Robot modularity with Xilinx and H-ROS

Industrial, Vision Focus Applications

"Xilinx dominates the Industrial IoT market with an 80% share." -marketrealist.com, July 2017

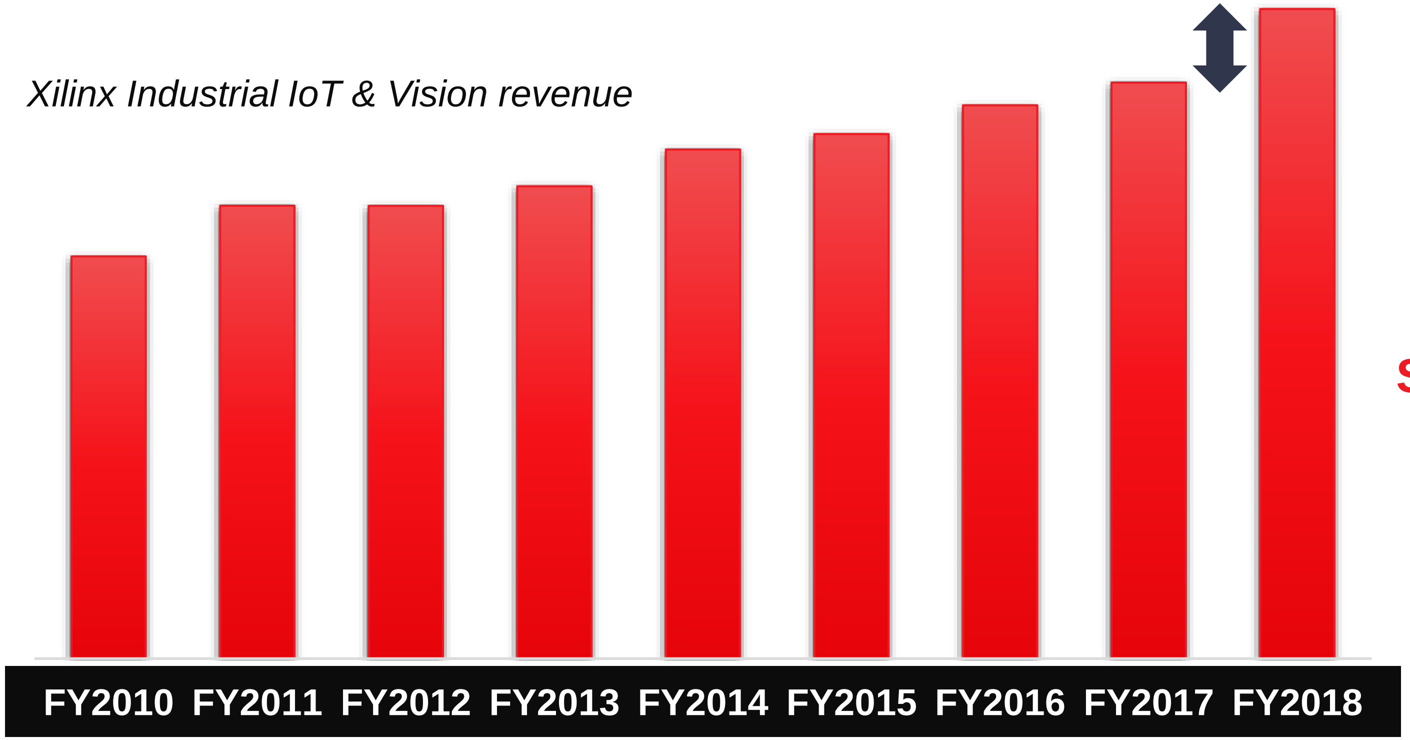
Robotics

- Principles driving Modern Robot Development
  - **Easy to develop** software framework
  - Precise, **deterministic control** over scalable number of axes of motion
  - Connectivity over Industrial Ethernet incl. **Time-Sensitive Networking** (TSN)
  - Diverse sensor inputs, enabling **sensor fusion**
  - Real-time analytics and **machine learning** supporting predictive maintenance
  - Support for complementary **Edge and Cloud Intelligence**
  - Compliance for **functional safety and cybersecurity**
  - Integrated human machine interface (**HMI**) incl. voice recognition
  - Smaller physical **footprint** and power through highest levels of integration
  - Extended **lifecycle**
  - **Reliability** over harsh environments

…and Modularity

More Industrial Customers are Choosing Xilinx

Explosive Zynq® SoC design win activity beginning production ramp in FY2018



ZYNQ™ ZYNQ® UltraSCALE+

Scalable IIoT Platforms from Edge to Cloud

- Security Processor
- Safety Processor
- GPGPU
- General Purpose Processor
- DSP/ GPU
- Analog

Traditional Role of Xilinx FPGAs as Companion Chip

Interfaces:
Custom IO + Industrial Communications

Since FY2013: SoC Integration of Additional Functions

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Scalable Platforms Increase Development Efficiency

Industry Challenge

> Develop a scalable platform across multiple Industrial IoT products

> Minimize development costs, especially software development

Xilinx Differentiated Solution

> Scalable embedded platform enabling reuse across product portfolio

> Xilinx and Ecosystem building blocks to accelerate designs

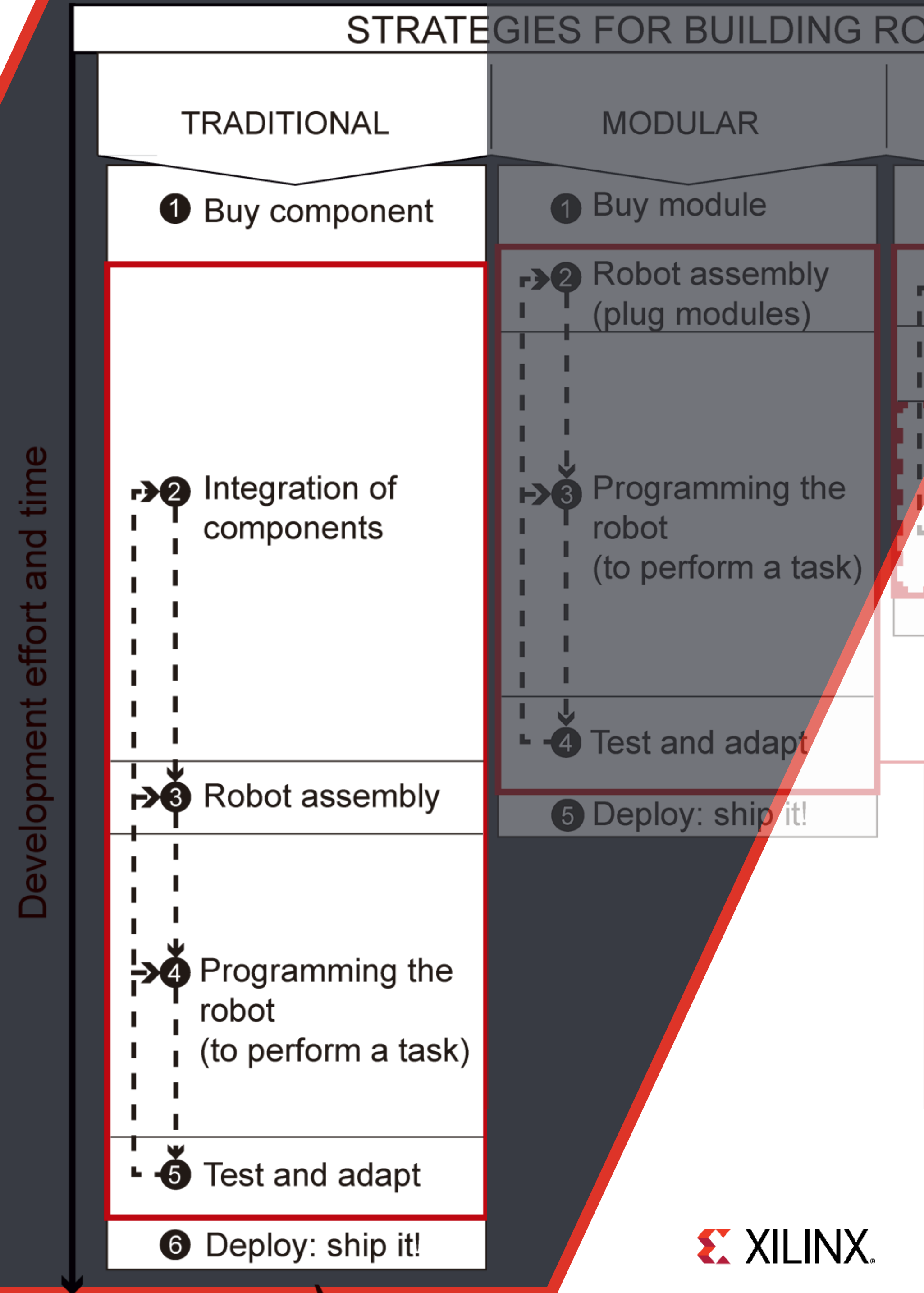
> Long lifecycle silicon with world-class quality and reliability

> Single chip support for full breadth of IIoT requirements

Agenda

- >**Insight and perspective on the robotics landscape**
- >**H-ROS, a solution for robot modularity**
- >The **H-ROS SoM**, empowering robot modularity
- >Capabilities of the new **MARA modular *cobot***
- >A special limited time offer

System integration **supersedes many other tasks** when building a robot



[1] Mayoral, V., Kojcev, R., Etxezarreta, N., Hernández, A., & Zamalloa, I. (2018). Towards self-adaptable robots: from programming to training machines. arXiv preprint arXiv:1802.04082. https://arxiv.org/pdf/1802.04082.pdf

[2] Mayoral, V., Kojcev, R., Hernández, A., Zamalloa, I., Bilbao, A.. (2018, August).Modular And Self-Adaptable (MASA) strategy for building robots. In Adaptive Hardware and Systems (AHS), 2018 NASA/ESA Conference.

Programming robots has been the focus for the last decade

[1] Mayoral, V., Kojcev, R., Etxezarreta, N., Hernández, A., & Zamalloa, I. (2018). Towards self-adaptable robots: from programming to training machines. arXiv preprint arXiv:1802.04082. https://arxiv.org/pdf/1802.04082.pdf

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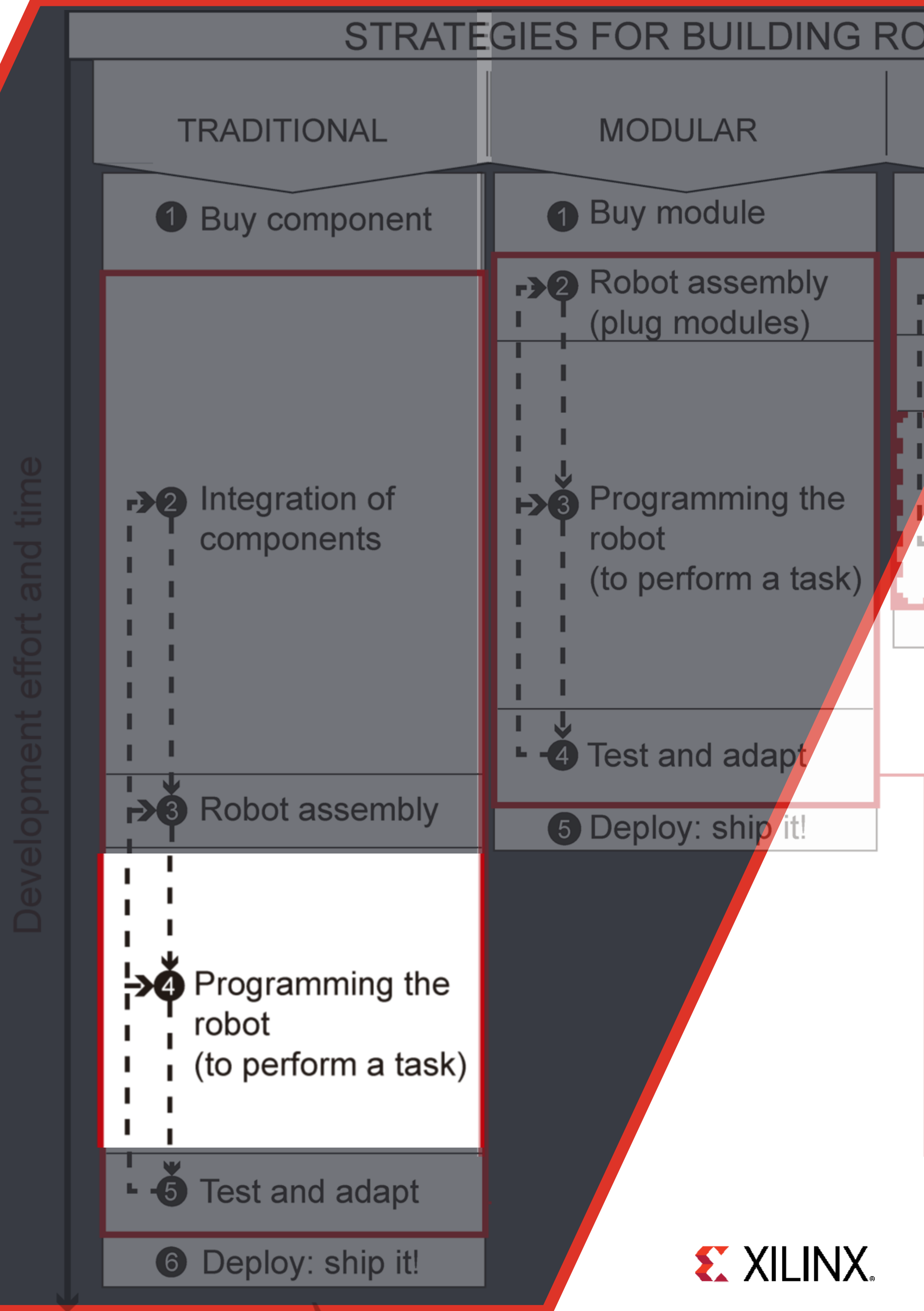
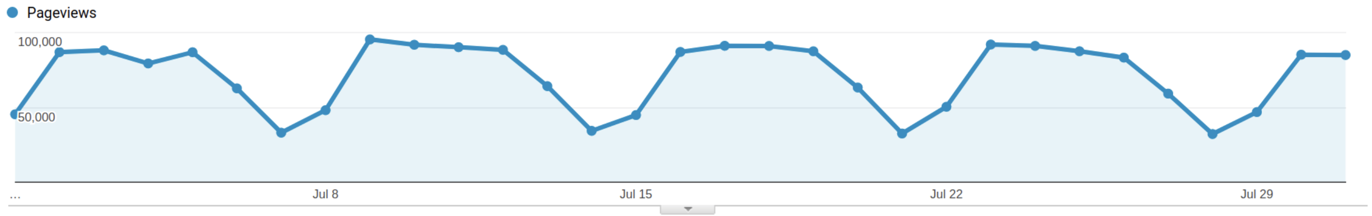


What is **ROS?**

Source: http://ros.org

What is **ROS?**

wiki.ros.org Visitors: July 2018



Pageviews	Unique Pageviews	Avg. Time on Page	Bounce Rate	% Exit
2,204,869	1,682,363	00:02:54	45.81%	29.18%

Site Content

Page

Page Title

Site Search

Search Term

Events

Event Category

	Page	Pageviews	% Pageviews
1.	/ROS/Tutorials	103,620	4.70%
2.	/	62,152	2.82%
3.	/kinetic/Installation/Ubuntu	55,985	2.54%
4.	/ROS/Installation	43,803	1.99%
5.	/kinetic/Installation	37,048	1.68%
6.	/cn/ROS/Tutorials	32,001	1.45%
7.	/ROS/Tutorials/InstallingandConfiguringROSEnvironment	29,558	1.34%
8.	/ROS/Tutorials/CreatingPackage	25,635	1.16%
9.	/ROS/Tutorials/WritingPublisherSubscriber(c++)	21,841	0.99%
10.	/ROS/Tutorials/NavigatingTheFilesystem	17,345	0.79%

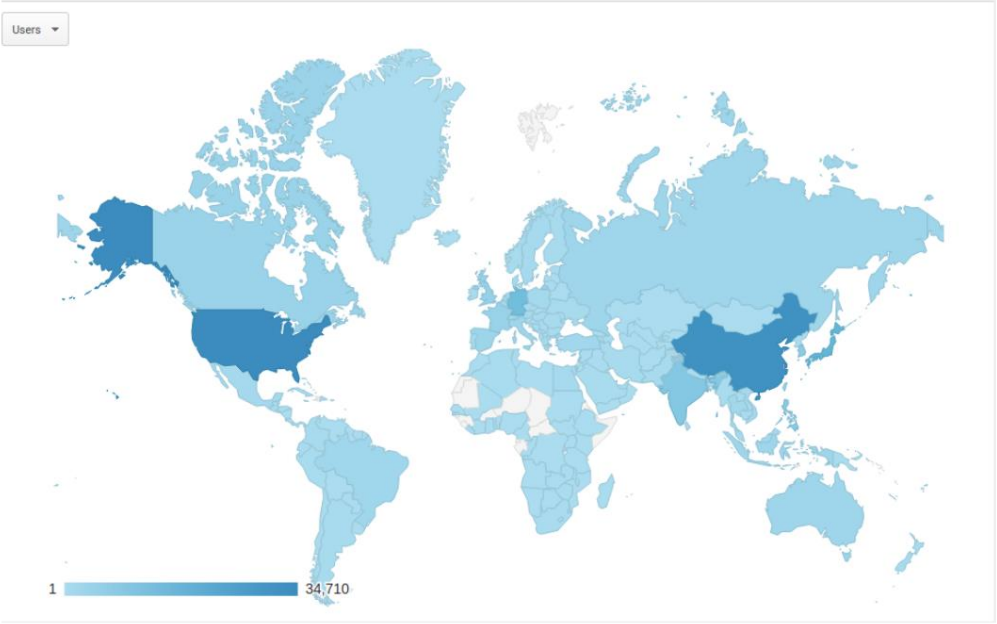
Site: wiki.ros.org
Source: Google Analytics
Annual Growth: 21%

Source: http://download.ros.org/downloads/metrics/metrics-report-2018-07.pdf

What is **ROS?**

1.	United States	34,710	(19.08%)
2.	China	31,946	(17.56%)
3.	Japan	15,518	(8.53%)
4.	Germany	12,711	(6.99%)
5.	India	8,400	(4.62%)
6.	Philippines	7,235	(3.98%)
7.	South Korea	6,790	(3.73%)
8.	United Kingdom	4,325	(2.38%)
9.	Taiwan	4,233	(2.33%)
10.	France	3,725	(2.05%)
11.	Canada	3,354	(1.84%)
12.	Spain	2,955	(1.62%)
13.	Singapore	2,842	(1.56%)
14.	Italy	2,744	(1.51%)
15.	Russia	2,465	(1.35%)
16.	Indonesia	2,461	(1.35%)
17.	Australia	2,436	(1.34%)
18.	Brazil	2,231	(1.23%)
19.	Hong Kong	2,147	(1.18%)
20.	Turkey	1,928	(1.06%)
21.	Netherlands	1,511	(0.83%)
22.	Thailand	1,437	(0.79%)
23.	Poland	1,335	(0.73%)
24.	Switzerland	1,242	(0.68%)
25.	Vietnam	1,125	(0.62%)

wiki.ros.org visitor locations:



Source: Google Analytics
Site: wiki.ros.org in July 2018

6

Source: http://download.ros.org/downloads/metrics/metrics-report-2018-07.pdf

ROS already addresses many of the programming needs

[1] Mayoral, V., Kojcev, R., Etxezarreta, N., Hernández, A., & Zamalloa, I. (2018). Towards self-adaptable robots: from programming to training machines. arXiv preprint arXiv:1802.04082. https://arxiv.org/pdf/1802.04082.pdf

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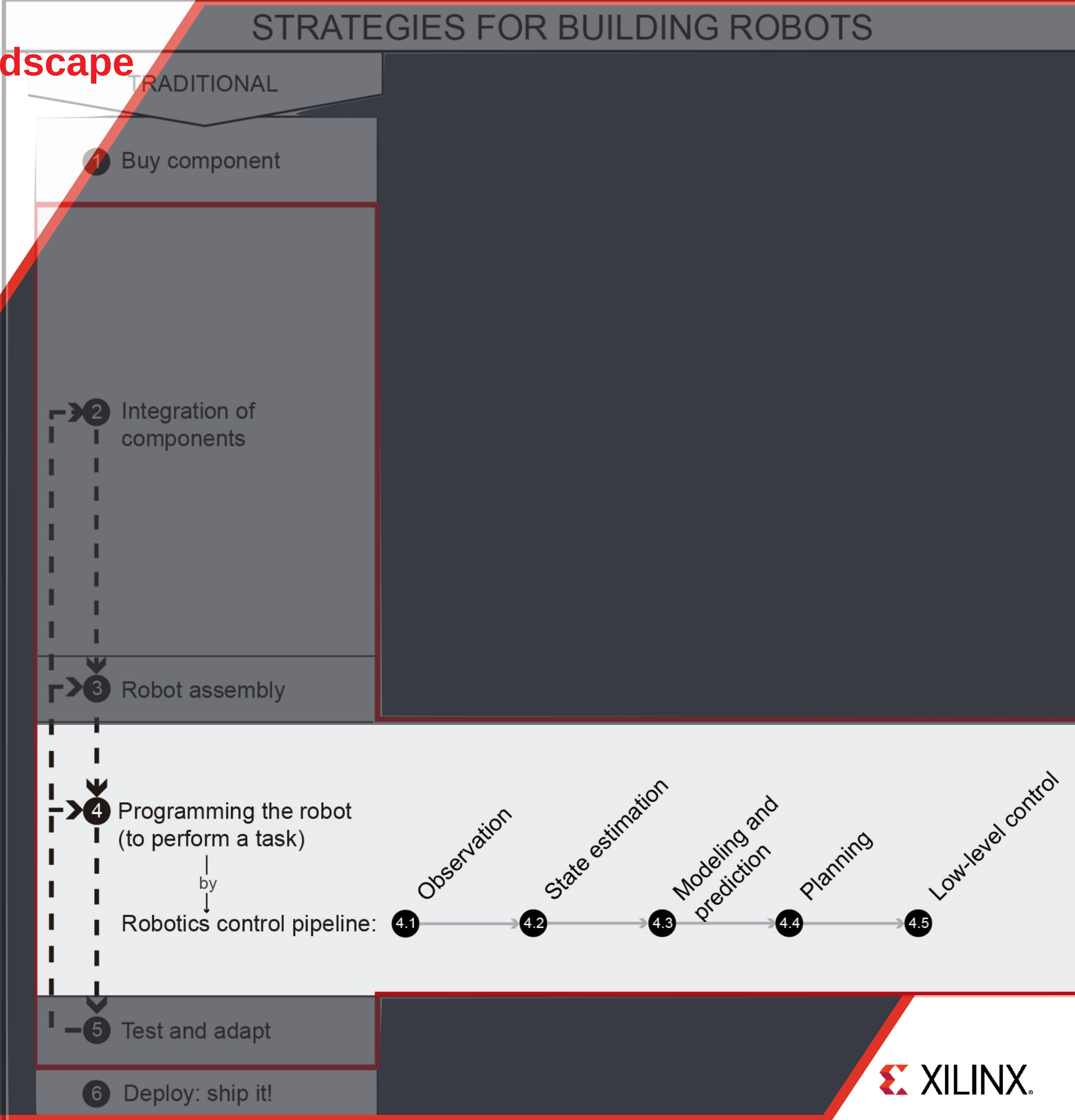

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System integration **goes beyond programming robots**

[1] Mayoral, V., Kojcev, R., Etxezarreta, N., Hernández, A., & Zamalloa, I. (2018). Towards self-adaptable robots: from programming to training machines. arXiv preprint arXiv:1802.04082. https://arxiv.org/pdf/1802.04082.pdf

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STRATEGIES FOR BUILDING ROBOTS

Modularity for system integration

XILINX. Acutronic Robotics

Modularity reduces the integration effort

[1] Mayoral, V., Kojcev, R., Etxezarreta, N., Hernández, A., & Zamalloa, I. (2018). Towards self-adaptable robots: from programming to training machines. arXiv preprint arXiv:1802.04082.
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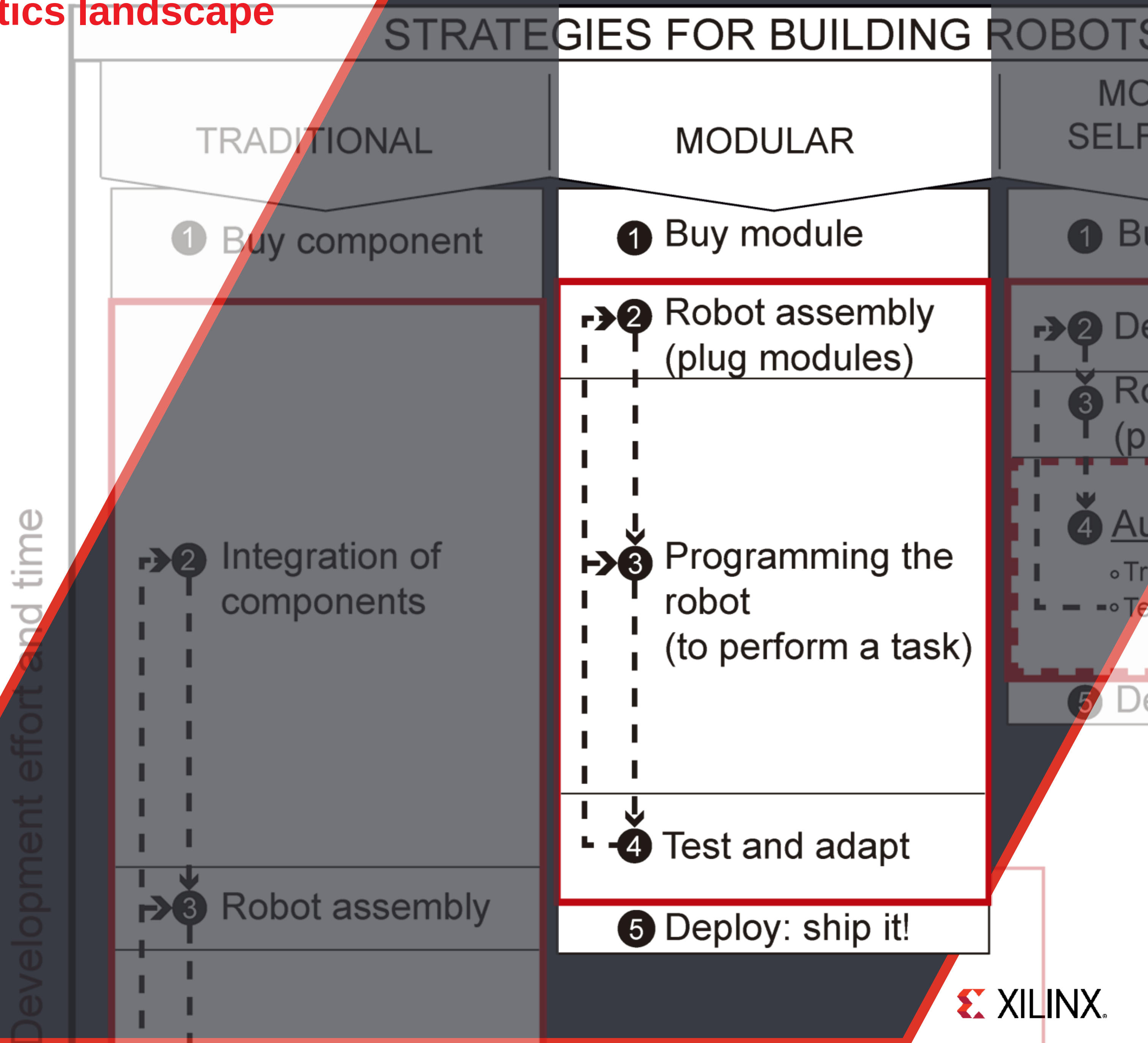


H-ROS, a solution for robot modularity

H-ROS, a solution for robot modularity

H-ROS

Functional safety and security

Hardware architecture

OS/RTOS and hypervisor

Middleware and analytics

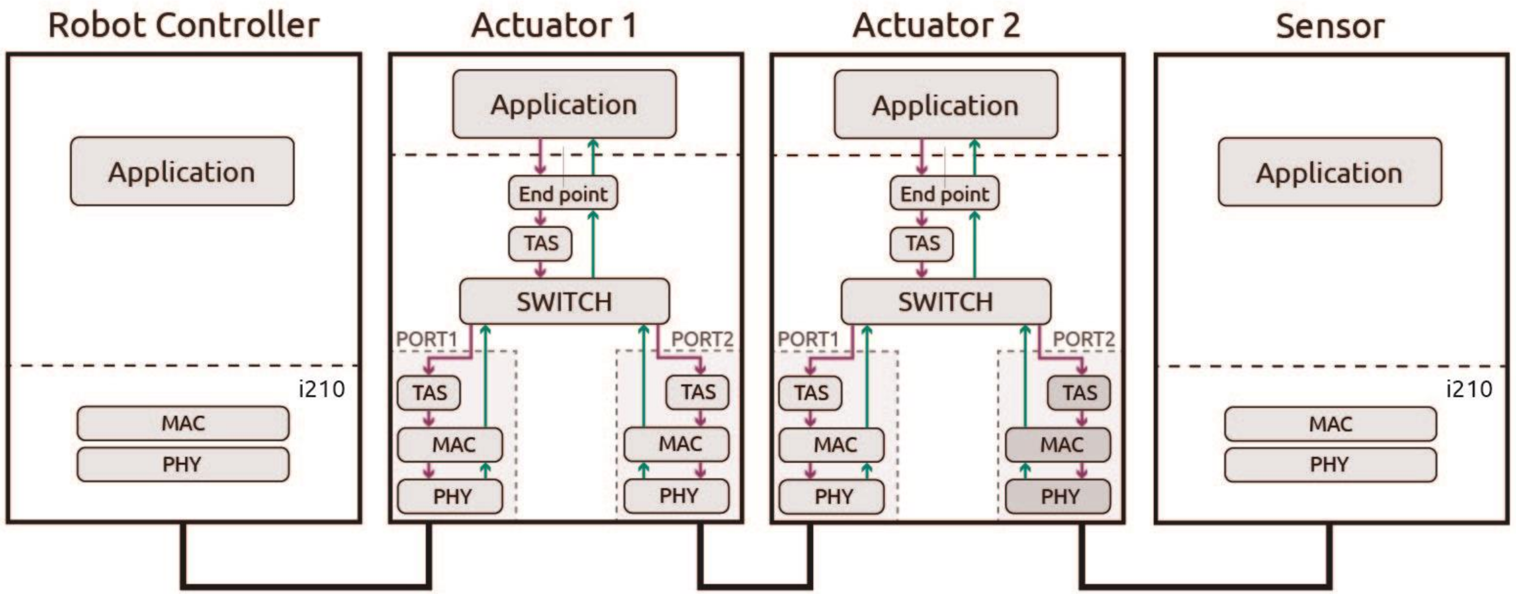
Application acceleration and machine learning

Advantages of H-ROS

Real-time capable link

H-ROS

Real-time capable link layer



[3] Gutiérrez, C. S. V., Juan, L. U. S., Ugarte, I. Z., & Vilches, V. M. (2018). Time-Sensitive Networking for robotics. *arXiv preprint arXiv:1804.07643*.

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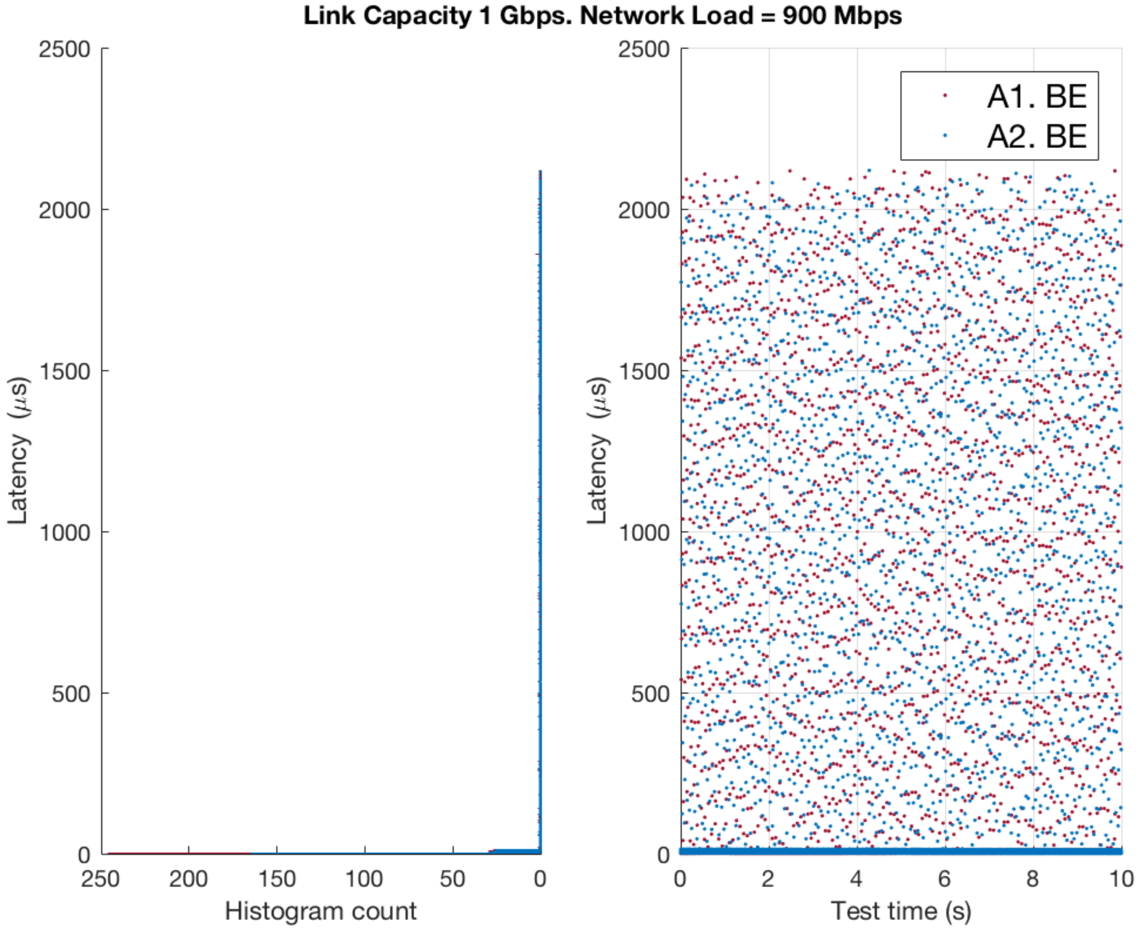
Real-time capable link layer



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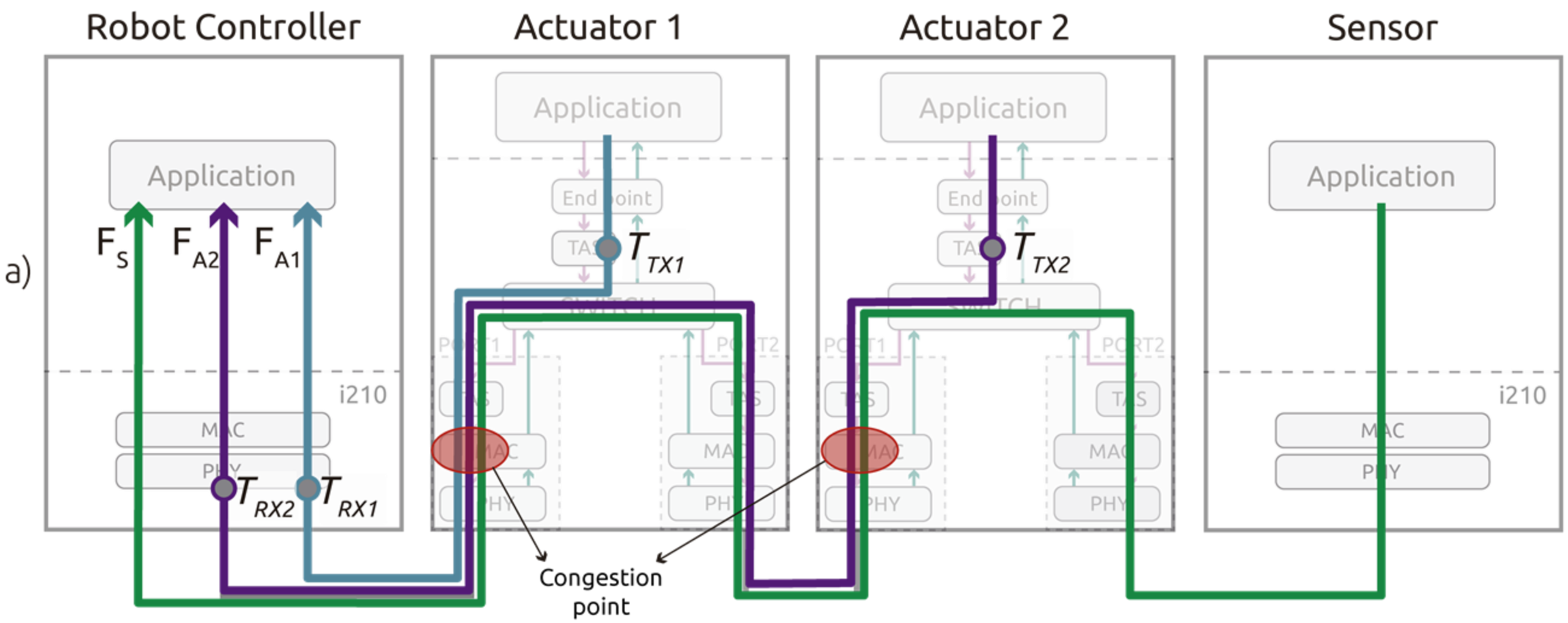
Real-time capable link layer



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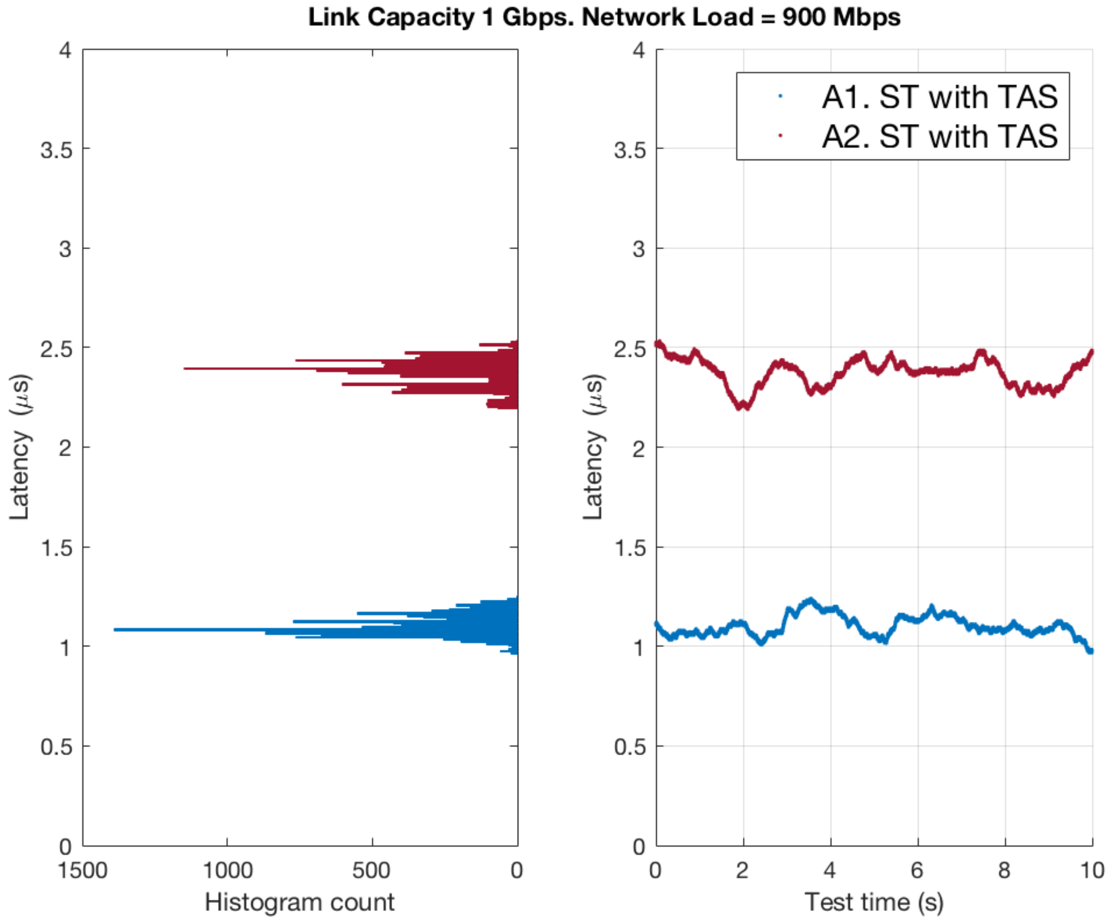
Real-time capable link layer



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Advantages of H-ROS

Safety
and security

Safety and Security

1 Safety: ISO 12100, ISO 10218

2 Security: ISO/IEC 27032, SP800-37

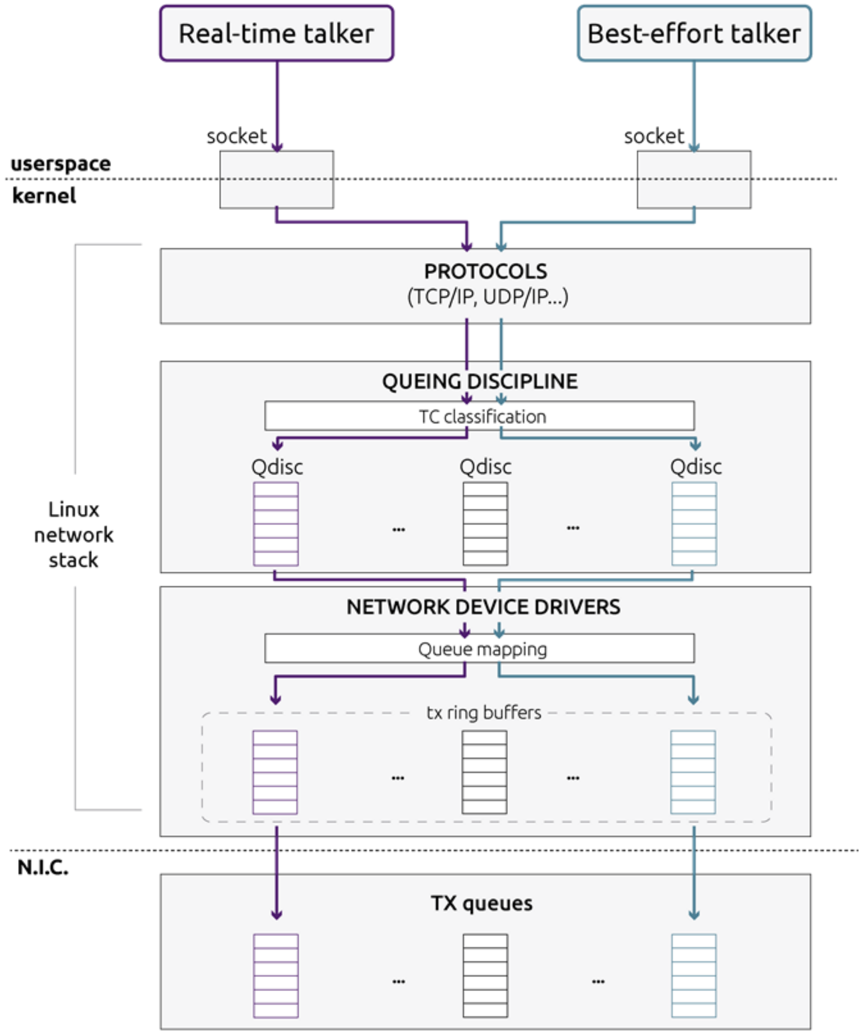
3 Modularity: ISO 22166

Advantages of H-ROS

RTOS and networking stack

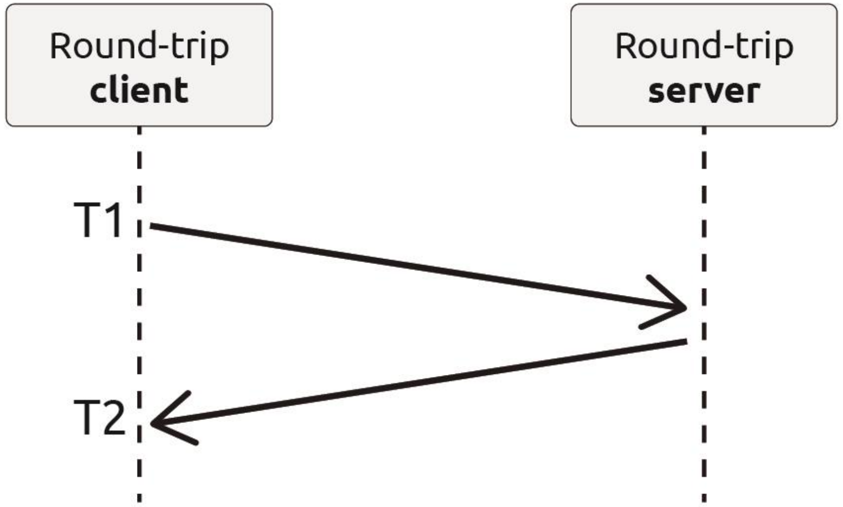
H-ROS, a solution for robot modularity

RTOS & networking stack



[4] Gutiérrez, C. S. V., Juan, L. U. S., Ugarte, I. Z., & Vilches, V. M. (2018). Real-time Linux communications: an evaluation of the Linux communication stack for real-time robotic applications. arXiv preprint arXiv:1808.10821.

RTOS & networking stack: test setup

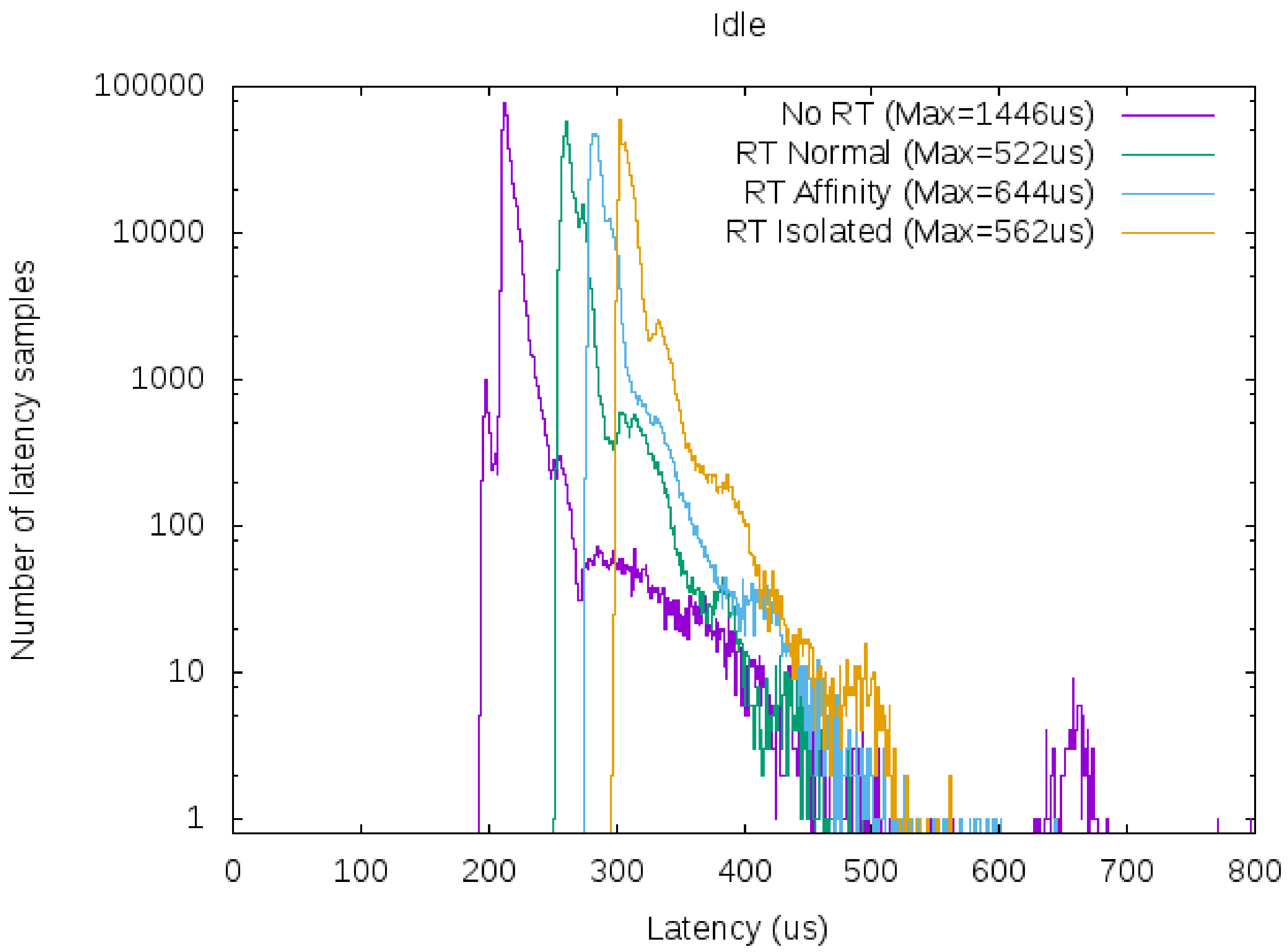


- **no-rt**, we use a vanilla kernel.
- **rt-normal**, we use a PREEMPT-RT kernel without binding the round-trip programs and network IRQs to any CPU.
- **rt-affinities**, we bind the IRQ thread of the priority queue and the client and server programs to CPU 1 of each device.
- **rt-isolation**, we run the roundtrip application in an isolated CPU.

[4] Gutiérrez, C. S. V., Juan, L. U. S., Ugarte, I. Z., & Vilches, V. M. (2018). Real-time Linux communications: an evaluation of the Linux communication stack for real-time robotic applications. arXiv preprint arXiv:1808.10821.

H-ROS, a solution for robot modularity

RTOS & networking stack: idle system



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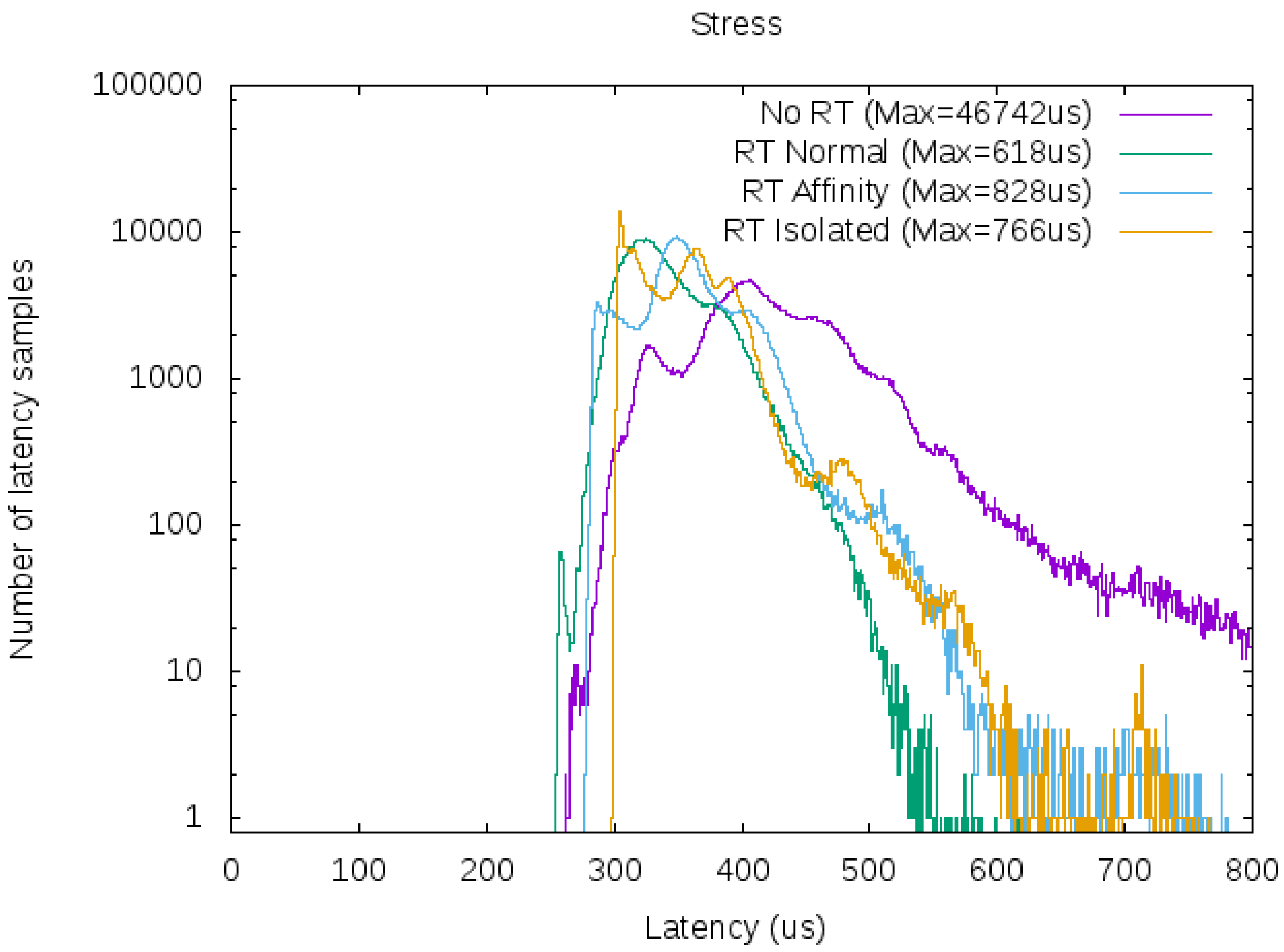
H-ROS, a solution for robot modularity

RTOS & networking stack: stressed system



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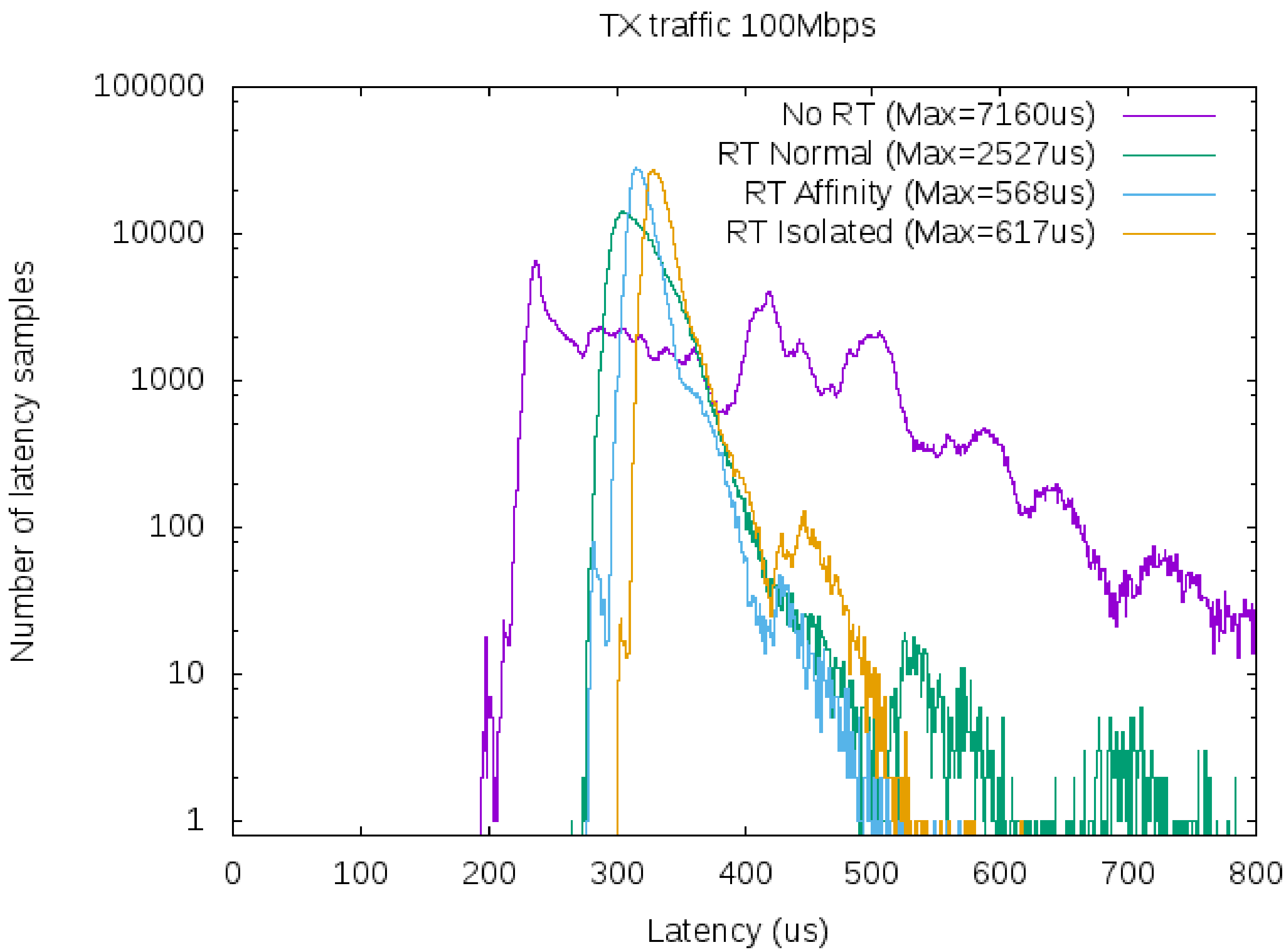
RTOS & networking stack: concurrent traffic



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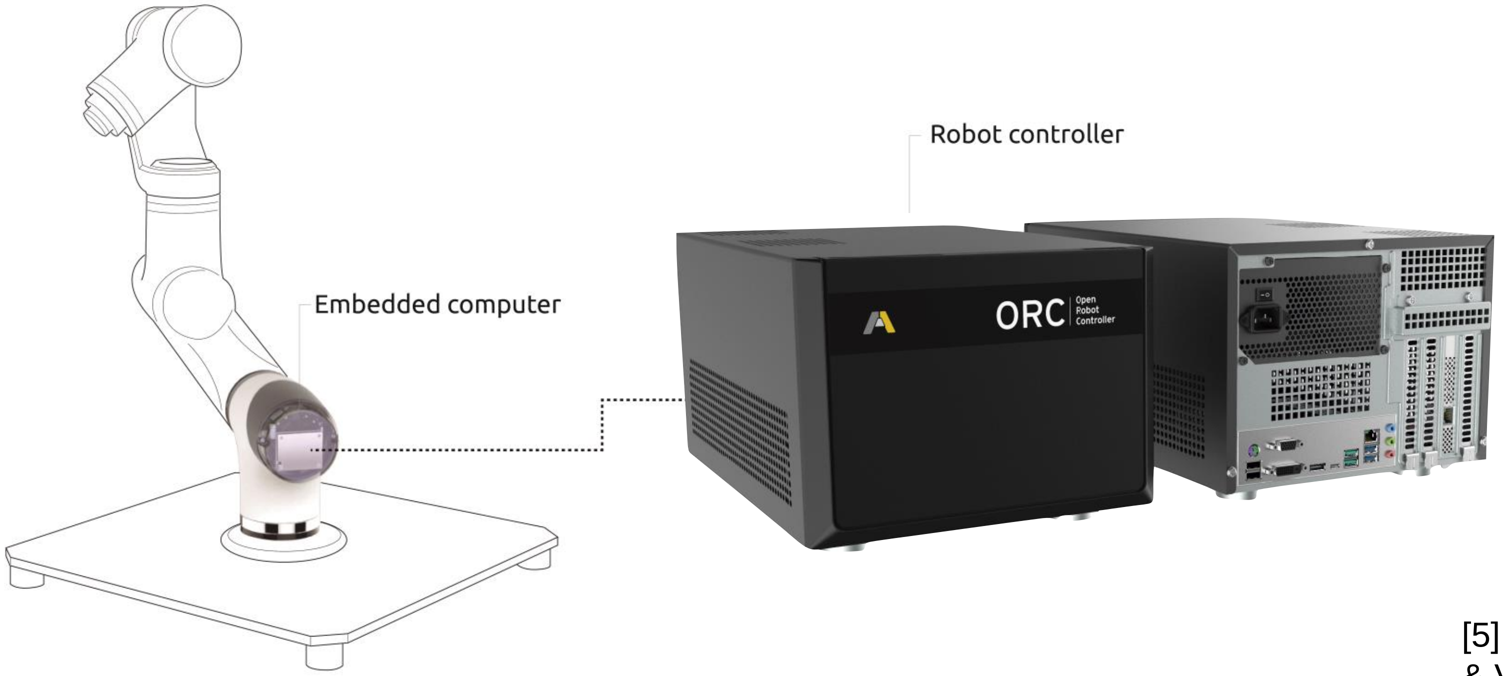
Advantages of H-ROS

Real-time robotics middleware

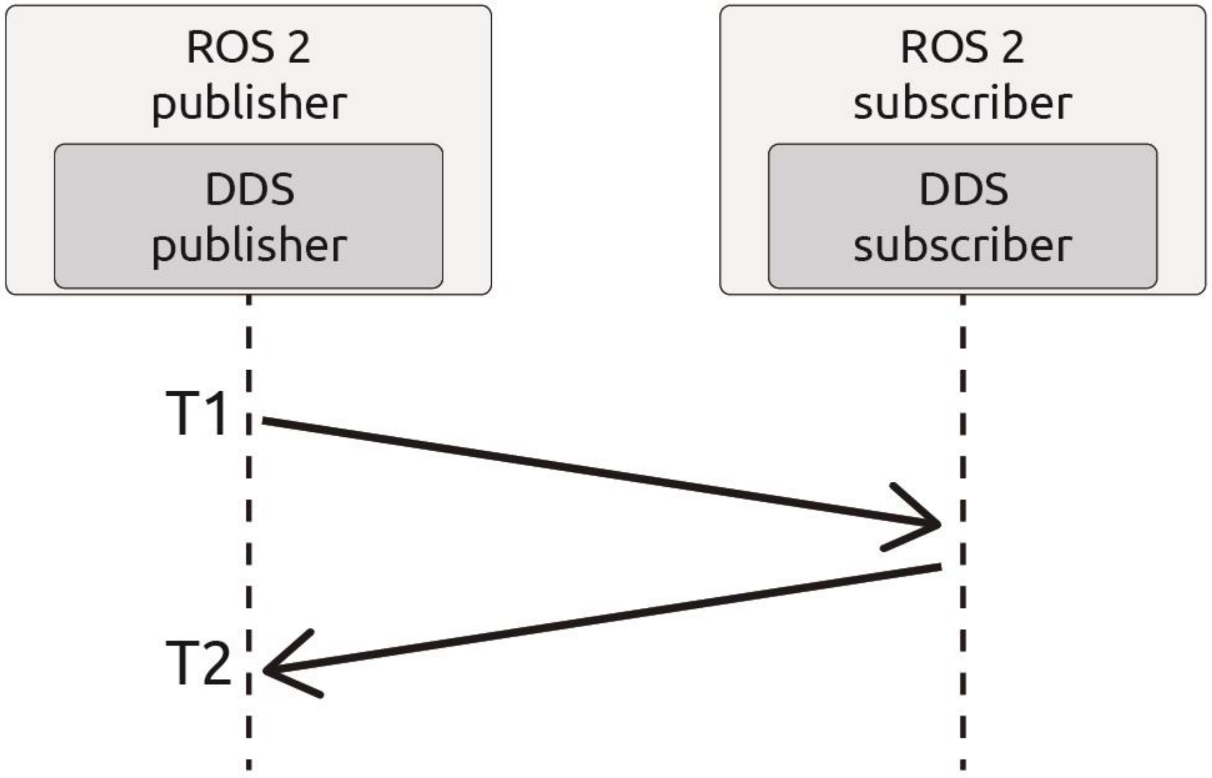
Real-time robotics middleware: setup 1



Middleware and analytics

[5] Gutiérrez, C. S. V., Juan, L. U. S., Ugarte, I. Z., & Vilches, V. M. (2018). Towards a distributed and real-time framework for robots: Evaluation of ROS 2.0 communications for real-time robotic applications. *arXiv preprint arXiv:1809.02595*.

Real-time robotics middleware: setup 2



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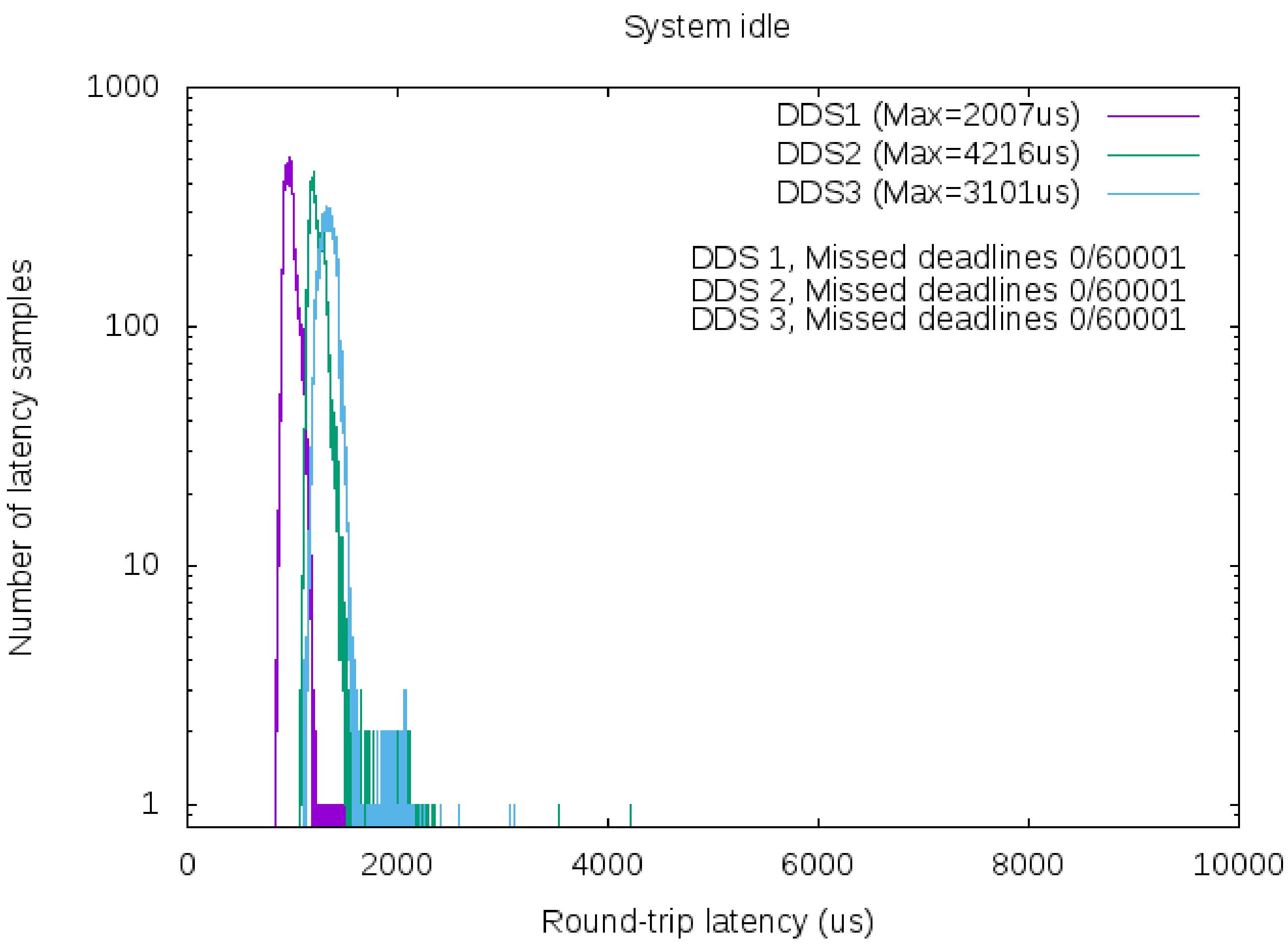
Real-time robotics middleware: idle



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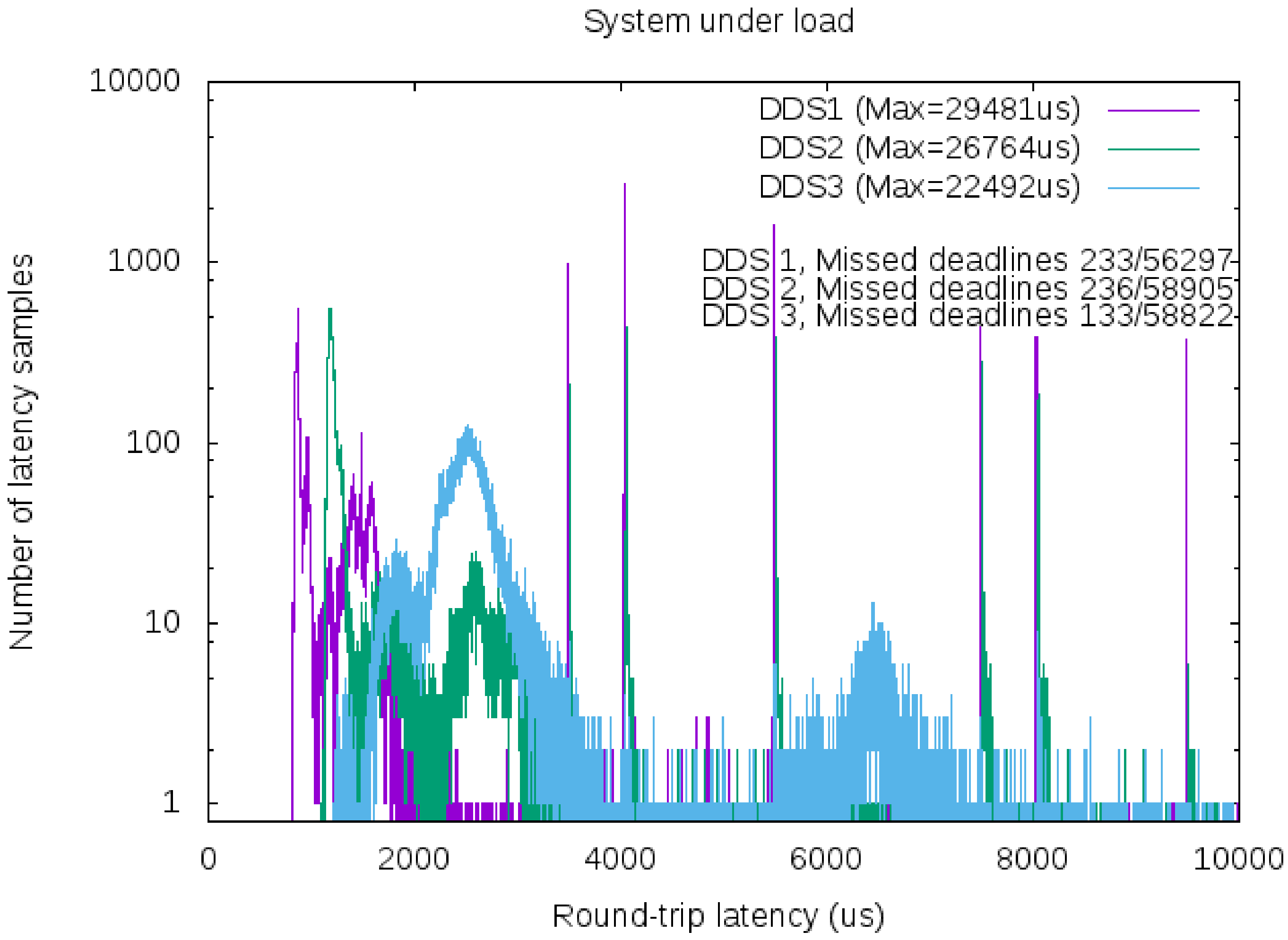
Real-time robotics middleware: stress



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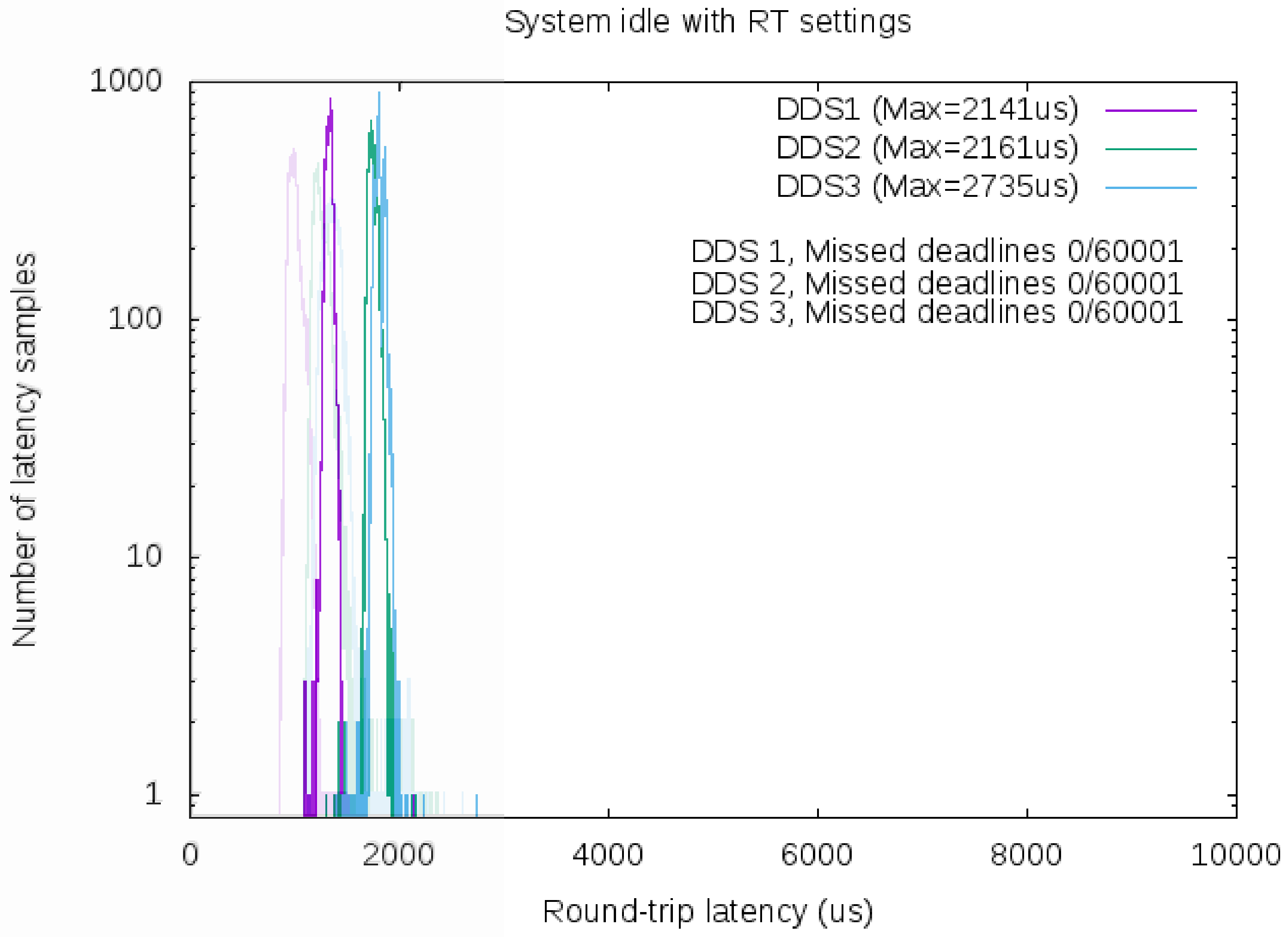
Real-time robotics middleware: idle w/RT



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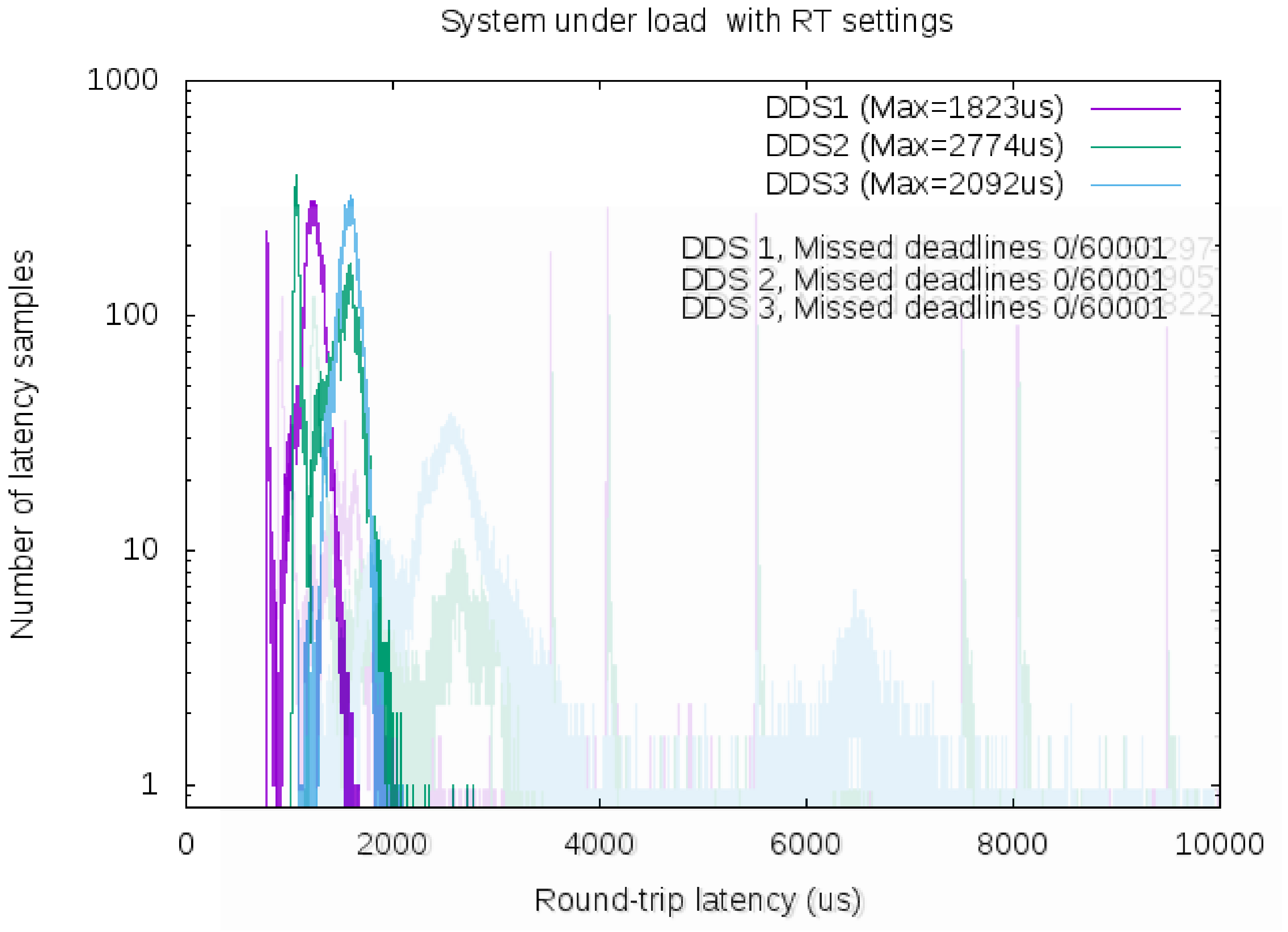
Real-time robotics middleware: stress w/RT



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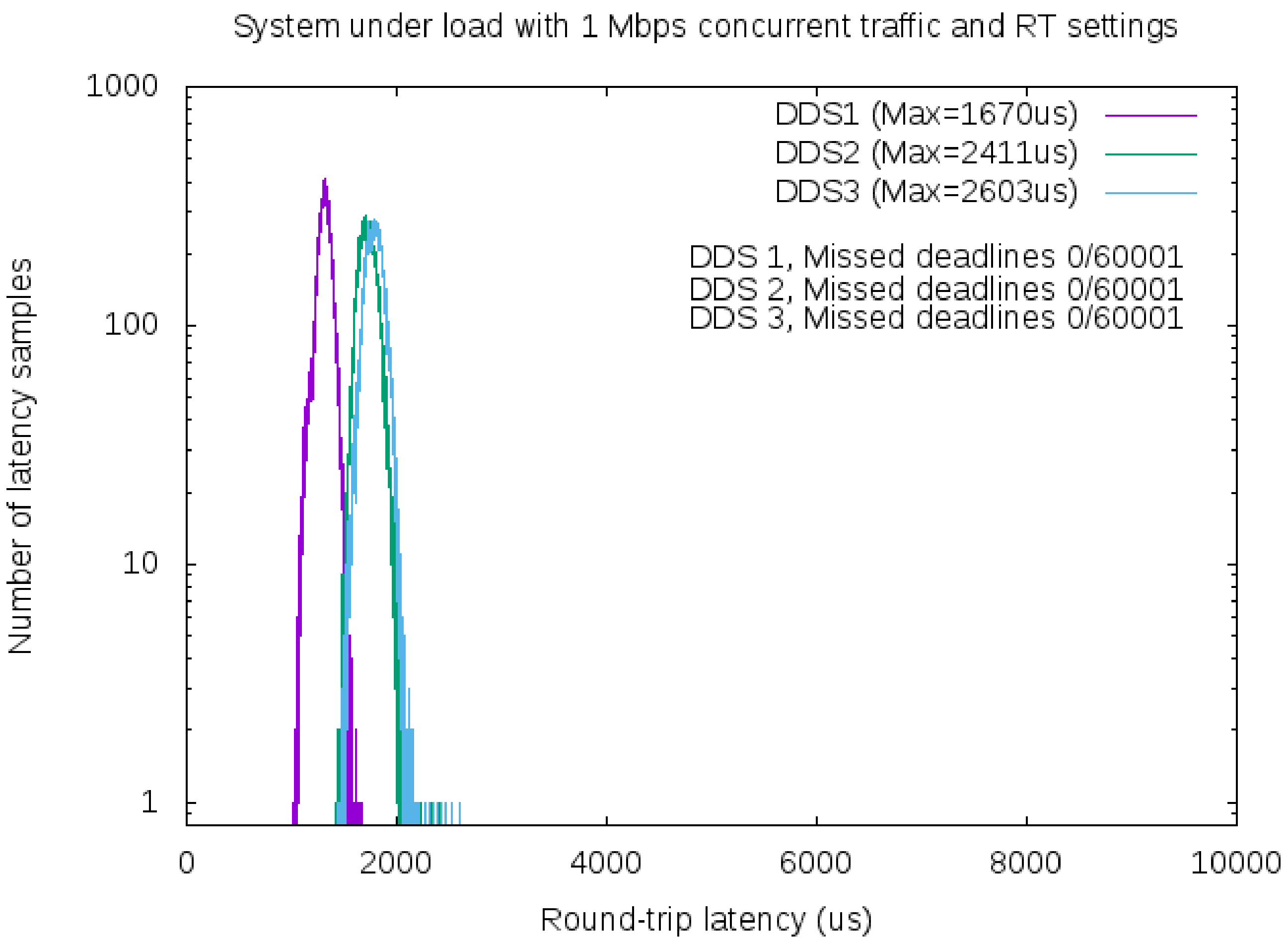
Real-time robotics middleware: stress w/RT and background traffic, 1 Mbps



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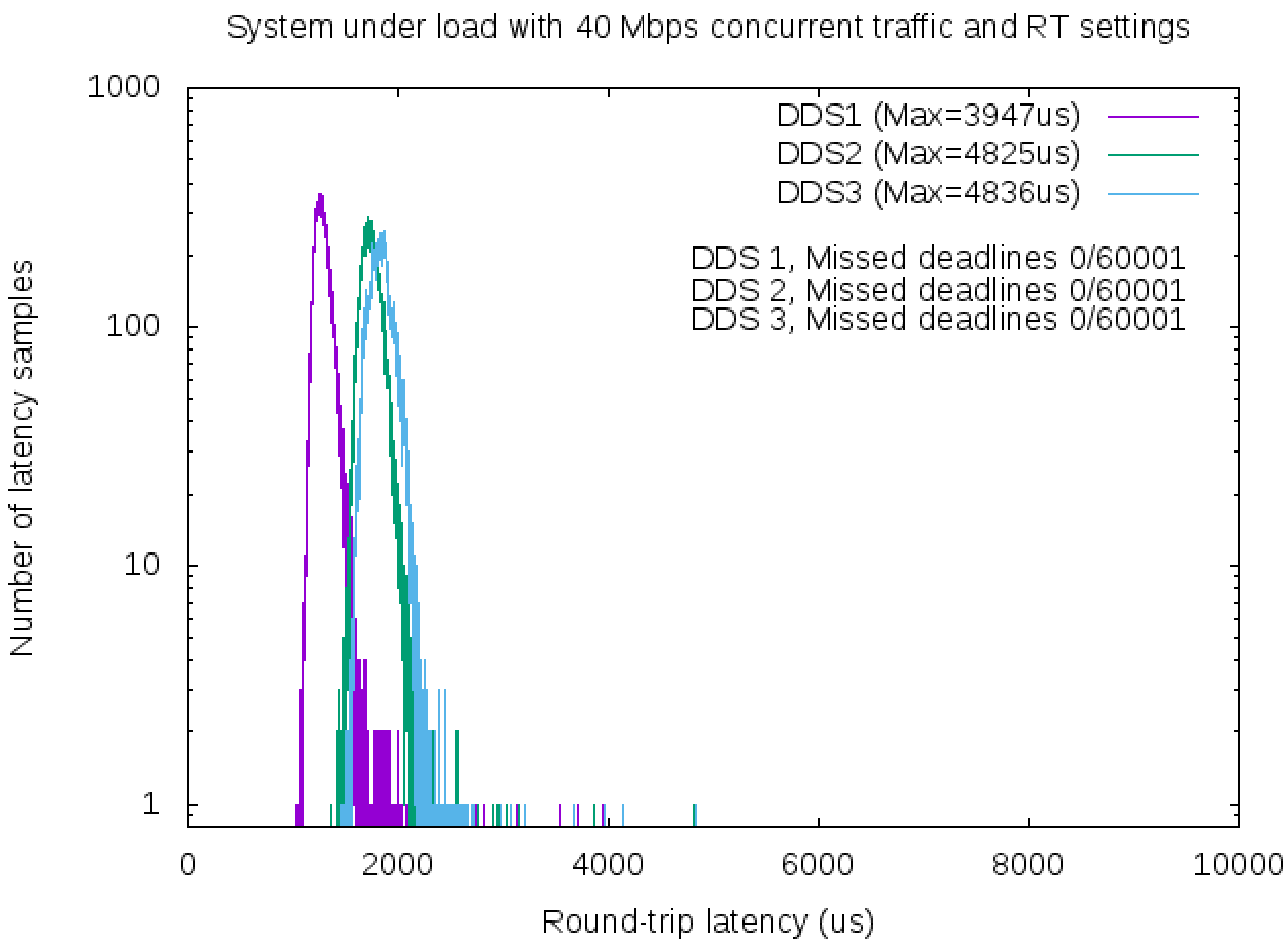
H-ROS, a solution for robot modularity

Real-time robotics middleware: stress w/RT and background traffic, 40 Mbps



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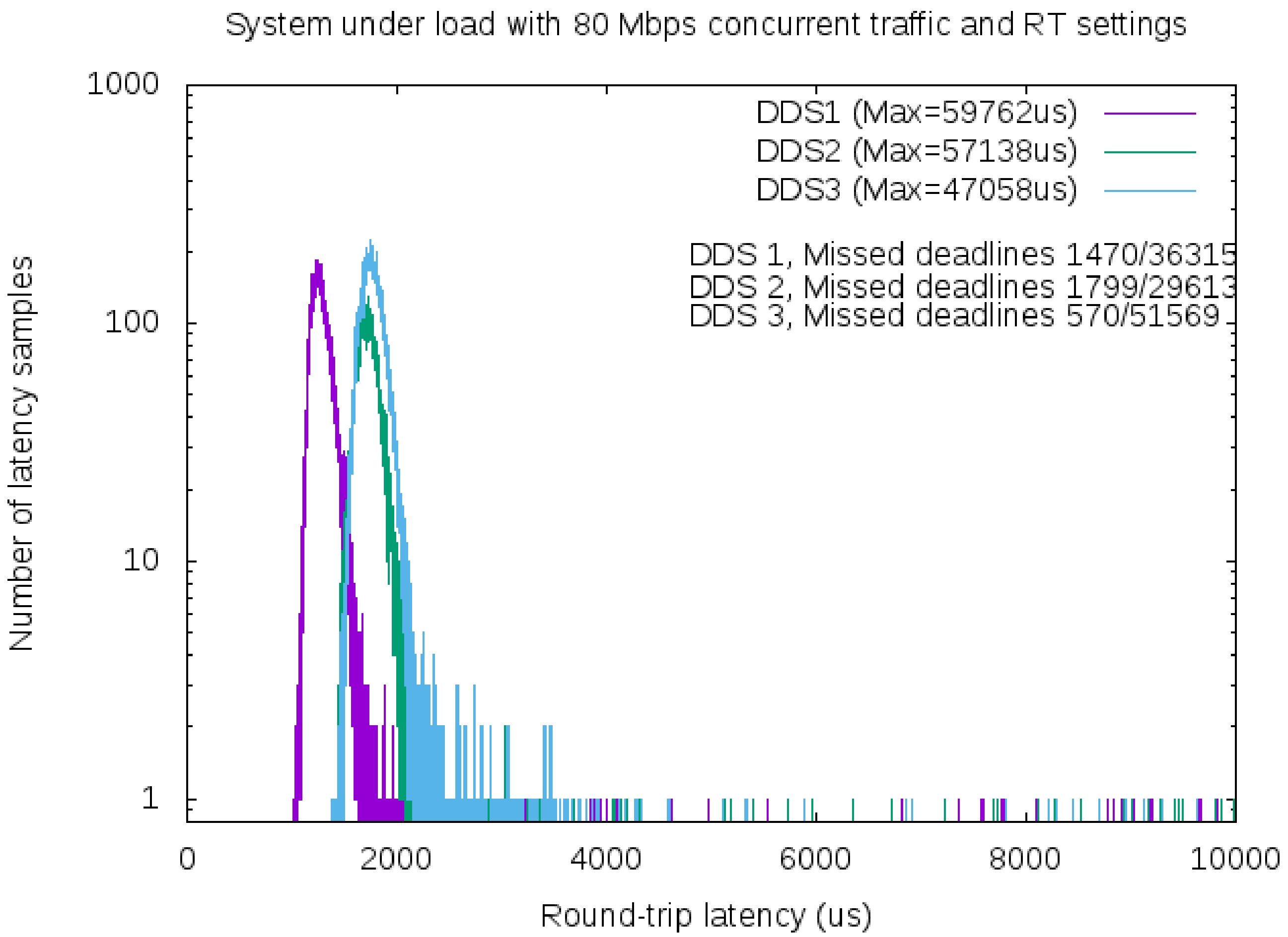
Real-time robotics middleware: stress w/RT and background traffic, 80 Mbps



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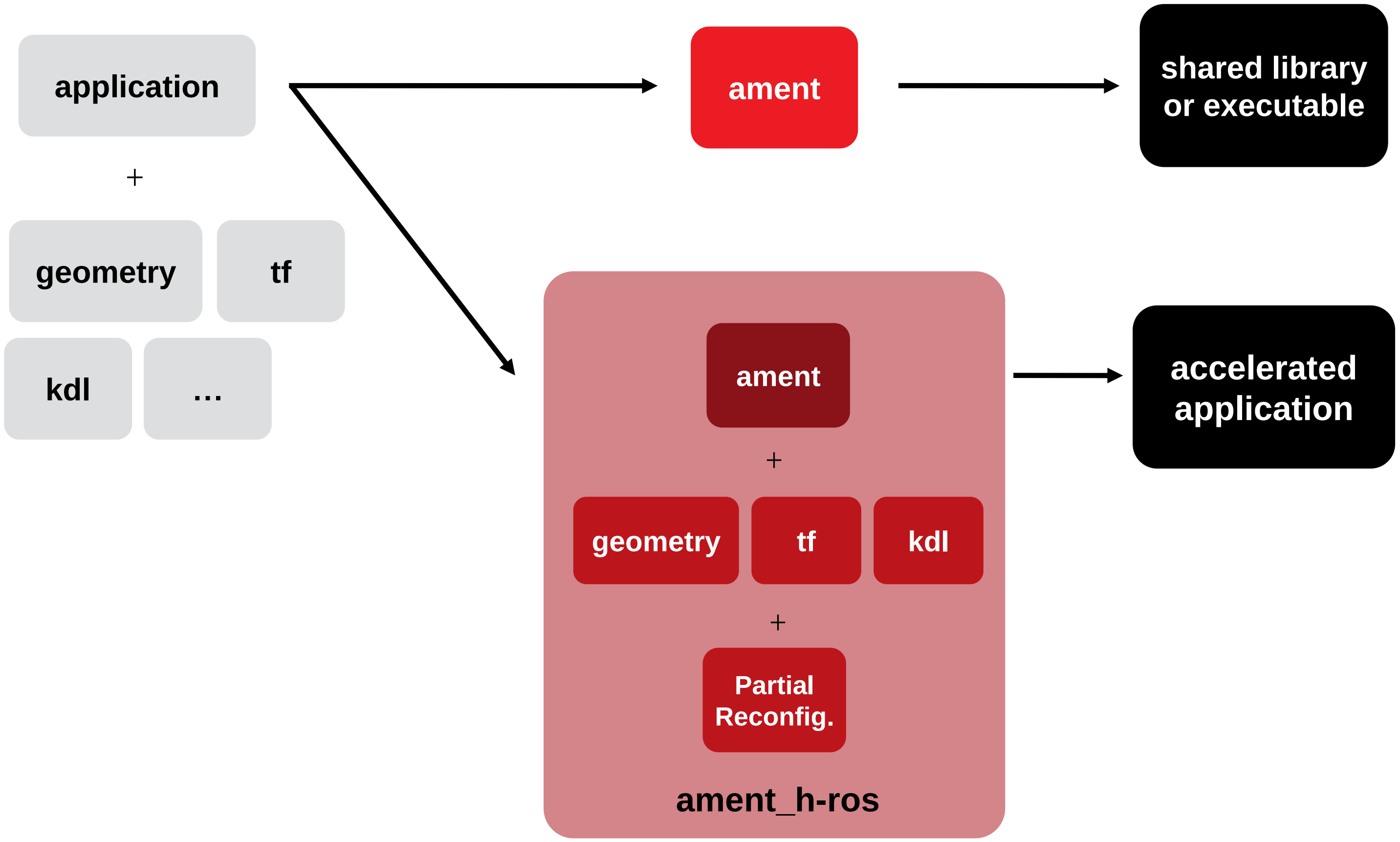
Advantages of H-ROS

Fast. Intelligent

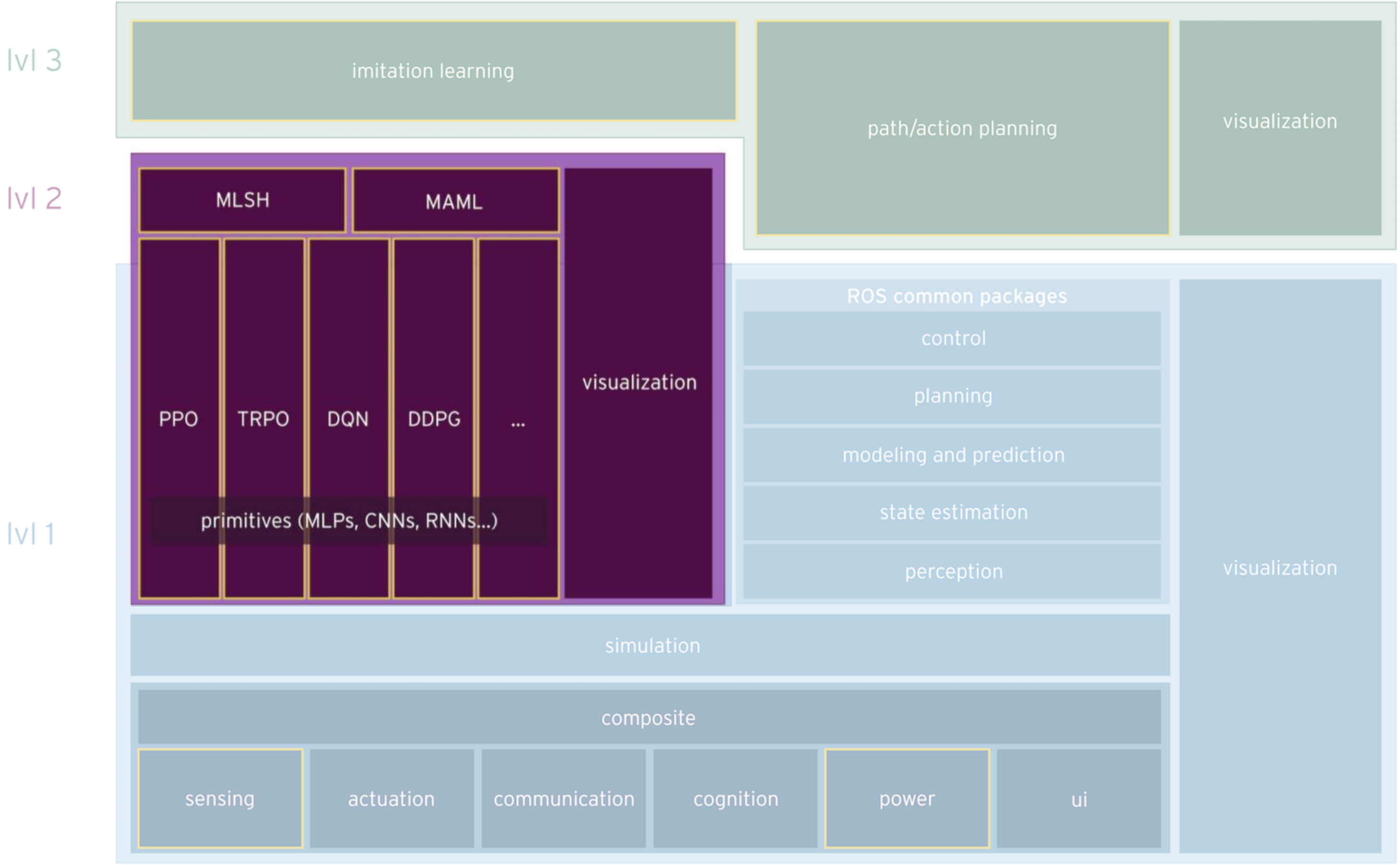
Fast: accelerating robot software with hardware



Application acceleration
and machine learning

H-ROS, a solution for robot modularity

Intelligent: powering a new generation of AI methods for robots



Application acceleration and machine learning

H-ROS SoM | empowering robot modularity

XILINX

Acutronic ROBOTICS

H-ROS SoM | empowering robot modularity

Introducing the first modular collaborative robot: MARA

MARA

Modular. Industrial.
Collaborative

ACUTRONIC ROBOTICS

XILINX

MARA

Flexible. Adaptable

Acutronic Robotics

XILINX

MARA

Extensible. Intelligent

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XILINX

Promotional Time Sensitive Networking IP + HW Bundle

> Includes Pair of Development Systems, Example Design, Xilinx TSN IP
>> Single part number, AES-ZU-TSN-SK-G
>> 2 x Avnet UltraZed board SOM w/ Zynq UltraScale+ MPSoC,
2 x UltraZed-EG PCIe Carrier Card,
2 x NEW Avnet Networking FMC

> Purchase Bundle through Avnet for $10,000
>> Orders must be placed by December 31, 2018
>> Regular price approximately $27,500 USD
>> http://www.ultrazed.org/product/tsn-hw-eval-kit

> Adaptability is key when standards aren't final

No Better Time to Get Industry's Most Popular and Adaptable TSN solution

Adaptable.
Intelligent.