New Horizons for European Open Source Robotics
Fraunhofer IPA
The organisation

- Fraunhofer Gesellschaft: the largest applied research organization in Europe
- Non-profit, network of 80+ institutes, 28k+ employees, €2.8B annual budget
- Fraunhofer IPA: focus on Manufacturing Engineering and Automation, €70M+ annual budget, located in Stuttgart – Germany, the “silicon valley of mechatronics”
Fraunhofer IPA
Adapting ROS internally

- Early ROS adopters in Europe (since the late 2000s)
- Developers of service robotics platforms (Care-O-bot)
- Piloting with SwRI the ROS-Industrial concept (2012)
- Managing RIC-EU starting in 2014

In house sw  ROS

Fraunhofer IPA
Bringing ROS into the Industry

2017

2019

2021

Mojin Robotics
Drag & Bot
NODE
ROS-Industrial

Recent achievements and new horizons

Recent Achievements

New Horizons
ROSIN
Making ROS better, business friendlier and more accessible

better

Software Quality
ROS-I best practices and tools: continuous integration, unit testing, code reviews

ROSIN further improves on them with code scanning, automated test generation, model-in-the-loop testing

rosin-project.eu/software-quality-assurance

business friendlier

New components
ROSIN FTPs: 3.5 Million € to third parties for ROS-Industrial development.
Develop missing components or improve existing ones.

Commercial release template (licensing, etc)

rosin-project.eu/ftps

more accessible

Education
ROSIN summer schools: Educate students

ROS-I academy: Educate professionals

Education projects: Fund your ROS education initiative

rosin-project.eu/education
ROSIN FTP highlights

Universal robots

- Cooperation between UR & FZI
  - Driver with official OEM support
  - Integration of ROS into UR Caps
  - External control
  - Many more

Follow-up activities:
https://github.com/PickNikRobotics/Universal_Robots_ROS2_Driver

<table>
<thead>
<tr>
<th>KPI (github)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributors</td>
<td>23</td>
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<td>Forks</td>
<td>173</td>
</tr>
<tr>
<td>Stars</td>
<td>291</td>
</tr>
</tbody>
</table>
ROSIN FTP highlights
Pilz GmbH & Co. KG

- Project executed by Pilz GmbH & Co. KG
  - Generating LIN, PTP and CIRC trajectories
  - Industrial accuracy and performance

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<thead>
<tr>
<th>KPI (github)</th>
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<tbody>
<tr>
<td>Contributers</td>
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<td>Forks</td>
<td>26</td>
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<tr>
<td>Stars</td>
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</tbody>
</table>

- Follow-up activities:
  https://github.com/ros-planning/moveit/tree/master/moveit_planners/pilz_industrial_motion_planner
ROSIN FTP highlights
Cyberbotics

- Project executed by Cyberbotics
  - Porting of the epuck robot to ROS 2
  - Real and simulated e-puck interfaces in webots
  - ROS2 support for the webots interface

<table>
<thead>
<tr>
<th>KPI (github)</th>
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<tbody>
<tr>
<td>Contributors</td>
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<td>Forks</td>
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</tr>
<tr>
<td>Stars</td>
<td>17</td>
</tr>
</tbody>
</table>

- One of the first robots supporting ROS2
- Webots is now part of ROS core packages (https://www.ros.org/reps/rep-2005.html)
ROSIN FTP results

Checkout https://www.rosin-project.eu/results
Recent achievements and new horizons

Recent Achievements

New Horizons
Cognitive Robotics & AI Innovation Center
ROS-I lighthouse in Baden-Württemberg - Germany

- Pre-funding of 2 M€ acquired in 2019 from regional government
  - Until now 41 transfer projects with companies from BW executed by center (Sick, Pilz, Siemens, ...)

- Follow-up funding of 23 M€ acquired in 2021 for coming four years
  - Approximately 10 M€ are invested in new and improved ROS based technologies
  - 30% of the developments are foreseen for open source release

ROS-Industrial Consortium – Christoph Hellmann Santos – cmh@ipa.fraunhofer.de
## ROS-Industrial Research Activities

**Hybrid model-driven engineering for ROS**

<table>
<thead>
<tr>
<th>Problem</th>
<th>ROS-Industrial Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>No integrated development solution available</td>
<td>Graphical ROS development toolchain</td>
</tr>
<tr>
<td>ROS-based robot systems are complex to understand</td>
<td>Graphical modeling of ROS-systems and -components</td>
</tr>
<tr>
<td>Ecosystem packages not modeled</td>
<td>Model-extraction using static and dynamic analysis approaches</td>
</tr>
<tr>
<td>MBSE is not common in the ROS community</td>
<td>Generation of boilerplate code for hand-written nodes</td>
</tr>
<tr>
<td>Testing by trial-and-error method</td>
<td>Validation of the composition and autogeneration of deployment artifacts</td>
</tr>
</tbody>
</table>

**Contact:**

Nadia Hammoudeh García  
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hhg@ipa.fraunhofer.de

**Technology readiness:**

- **ROS1:** Tested  
- **ROS2:** Under development

**Sources:**

https://github.com/ipa320/ros-model
Hybrid model-driven engineering for ROS

Step 1: Model-extraction

Step 2: Graphical ROS system design

Step 3: Generating ROS files

Launchfiles
- .launch

Python boilerplate code
- .py

C++ boilerplate code
- .cpp

Folder

ROS workspace structure

ROS-Industrial Research Activities

ROS-Industrial Consortium – Christoph Hellmann Santos – cmh@ipa.fraunhofer.de
ROS-Industrial Research Activities
Model-based observer generation

Goal:
- Model-based diagnosis and monitoring framework for running ROS systems

Features:
- **ROS Graph Observer:** Continuous evaluation of ROS components and interfaces
- **Property Observer:** Design-time application-independent generation of property observers (ranges or complex functions)
- **Integration** with common ROS diagnostics tools

Contact:
Harshavardhan Deshpande
+49 711 970-3737
hsd@ipa.fraunhofer.de

Technology readiness:
- **ROS1:** Tested – Documentation in progress
- **ROS2:** Under development

Sources:
https://github.com/rosin-project/rosgraph_monitor
Model-based observer generation

ROS Graph Observer

- **ROS Graph Observer**
  - **rosgraph_monitor**
    - **desired. rossystem**
      - **Model interpreter**
        - **Model comparison**
          - **Controlled rossystem**
            - **Trigger**
              - **Current. rossystem**
                - **Diagnostic_msg**
                  - **Diagnostic_aggregator**
                    - **Running ROS System**
                      - **Toplevel System diagnostics**

Property Observer

- **Property Observer**
  - **Running ROS System**
    - **ros_graph_parser**
      - **battery.properties, value**
        - **Battery Monitor**
          - **Properties, value**
            - **Diagnostics_wrapper**
              - **/power_state (sensor_msgs/BatteryState)**
                - **/diagnostics (diagnostic_msgs/DiagnosticArray)**

ROS-Industrial Consortium – Christoph Hellmann Santos – cmh@ipa.fraunhofer.de
## ROS development roadmap

<table>
<thead>
<tr>
<th>2021</th>
<th>2022</th>
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<tbody>
<tr>
<td><strong>ROS2 Model-Driven Development:</strong></td>
<td><strong>ROS2 Model-Driven Development:</strong></td>
</tr>
<tr>
<td>• Component model extraction</td>
<td>• Modeling Hardware characteristics</td>
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<tr>
<td>• Interface Documentation generation</td>
<td>• Kinematic model generation (URDF)</td>
</tr>
<tr>
<td>• Launchfile generation</td>
<td>• Deployment artifact generation</td>
</tr>
<tr>
<td>• Runtime checkers</td>
<td>• Automated redundant deployment</td>
</tr>
<tr>
<td></td>
<td>• Gluecode and monitors generation</td>
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</tbody>
</table>

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**ROS2 Runtime Reliability:**
- Automated redundant deployment
- Gluecode and monitors generation

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**Cognitive Robotics & AI Innovation Center**

 ROS-Industrial Consortium – Christoph Hellmann Santos – cmh@ipa.fraunhofer.de
Easy programming for welding robots
- Seam detection
- Collision-free, optimal path planning
- Work piece pose detection
- Easy programming through ROS integration in UR caps

Want to test?
- Contact: Johannes.Stoll@ipa.fraunhofer.de
ROS 2 Industrial Training

**Description**

The ROS 2 Industrial Training teaches the basics of ROS 2 and how to use ROS 2 for manipulation and for navigation. The class is completed by a session of best practices, which teaches how ROS 2 development is done best. The goal of the training is to get all the information needed to start developing with ROS.

Attendees should have basic knowledge:
- Linux and Terminal
- Python

**Cost:**
- 800 € (Remote), 1200 € (Presence), 0 € (ROS-I Members)

**Planned trainings in 2021:**
- 09. – 12.03.2021 (Remote)
- 18. – 21.05.2021 (Remote)
- 21. – 24.09.2021 (TBD)
- 16. – 19.11.2021 (TBD)

**Agenda**

<table>
<thead>
<tr>
<th>Day</th>
<th>Courses</th>
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<tbody>
<tr>
<td>Day 1</td>
<td>09:00 – 16:30</td>
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<tr>
<td></td>
<td>ROS 2 basic concepts</td>
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<tr>
<td></td>
<td>ROS 2 file system</td>
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<td>ROS 2 terminal</td>
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<td>Day 2</td>
<td>09:00 – 16:30</td>
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<tr>
<td></td>
<td>ROS 2 extended concepts</td>
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<td>ROS 2 handling coordinates with tf2</td>
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<td>ROS 2 manipulation basics</td>
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<td>Day 3</td>
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<td>ROS 2 navigation basics and localization</td>
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<td>ROS 2 navigation</td>
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<td>Day 4</td>
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<td>ROS 2 Best practices</td>
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