



Exploring Alternatives and Designing the Next Generation of Real-time Control System for ALMA Observatory

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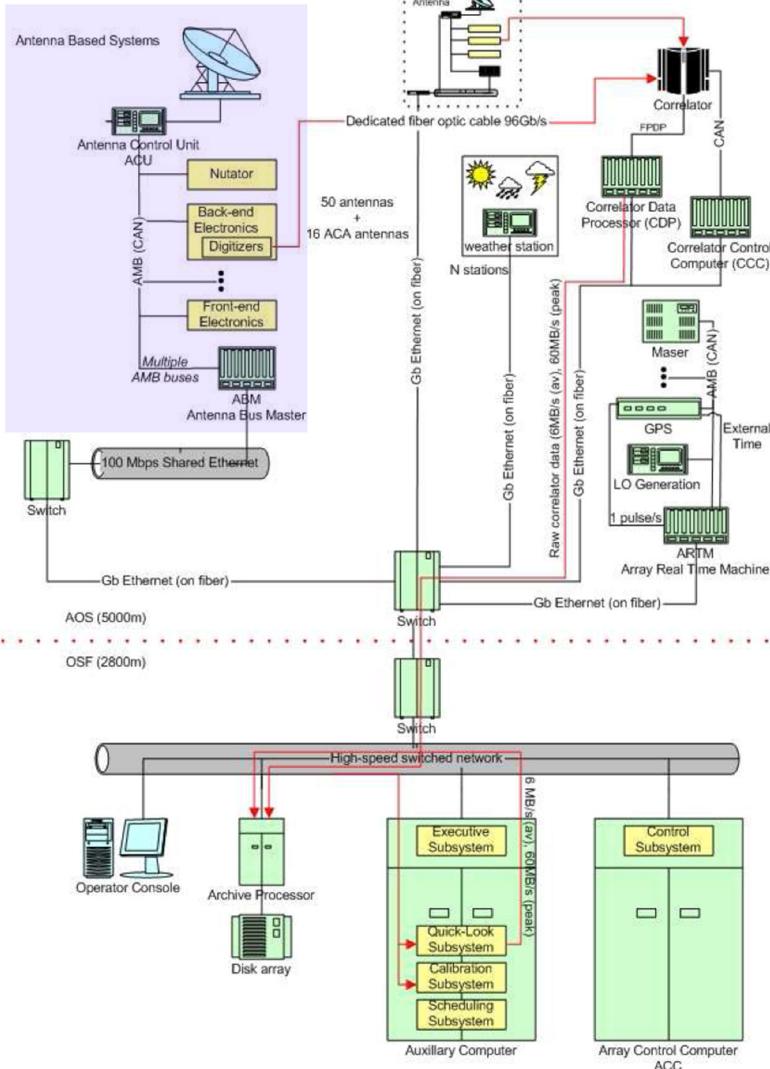
Atacama Large Millimeter/submillimeter Array
In search of our Cosmic Origins

ALMA Observatory



Credit: Clem & Adri Bacri-Normier (wingsforscience.com)/ESO

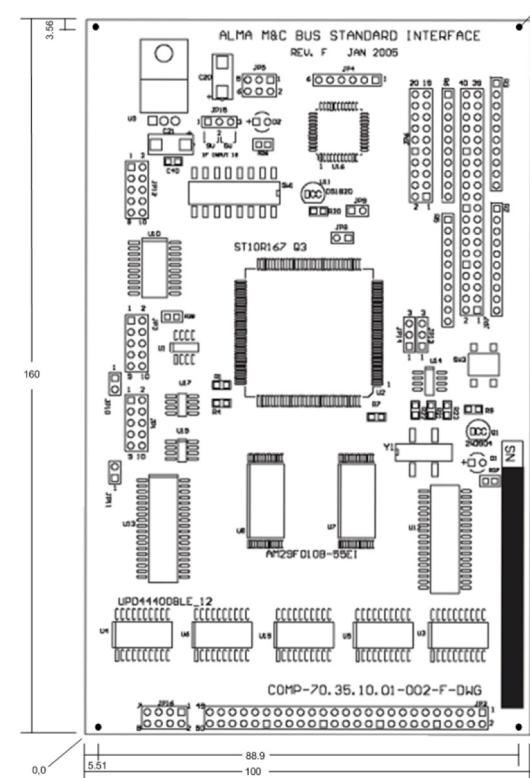
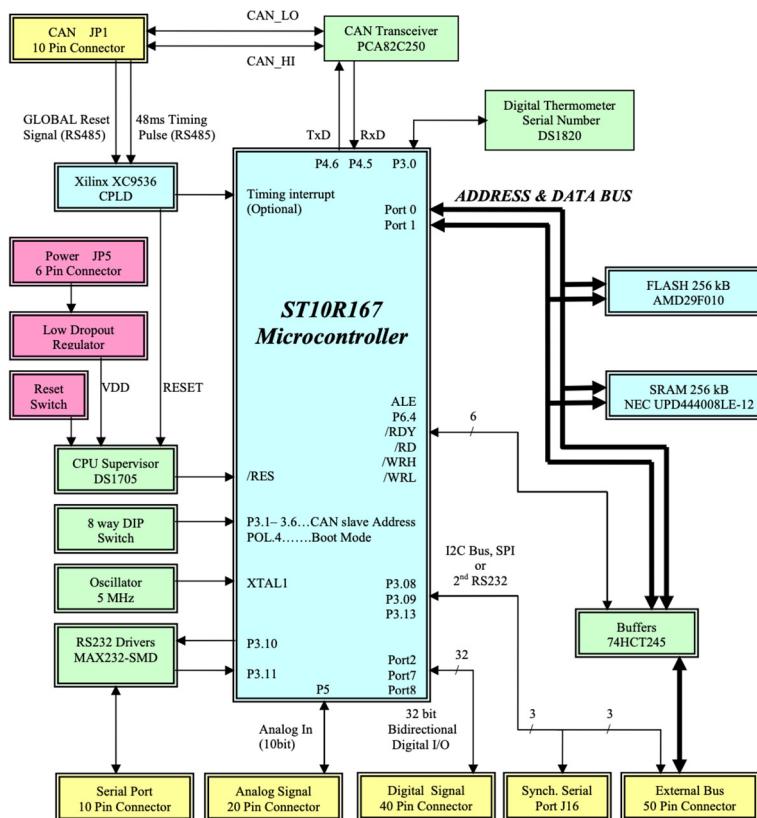
Antenna Control Bus



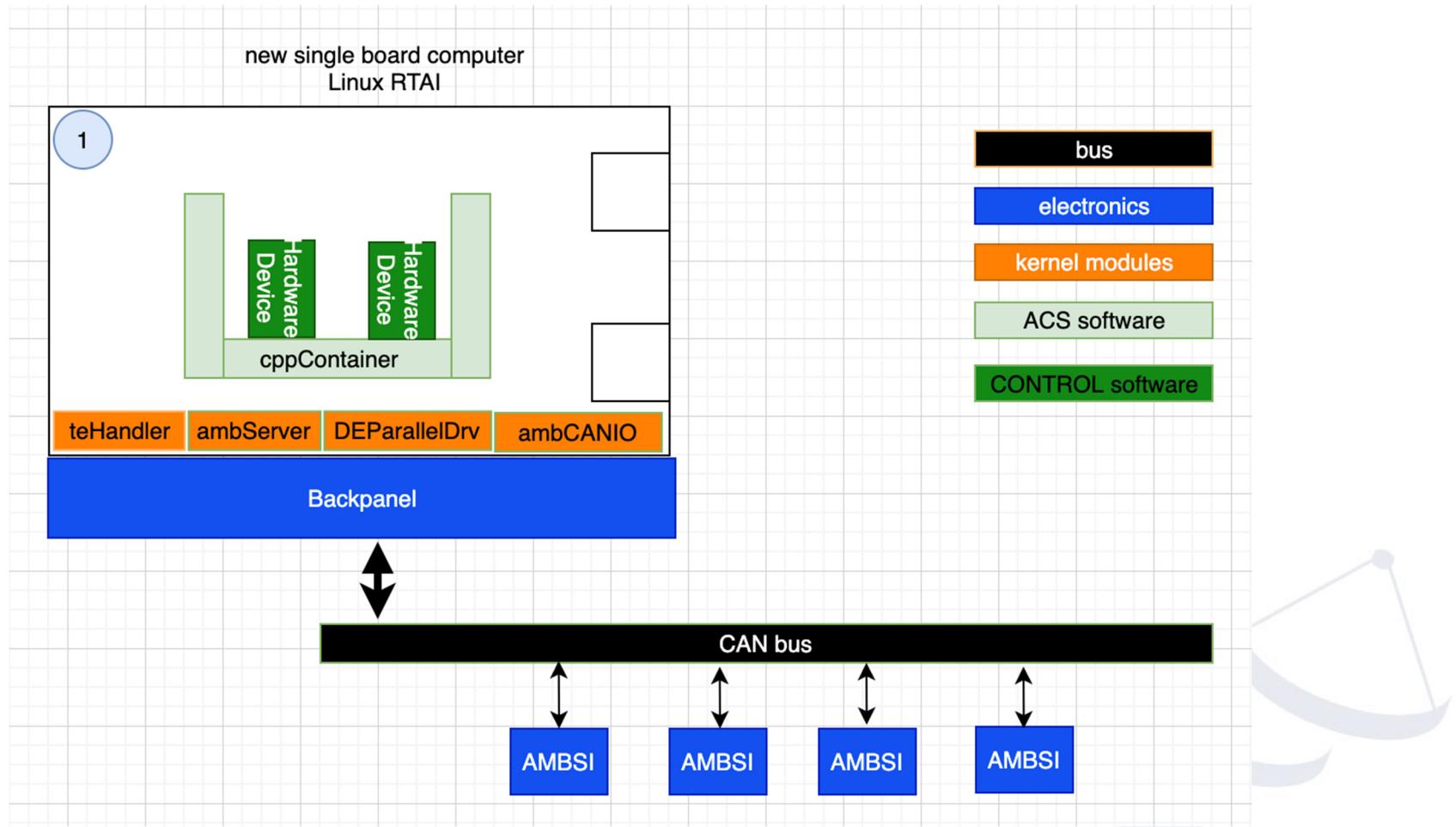
Consolidation factors of servers in the production STE					
Item	Description	Type	Quantity	Consolidation Factor	Number of blade servers
1	Antenna Bus Master	abm	66	8	8.5
2	Central LO Realtime Computers and DMC	lo-x,dmc	9	8	1.25
3	BL CDPMaster, CCC	cob-cdpm, cob-cc	2	1	1
4	BL CDP Nodes	cob-cdpn	16	4	4
5	ACA CDPMaster, CCC	coj-cdpm, coj-cc	2	1	2
6	ACA CDP Nodes	coj-cdpn	32	4	8
7	General network services servers	gns	2	1	1
8	General application servers	gas	6	1	6
	Total		135		31.375

Servers in the production STE			
Item	Description	Type	Quantity
1	Antenna Bus Master	abm	66
2	Central LO Realtime Computers and DMC	lo-x,dmc	9
3	Base Line Correlator CDPMaster, CCC	cob-cdpm, cob-cc	2
4	Base Line Correlator CDP Nodes	cob-cdpn	16
5	ACA Correlator CDPMaster, CCC	coj-cdpm, coj-cc	2
6	ACA Correlator CDP Nodes	coj-cdpn	32
7	General network services servers	gns	2
8	General application servers	gas	6
	Total		135

ALMA Monitor & Control Bus Standard Interface



Current Architecture



Quimal Project Status

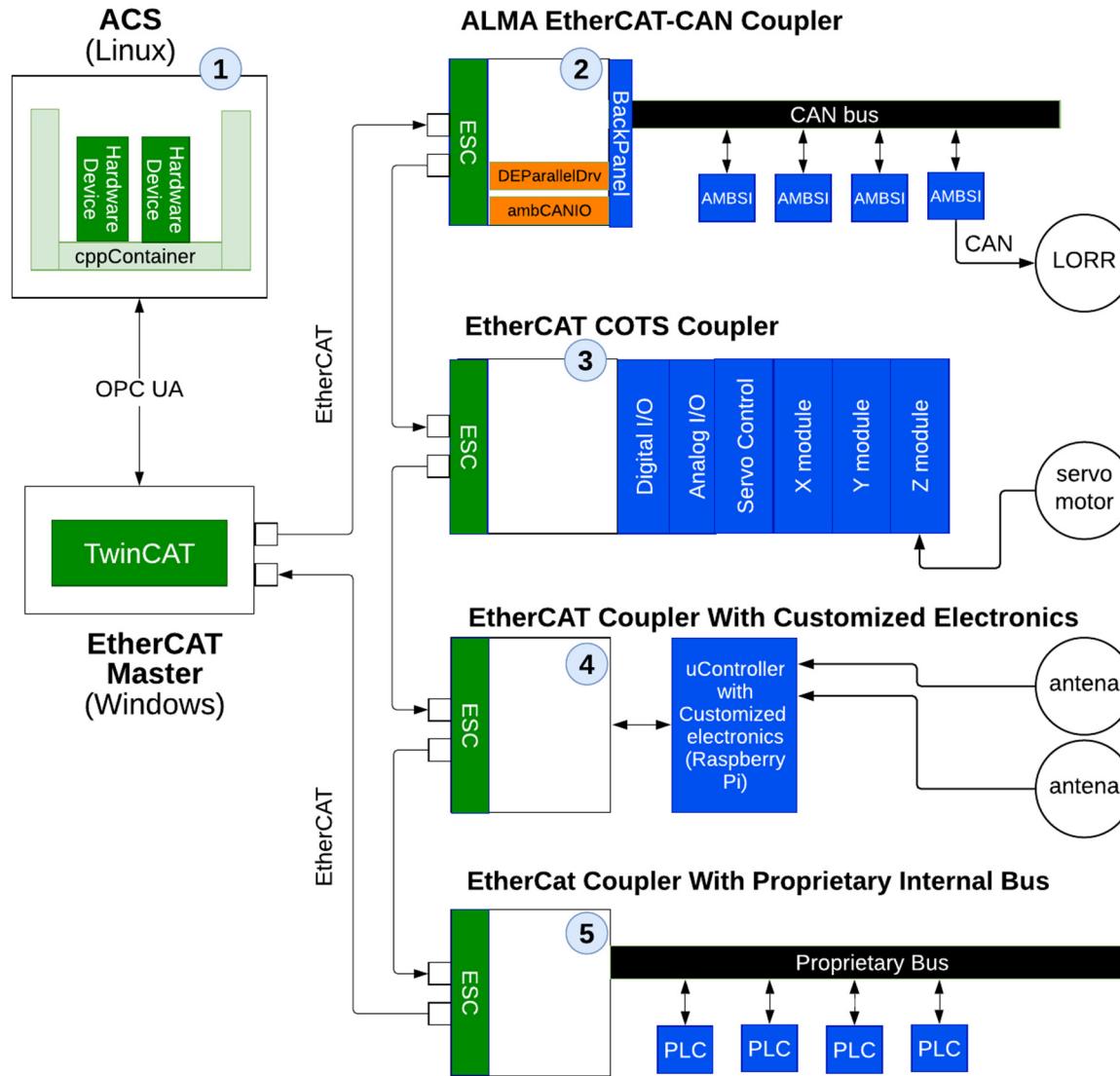
Folio	Nombre IR	Nombre proyecto	Duración Proyecto	Institución Patrocinante	Tipo de postulación	Monto adjudicado	Monto adjudicado	Monto adjudicado año 3	Total Adjudicado	Pr
QUIMAL190009	Patricio Galeas	Explore alternatives and design the next generation real-time control system for the observatories	2	Universidad de la Frontera	Institucional	\$157.358.940	\$42.640.000	\$0	\$199.998.940	
QUIMAL190004	Marcos Diaz Quezada	cubesat space telescope designed to protect our dark night skies	3			\$136.000.000	\$63.200.000	\$500.000	\$199.700.000	
TOTAL						\$293.358.940	\$105.840.000	\$500.000	\$399.698.940	

Control Buses Comparison

Comparison Table

	EtherCAT	CAN-Bus	RS232	RS485
Speed/Cable Length	100 Mbps at 100 m between two nodes for full speed	1 Mbps at 40 m from the start to end nodes	19,200 bps at 15 m from the start to end nodes	1 Mbps at 120 m from the start to end nodes
Cable Topology	Daisy Chain, Point-to-Point, Combination of the above	Daisy Chain	Point-to-Point	Daisy Chain, Point-to-Point
Max Number of Nodes	65535	128	1	32
Open Source Software	Yes	Most of CANOpen is proprietary	No predetermined protocol	No predetermined protocol
Required Hardware at master	Regular Ethernet adapter	PCI, USB, IC-type interface	PCI, USB, IC-type interface	PCI, USB, IC-type interface





New Architecture

Use Cases to be implemented:

use case 1) ALMA OPCUA Hardware Device driver and EtherCAT master (ex ABM)

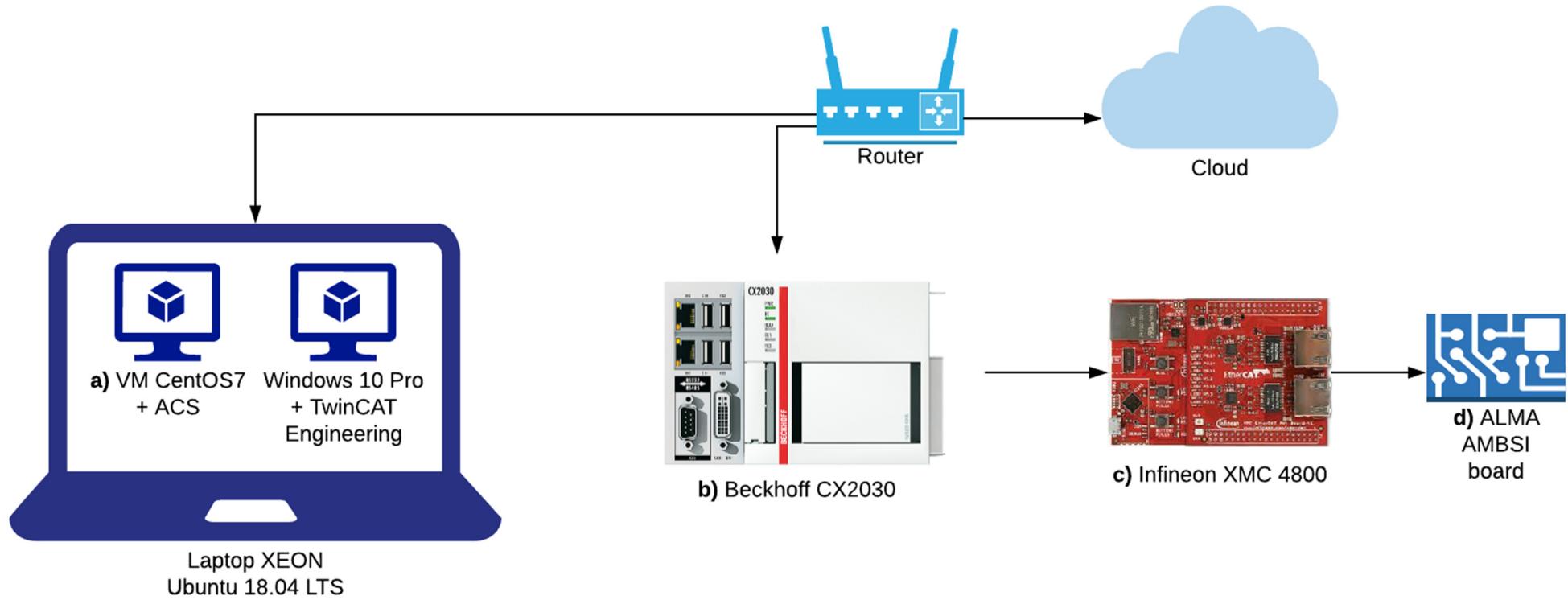
use case 2) EtherCAT Coupler for ALMA current CAN bus device

use case 3) COTS EtherCAT Coupler with digital, analog I/O.

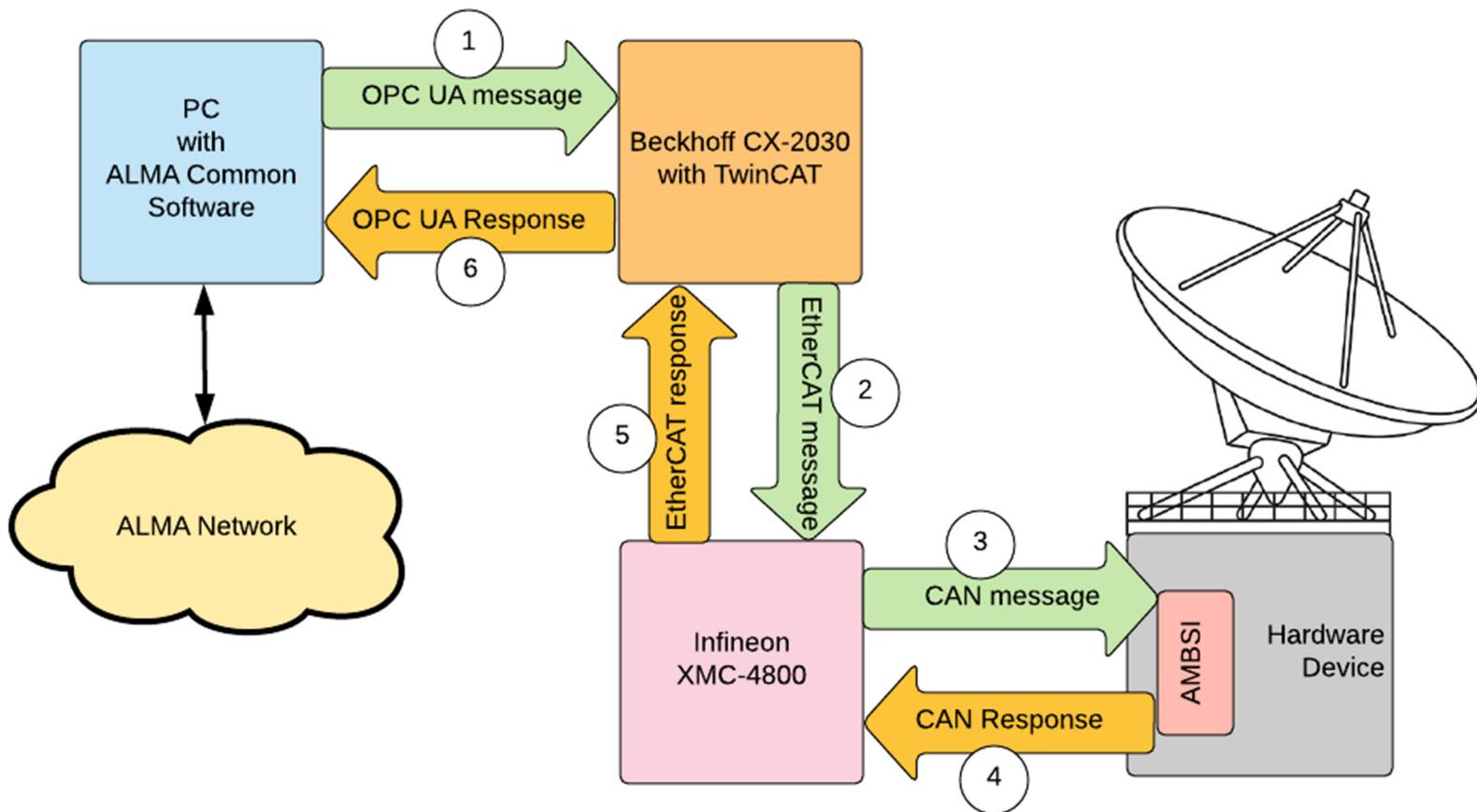
use case 4) EtherCAT Coupler with customized electronic of new hardware related to the ALMA-2030 initiative.

use case 5) EtherCAT coupler to interface proprietary bus

Physical Setup

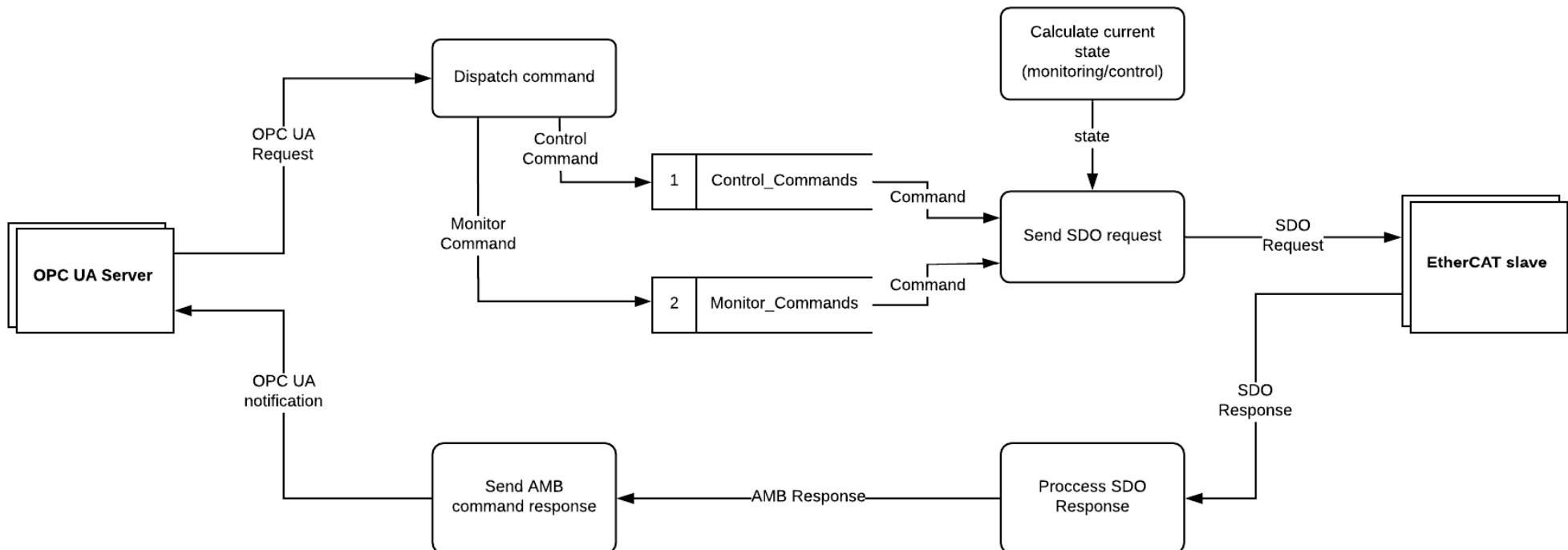


M&C Message Flow

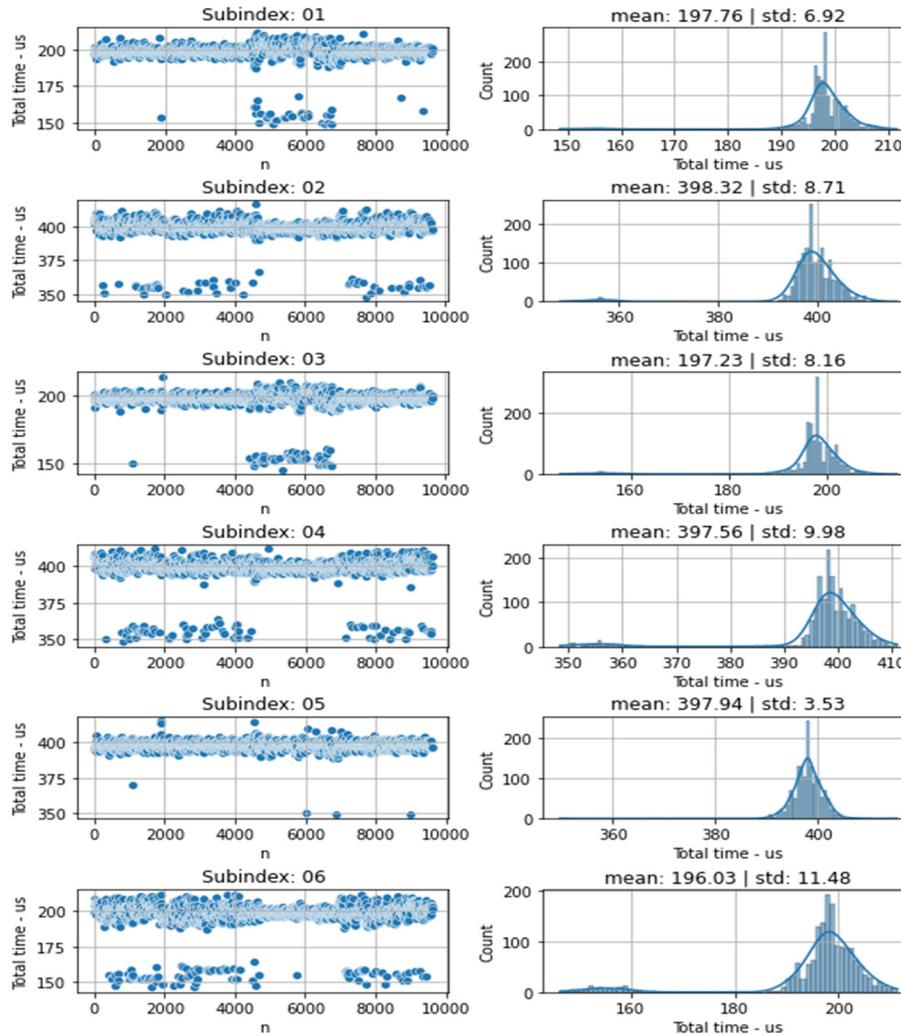


M&C Message Flow

5001:0	ALMA_CAN_Device1	> 6 <
5001:01	AMBSI_SERIAL_NUMBER	RO 0xe70008027e4fe110
5001:02	AMBIENT_TEMPERATURE	RO 0x100F0046 (269418566)
5001:03	PROTOCOL_REV_LEVEL	RO 0x00000000 (0)
5001:04	CAN_ERROR	RO 0x00000000 (0)
5001:05	TRANS_NUM	RO 0x64000000 (1677721600)
5001:06	SW_REV_LEVEL	RO 0x00000002 (2)



Results



5001:0	ALMA_CAN_Device1	> 6 <
5001:01	AMBSI_SERIAL_NUMBER	RO 0xe70008027e4fe110
5001:02	AMBIENT_TEMPERATURE	RO 0x100F0046 (269418566)
5001:03	PROTOCOL_REV_LEVEL	RO 0x00000000 (0)
5001:04	CAN_ERROR	RO 0x00000000 (0)
5001:05	TRANS_NUM	RO 0x64000000 (1677721600)
5001:06	SW_REV_LEVEL	RO 0x00000002 (2)

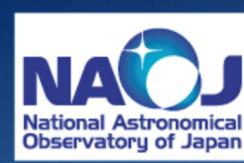
- Test: send 10000 messages defined in the OD of a hardware device
- Time of fly were extracted analyzing TCP packages by using Wireshark.
- Sub-index 1,3 : 200 uS
- Sub-index 2,4 : 400 uS



Conclusion & Future Works

- A tentative alternative based on COTS hardware is presented to solve the obsolescence problem of the existing Realtime Computer.
- Demonstrated that EtherCAT is a suitable protocol to replace the existing fieldbus based on a customized version of CAN protocol.
 - SDO structure suits to the purpose of monitoring and control, but PDO could allow more performance (under investigation).
- This architecture also fulfills the possible scenarios of new systems that may come with ALMA2030 initiatives.
- XMC-4800 is a very versatile micro-controller (120MHz), and the feature of MultiCAN suits perfectly to replace the existing ABM with 5 independent CAN buses. We also want to test other brand of ESC: TI Sitara AM335x, Microchip 9254, etc.

Questions?



Acknowledgements

ACS presentations were originally developed by the ALMA Common Software development team and has been used in many instances of training courses since 2004. Main contributors are (listed in alphabetical order): Jorge Avarias, Alessandro Caproni, Gianluca Chiozzi, Jorge Ibsen, Thomas Jürgens, Matias Mora, Joseph Schwarz, Heiko Sommer.

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