

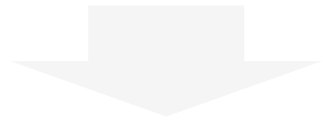
ROSCon 2022

micro-ROS goes Automotive: supporting AUTOSAR-based microcontrollers

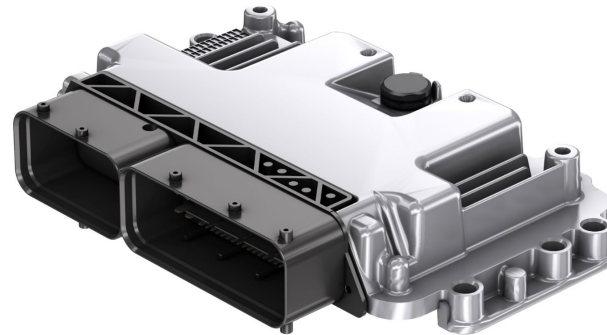
Jan Staschulat and Ralph Lange, Bosch Research

2

ROS



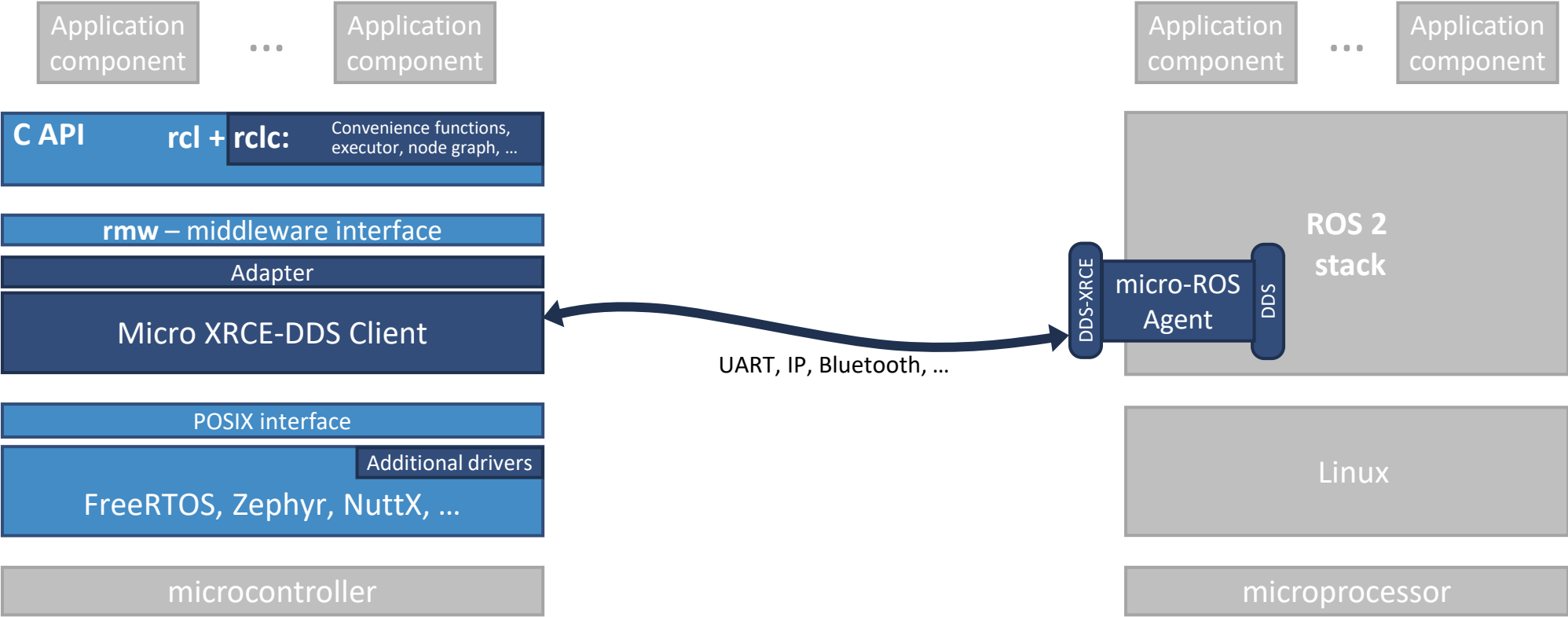
Linux-based
computer



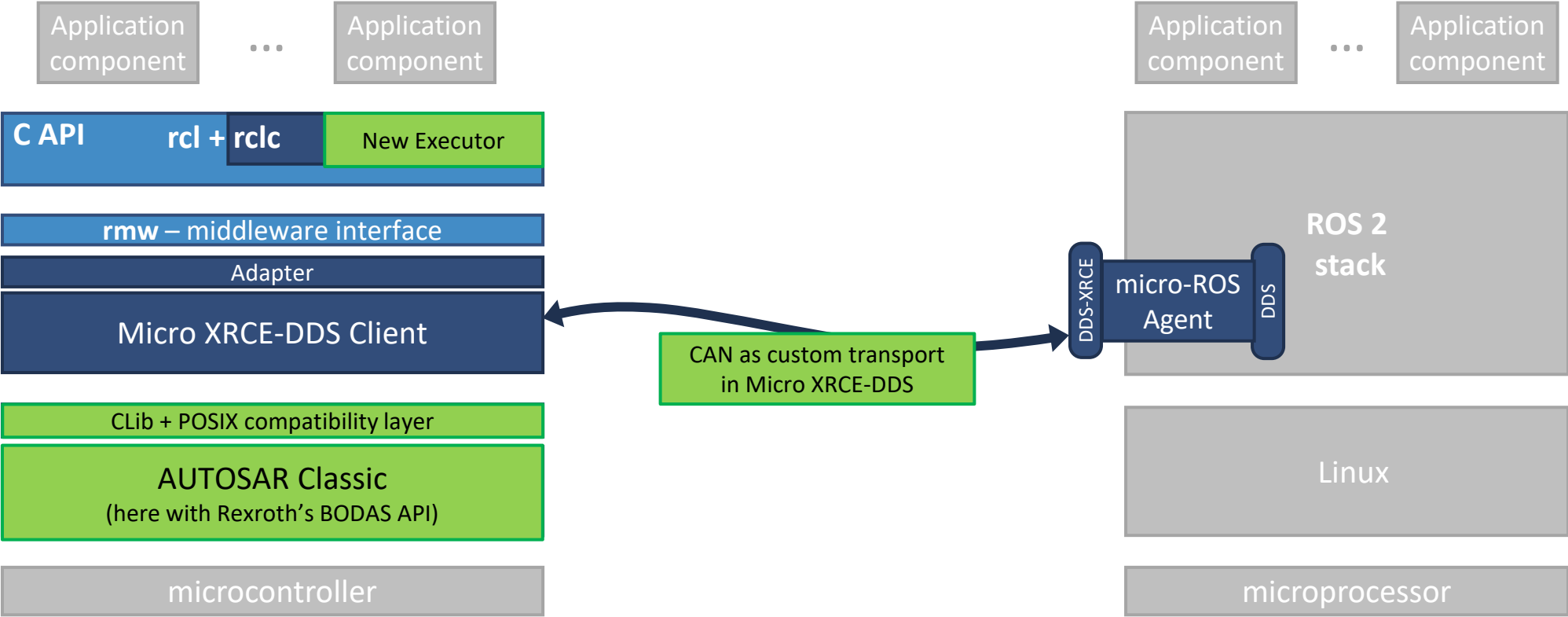
Sensors,
Actuators

- 300 MHz Clock Frequency
- 1 MB SRAM
- AUTOSAR Classic

Micro-ROS Architecture



Modified Architecture



Challenge 1: Mapping ROS Execution to AUTOSAR Tasks

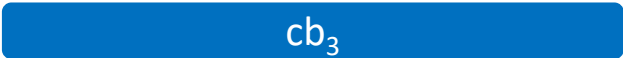
ROS 2

POSIX threads

Node 1 Executor

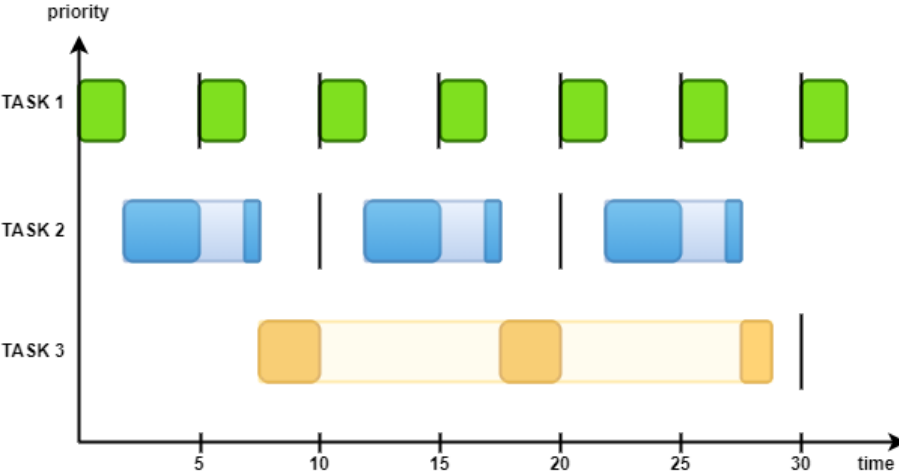


Node 2 Executor



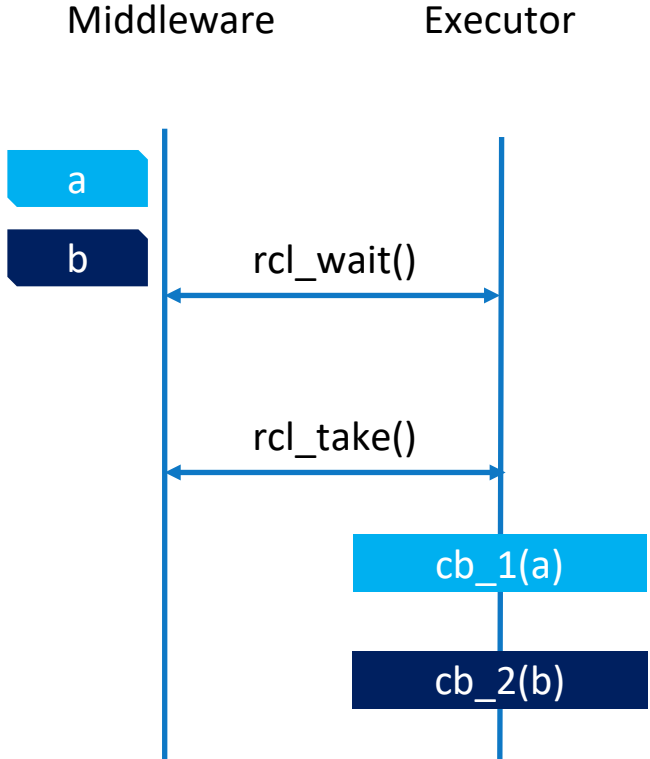
AUTOSAR Classic

Fixed Periodic Task Scheduling

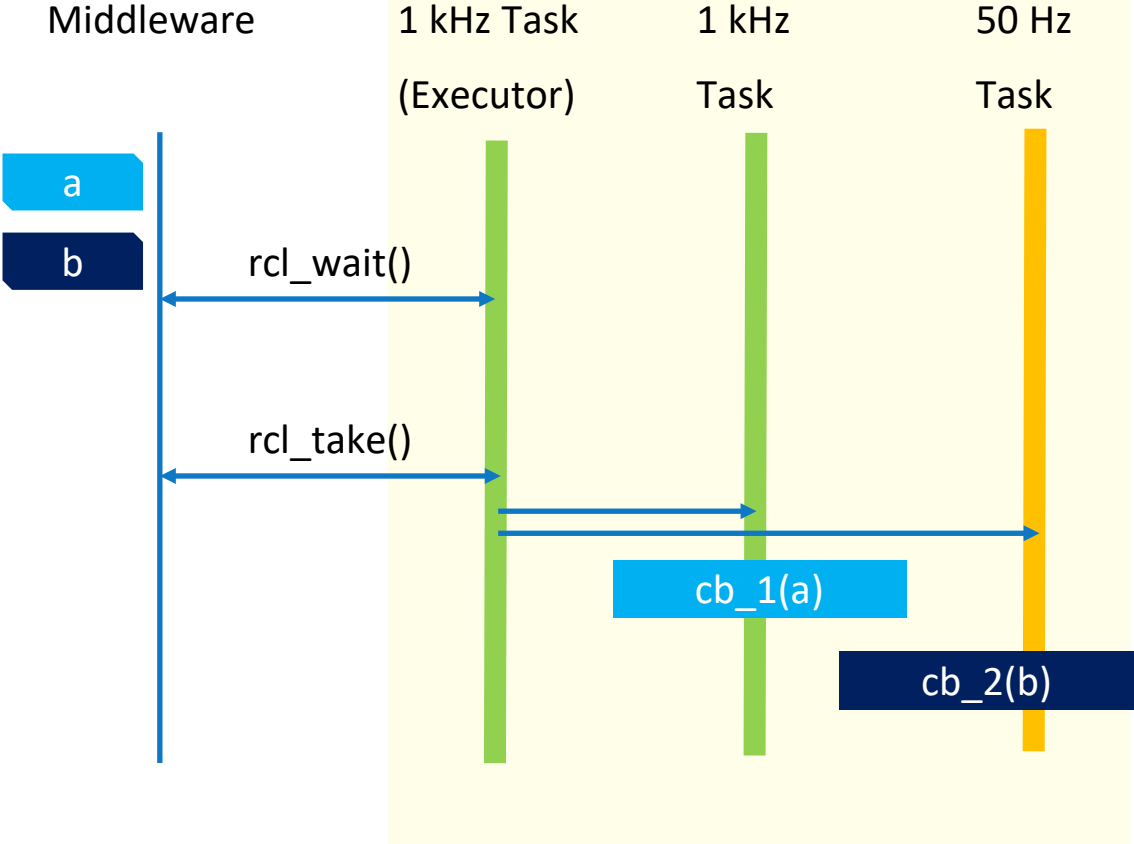


Solution: Dispatching Executor

ROS 2



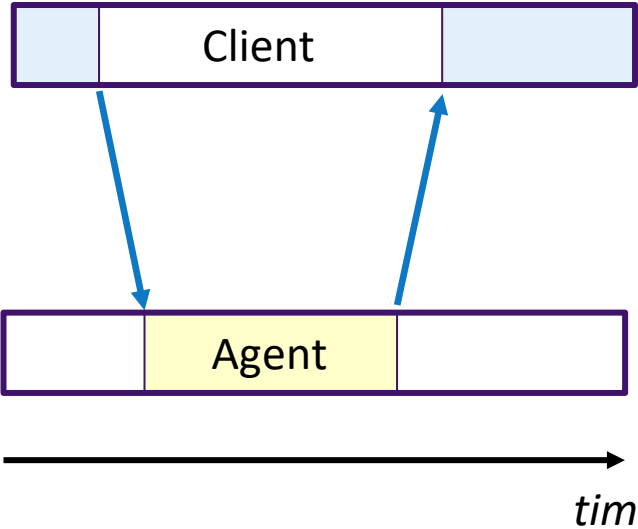
AUTOSAR Classic



Available in github.com/ros2/rcl (for Rolling)

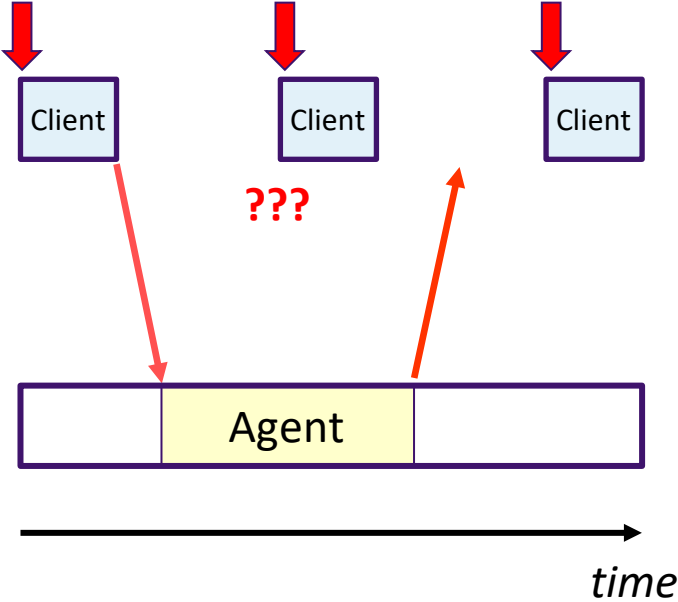
Challenge 2: Handling blocking initializations in rcl and rmw

On POSIX



Client thread **waits** for Agent's reply

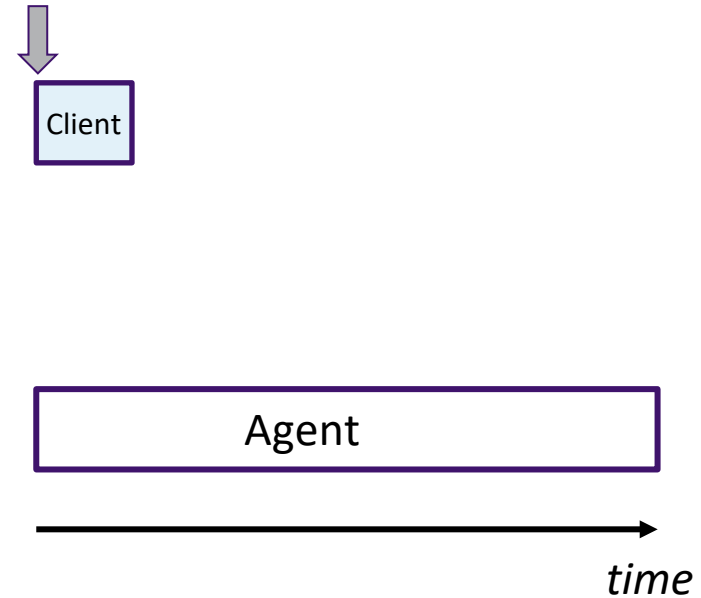
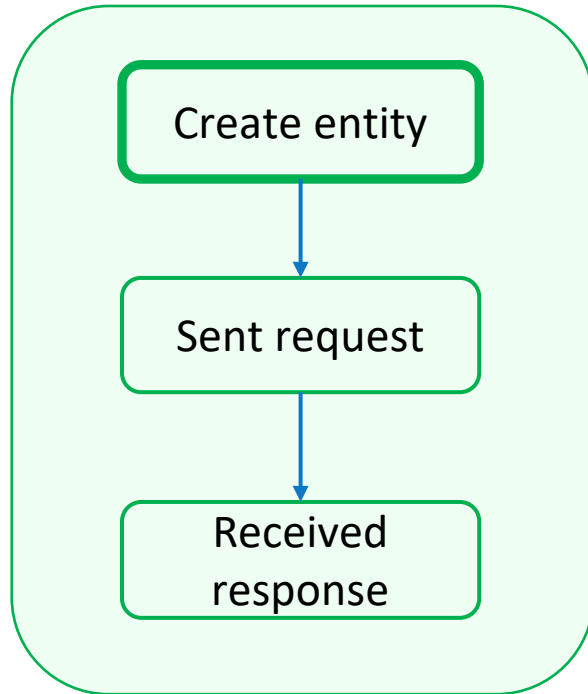
On AUTOSAR Classic



Periodic tasks **cannot wait** in stack

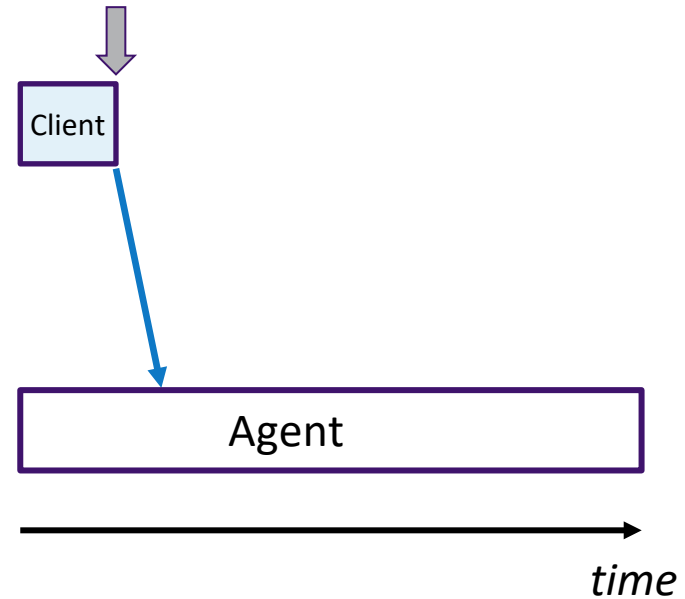
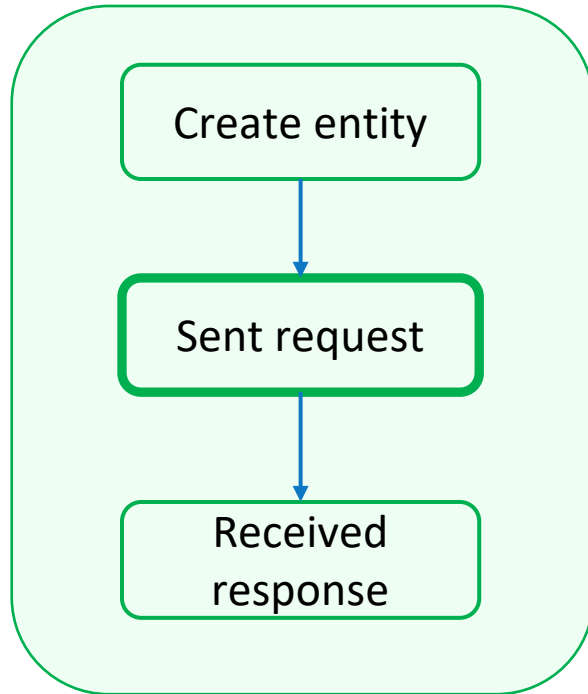
Solution: Refactoring into state machine

State machine



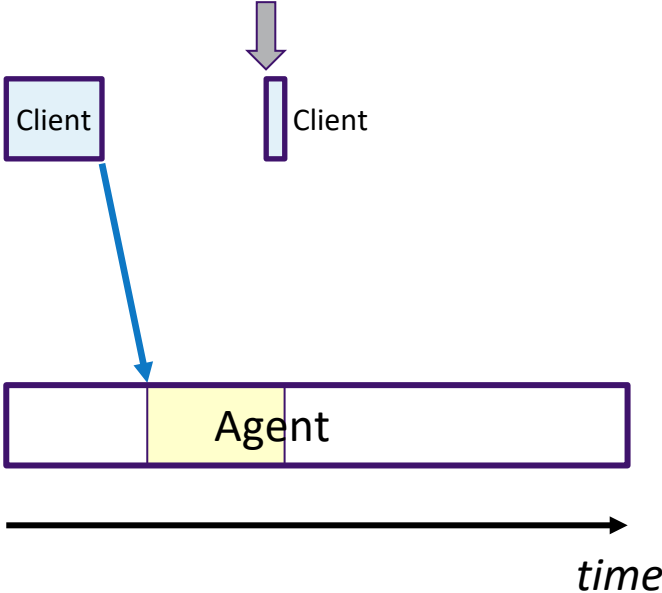
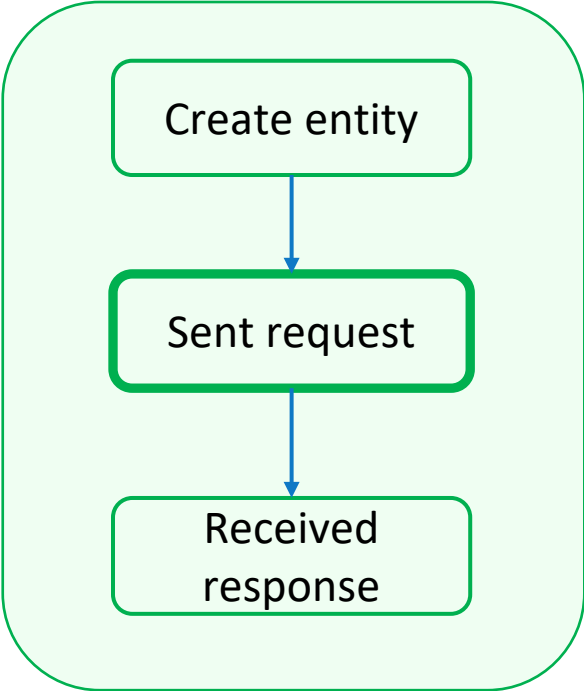
Solution: Refactoring into state machine

State machine



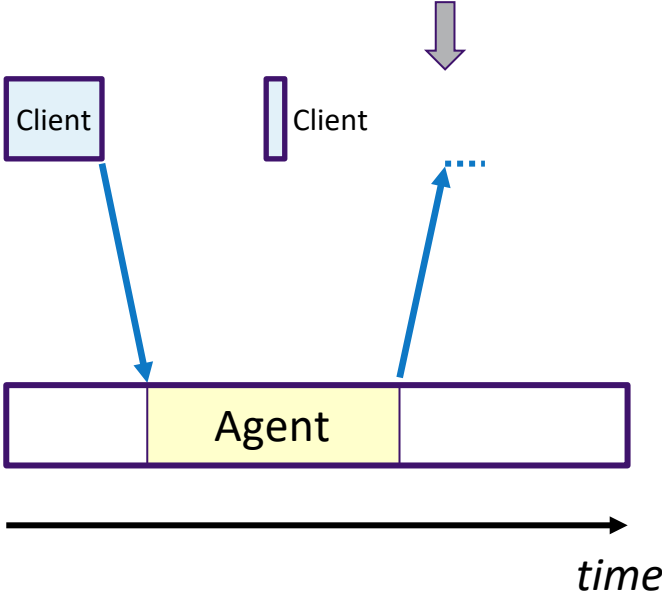
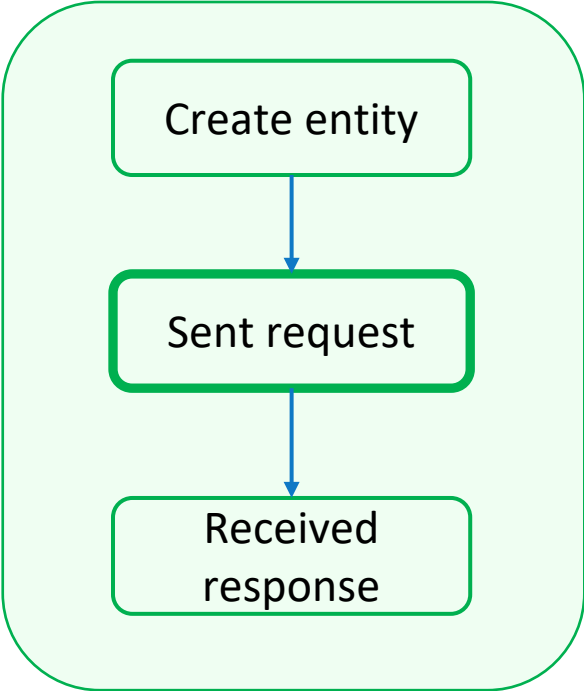
Solution: Refactoring into state machine

State machine



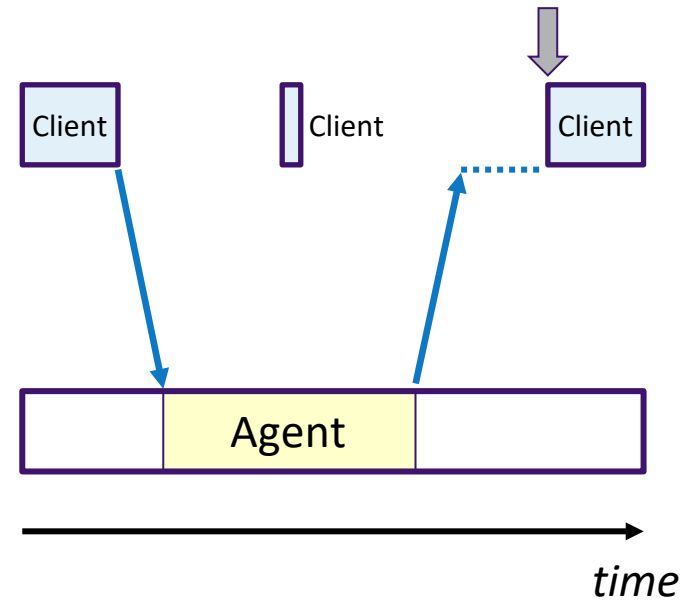
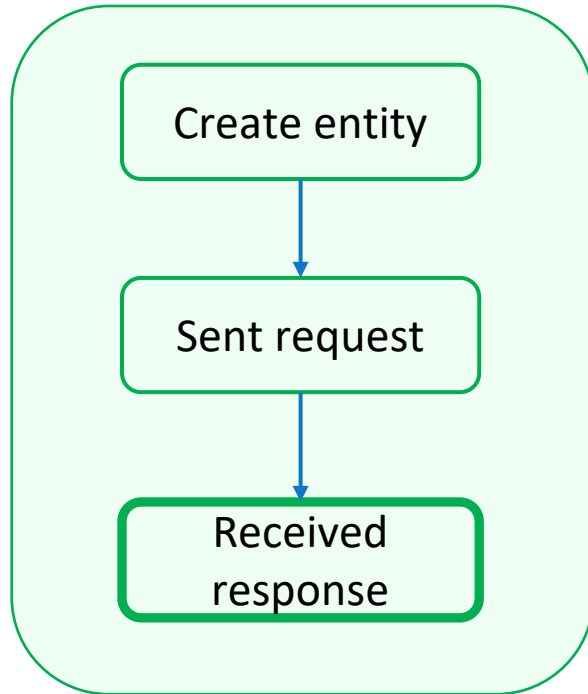
Solution: Refactoring into state machine

State machine

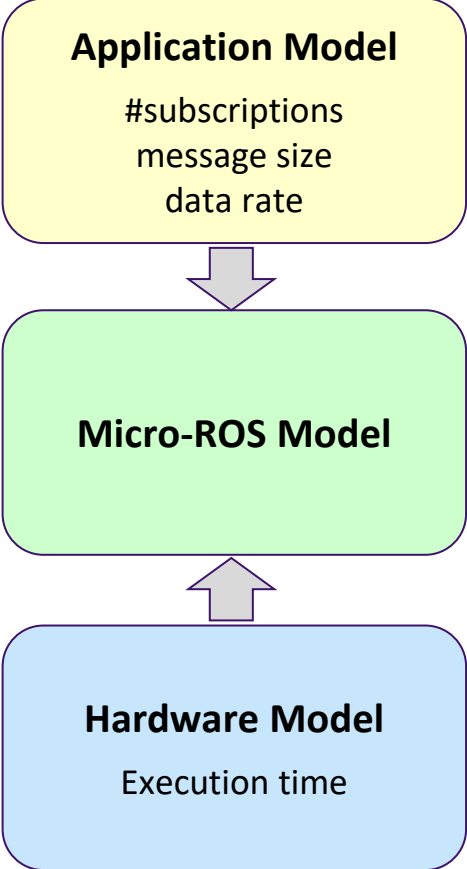
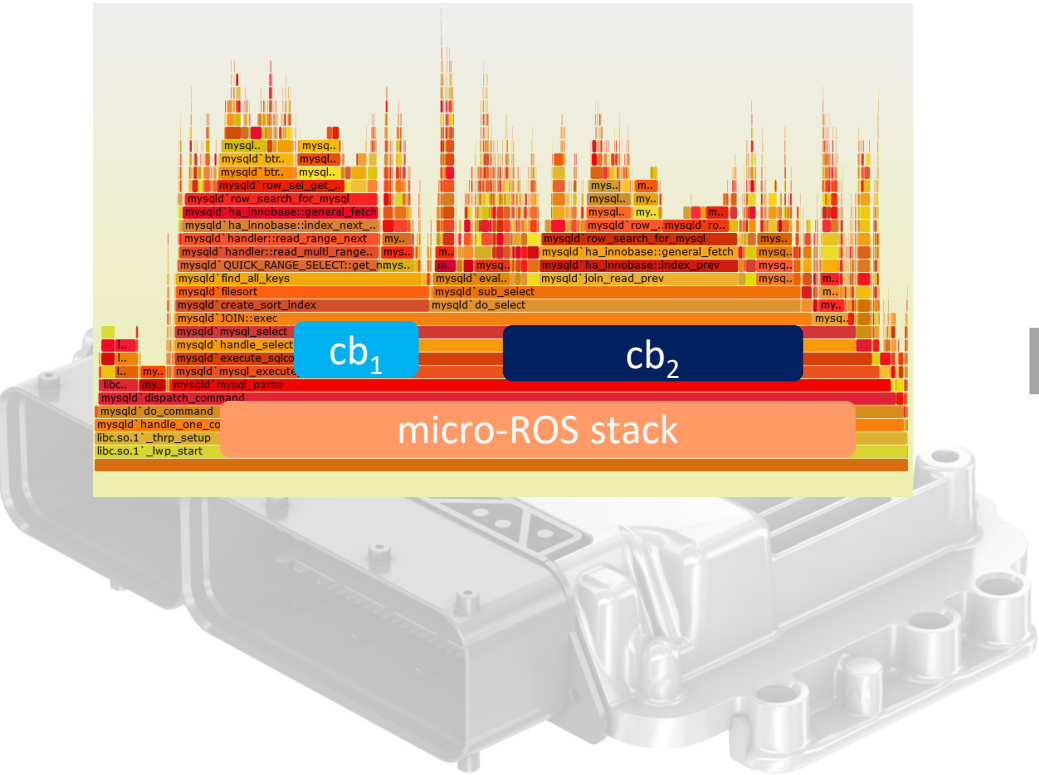


Solution: Refactoring into state machine

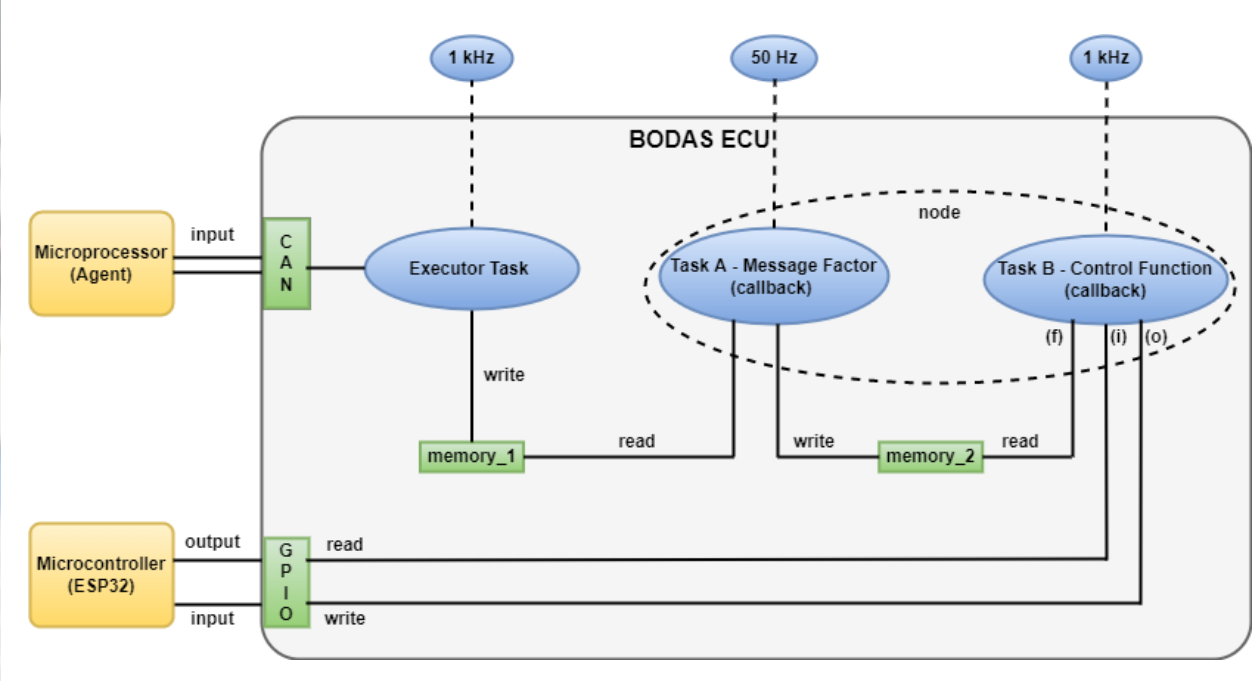
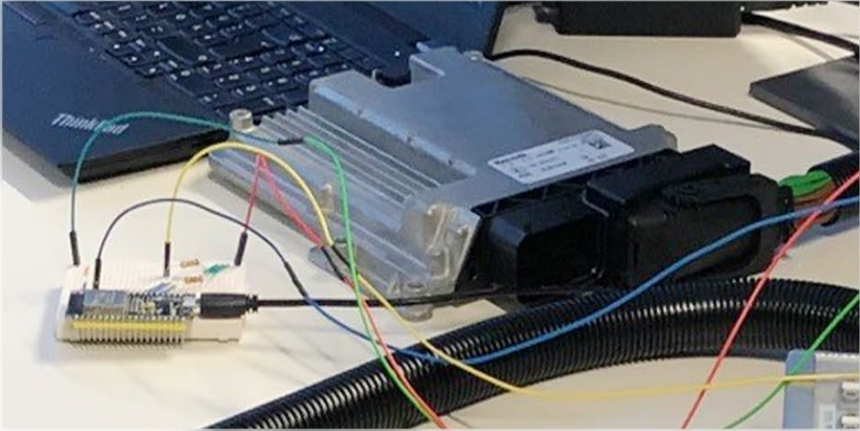
State machine



How to model the performance of a micro-ROS application?

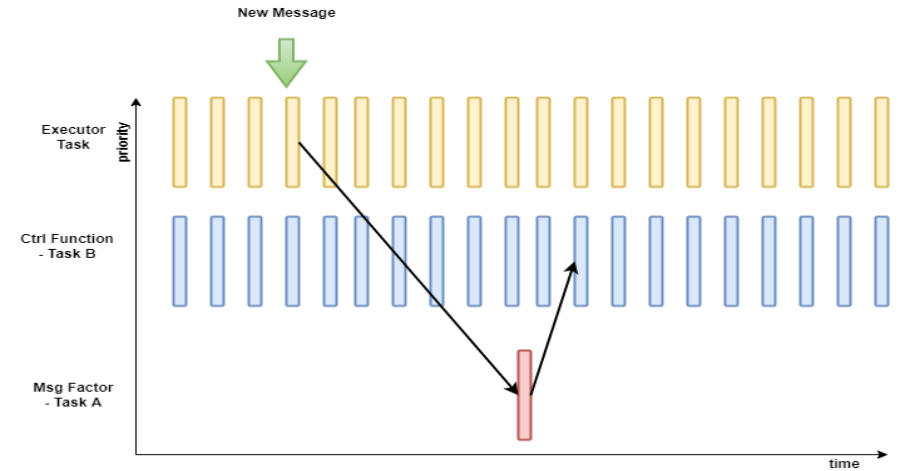


Demonstrator with BODAS Controller by Bosch Rexroth



Results

- Runtime overhead by micro-ROS stack is < 3%
 - ... despite quick user code callbacks
- Model estimates response times with error of $\approx 6\%$



	Real HW	Model
min latency [us]	970	1029
avg latency [us]	10320	n/a
max latency [us]	19978	20070



Ported micro-ROS stack to AUTOSAR-based platform

- ▶ rcl Dispatching Executor to map execution model
 - ▶ Refactored blocking initializations into state machines
 - ▶ Support for classical CAN as custom transport
 - ▶ micro-ROS performance model in Amalthea
- ▶ Many thanks to Kaiwalya Kalyan Belsare and Suraj Rao Bappanadu for the contributions in their Master's theses!

Learn more?

- ▶ Jan.Staschulat@de.bosch.com | github.com/JanStaschulat
- ▶ Ralph.Lange@de.bosch.com | github.com/ralph-lange

... also see upcoming chapter "micro-ROS"
in Springer's ROS Book Vol. 7

