Preliminary Software Architecture for an ADCS Module in Space ROS-Enabled Nanosatellites

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- The IAAPP - UNSA is dedicated to scientific and technological research and to the training of researchers.
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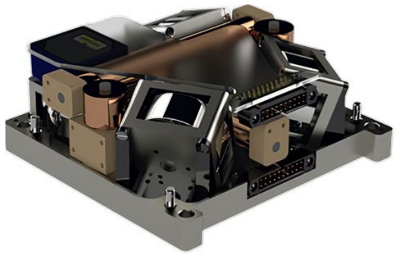
Introduction

ADCS MODULE
Responsible for determining and controlling its orientation in space. It uses sensors (such as gyroscopes and magnetometers) to measure attitude and actuators (such as reaction wheels and magnetotorquers) to adjust it according to mission requirements.

ROBOT OPERATING SYSTEM
An open-source software framework designed for developing robotic applications. It provides tools, libraries, and a modular architecture for communication between nodes

SPACE ROS
An extension of ROS adapted for space applications. It incorporates improvements in safety, reliability, and real-time determinism, making it suitable for controlling satellites and robots in space environments while aligning with aerospace standards.



ROS

spaceROS

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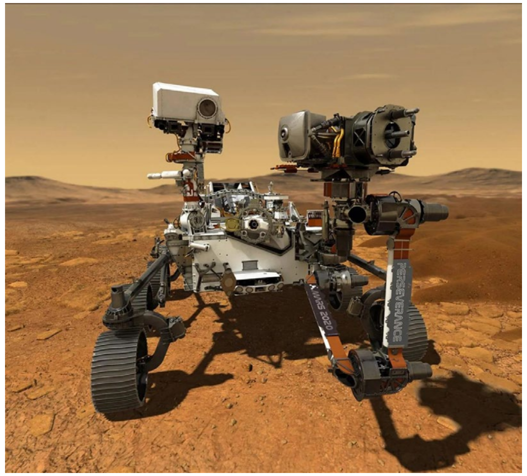
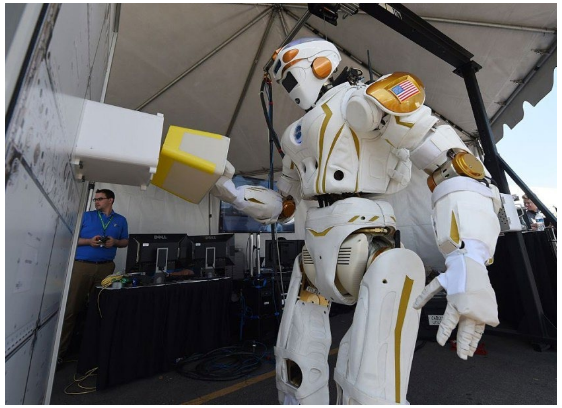
Robot Operating System in Space

Robonaut 2, 2011



Perseverance, 2021



Valkyrie, 2023

Spheres, 2003

Astrobee, 2019

NASA

open robotics

Terry Fong Presentation ROS in Space 2013

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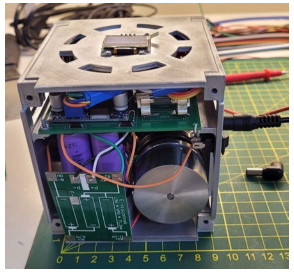
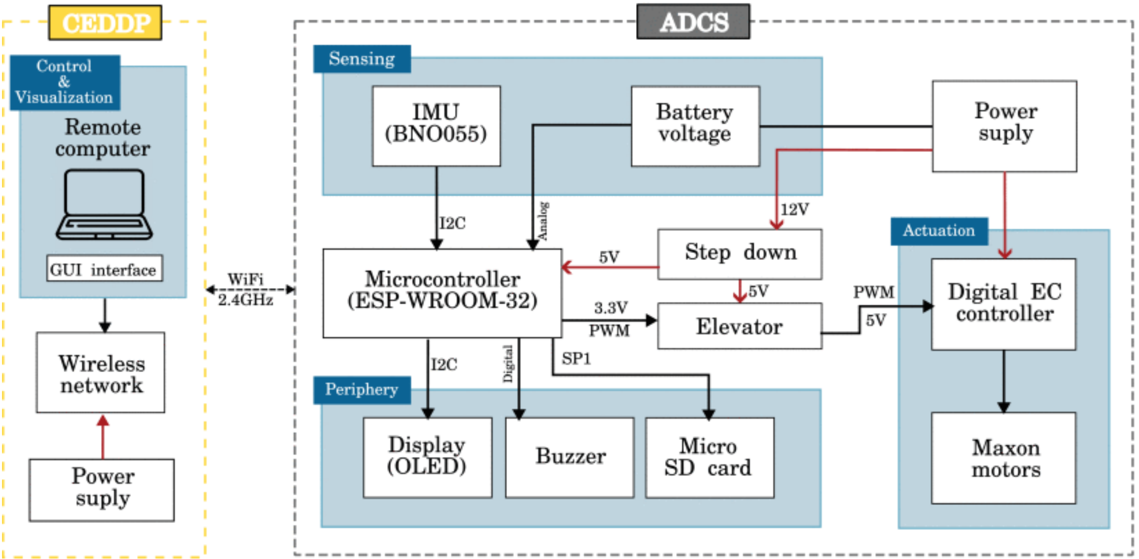
Experimental Setup

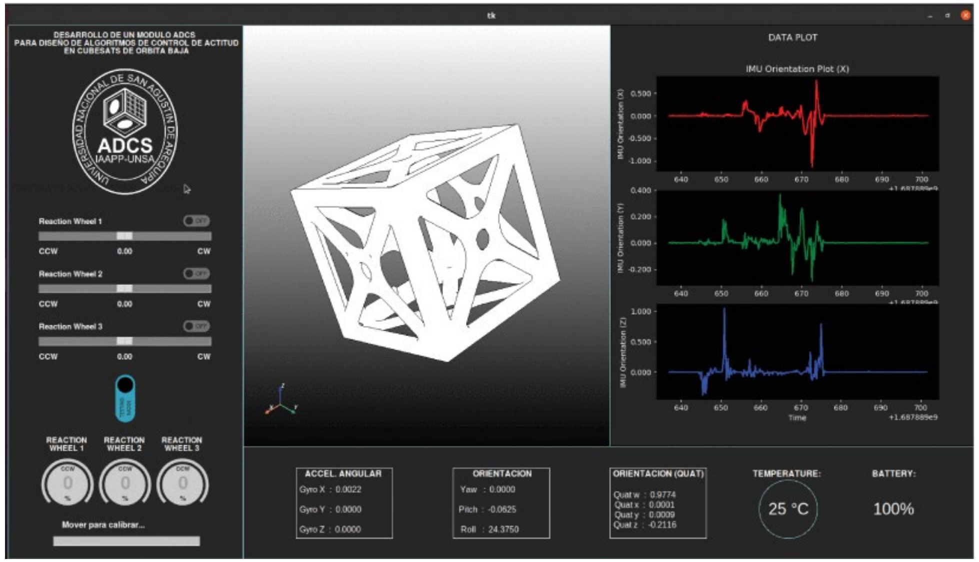


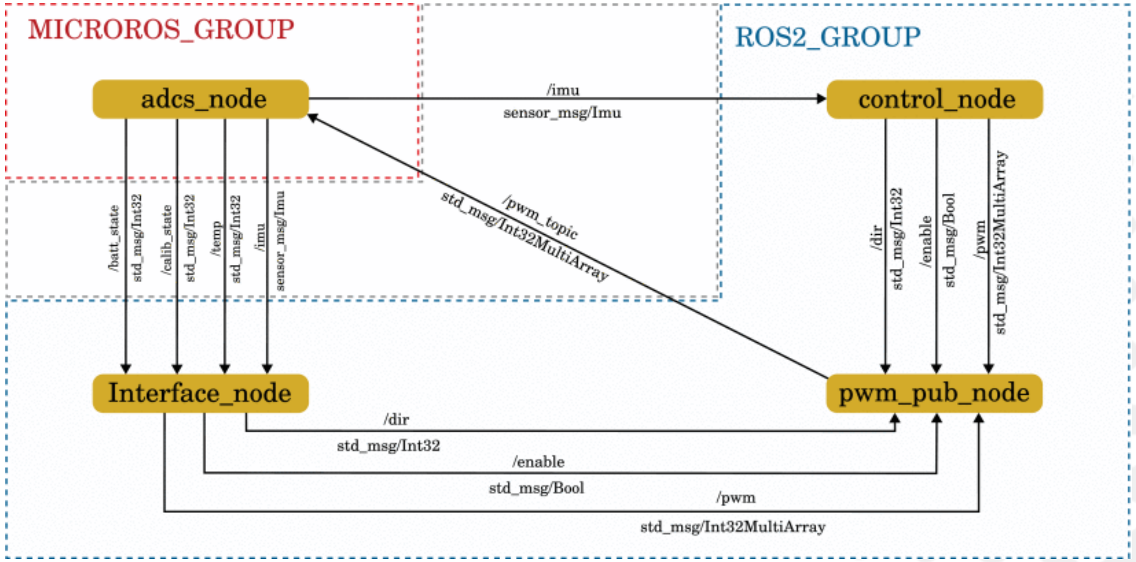
(1) **Hardware architecture**
(2) **Graphical user interface**
(3) **Software architecture**



(1)

(2)





(3)

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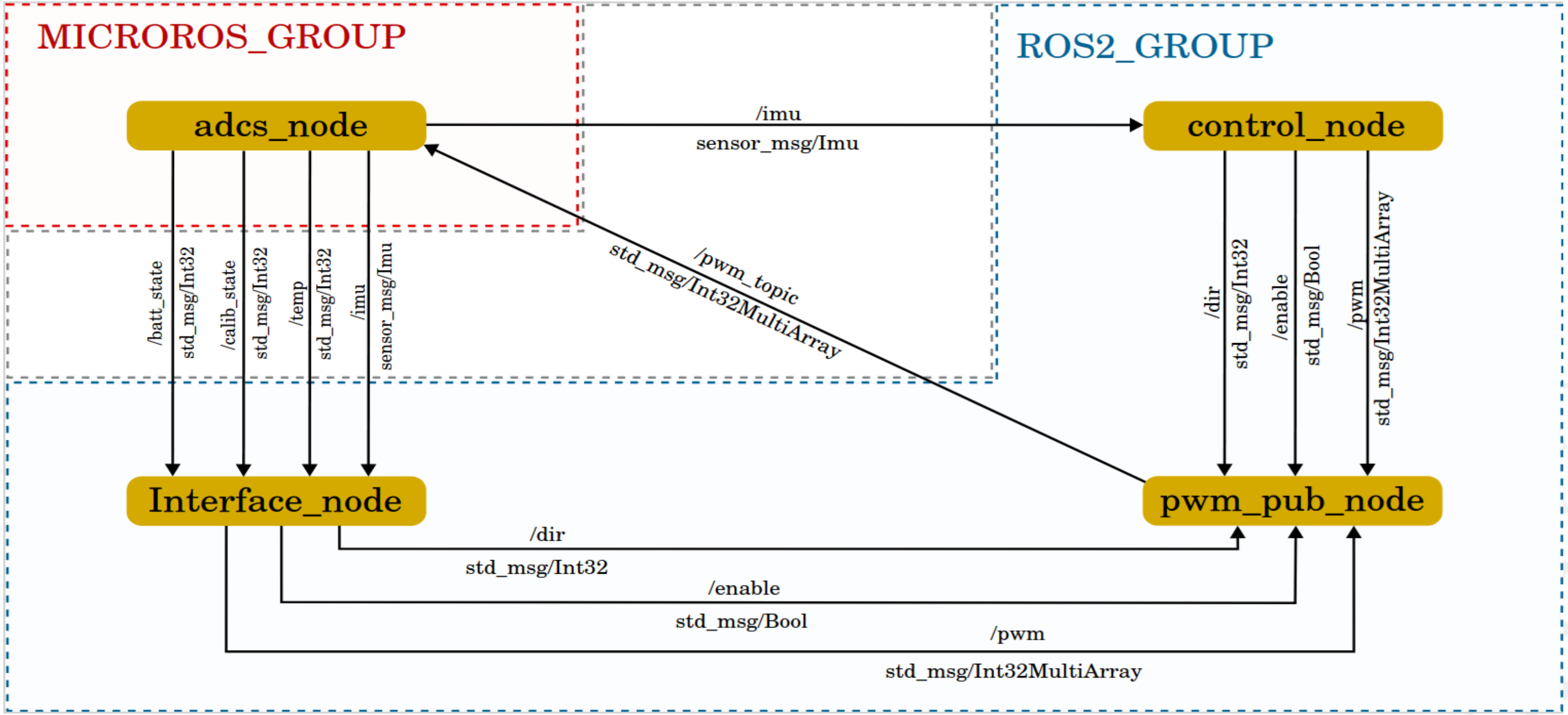
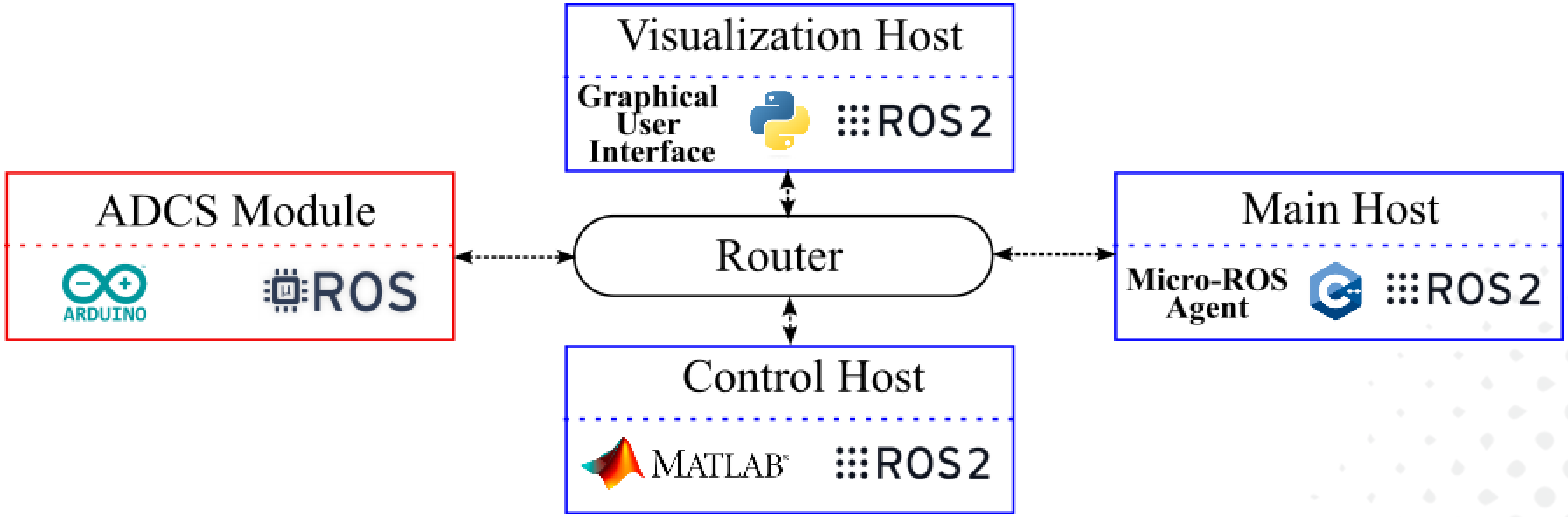
Software Architecture (preliminary designed)



Software Architecture
(under development)

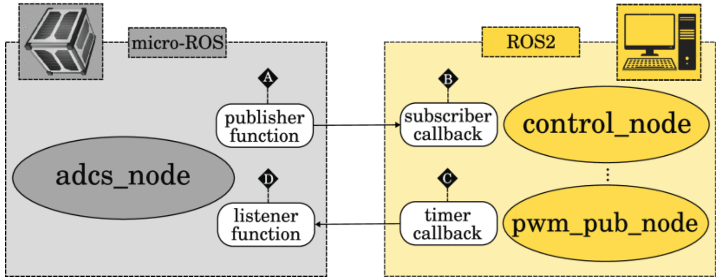


Evaluation Setup

(1) **Mensaje Loss**
(2) **Latency**
(3) **Periodicity**

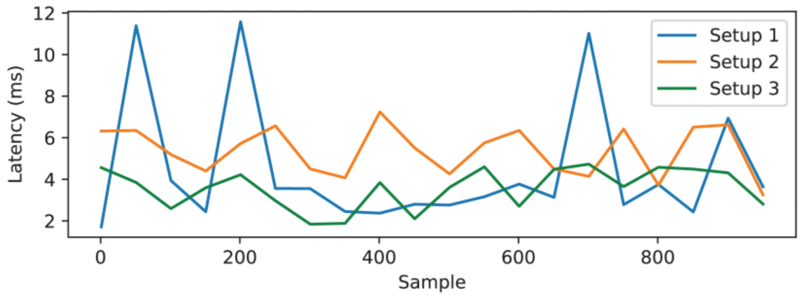
Setup 1		
Function QoS profile	Publisher function (A) REALIABLE	Suscriber callback (B) RELIABLE
Function QoS profile	Listener function (D) RELIABLE	Timer callback (C) RELIABLE
Setup 2		
Function QoS profile	Publisher function (A) BEST EFFORT	Suscriber callback (B) BEST EFFORT
Function QoS profile	Listener function (D) BEST EFFORT	Timer callback (C) RELIABLE
Setup 3		
Function QoS profile	Publisher function (A) CUSTOM	Suscriber callback (B) CUSTOM
Function QoS profile	Listener function (D) CUSTOM	Timer callback (C) CUSTOM

Function	Parameter	Custom Setting
ALL	History Depth Reliability Durability	KEEP_LAST 2 BEST_EFFORT VOLATILE



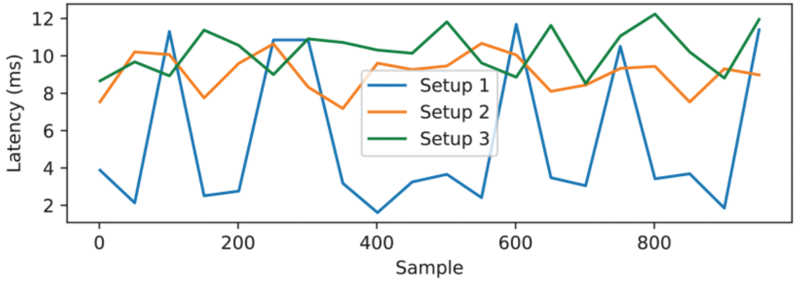
Scenario	A->B	B->C	C->D
Setup 1	0/1000	122/1000	9/1000
Setup 2	0/1000	3/1000	0/1000
Setup 3	0/1000	56/1000	0/1000

(1)



(a)

(2)



(b)

		Parameter			
Entity	Metric	Avg.	St. d	Min.	Max.
A	Frec.(Hz)	100.123	0.910	99.415	101.712
B	Frec.(Hz)	100.007	0.0202	99.935	100.073
C	Frec.(Hz)	99.100	0.001	99.996	100.001
D	Frec.(Hz)	99.887	0.634	99.318	101.365

		Parameter			
Entity	Metric	Avg.	St. d	Min.	Max.
A	Frec.(Hz)	97.307	1.928	93.396	100.292
B	Frec.(Hz)	96.993	0.342	96.450	97.756
C	Frec.(Hz)	99.998	0.006	99.969	100.010
D	Frec.(Hz)	94.230	2.125	91.491	98.441

		Parameter			
Entity	Metric	Avg.	St. d	Min.	Max.
A	Frec.(Hz)	100.213	1.024	99.318	102.304
B	Frec.(Hz)	99.982	0.021	99.937	100.011
C	Frec.(Hz)	100.002	0.002	99.999	100.009
D	Frec.(Hz)	100.032	0.725	99.318	101.610

(3)

Conclusions

The proposed preliminary software architecture demonstrates the feasibility of adopting the Space ROS framework for nanosatellite applications, particularly in the development of ADCS modules.

By implementing and validating this architecture on an educational CubeSat platform using ROS 2 and micro-ROS, show that it is viable and scalable for future use in real space missions.

This work contributes to the ongoing efforts to expand and mature Space ROS, promoting the development of modular, reusable, and standards-compliant flight software for the next generation of space systems.

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