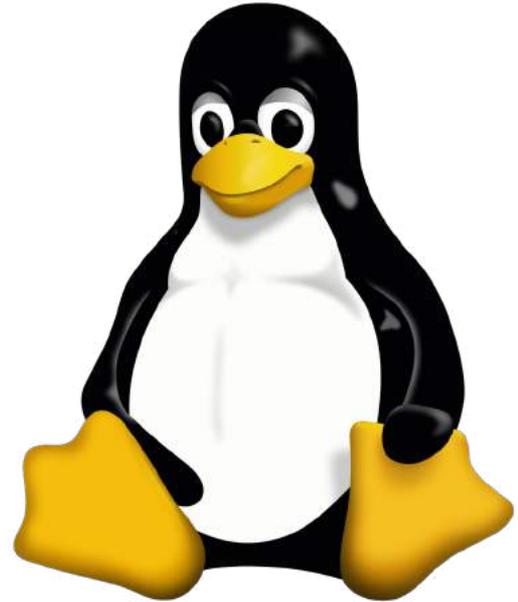
- Made MQTT open and helped Daimler, Toyota, Ford, Scania, VW Group, Continental AG adopt it
- Launched IBM IoT and IBM's AutoLab automotive innovation lab
- Likes cars but **loves** developing accessible AVs for aging & disabled
- Open Robotics ROS 2 Technical Steering Committee, Edge AI WG Leader
- Autoware TSC, Autoware HW WG Co-Leader
- Eclipse OpenADx SC, Eclipse CycloneDDS

Why Open Source?

past*



today



*developed with 95% identical requirements

Why Open Source?

today*



tomorrow



*developed with 95% identical requirements

Is Safety too important to be closed source?

From Linux we learned ...

- together we can do hard things
- when we contribute & share
- more eyes on the code makes it secure & safer

OEMs and Tier 1s have armies of developers ...

- working on same requirements
- but each with its own silo'd closed source

We Can Make Open Source Safe

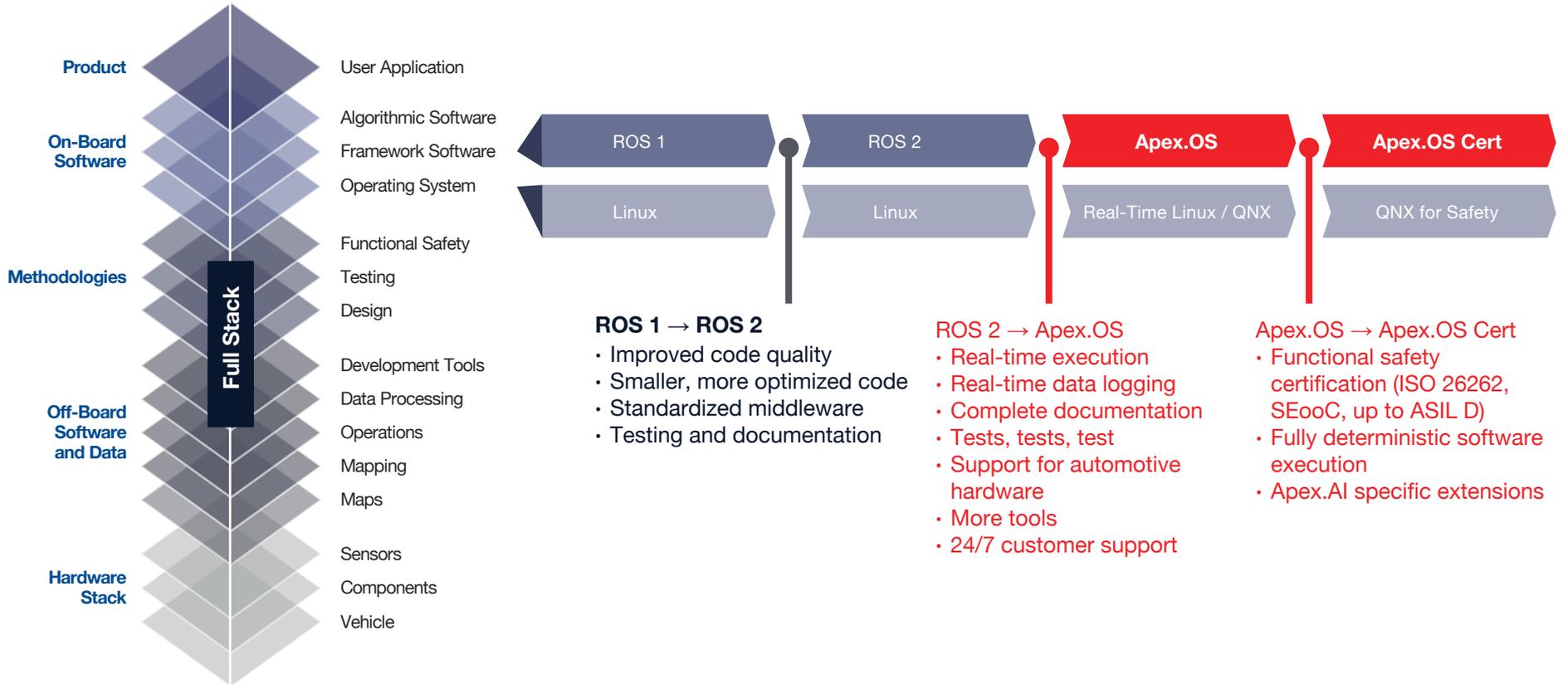
for example ...

ASIL-D ISO 26262 distro of Open Robotics ROS 2
Apex.AI developed, TUV Nord Certified



<https://discourse.ros.org/t/ros-2-iso-26262-certification-and-thank-you/19249>

Evolution from ROS to **Apex.OS**



Why Racecars?

[Madhur Behl](#) of [University of Virginia AV lab](#) & [F1TENTH.org](#)

- Most crashes are failures in perception or estimating agents behaviors.
- Racing presents close-in high speed situations **much** more frequently
- Vehicles need to be able to steer aggressively. Race to learn expert level maneuverability, develop an agile controller.





Castroneves
11 3
Davison
12 33
Sato
13 30
Andretti
14 98
Ericsson
15 7
Dixon
16 9





Indy Autonomous Challenge in the News

- IAC racecar unveil at CES 2021 had 2 billion media impressions and 900 news mentions
- Wall Street Journal - July, 1st in series
- Fortune - September, 1st in series
- Automotive News, The Robot Report, Strategy Analytics interviews about IAC teams using Autoware, ROS 2, CycloneDDS

RACE at Indy Motor Speedway Oct 23 2021

indyautonomouschallenge.com

Support IAC University teams! Ask me how

THE WALL STREET JOURNAL

engadget

THE DRIVE

c|net

FORTUNE

IEEE SPECTRUM

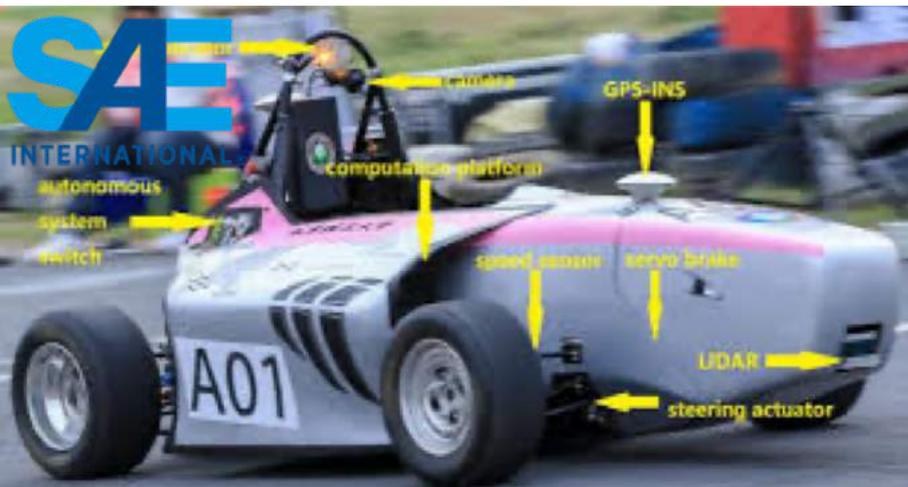
Automotive News

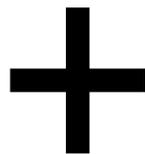


Autoweek

THE ROBOTREPORT

STRATEGYANALYTICS





AUTOWARE

ROS 2



CycloneDDS

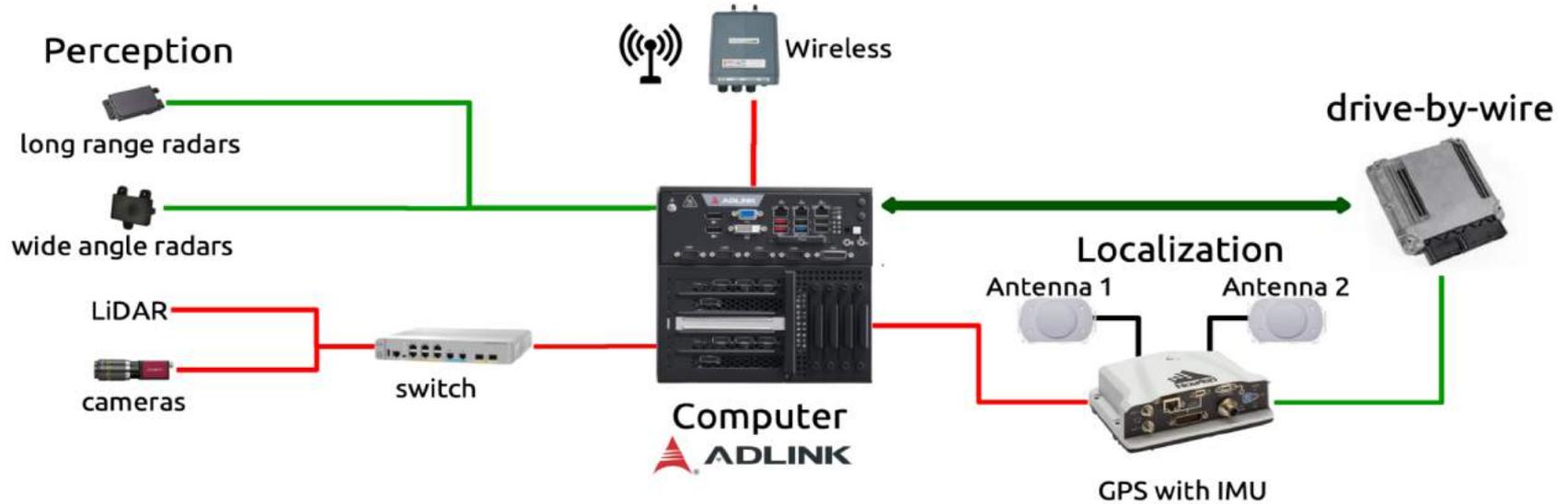


iceoryx



zenoh

IAC Racecar AD Architecture



ROS 2

- Foxy - **Now** is the time
- 115 engineers, ~\$8M effort
- Completeness
- Quality
- Performance
- Security
- Navigation

ros.org





THE
AUTOWARE
FOUNDATION

The Autoware Foundation is a non-profit organization supporting open source projects for self-driving mobility.



AUTOWARE.AUTO

Autonomous driving for **ROS 2**

autoware.org



What is Autoware.Auto?



- Autonomous Driving packages for ROS 2
- Developed from the ground-up with the following in-mind:
 - Safety
 - Code quality (multiple linters/ static analyzers enforced)
 - Static memory allocation
 - Modularity
 - Documentation, documentation, documentation
- Website: autoware.auto/
- Repository: gitlab.com/autowarefoundation/autoware.auto/AutowareAuto





Non-profit foundation
providing open source
IoT projects for
industrial, robotics,
autonomous driving

eclipse.org



Eclipse IoT



Eclipse OpenADx



Eclipse CycloneDDS



Eclipse iceoryx



Eclipse zenoh

What is Eclipse CycloneDDS?

Eclipse CycloneDDS is ...

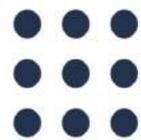
- Easy, fast, small and reliable
- Built into Open Robotics ROS 2
- ROS 2 Galactic default (May 2021)
- Autoware default for autonomous driving developers

github.com/eclipse-cyclonedds

 [@EclipseCyclone](https://twitter.com/EclipseCyclone) #DDS



AUTOWARE



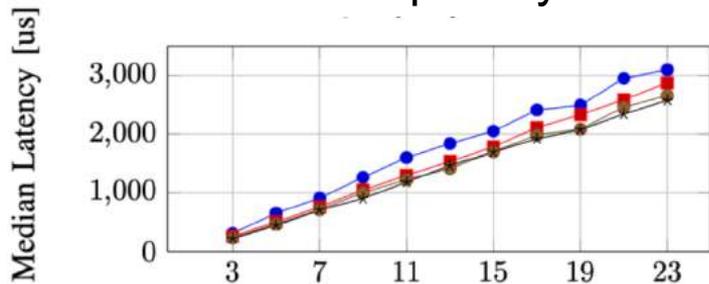
ROS 2



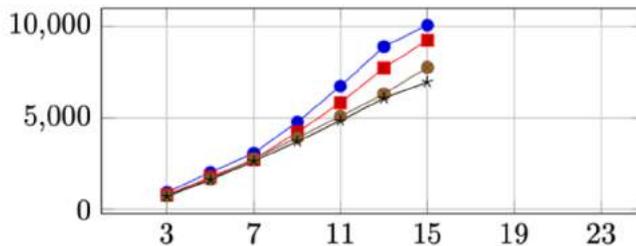
OpenADx

Open Source is faster & better at AD workloads

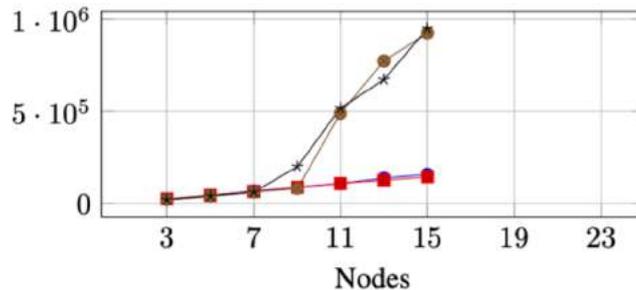
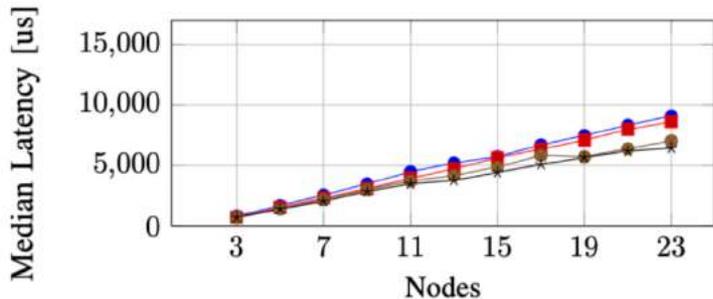
ROS 2 with Eclipse CycloneDDS



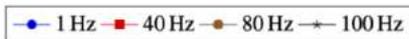
ROS 2 with RTI Connex



100 byte messages
e.g. drive-by-wire,
GNSS



500 KB messages
e.g. LiDAR point
clouds, camera data



Source: Jan 12th 2021 [Barkhausen Institute GmbH](https://www.barkhausen-institute.com) research for automakers [report](#), [test code](#), [test data](#) using ROS 2 Foxy Fitzroy 20200807 on Intel i7-8700 CPU @ 3.2 GHz x6 with 32GB RAM. Use independent benchmarks **and** test it yourself. <https://arxiv.org/pdf/2101.02074.pdf>



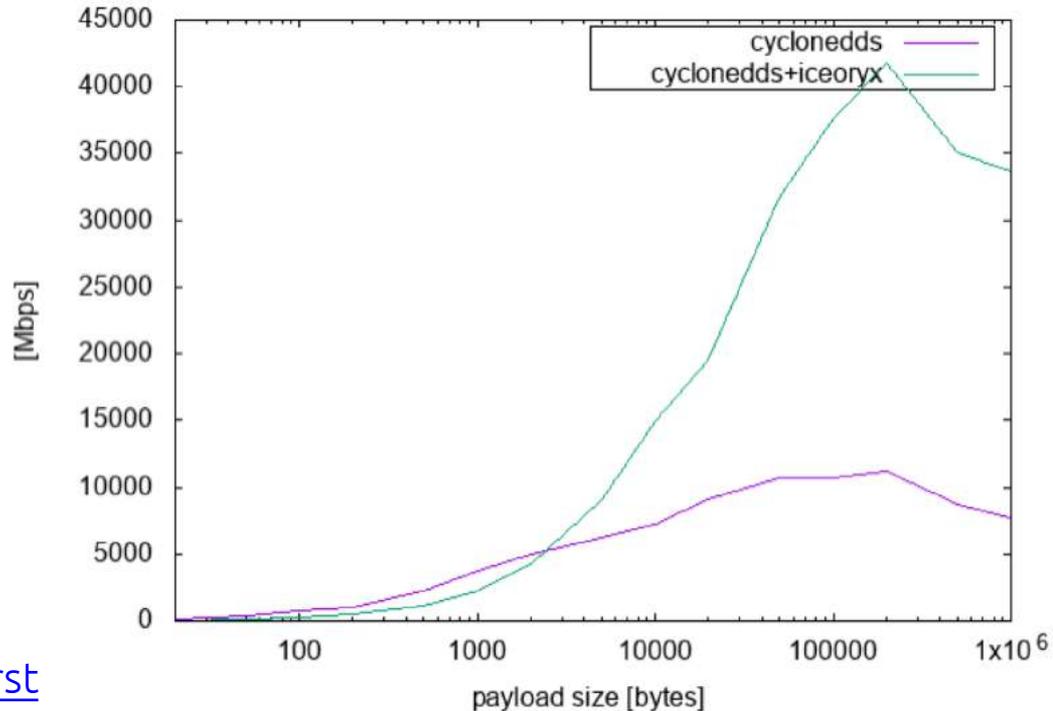
for fast DDS 🏎️ 🐢 🚀

Eclipse iceoryx

- zero-copy shared mem pub/sub
- cyclonedds with built-in iceoryx
- 7x faster* point clouds, images
- >10x faster with zero-copy API being added to cyclonedds

*on AMD threadripper

github.com/eclipse/iceoryx
[github.com/eclipse-cyclonedds/cyclonedds/
blob/iceoryx/docs/manual/shared_memory.rst](https://github.com/eclipse-cyclonedds/cyclonedds/blob/iceoryx/docs/manual/shared_memory.rst)

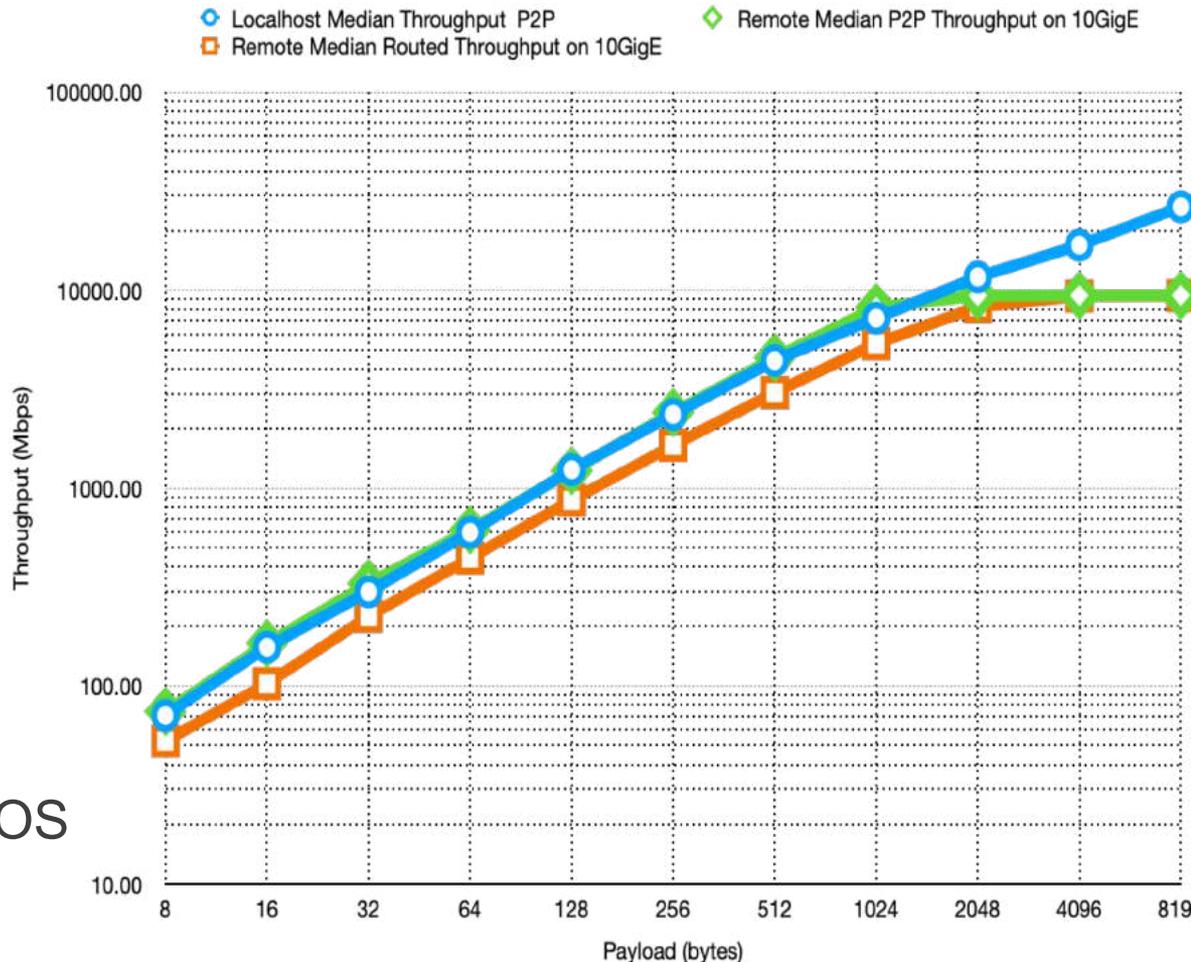




Eclipse Zenoh

- ROS 2 DDS bridge
- scalable discovery
- V2X and swarms
- DDS to cloud
- LTE, 5G, LoRA, satellite
- fast, saturates 10GbE
- microcontrollers, micro-ROS

zenoh.io





U.S. Department
of Transportation

**Federal Highway
Administration**



CARMA migrating to ROS 2 with CycloneDDS and Zenoh

■ Next Generation ROS ros2, foxy, cyclonedds, iceoryx



It's been a while since we've seen tlochrame — their last post was 1 year ago.



tlochrame

Nov '20

CARMA ²⁴, a program within the **Federal Highway Administration** ³, which is an agency inside the **U.S. Department of Transportation** ², is an initiative focused on improving the transportation system by leveraging emerging automated driving technology and vehicle-to-everything (V2X) technology to enable increased safety and operational performance in moving people and goods through cooperative driving automation (CDA).

CARMA Platform is a software piece developed within the program that is installed on a vehicle to allow it operate with SAE ADS L3 functionality and SAE CDA Class A through D cooperation. Originally developed on ROS, we have started the process of migrating CARMA Platform to ROS 2 with Eclipse Foundation's CycloneDDS as our ROS Middleware. CycloneDDS is a Tier-1 RMW and **the Autware Foundation** ²'s default for autonomous driving developers. Our team will be kicking off the development work for this shortly. The first release including initial code for CycloneDDS in CARMA Platform is planned for our **ELISE release in April** ¹. We will be working with Autware.Auto, ROS2 + CycloneDDS with built-in iceoryx throughout the year with a plan to complete migration to ROS 2 in our **DIVO release in November 2021**. Also noting that CycloneDDS & iceoryx are projects of **Eclipse OpenADx** ³ autonomous driving WG.

<https://discourse.ros.org/t/carma-migrating-to-ros-2-with-cyclonedds-and-zenoh/17541>



Joe Speed [linkedin.com/in/joespeed](https://www.linkedin.com/in/joespeed)



@JoeSpeeds



ADLINK