The ELT M1 Local Control Software: from Requirements to Implementation

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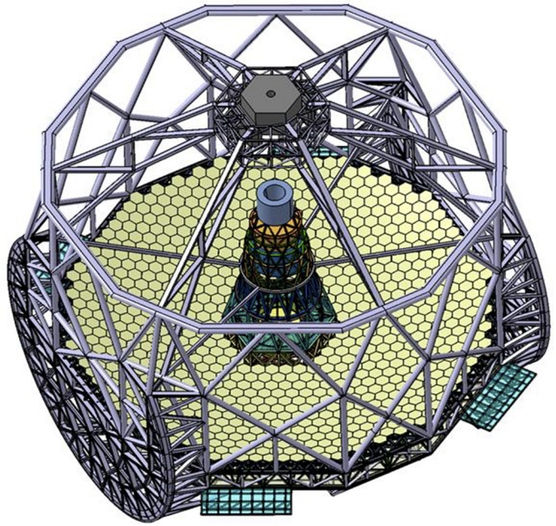
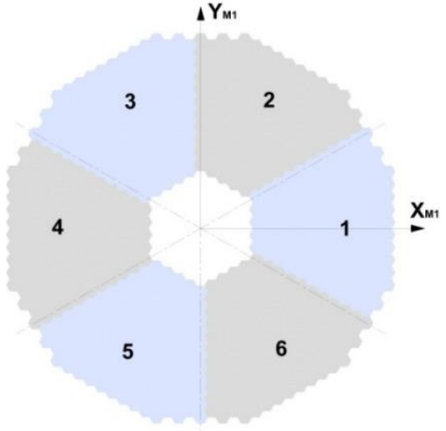
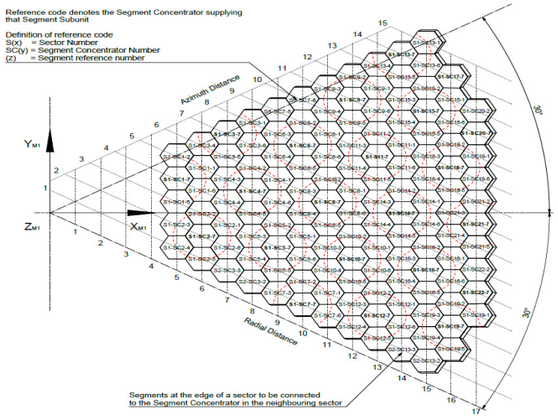
M1 Local Control System - Overview

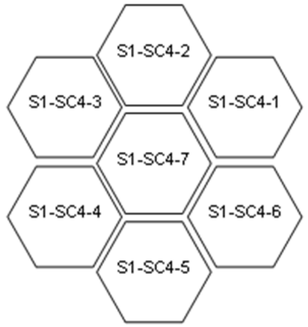


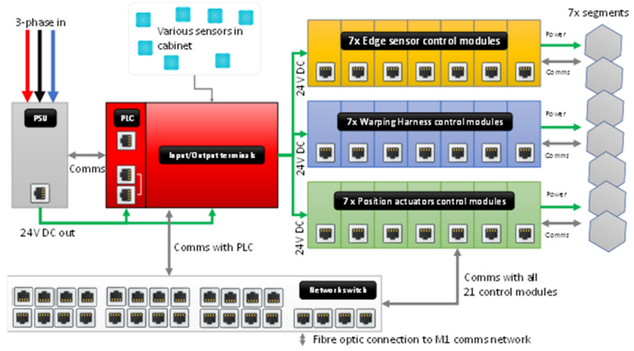


M1 = 39-m diameter, 798 hexagonal segments (1.4m each) grouped in 6 sectors.

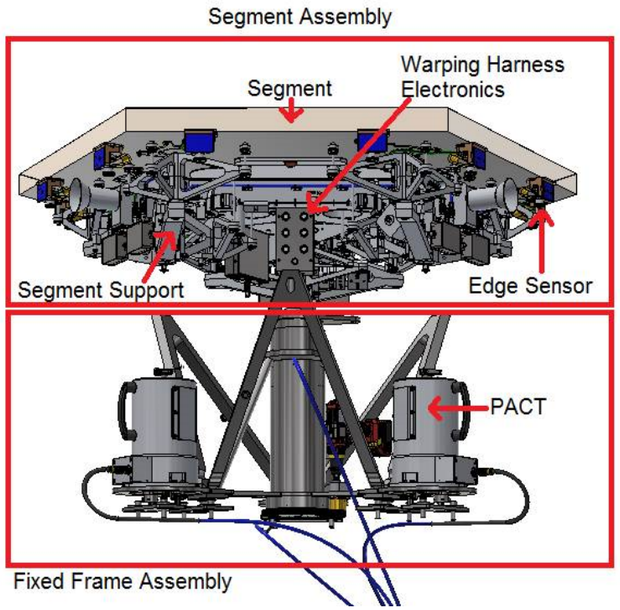


1 sector = 133 segments
(6 sector distributor cabinets)





1 flower = up to 7 segments
(132 segment concentrator cabinets)



1 segment is controlled by:

- ES controller (6 sensors piston/shear/gap)
- PACT controller (3 actuators + 3 sensors piston/tip/tilt)
- WH controller (9 actuators + 9 sensors)

M1LCS – Main SW Requirements

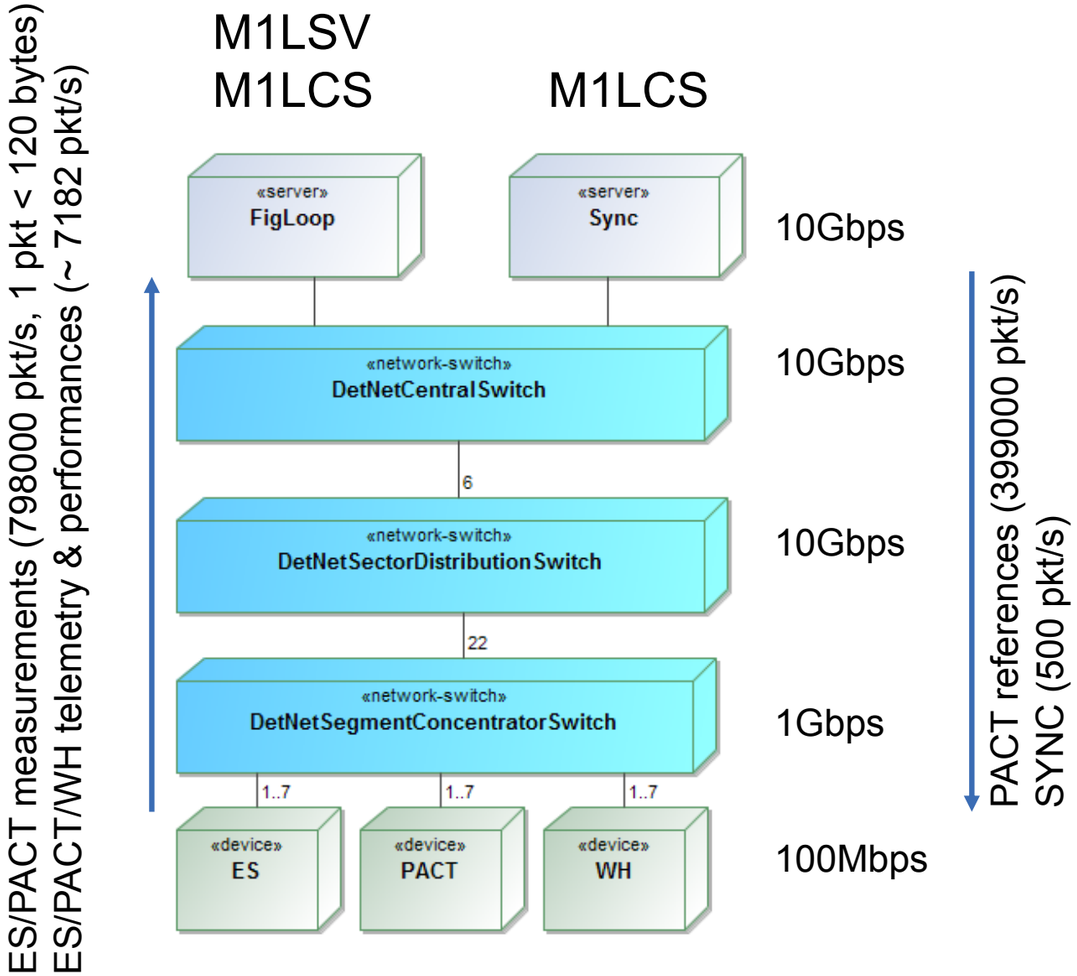
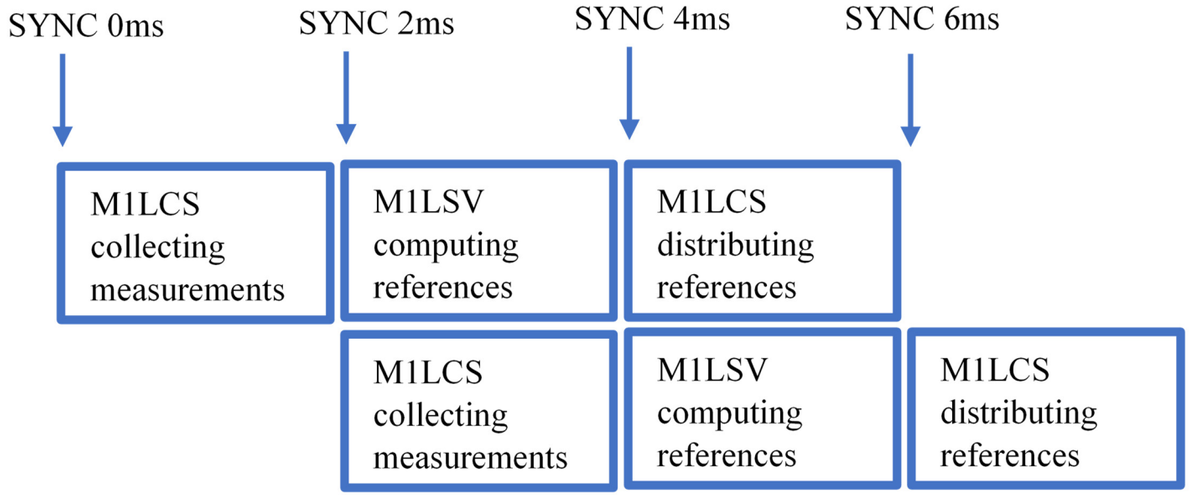
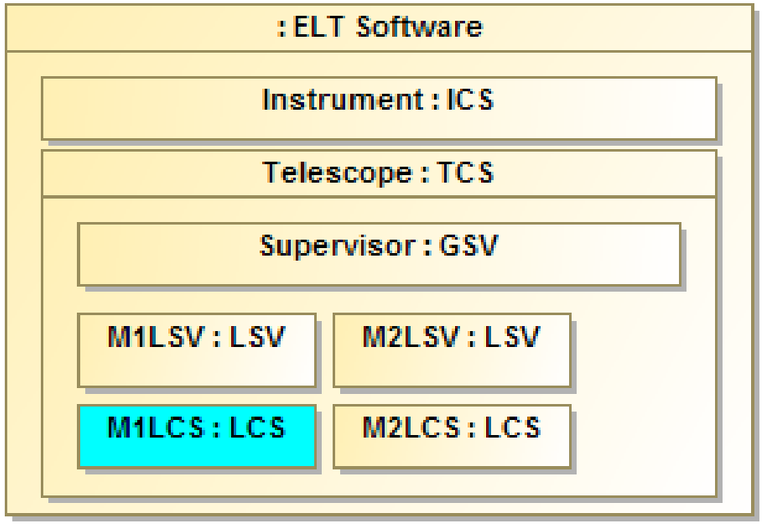


Figure Loop: obtain and maintain a given mirror optical quality for the duration of the observation.

- Generate SYNC message every 2ms
- Collect ES/PACT measurements within 2ms (M1LCS)
- Compute new PACT references within 2ms (M1LSV)
- Apply new PACT references within 2ms (M1LCS)



M1LCS – SW Architecture



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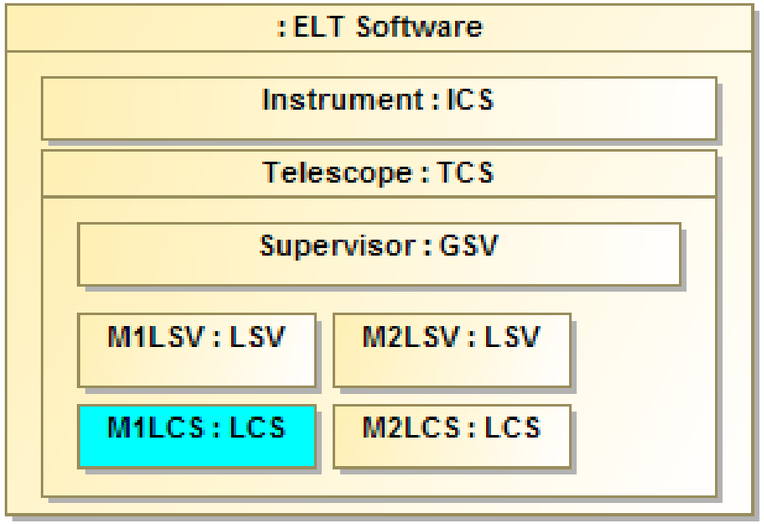
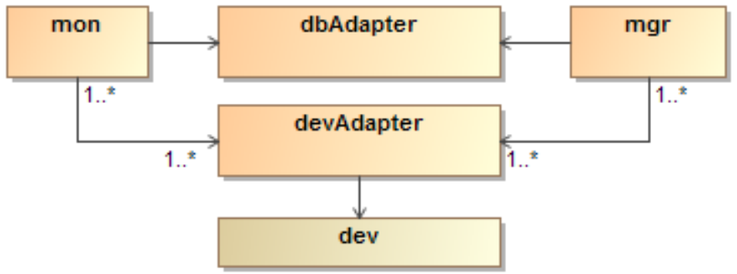


Adaptation of some JPL State Analysis patterns:

- Estimator/Controller/Adapter (Monitor/Manager/Adapter)
- FDIR based on Goal monitoring



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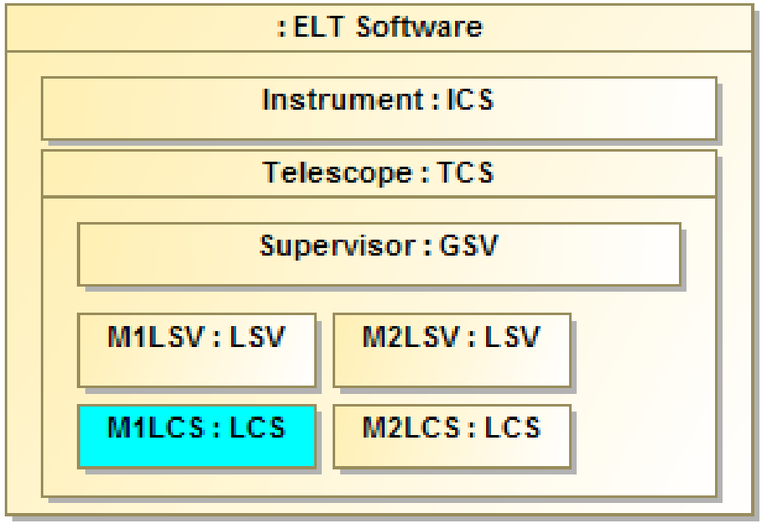

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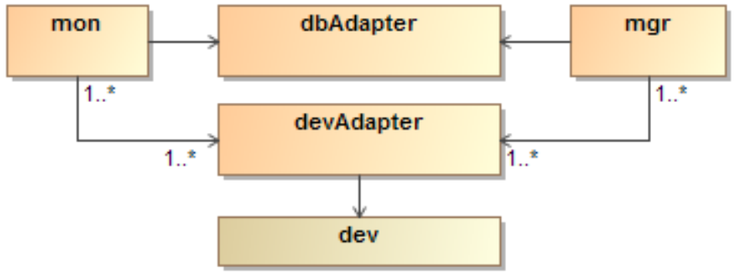

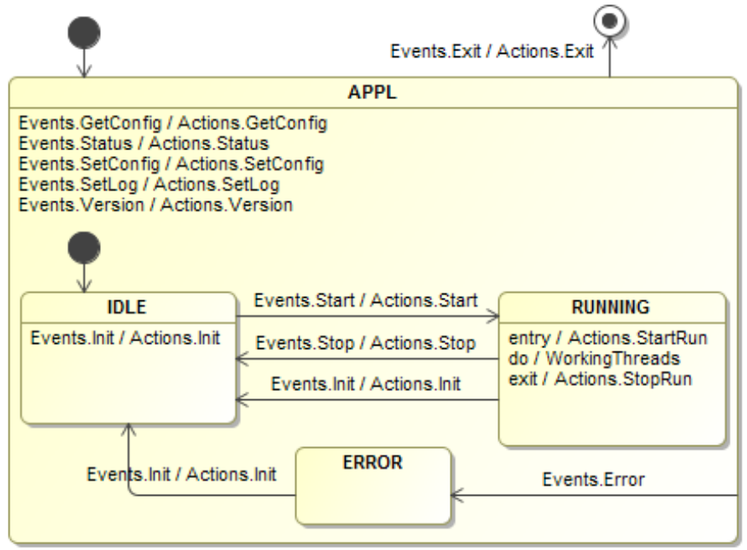

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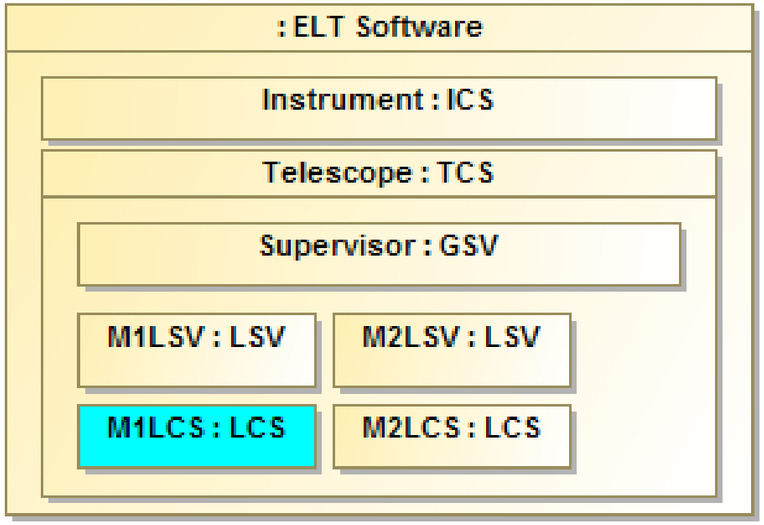

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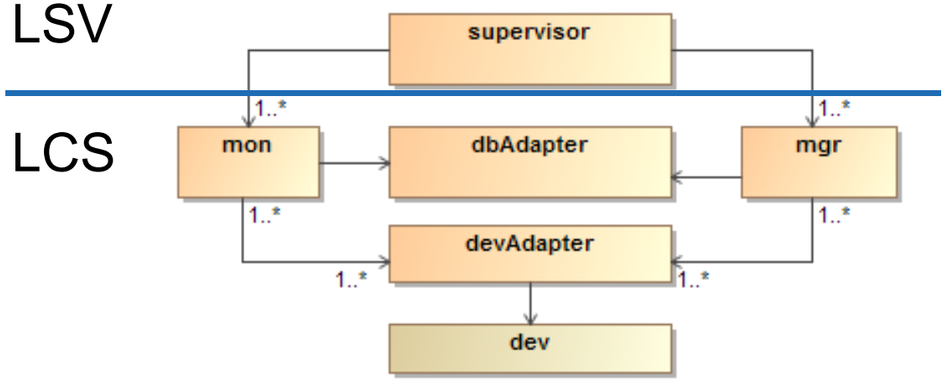
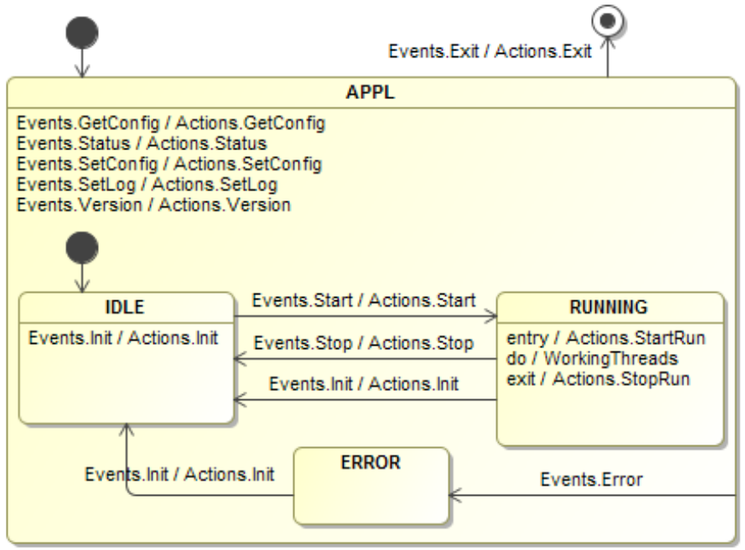
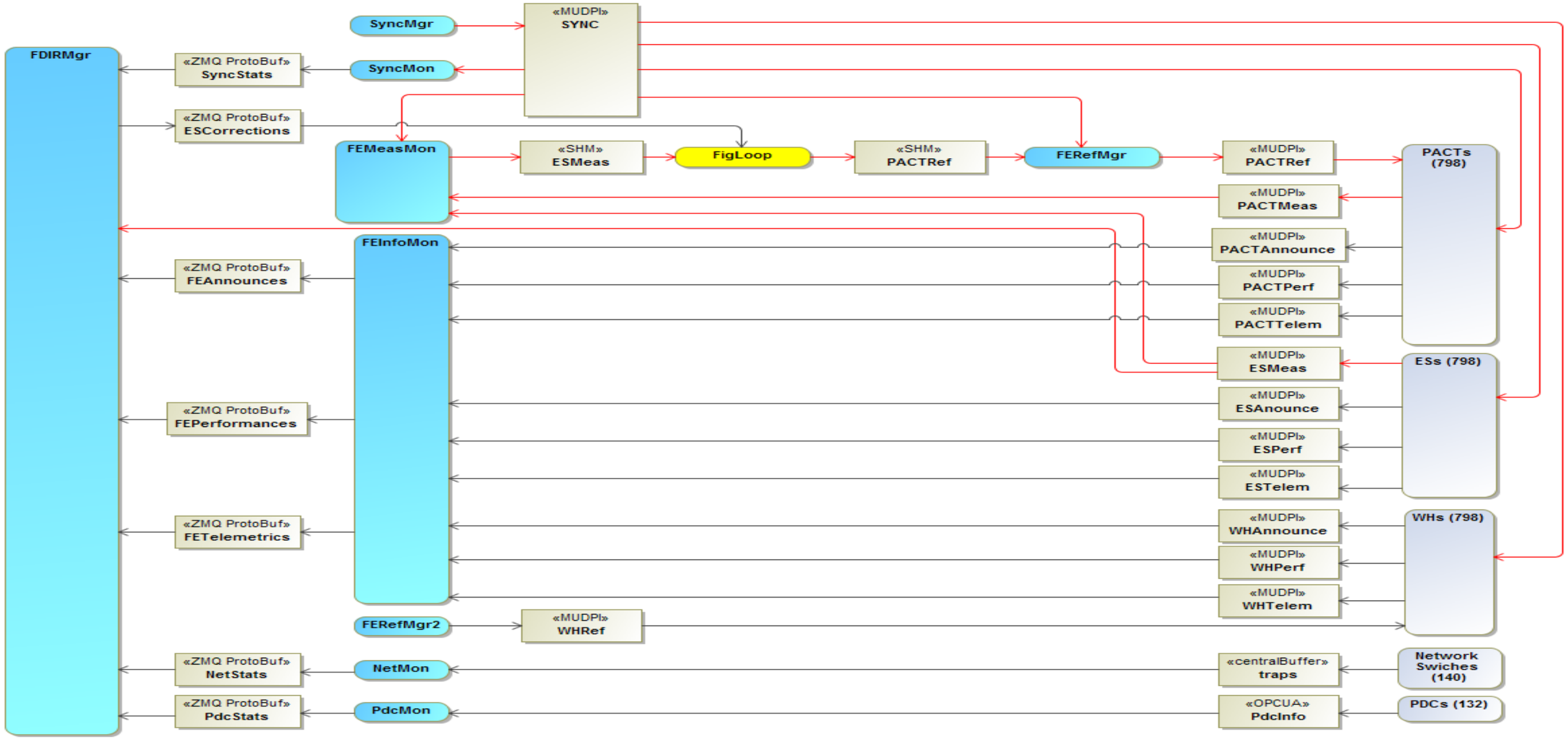
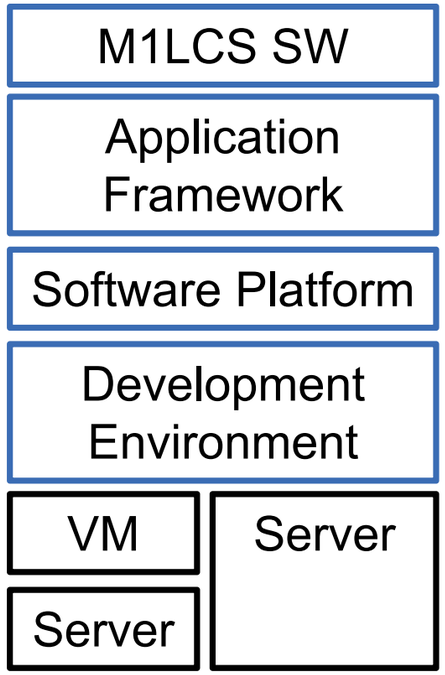




M1LCS - Data Flow (500Hz in red)



M1LCS – SW Implementation

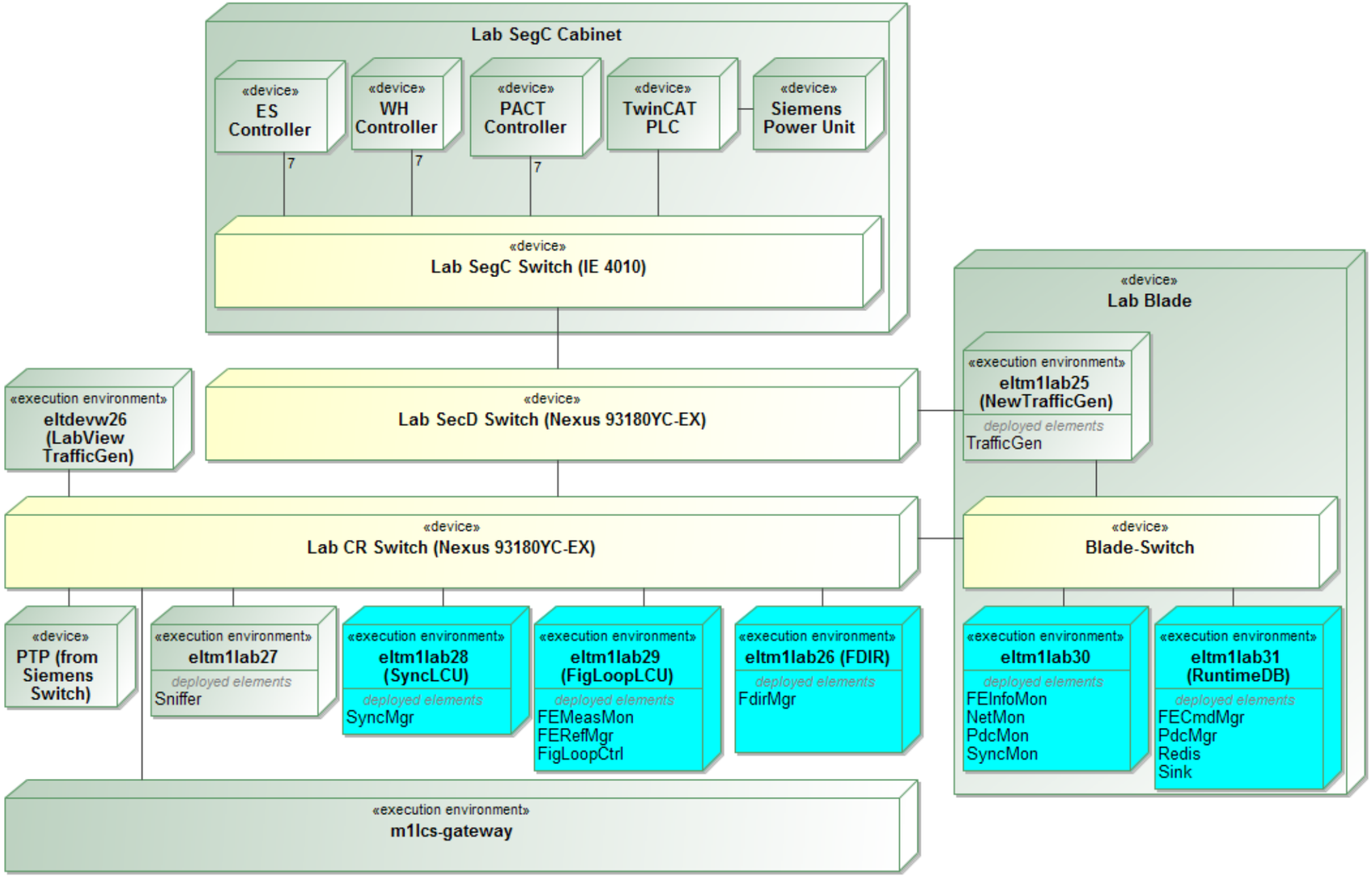


Development Environment	
OS	Linux CentOS RT patch (CERN dist.)
Languages	C++/C, Python
Building	Waf (+ ESO wtools)
GUI	Qt, PySide2
Unit Tests	Google Tests
Int. Tests	Robot Framework
Deployment	Nomad/Consul
CI	Jenkins
Quality	Cpplint, cppcheck, valgrind

Application Framework (RAD)	
Event Loop	Boost ASIO + AZMQ
State Machine Engine	SCXML interpreter: scxml4cpp (ESO)
Code generation	Event DSL / codegen (ESO) SysML Statecharts / COMODO (ESO) Templates / Cookiescutter

Software Platform (Temporary)	
Middleware	ZMQ, MUDPI (UDP), OPC-UA (open62541); [ZMQ ser/deser: Google ProtoBuf]
Configuration	File based (YAML) + Redis
In-memory DB	Redis (hiredis)
Error Handling	Exception
Logging	EasyLogging
Alarm	Based on Redis

M1LCS – Lab Deployment



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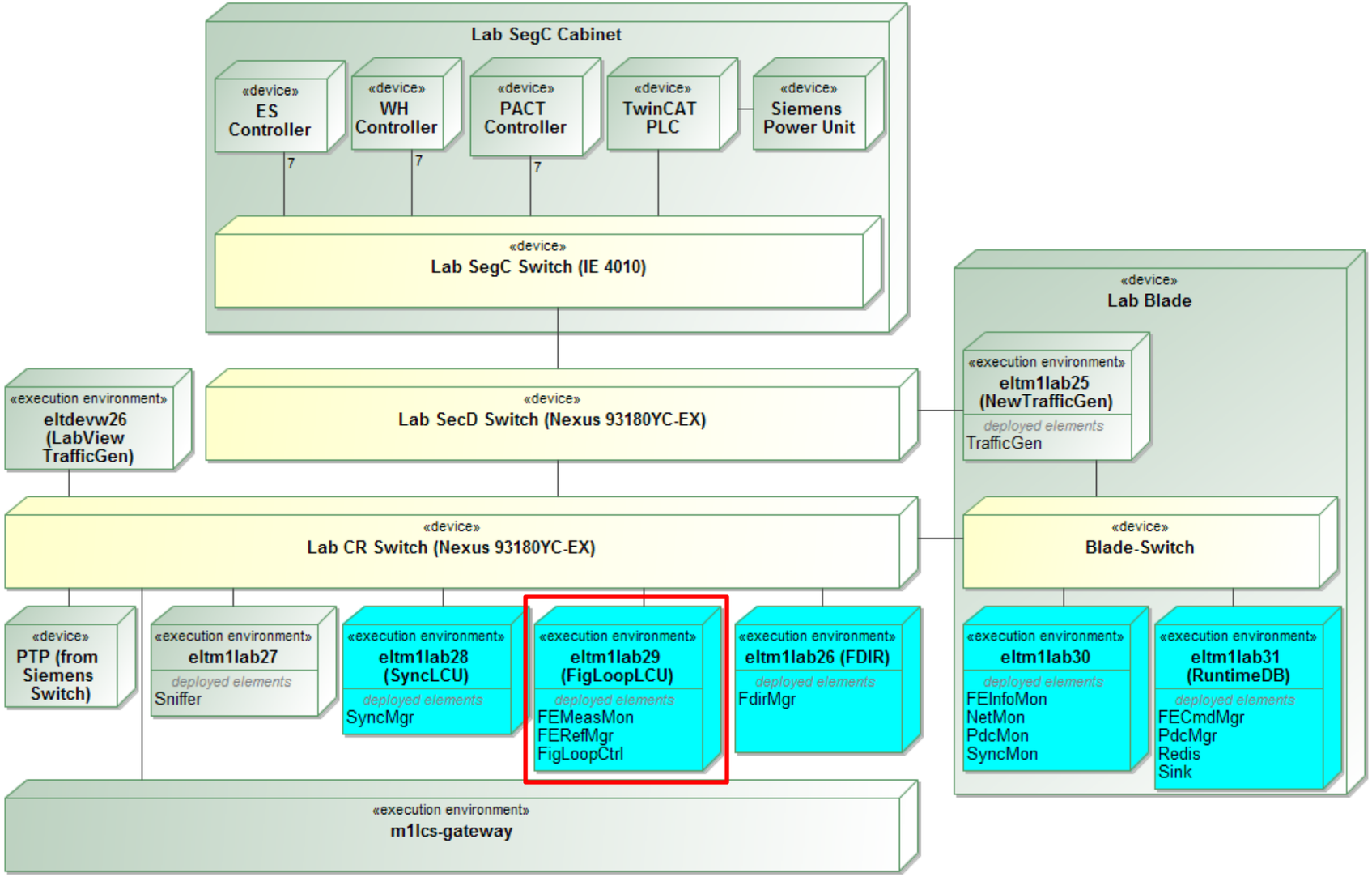
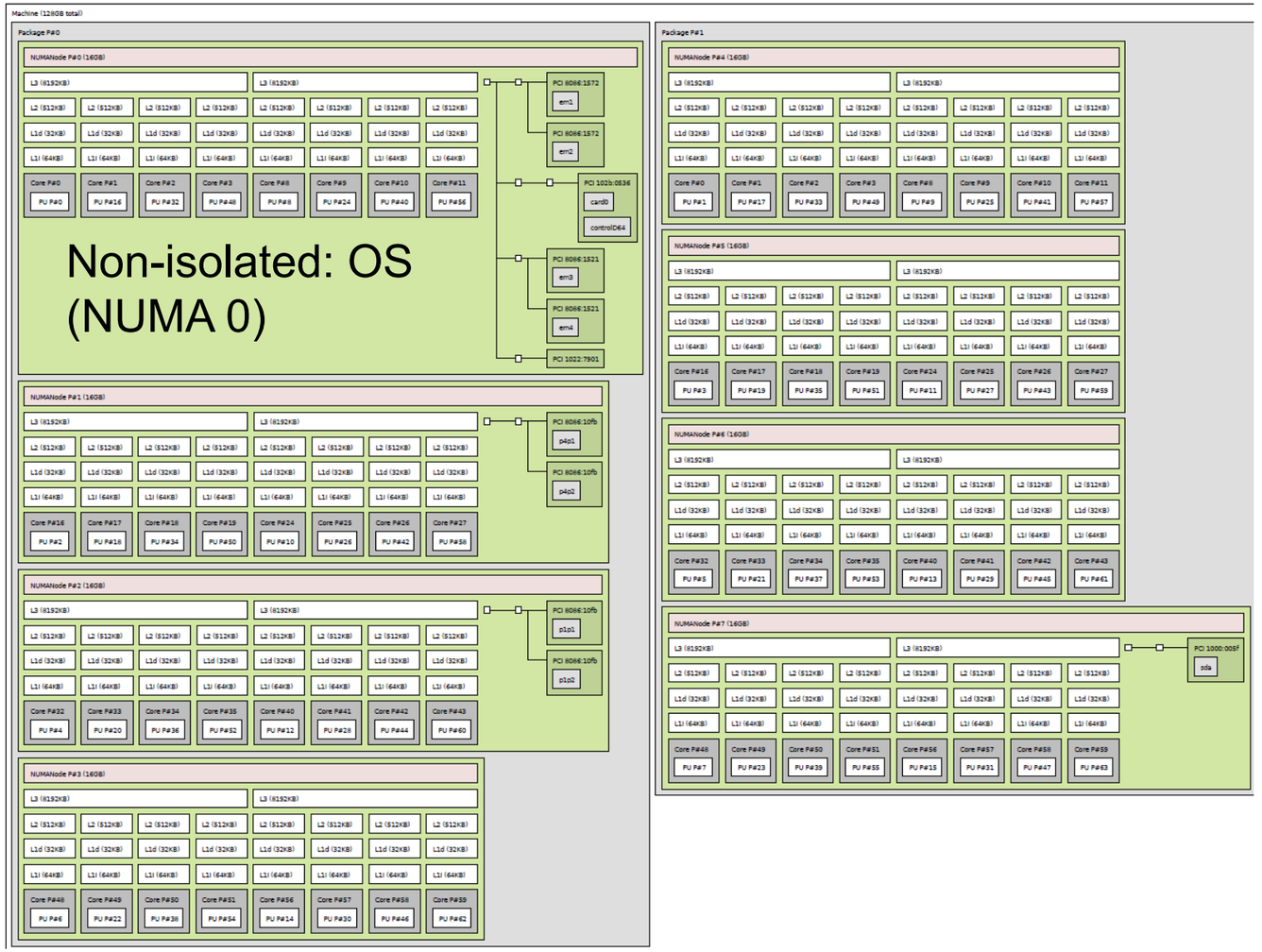


M1LCS/LSV – Figure Loop on AMD Epyc

1 CPU: 4 dies/NUMA nodes
1 Die (Zeppelin):
- 4+4 cores (2 core-cortex)
- 8+8MB L3
- 1+1 memory channels

Die -> NUMA node -> PCI



>lstopo
>numactl -H

CPU-0 (M1LCS) **CPU-1 (M1LSV)**

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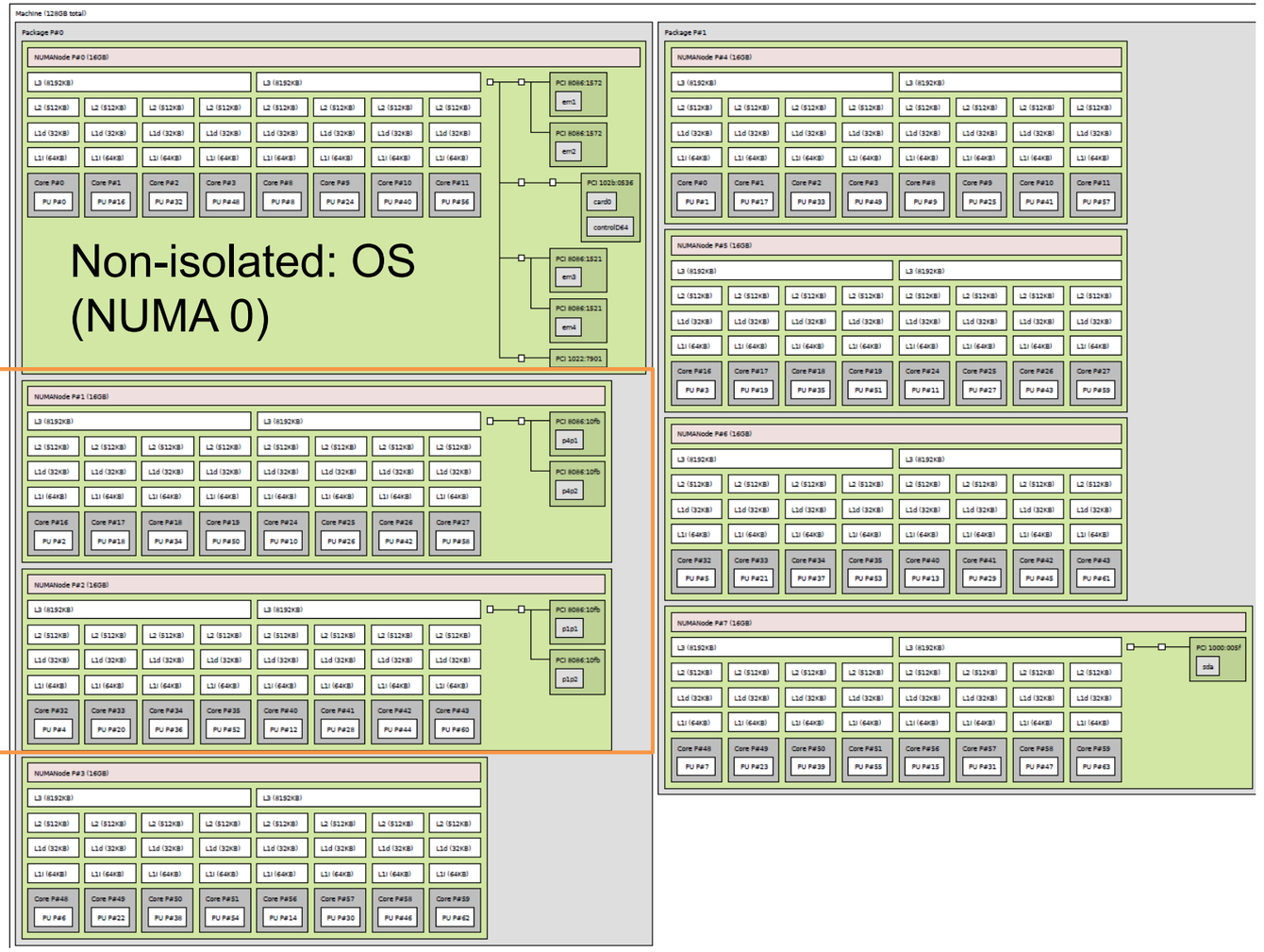
FEMeasMon
6+2 threads to acquire ES+PACT meas.
(NUMA 1,2 -> 2 PCI slots/NICs)



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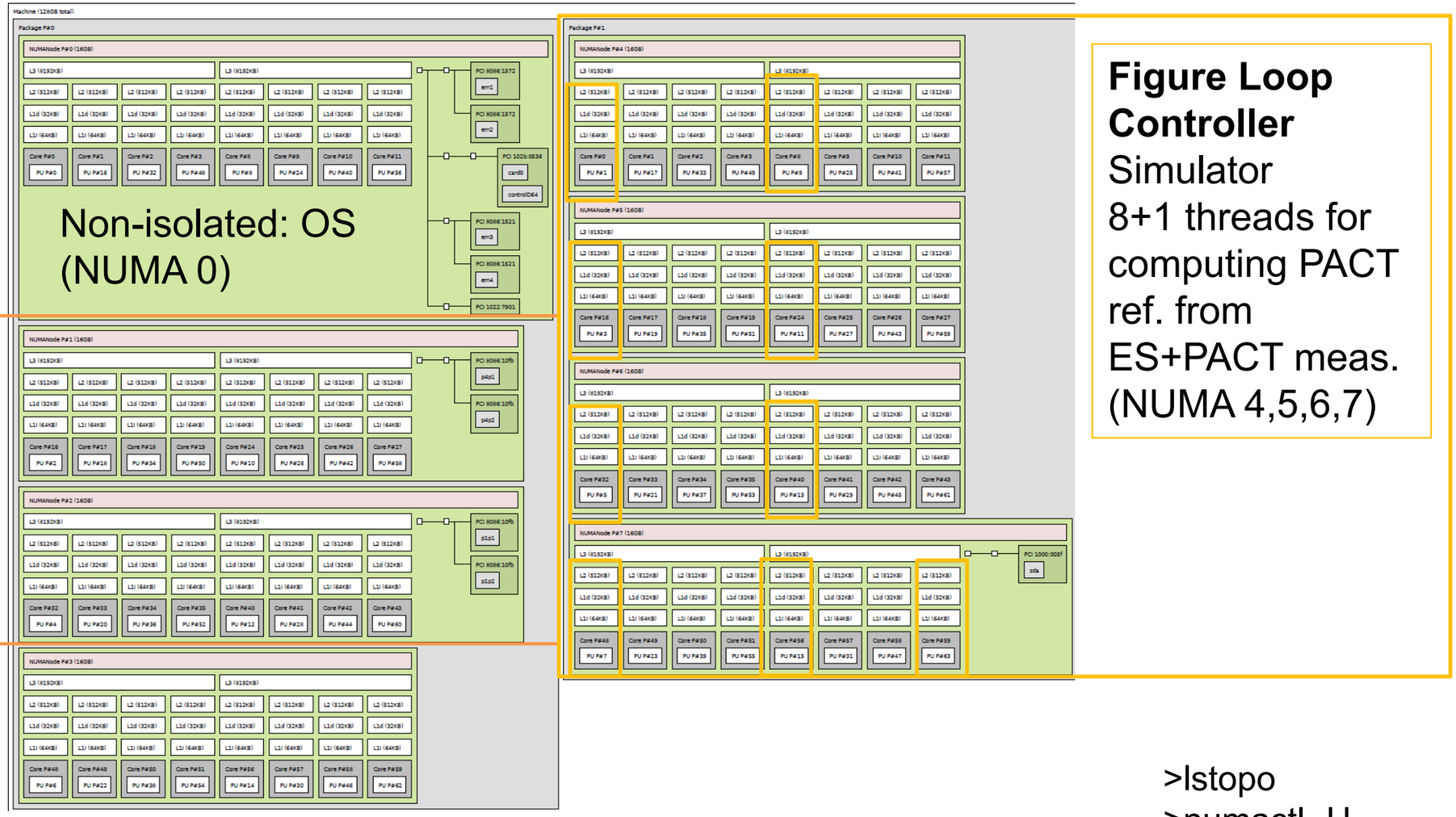

Figure Loop Controller
Simulator
8+1 threads for computing PACT ref. from ES+PACT meas.
(NUMA 4,5,6,7)

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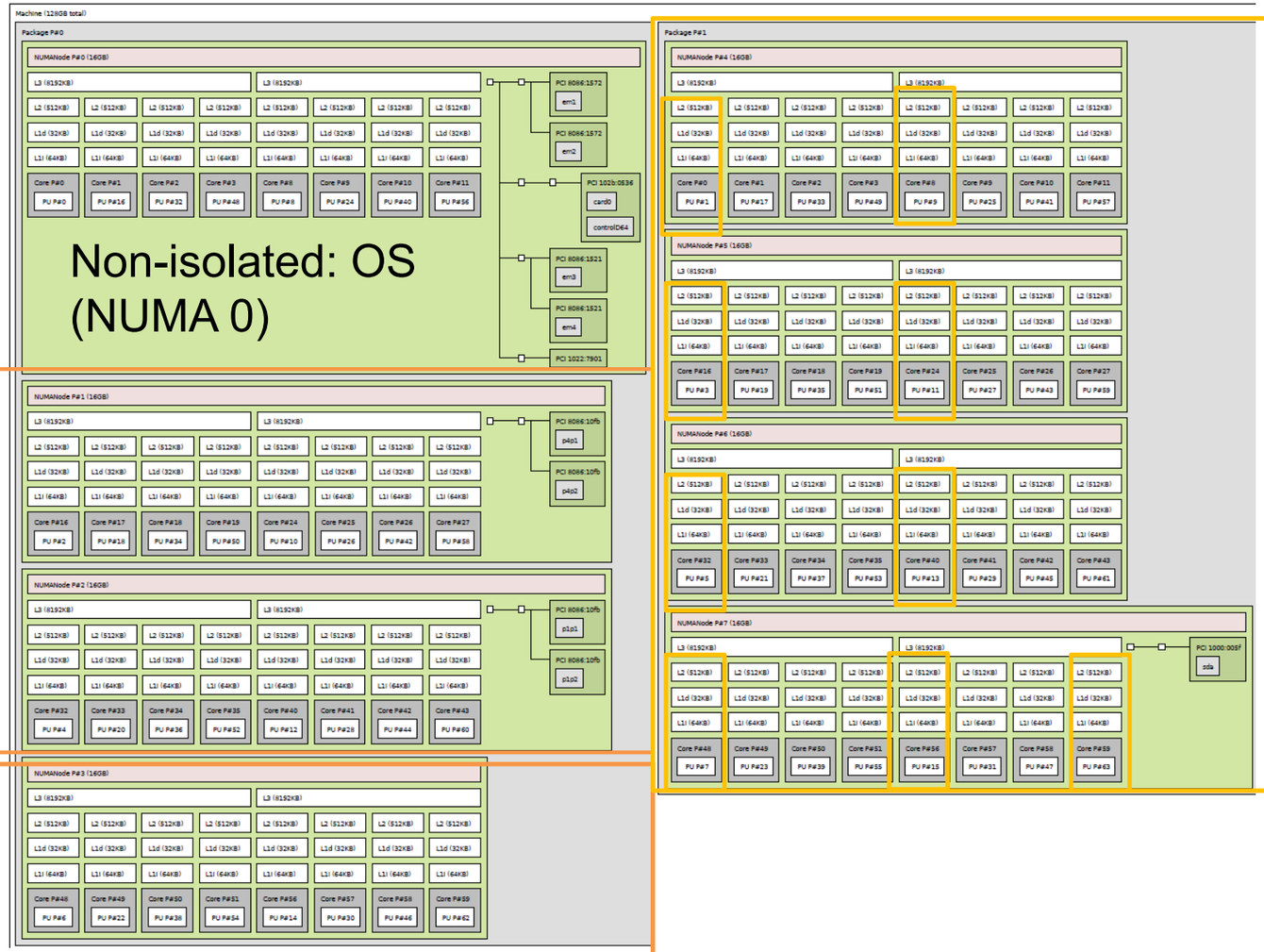
FERefMgr
4+2 threads to send PACT ref. (NUMA 3)



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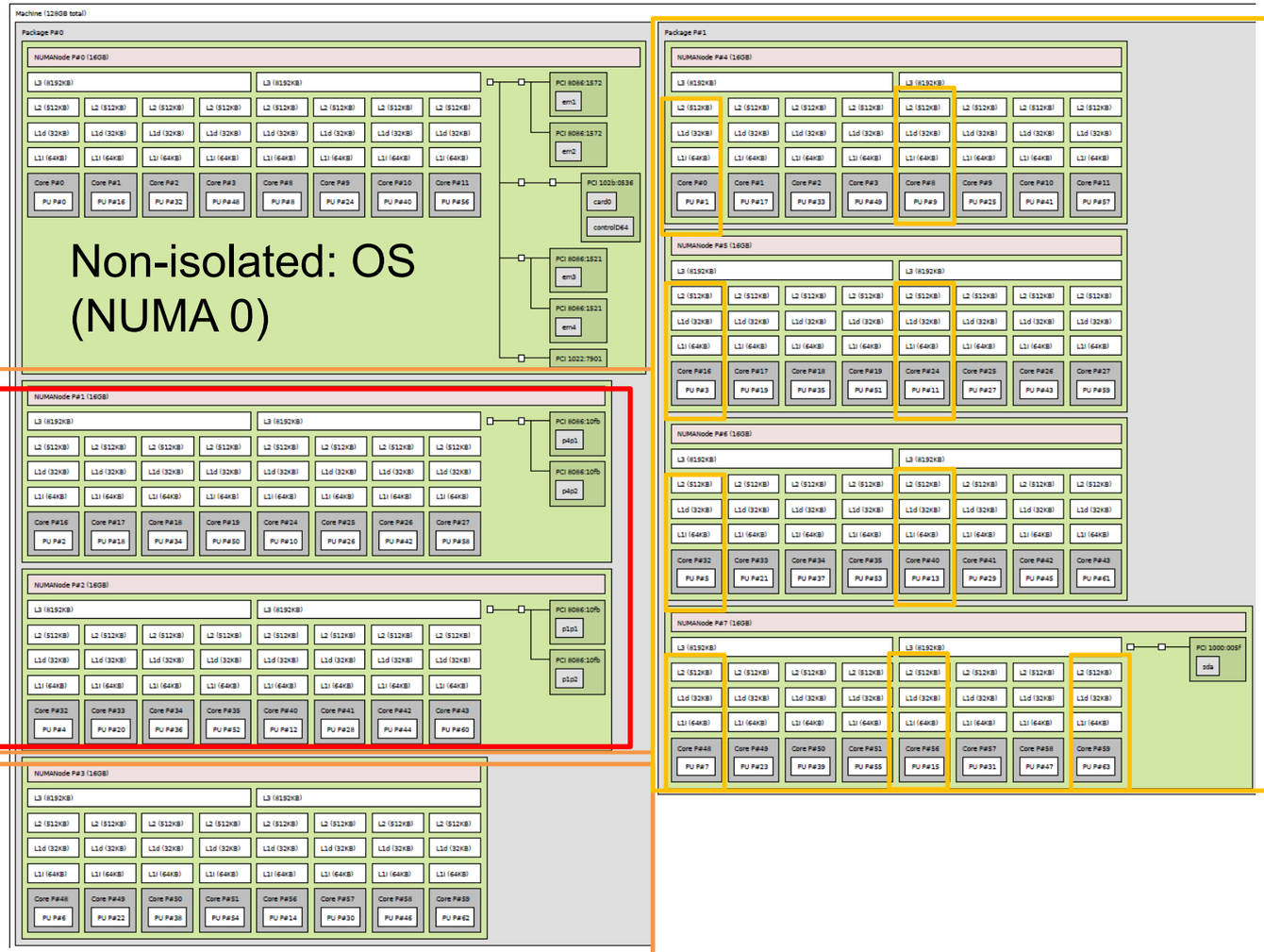

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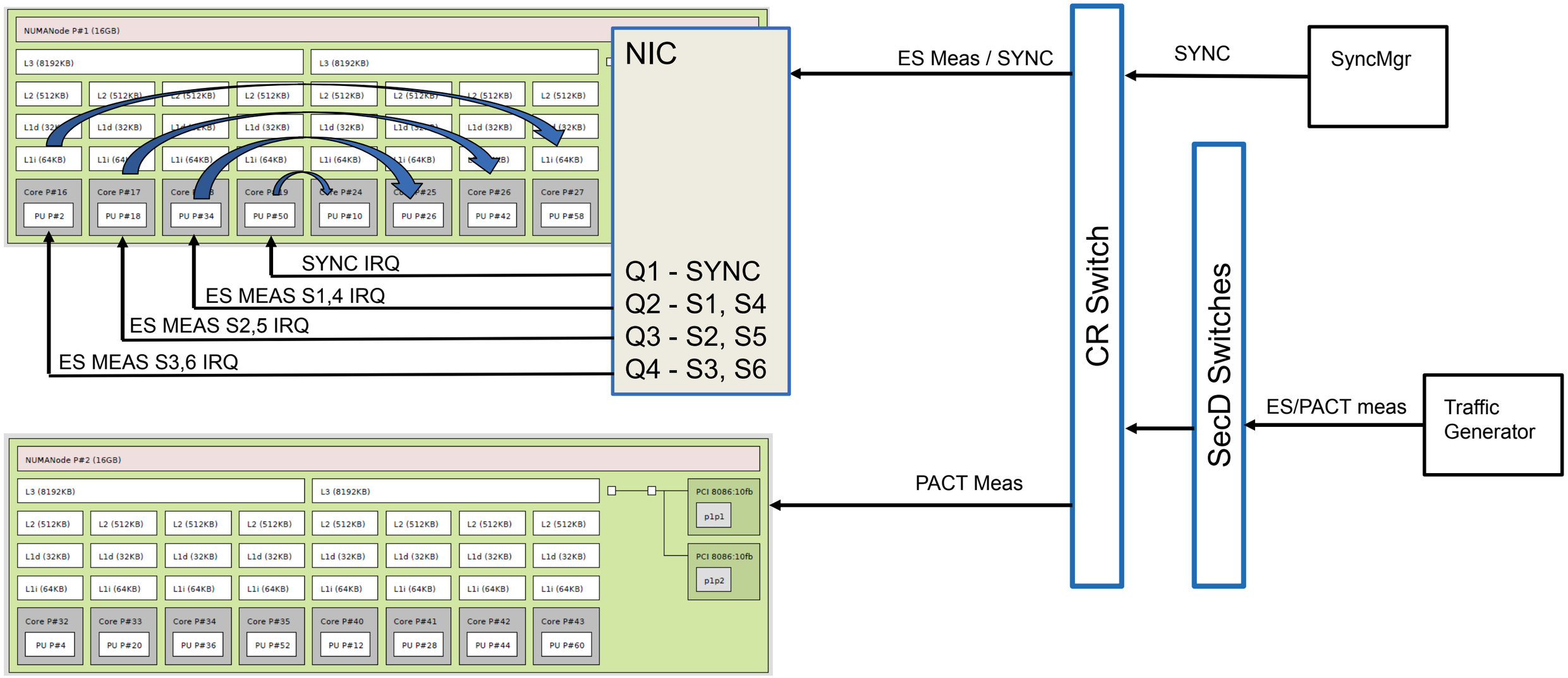
M1LCS – Measurements Packet Flow



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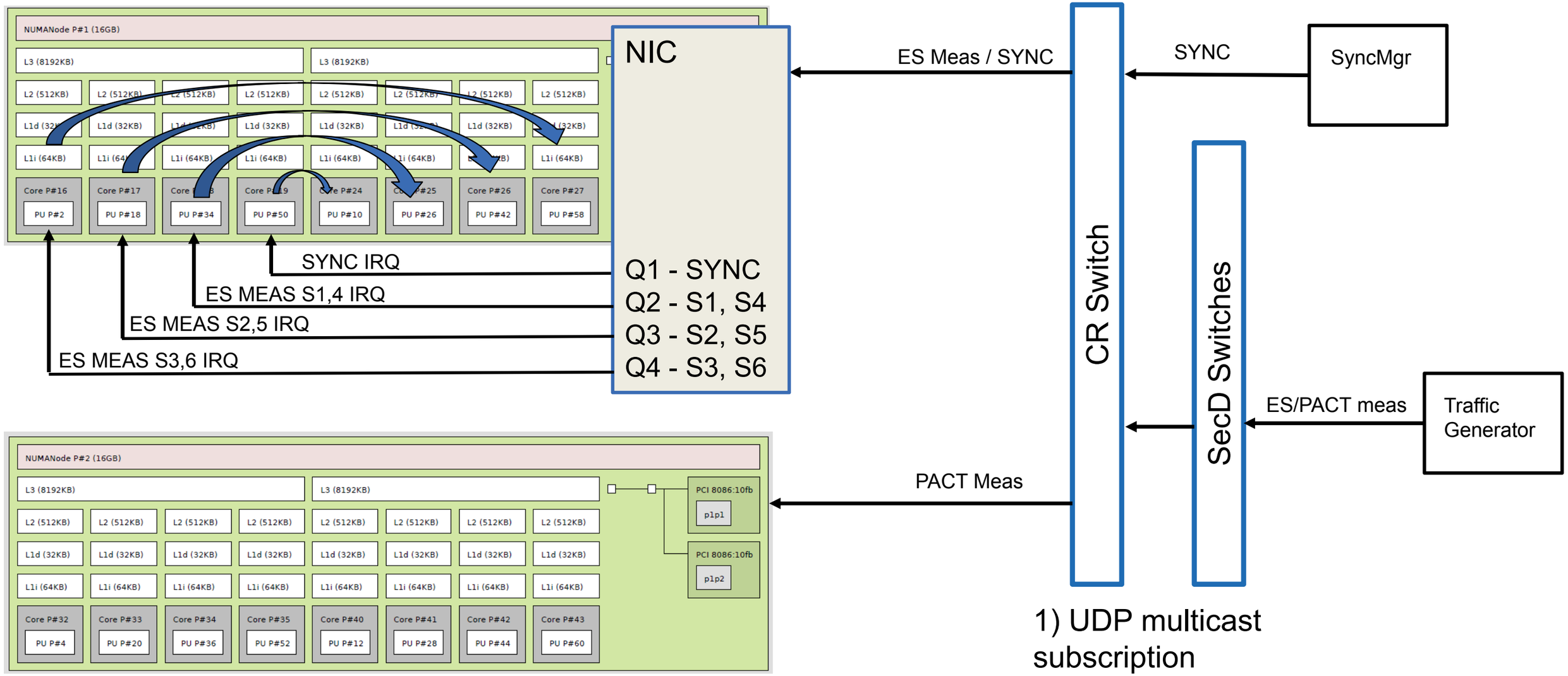

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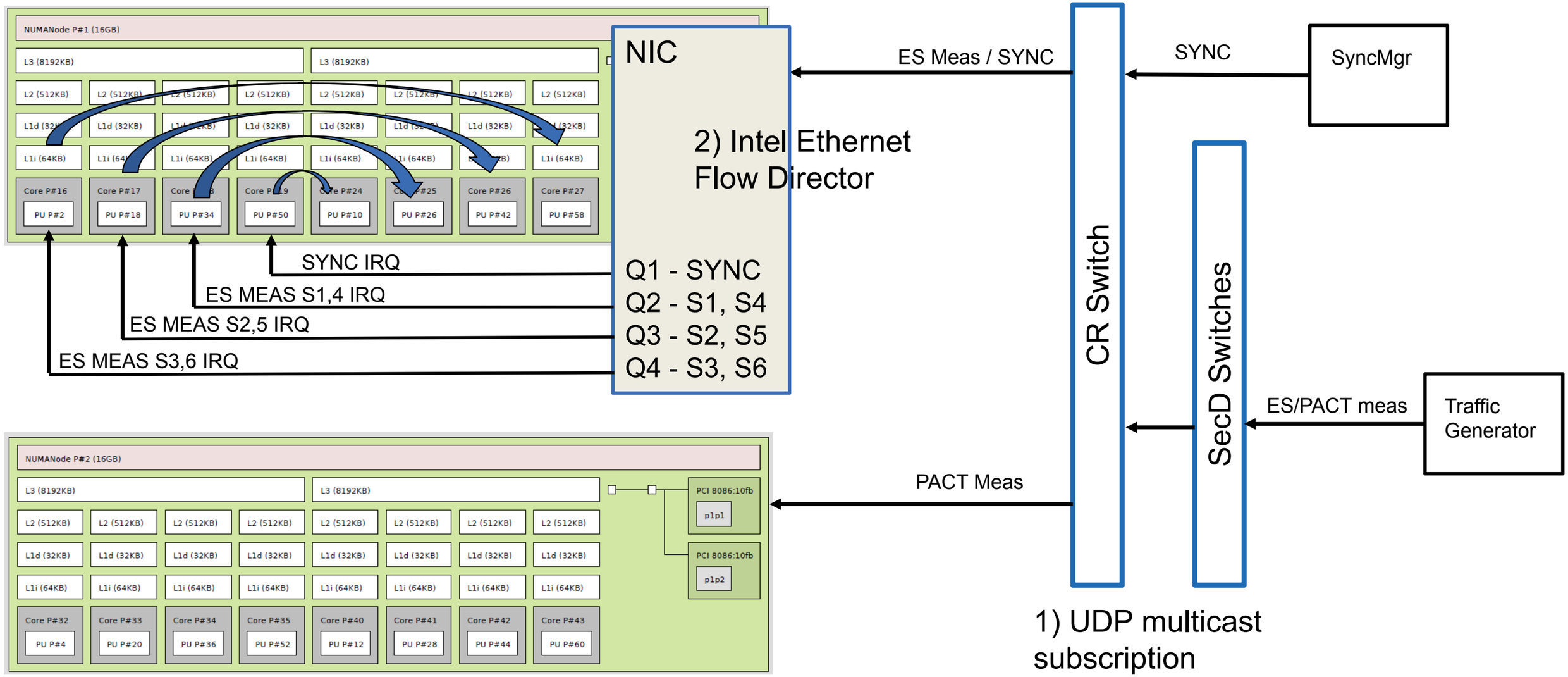

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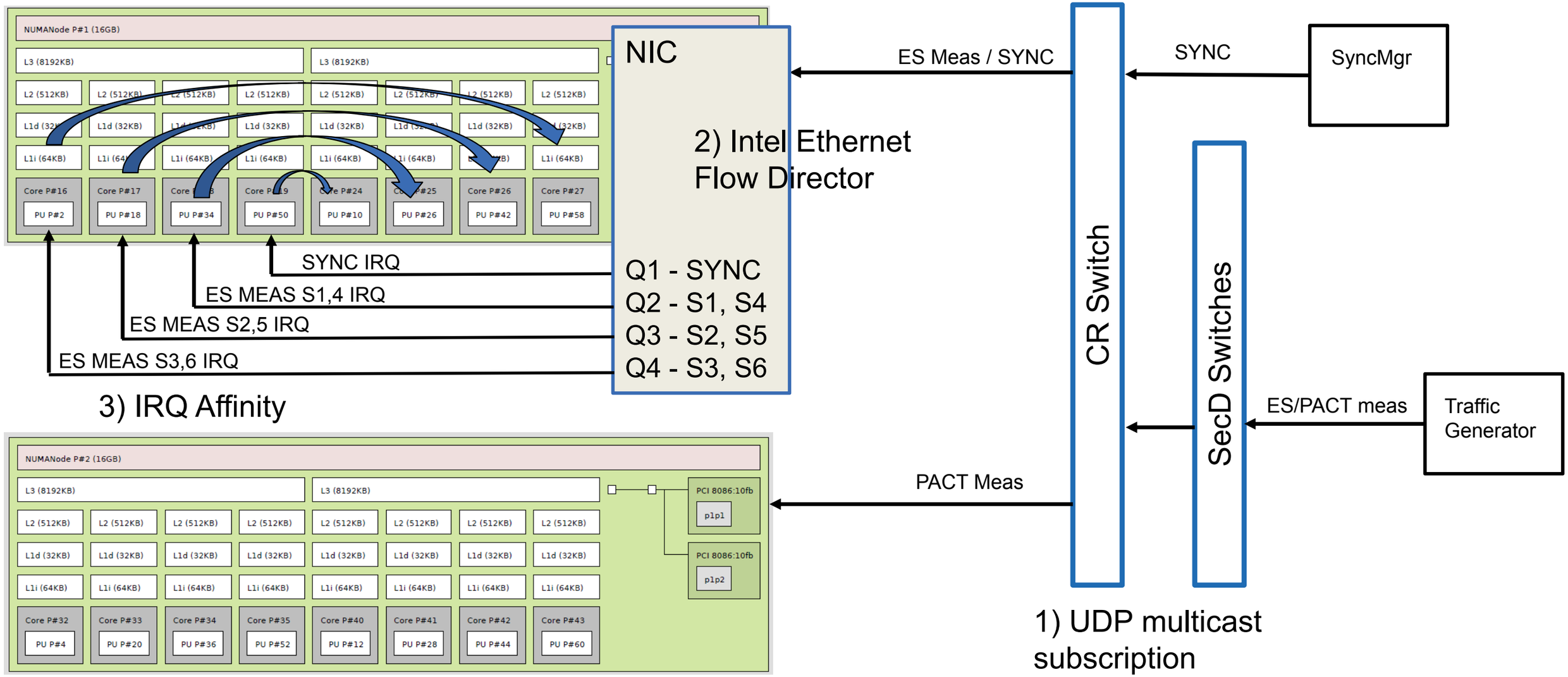

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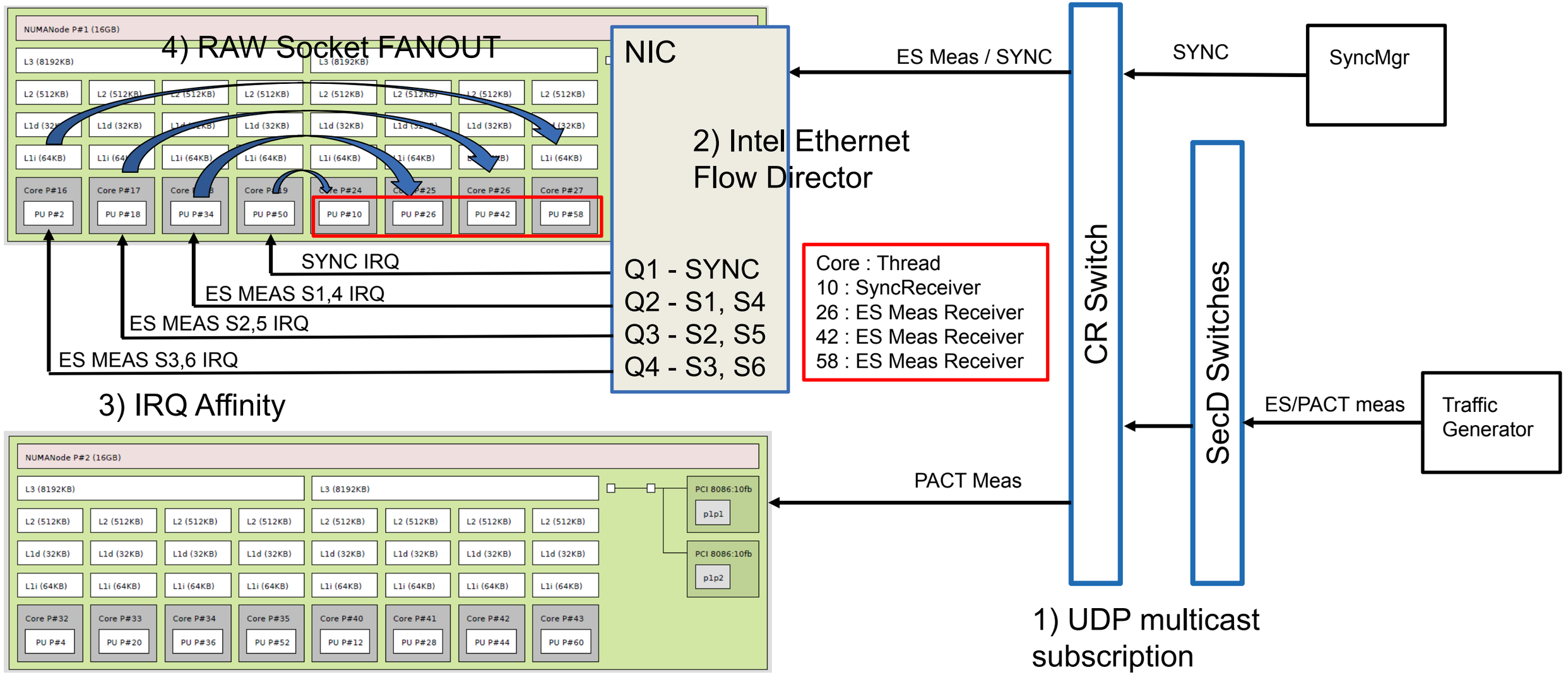
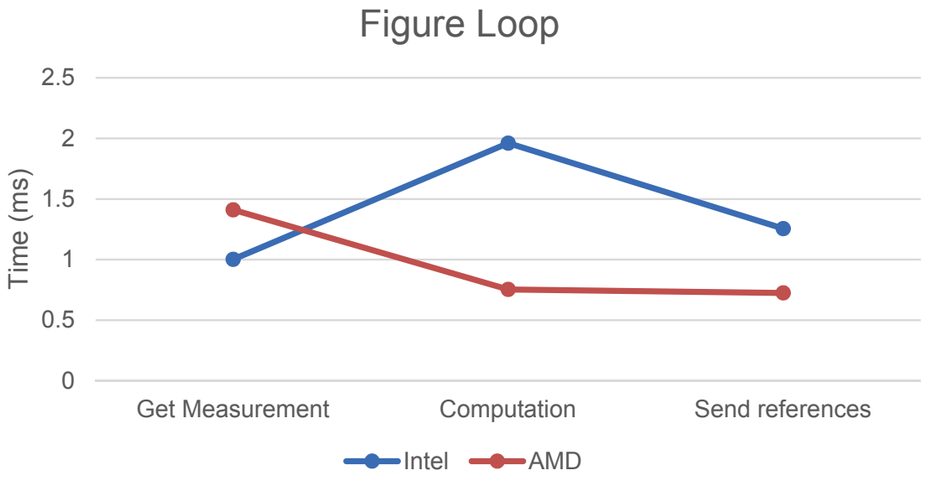


M1LCS – Figure Loop Results



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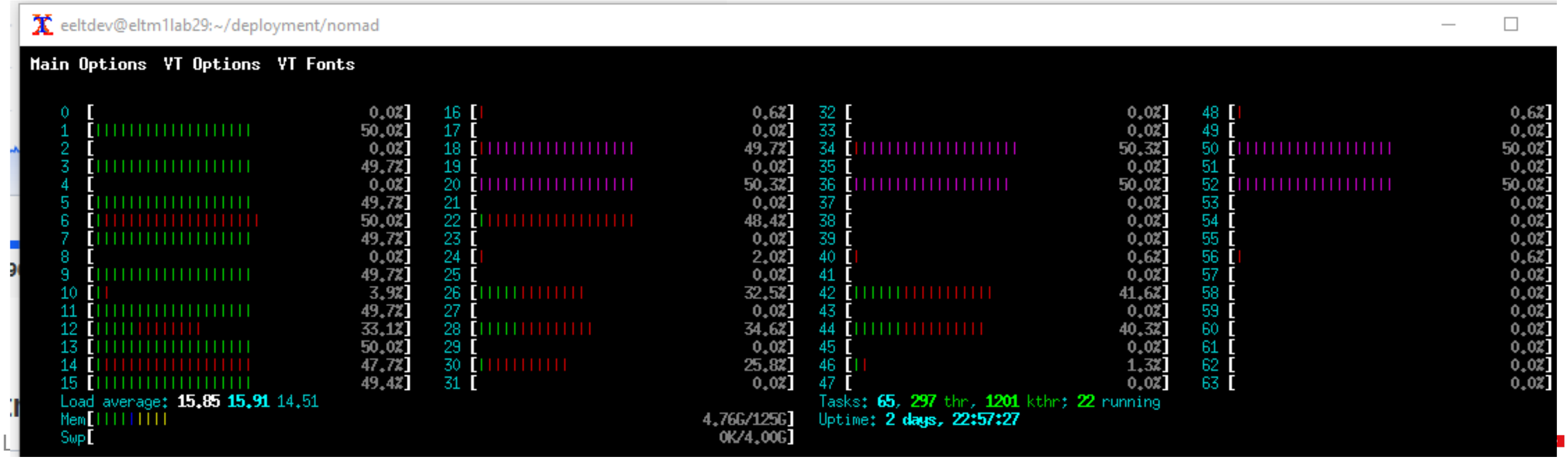
m1FEMeasMon.ctr.update.time_last_packet	0.001139	
m1FigLoop.ctr.update.cycle_time	0.000685	< 0.002s
m1FERefMgr.ctr.update.cycle_time	0.000537	< 0.002s



Questions?