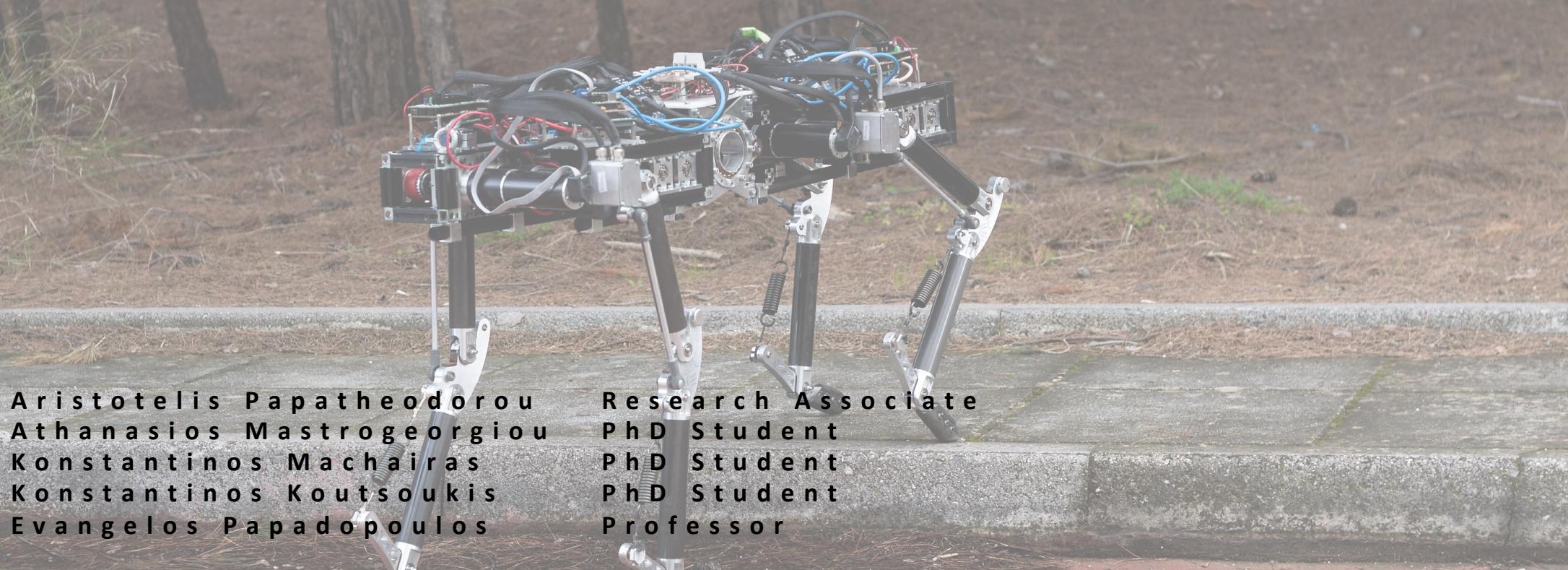


# Middleware interconnecting ROS/ROS<sub>2</sub> with EtherCAT protocol

Legged Robots Team / Control Systems Lab / School of Mechanical Engineering  
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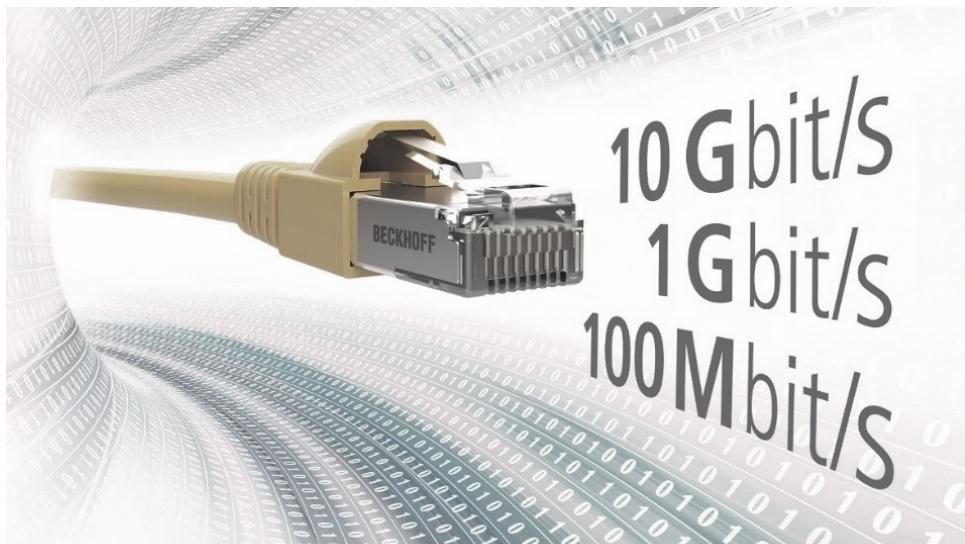
# Table of Contents

- What is EtherCAT ?
- Why EtherCAT ?
- EtherCAT Functional Principle
- Typical EtherCAT Slave
- Intro to EtherLab
- Why EtherLab ?
- ether\_ros2 – ROS2 wrapper for Etherlab
  - Overview
  - A simple example (led blinking)
  - Adding a new slave type
  - YAML network config
- Case study: Laelaps II quadruped by CSL Legged Robots Team
- Next steps





# What is EtherCAT ?



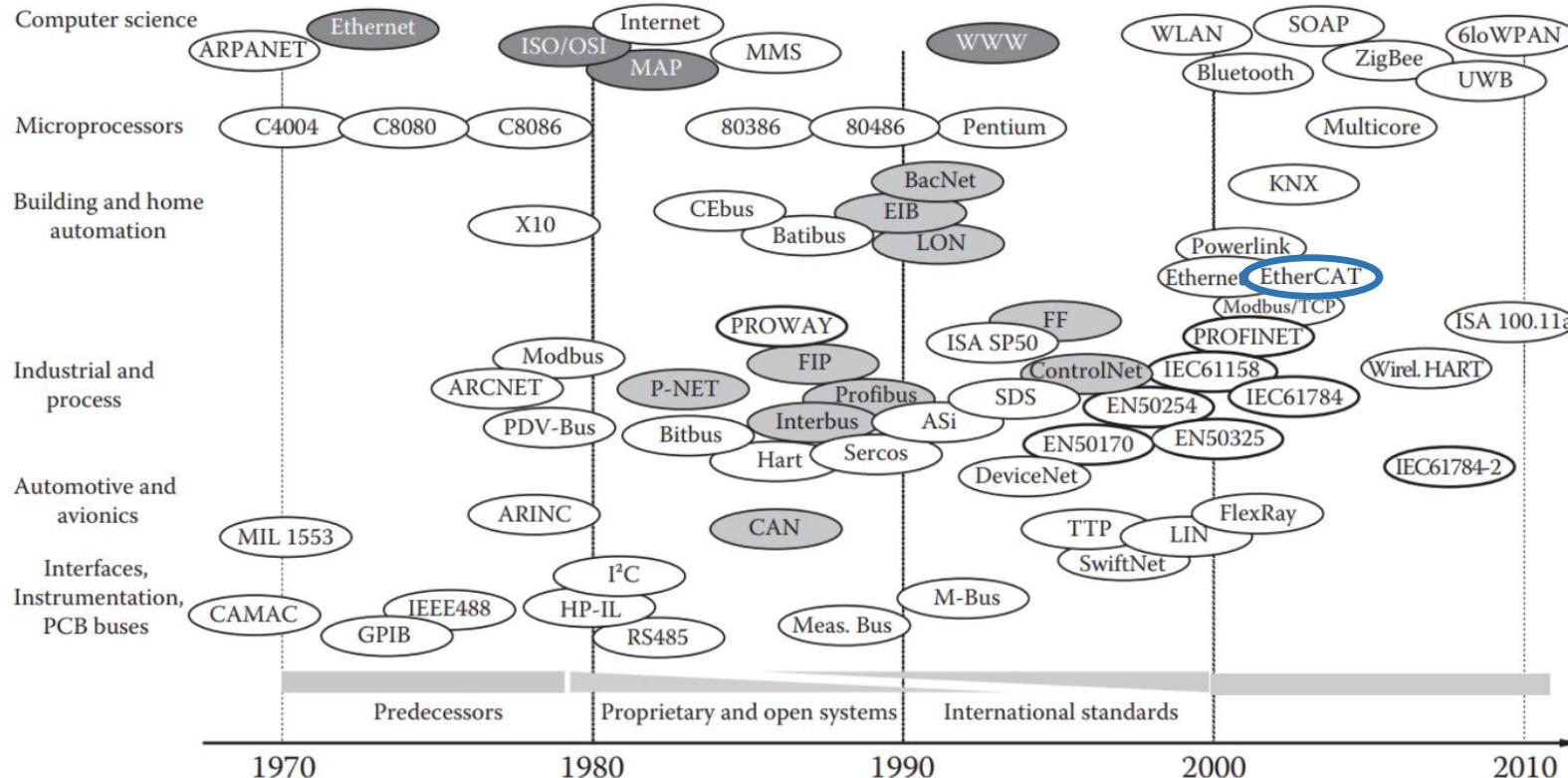
## EtherCAT Technology

EtherCAT is a high-performance, low-cost easy to use Industrial Ethernet technology with a flexible topology.

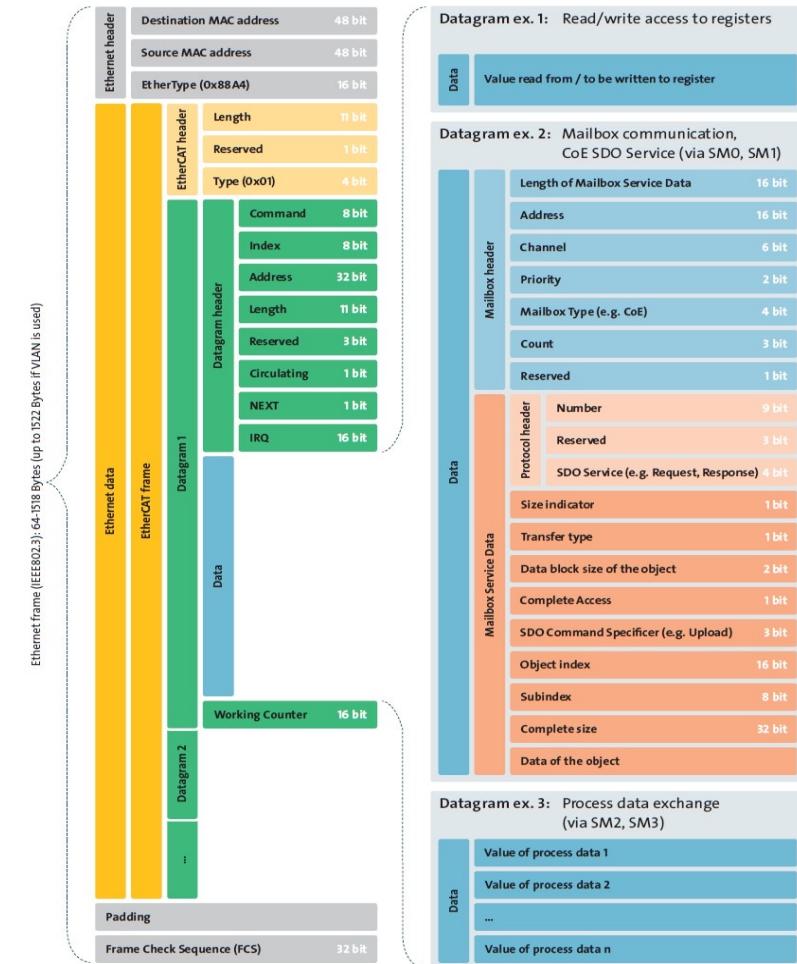
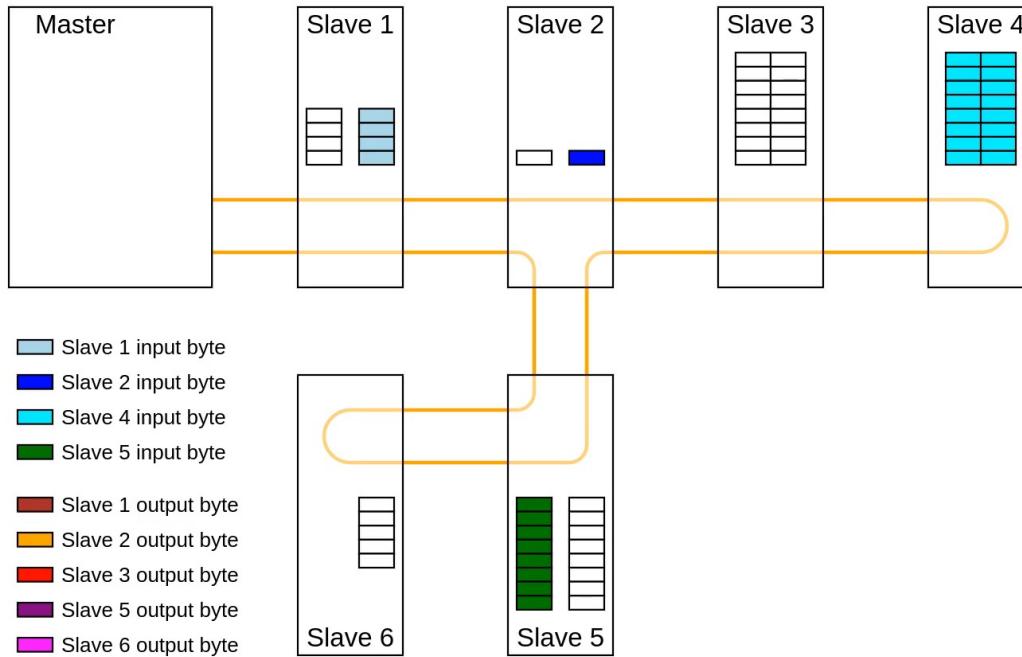
### Key features:

- Full Duplex Communications.
- Master-Slave Architecture.
- Fastest industrial Ethernet technology.
- Suitable for both centralized & decentralized system architectures.
- Wide protocol support (CAN / SERCOS over EtherCAT)
- Proven technology, widely used in many fields (Robotics Power Plants, Wind Turbines, Medical devices etc.).

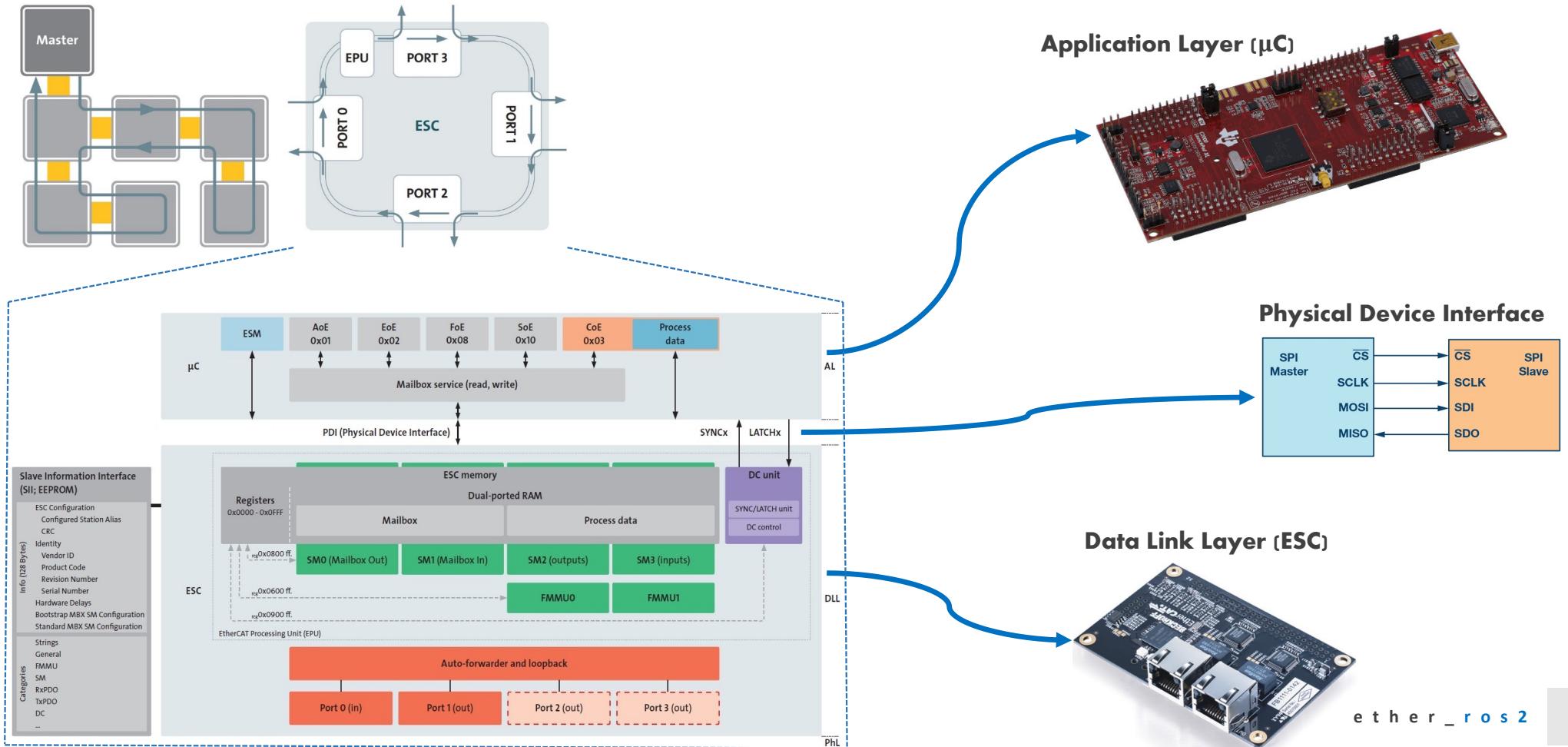
# Why EtherCAT ?



# EtherCAT Functional Principle



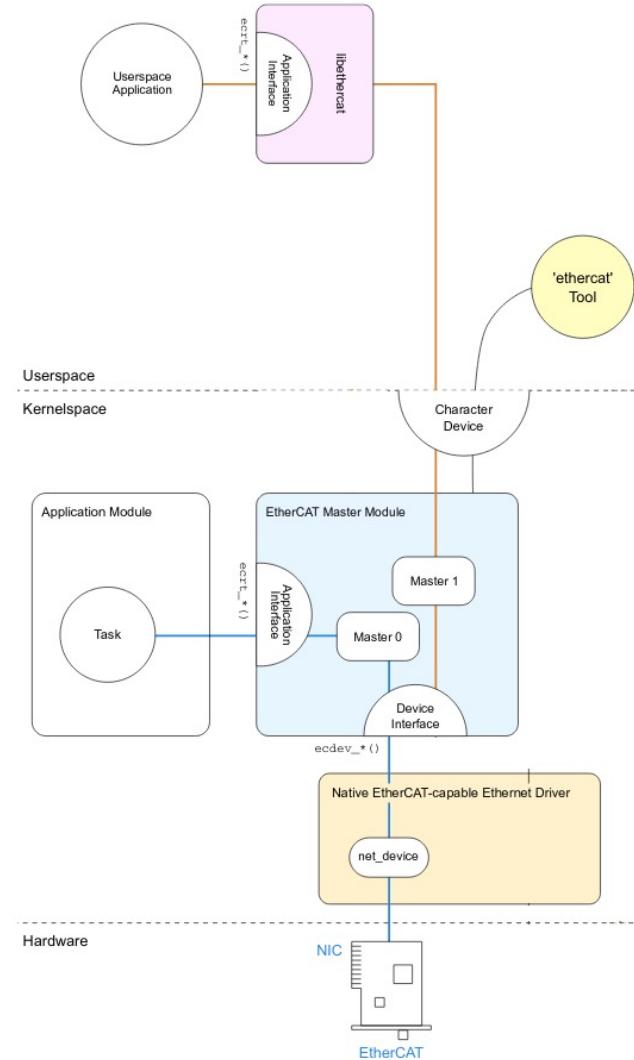
# Typical EtherCAT Slave



# Intro to EtherLab

EtherLab is an Open Source Toolkit for rapid realtime application development under Linux

- Utilizes the **native** Ethernet driver
- Supports **any realtime environment** through independent architecture
- Has **seamless integration** in any GNU/Linux distribution
- Provides virtual read-only **network interface** for **debugging** and traffic **monitoring** purposes
- Provides userspace **command-line tool** 'ethercat'
- **Conforms** to IEC/PAS 62407



# Similar ROS packages for EtherCAT Master

- Deprecated [ROS Industrial SOEM](#)
- [SOEM](#) package
- ANYbotics [forked SOEM](#) package

# Why EtherLab ?

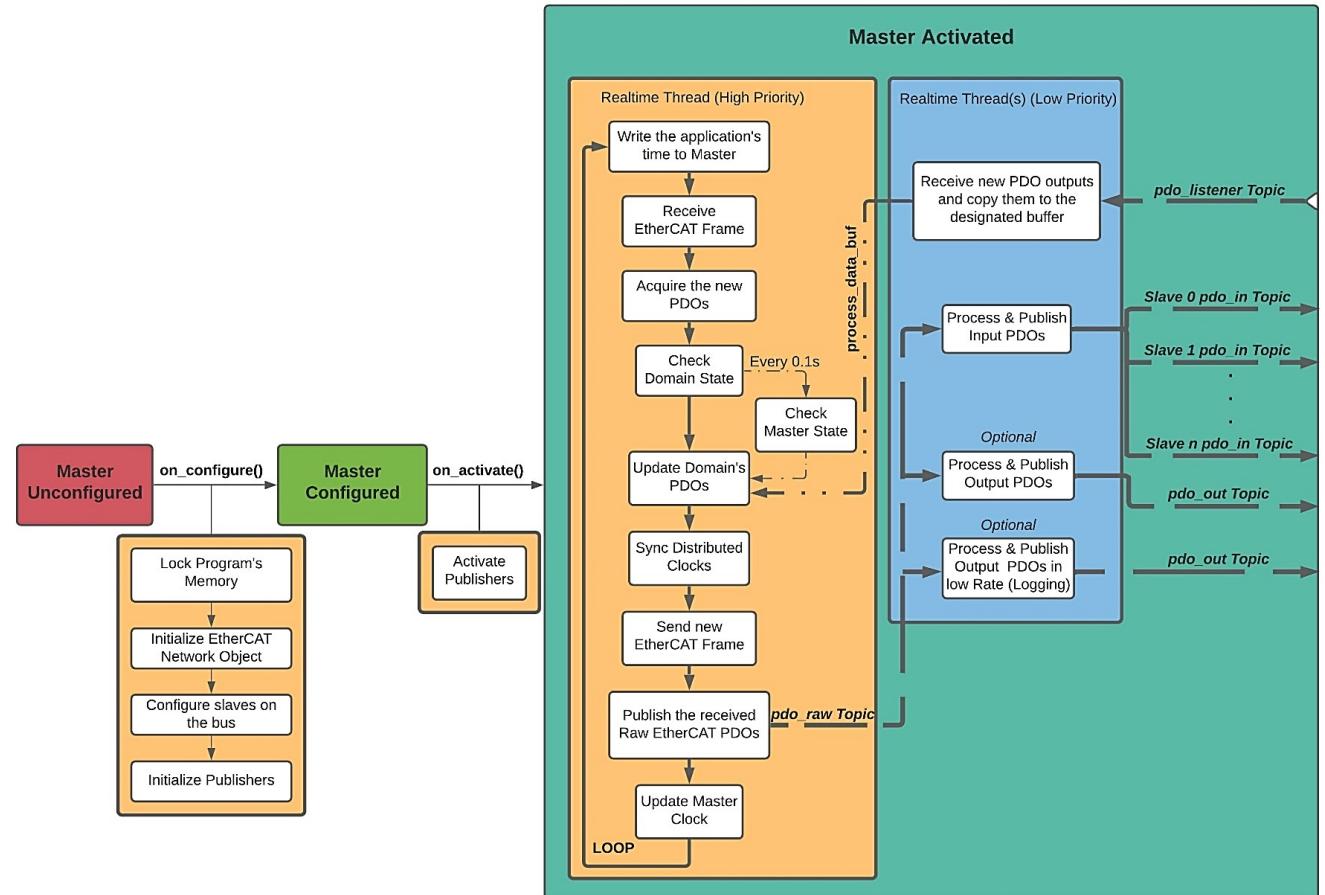
- Designed for [hard realtime applications](#)
- Complete [integrability](#) of EtherCAT protocol
- [Kernel Space runtime](#), with user-space API vs. user-space runtime of SOEM (and its latency drawbacks)
- [Advanced Diagnostic features](#)



# Overview of ether\_ros2 (1/2)

## Highlights

- Composable, Lifecycle Node
- Optimized intra-process communications for minimum latency
- Spinlock protected inter-thread data transactions
- Generic design that can support any application
- Easy to use, modifiable package





# Overview of ether\_ros2 (2/2)

## Topics

- /ether\_ros2/transition\_event
- /pdo\_in\_X
- /pdo\_listener
- /pdo\_out
- /pdo\_raw

## Services

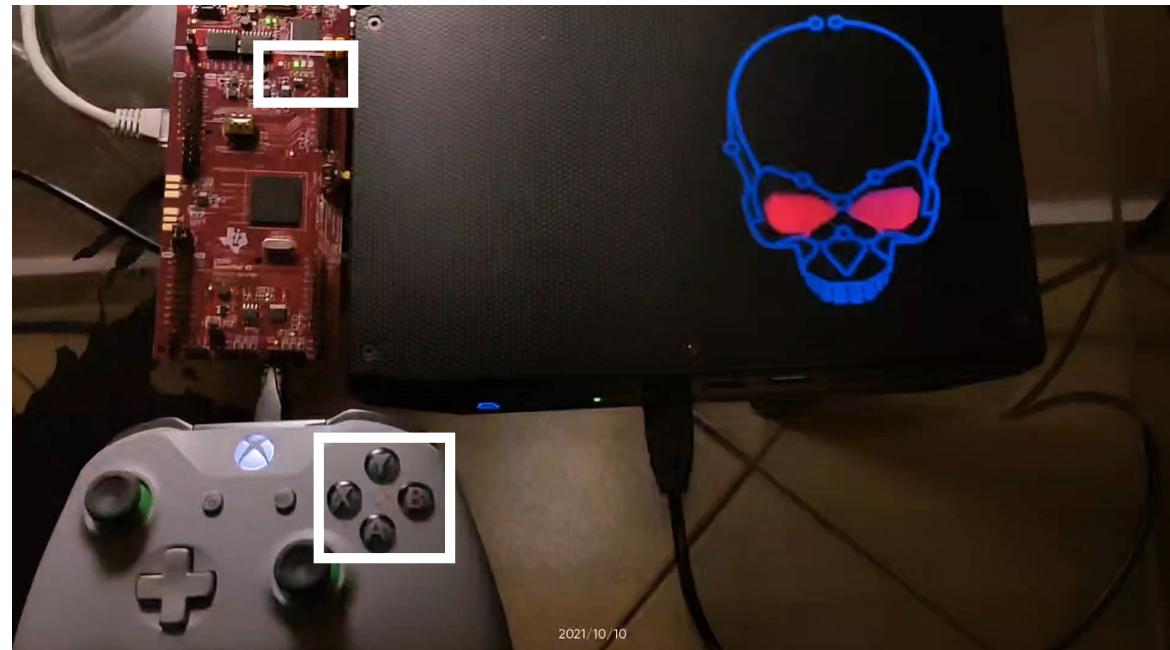
- /ether\_ros2/change\_state
- /ether\_ros2/describe\_parameters
- /ether\_ros2/get\_available\_states
- /ether\_ros2/get\_available\_transitions
- /ether\_ros2/get\_parameter\_types
- /ether\_ros2/get\_parameters
- /ether\_ros2/get\_state
- /ether\_ros2/get\_transition\_graph
- /ether\_ros2/list\_parameters
- /ether\_ros2/set\_parameters

## Messages

- ModifyPdoVariables.msg
- PdoInX.msg
- PdoOut.msg
- PdoRaw.msg

# Simple Example of ether\_ros2

- ether\_ros2 & ether\_ros2\_manager run inside the same container (**high priority**)
- joy\_node runs as another process with **lower priority**





# Adding a New Slave Type in ether\_ros2

Create & Populate Input PDOs' message file

# YAML



## Advantages

- Runtime configuration of the EtherCAT network
- User-Friendly slave configuration method
- No source code modifications

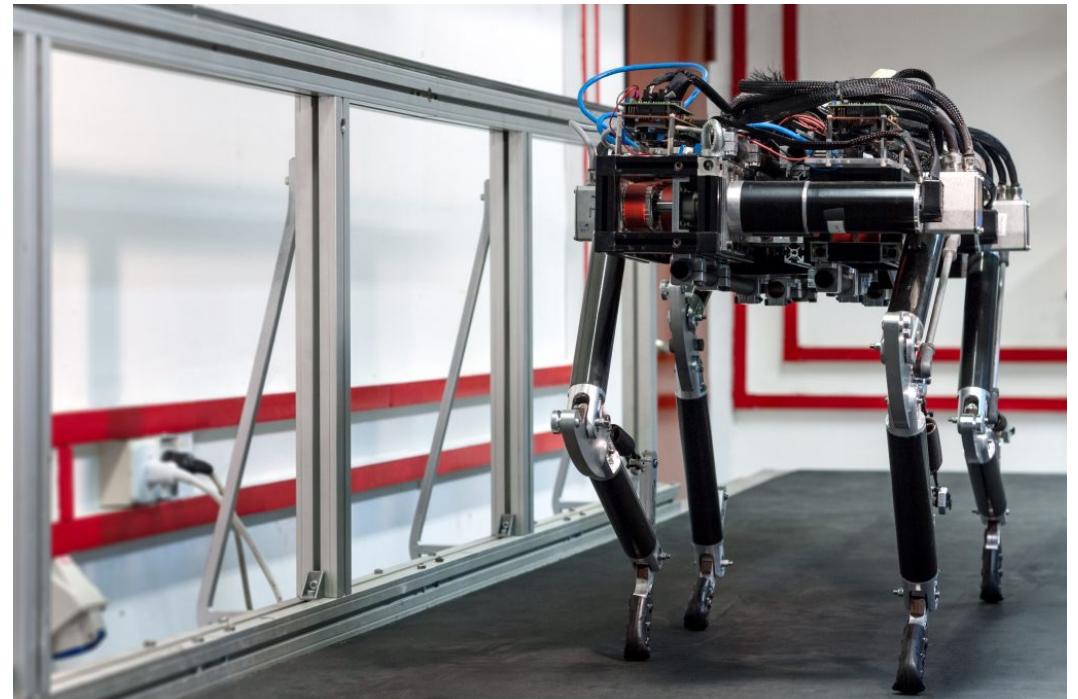
# Laelaps II Quadruped

by legged robots' team @ CSL [[nereus.mech.ntua.gr/legged](http://nereus.mech.ntua.gr/legged)]



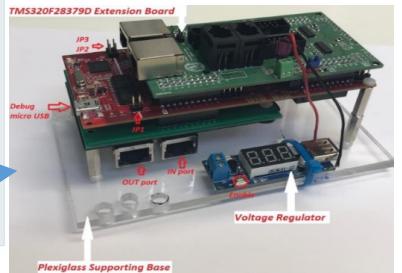
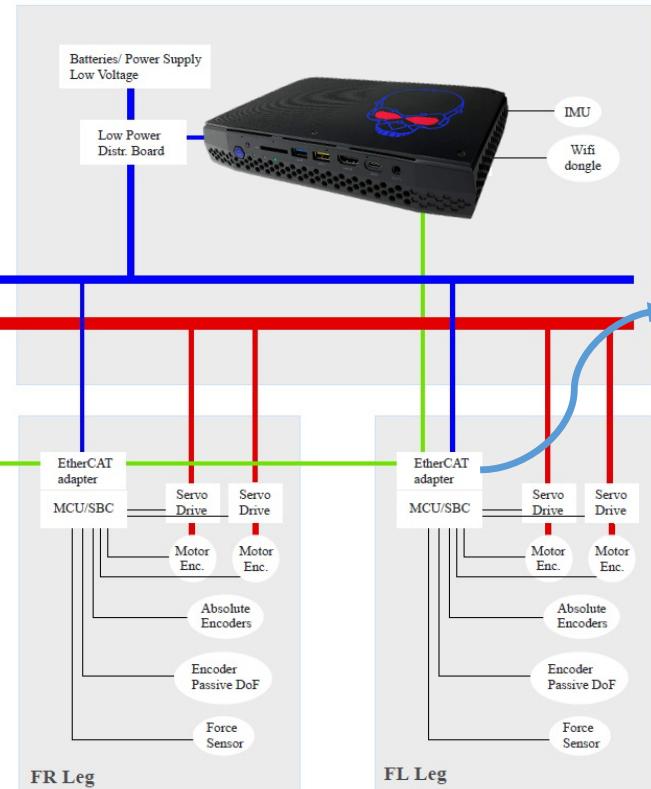
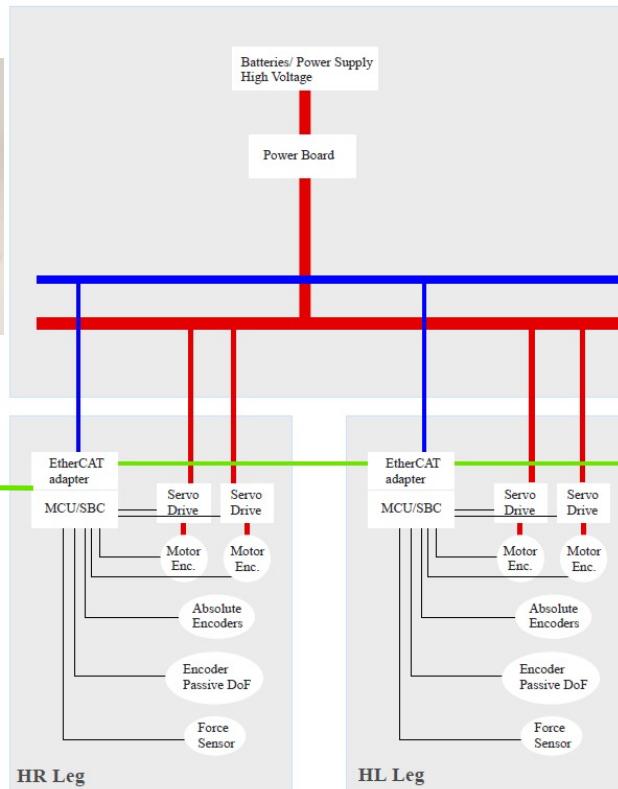
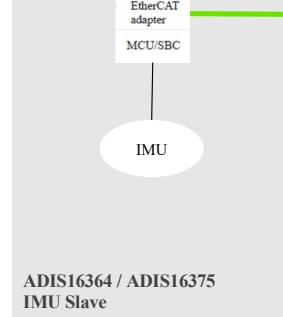
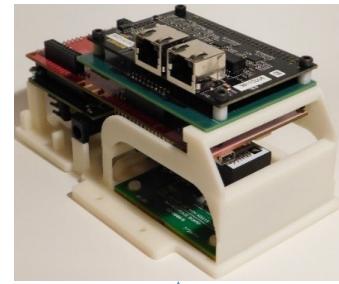
## Decentralized Architecture

- Increased Modularity
- Low Cost
- Higher overall processing power (in parallel)
- Expandability / Flexibility
- Reduced cable count



# Laelaps II Architecture

— High Voltage Power      — Low Voltage Power      — Signals      — EtherCAT Cable



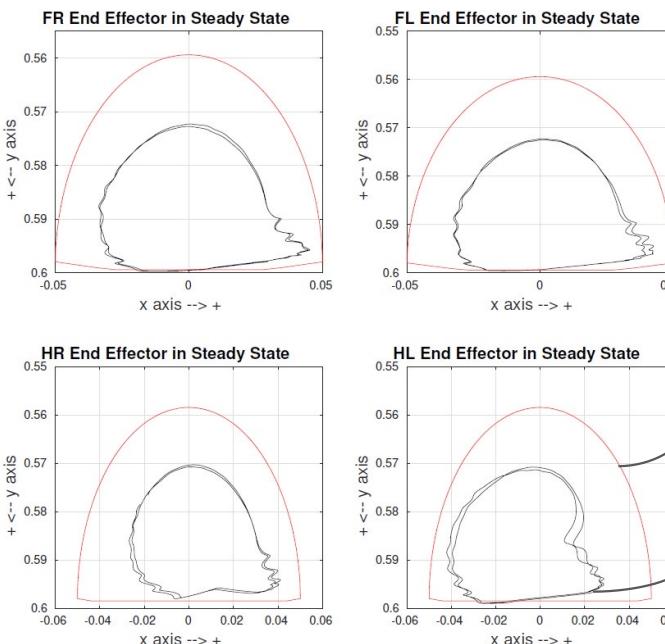
# Full Walking Experiment (1/2)

## Experiment's Details

- Gamepad controlled motion
- Accurate synchronization and steady gait cycles
- Intensive, high throughput operation
- Maximum achieved velocity during trotting: 0.1 [m/s]



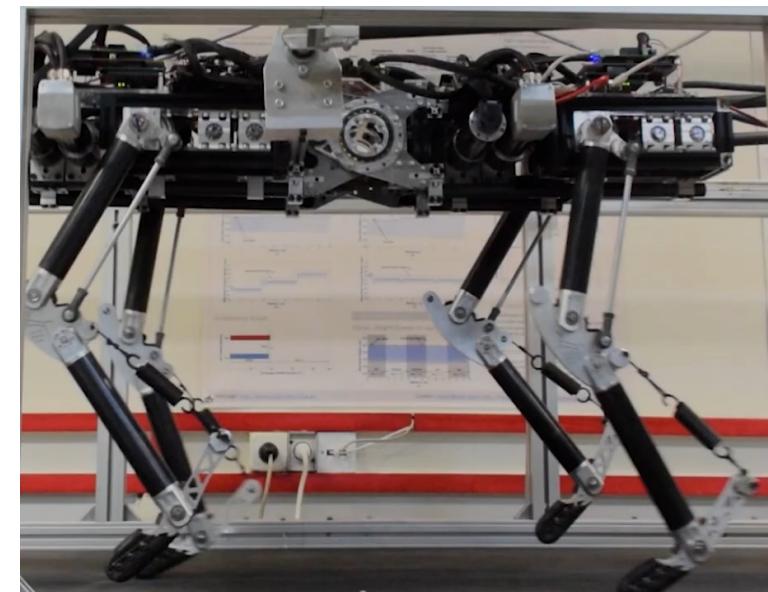
# Full Walking Experiment (2/2)



## Trajectory Planning

- Toes' trajectories controlled & synchronized by the ether\_ros2

Reference trajectory  
Actual trajectory



# Next Steps

- Integrate Quality of Service (QoS) policies to optimize communication among the nodes
- Profile & Measure the latencies of the package to identify and eliminate any potential bottlenecks
- Model the package's behavior to be used in the control design process
- Create tutorials for easy integration of the package to an arbitrary application
- Make it available to the community as a complete & all-in-one EtherCAT Master solution



# Members of the legged team involved in the project



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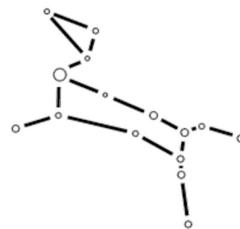


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# THANK YOU



check our work @  
[csl-ep.mech.ntua.gr/legged](http://csl-ep.mech.ntua.gr/legged)

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