Continental
The Future in Motion

Eclipse eCAL (enhanced communication abstraction layer)

SDV Contribution Day – June 2022

About myself

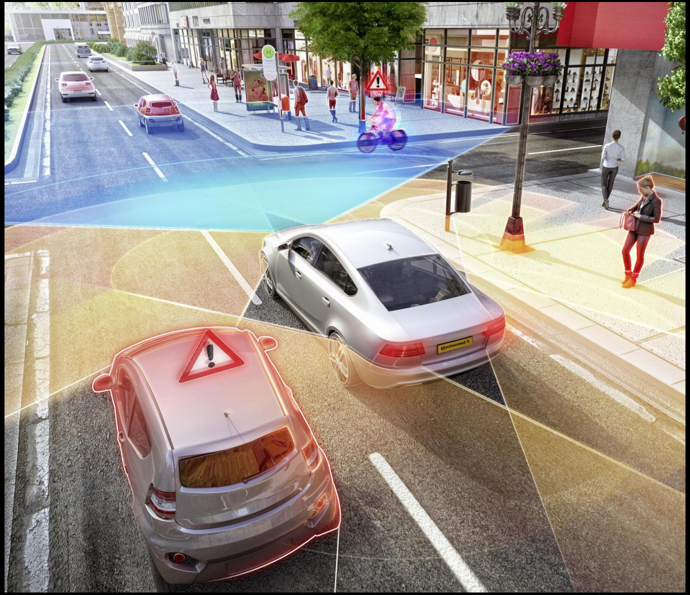
- 2022 – present
  - Head of SDF Development Platform, Innovation Line Driverless, ADAS
- 2017 – 2022
  - Team Lead, Base Software Development and Integration, R&D SW Engineering
- 1997 – 2017
  - Middleware development for AD systems (eCAL)
  - Rapid prototyping HMI development
  - Anti-lock braking system for Electro-Hydraulic-Brake systems
  - Various other research projects ..
- 1997
  - Diploma Electrical Engineering, Technical University Dresden / Germany

eCAL (**e**nhanced **C**ommunication **A**bstraction **L**ayer) is a fast publish-subscribe middleware that can manage inter-process data exchange as well as inter-host communication.

https://continental.github.io/ecal/

Motivation

Autonomous Driving challenged us ..



- high-performance computer systems needed
- new sensor technologies introduced
- large quantities of data must be transmitted extremely fast
- software components may run on different processor cores
- software components may run on different domain controllers
- software components may run on different operating systems
- all data flows needs to be monitored, recorded and finally analyzed

What about existing solutions ?

What about existing solutions ?

2015 and earlier

- Robotic Operation System ROS 1
  - bad overall performance for AD systems
  - no Windows support
- Data Distribution Service (DDS) implementations
  - slow inter-process communication
  - high costs
  - complex build / configuration / API
  - no Windows support

Today

- Robotic Operation System ROS 2
  - simple, nice API as ROS 1
  - powerful, flexible RMW concept
  - integrates DDS implementations
    - shared memory support
    - open-source alternatives
    - Windows supported

What distinguishes eCAL from ROS 2 ?

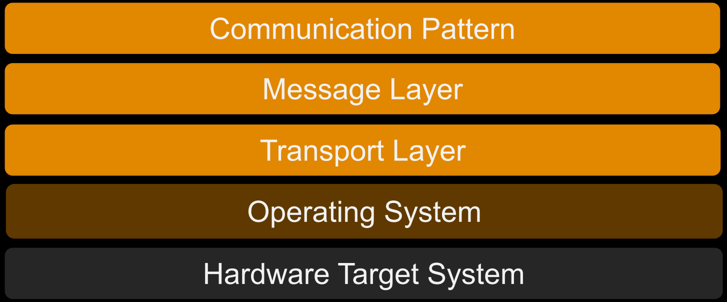
Customized for autonomous driving

- eCAL is message protocol agnostic
  - different protocols, different use cases
  - message schema evolution well supported
- eCAL is a library
  - minimalistic API
  - easy to build / extend / configure
- eCAL has powerful tools
  - live data monitoring based on dynamic protocol reflection + plugin concept for 2D / 3D
  - distributed recording concept – unique selling point ☺

Architecture overview

Architecture overview

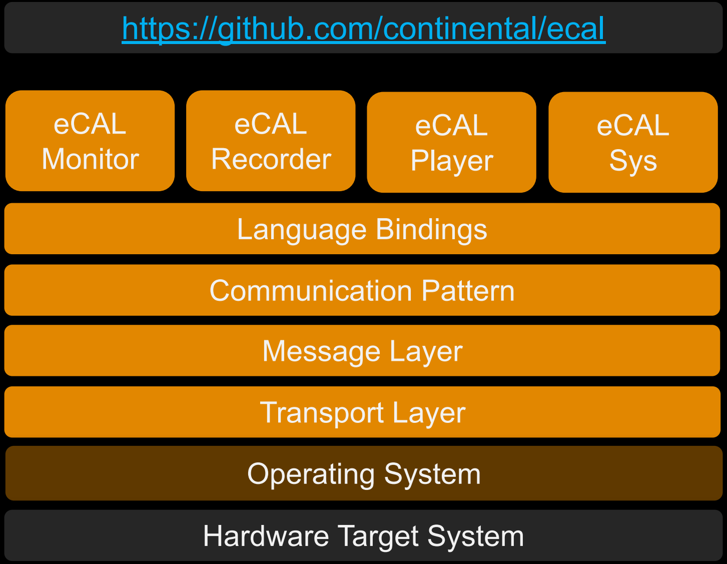
- supports **POSIX** as well as **Windows** operating systems
- supports different transport protocols
  - inter-process communication: **shared memory**
  - inter-host communication: **udp multicast / tcp**
- supports **different serialization formats**:
  - google::protobuf
  - capnproto
  - google::flatbuffers, messagepack, json ..



- supports **publish / subscribe** and **client / server** pattern
- **brokerless dynamic design**
-

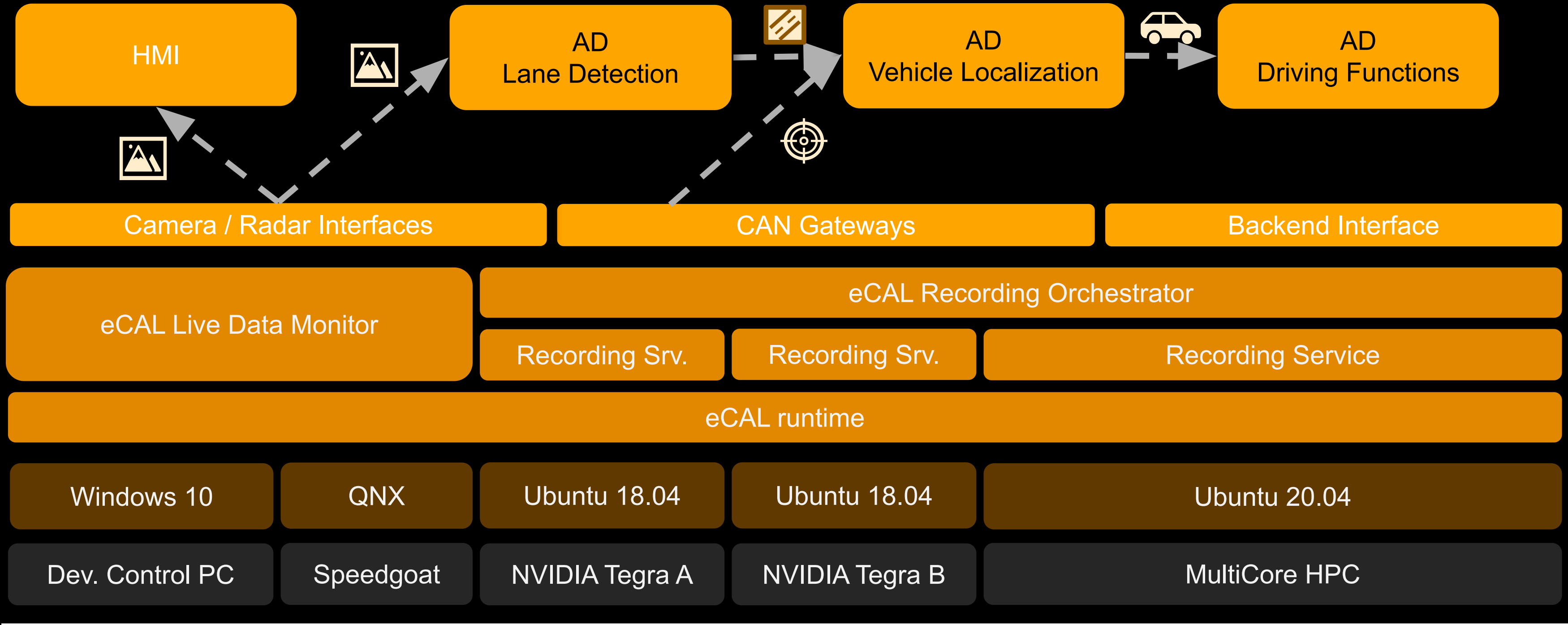
Architecture overview

- language bindings for C, C++, C#, Python, Rust, Go, M-Script, Simulink
- shipped with **eco system tools** for
  - **live monitoring** of all software component interfaces
  - orchestrated, **distributed message recording**
  - **message replay** real-time or stepwise
  - automated software **component start, stop** and supervising
  - all tools realized as command line and GUI application
- **open sourced** by Continental under Apache 2 license since 2019


https://github.com/continental/ecal

Typical use cases

Autonomous Vehicle communication stack



HMI

AD Lane Detection

AD Vehicle Localization

AD Driving Functions

Camera / Radar Interfaces

CAN Gateways

Backend Interface

eCAL Live Data Monitor

eCAL Recording Orchestrator

Recording Srv.

Recording Srv.

Recording Service

eCAL runtime

Windows 10

QNX

Ubuntu 18.04

Ubuntu 18.04

Ubuntu 20.04

Dev. Control PC

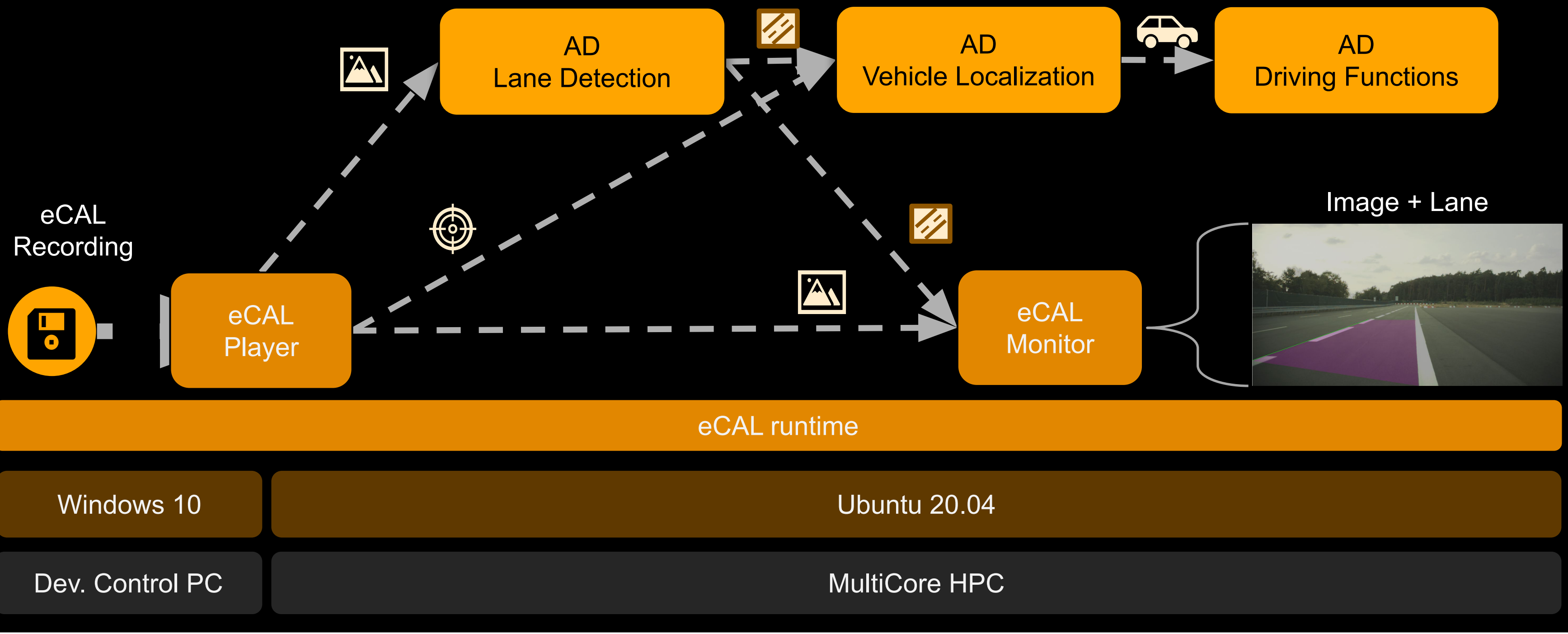
Speedgoat

NVIDIA Tegra A

NVIDIA Tegra B

MultiCore HPC

Software component validation



AD
Lane Detection

AD
Vehicle Localization

AD
Driving Functions

eCAL
Recording

eCAL
Player

eCAL
Monitor

Image + Lane

eCAL runtime

Windows 10

Ubuntu 20.04

Dev. Control PC

MultiCore HPC

Demo

person publish c++
eCAL Monitor
eCAL Recorder
eCAL Player
person subscribe c++
person subscribe python
eCALize it !
eCAL Measurements
AD Demo Measurement

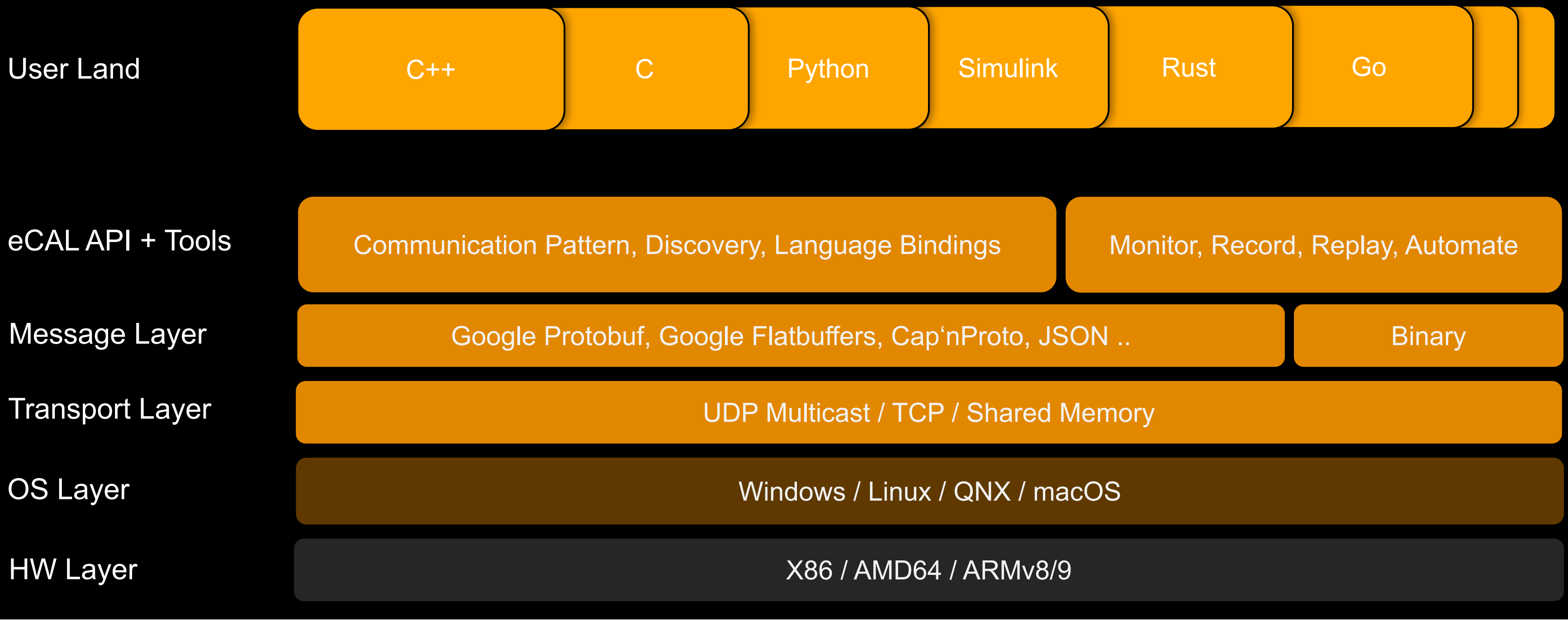
Summary

- eCAL is designed for autonomous driving applications
- eCAL combines modern communication patterns with state-of-the-art message protocols
- eCAL has powerful tools for rapid prototyping
- eCAL is open source since 2019 and looking forward to be part of the Eclipse family ☺

Thank you for your attention

Backup

Architecture overview (technical)



User Land

C++

C

Python

Simulink

Rust

Go

eCAL API + Tools

Communication Pattern, Discovery, Language Bindings

Monitor, Record, Replay, Automate

Message Layer

Google Protobuf, Google Flatbuffers, Cap‘nProto, JSON ..

Binary

Transport Layer

UDP Multicast / TCP / Shared Memory

OS Layer

Windows / Linux / QNX / macOS

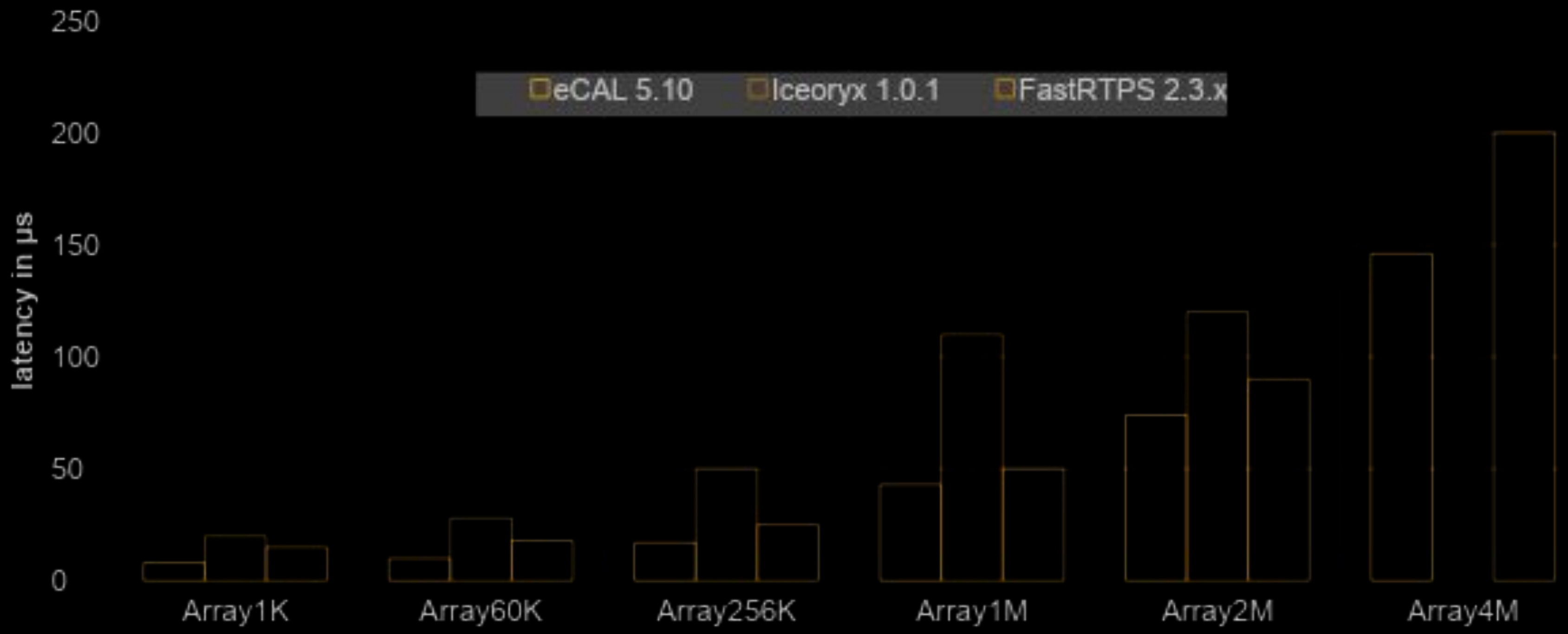
HW Layer

X86 / AMD64 / ARMv8/9

eCAL and friends

- OSS projects using eCAL
  - ROS2 middleware plugin RMW_ECAL – https://github.com/continental/rmw_ecal
  - Mathworks Simulink toolbox – https://github.com/mathworks/ecal-toolbox
  - Agtonomy Trellis hybrid autonomy agriculture vehicles – https://github.com/agtonomy/trellis
  - Generic Foxglove Studio Visualization interface (part of next eCAL OSS release) – https://foxglove.dev/
- OSS projects used by eCAL (the bigger ones)
  - google protobuf – https://developers.google.com/protocol-buffers
  - hdf5 hierarchical data format – https://www.hdfgroup.org/solutions/hdf5/
  - asio c++ – https://think-async.com/Asio/
  - fineftp-server – https://github.com/continental/fineftp-server
  - tcp_pubsub – https://github.com/continental/tcp_pubsub
  - iceoryx (optional shm layer) – https://github.com/eclipse-iceoryx/iceoryx

Local IPC Performance (Q2/2022)


latency in µs
eCAL 5.10
Iceoryx 1.0.1
FastRTPS 2.3.x
Array1K
Array60K
Array256K
Array1M
Array2M
Array4M