

Centre de Physique des Particules de Marseille

ATLAS LAR CALORIMETER UPGRADES Phase 1 Control and Monitoring and Phase 2 AIDAQ Project

November 23, 2020

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ATLAS LAR UPGRADES

Overview

Context

- ATLAS LAr
- LHC-HL
- Phase 1 upgrade

2 Ltdb Control

3 Phase 2: AIDAQ

- Implementation
- Results



ATLAS LAr



- Is integrated in the ATLAS Detector Control System (DCS)
- The Run Control Application configured it for data taking

LHC-HL Plan



- Phase 1 (now): Trigger Readout upgrade
- Phase 2: Main readout upgrade



LTDB:

- Digitizes Super Cell Signals at 40 MHz, 12b precision
- Send ADC to LDPS
- 320 Channels per board
- Send old layer sums to legacy trigger system (backup)
- Increased granularity



Ltdb Control and monitoring



Have a fast and reliable control and monitoring ?

- about 120 boards
- containing about 135 components who may need a specific configuration
- Some components have hardware issue and need a different configuration process
- about 400k Registers in total
- Some components need a calibration
- The control is done through a GBT SCA asic providing several I2C bus, GPIO and monitoring Adc

LTDB control: Choosen setup



Felix-712:



- Switch that handle 40 slow control links
- GBT protocol (Rad-Hard optical links) (CERN

elixcore:	•	Server to control the felix	

OpcUaScaServer:

- Server to provide abstraction over the Felix
- Provide function at GBT-SCA level
- For example I2CSlave.write, Gpio.read

- Develloped at CPPM
- Server which provide to TDAQ (Run Control) or DCS high level functions to control the LTDB and monitoring values.
- For example one function per TDAQ transition (Init,Configure)
- Can handle several hardware errors with retries or dedicated functions
- Multi-threaded, a configuration take 9s now
- Is able to read BE boards (LDPS) for calibrations
- One C++ class per component

My DCS Client



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TDAQ Client(Included in ATLAS partition)

000			X AT	LAS TDAQ SOFTWARE - Partition	ATLAS		
File Commands	Access Con	trol Settings L	ogging Level He	lp.			
🗐 Commit & Rele	oad 🌸 Lo	ad Panels		Total dead-time (%)		N/A	Utilities
RUN CONTROL S	TATE	INITIAL	Run Control Se	egments & Resources Data	set Tags PMG		
Run Control Comma	ndr		? INITIAL	RootController		BootContro	ller
SHUTDOWN	IND	FIALIZE	🗢 🙀 Online S	egment		_	
			► ﷺ Infrastr	ucture		• CHIP-ATLAS	
UNCONFIG	00	ONFIG	 CONFIGURE 	D TDAQ		• Calorimeters	
			CONFIGURE	D InnerDetectors		• CoralServerATL/	6
STOP	5	TART	• INITIAL	@ Calorimeters		• DUC	
			 gp mira conecia 	inclure		UF OF CARE	
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Lumi Block	5		 CONF 	IGURED LArDatabase		Defeos:InnerDe	tectors
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😳 🕈 Subscrip	tion criteria	warning .	ERROR 🔤 FATAI	INFORMATION Expres	sion		Subscribe
TIME	SEVERITY	APPLICATION	NAME		MESSAGE		
10:52:28	WARNING	LDPBC_A	ers::Message	[RUNTIME] object 'LArC-025': LA	TOME in slot '1' is DISAE	ILED, skipping it.	
10:52:28	WARNING	LDPBC A	ers::Message	IBUNTIMET object 10 LATOME cri	te ID is undefined.	LED, MUDPING K.	
10:52:28	WARNING	LDPBC_A	ers::Message	[RUNTIME] object ": LATOME ca	mer slot is undefined.		
10:52:28	WARNING	LDPBC_A	ers::Message	[RUNTIME] object ": LATOME co	mmissioning path is 'ma	pping/production/data/EMBA	4/.
10:52:20	WARNING	MOTEndcanf	ers::Message	[RUNTIME] Object TARC-0251 DA	TOME IN SIDE O' IS DISAE	ILEU, skipping it.	
► 10:51:42	WARNING	MDTBarrelC	ers::Message	Test was not started by Test M	anagen		
10:51:42	WARNING	MDTBarrelA	ers::Message	Test was not started by Test M	anagen		
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Clear 😹 Messa	ge format	Visible	rows 100	Current ERS subscription	sev-ERRO	R or sev–WARNING or sev	-FATAL

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ATLAS LAR UPGRADES

- We want to develop a neural network to compute energies coming from the ADC of the liquid Argon Calorimeter of ATLAS.
- To increase the performance with the Hi-Lumi pile up.
- Implemented in the new readout board, the LASP
- 2 Stratix 10 FPGAs.







Phase 2 upgrade: AIDAQ



LSTM cell



Implementation

I made a Design fully unrolled to decrease $\ensuremath{\mathsf{IIx}}$

Schematic with a 3 timestamp 1 Layer LSTM



Phase 2 upgrade: AIDAQ





- Test with 10 inputs ->Correct number of output
- outputs are correct
- First 2 value with un-fixed latency
- But after these 2 , fix latency and II at 1 !

On simulation for 2 billions inputs we compared the output of the "HLS lstm" and the one from our C++ reference.



The differences in output come only from the Look Up table used by nnet::activations. With "real" mathematic it match perfectly

Phase 2 upgrade: AIDAQ



- Stratix10, 1SG280HU2F50E2VG
- Quartus 20.2 (Migration to 20.3 is ongoing)
- Internal vector size 4
- 10 timestamps
- 10 inputs
- ac_fixed <16,6,true >type

Clock and latency

Clock Frequency Summary						
	Quartus Fitter: Clock Frequency (MHz)	Compile Target Frequency (MHz)	Compile Estimated Frequency (MHz)			
Clock 1x	TBD(?)	480	480			

Verification Statistics						
	Invocations	Latency (min,max,avg)	II (min,max,avg)	Details		
Spacer	Invocations	Latency (min,max,avg)	ll (min,max,avg)	Details		
base_network	10	522,534,532.3	1,1,1	Click for details		
Explicit component invocations	0	n/a,n/a,n/a	n/a,n/a,n/a	Click for details		
Enqueued component invocations	10	522,534,532.3	1,1,1	Click for details		

	ALUTs	FFs	RAMs	MLABs	DSPs	Details
♥ System	62803 (3%)	76796 (2%)	207 (2%)	98 (0%)	186 (3%)	
♥ base_network	62803 (3%)	76796 (2%)	207 (2%)	98 (0%)	186 (3%)	1 compute unit.
Component call	0	0	0	0	0	16b wide with
Component return	0	0	0	0	0	16b wide with
Variable: - 'inputs' (Istm_cell.cpp:107)	72	288	0	0	0	Register,\n9 re
base_network.B1.start	62731 (3%)	76508 (2%)	207 (2%)	98 (0%)	186 (3%)	

- Devellopment is on-going
- First working lstm is done
- More work to be done to be able to include it in HLS4ML
- Take too much ressources for our use
- Can be reduce with multiplexing.

Questions ?

We want to develop a LSTM network for ATLAS and also include LSTM on quartus HLS4ML. For these we need to acheive different steps

- Understand HLS for quartus, LSTMs networks ,HLS4ML : Acheived
- Devellop a LSTM in HLS specific to our application : Acheived
- Use HLS4ML librairies : For now only activation function use it (nnet_activation.h)
- Implement it in FPGA (Stratix 10) : Work in progress
- Move to a fully configurable LSTM with parameters : Work in progress
- Include in HLS4ML : To be done