# MARTe2 and MDSplus Integration for a Comprehensive Fast Control and Data Acquisition System

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# Data Acquisition and Real-Time control in long lasting experiments

- In the past two different HW and SW solutions
  - Fast computation and low latency for real-time control
  - Bulk transfer and high data throughput for data acquisition

- Not anymore valid when streaming data in long lasting experiments
  - Current bus and disk technology allow managing high speed data movement from ADC to disk
  - Availability of different cores on computer allows co-existence of real-time tasks with other system activities

- Same Hardware prescribed in ITER for data acquisition and real-time control
  - The only difference in underlying bus (DAN, SDN)

# Uniformity in Hardware means Uniformity in Software?

- Separate Frameworks have been traditionally used for real-time control and data acquisition

- MARTe and MDSplus have already been integrated in the past
  - MDSplus used to store data produced by MARTe
  - Configuration data and reference waveforms used in MARTe retrieved from MDSplus pulse files

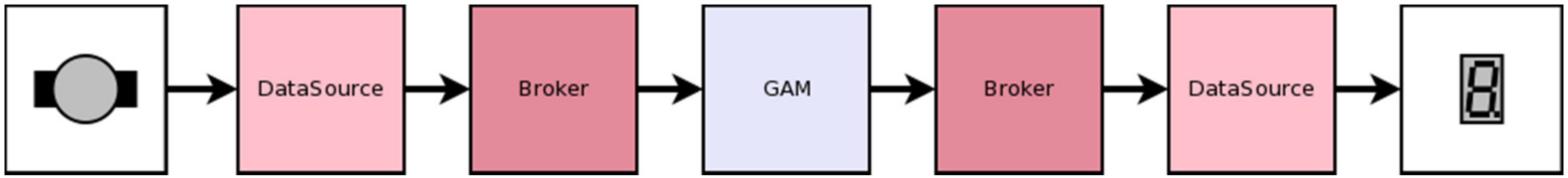
- Data Plumbing implemented BUT the two systems were mainly independent
  - Two systems to be learnt, maintained and configured in day-per-day operation

# MARTe => MARTe2

- MARTe2 is a completely re-written version of MARTe developed under strict quality standards
  - MISRA compliance
  - Full test units for largest code coverage
- MARTe2 improves MARTe platform abstraction
  - From bare-metal microcontrollers to full fledged Linux
  - OS abstraction performed at several layers, with or without threads
- MARTe2 introduces a new and more powerful system abstraction
  - MARTe Generic Application Modules (GAMs) now enriched with two new components: **DataSources** and **Brokers**

# MARTe2 Data Sources and Brokers

- In the former MARTe GAMs were associated to real-time threads and exchanged data in shared memory
  - I/O carried out by specialized GAMs
- In MARTe2 a GAM can only exchange data with DataSource components
  - Data Sources can implement memory buffers or I/O devices
- A step further: Broker objects manage data exchange between GAMs and Data Sources
  - Broker not exposed in the configuration, but chosen by the Data



# Data Sources and Brokers
# A way to complicate one's life?

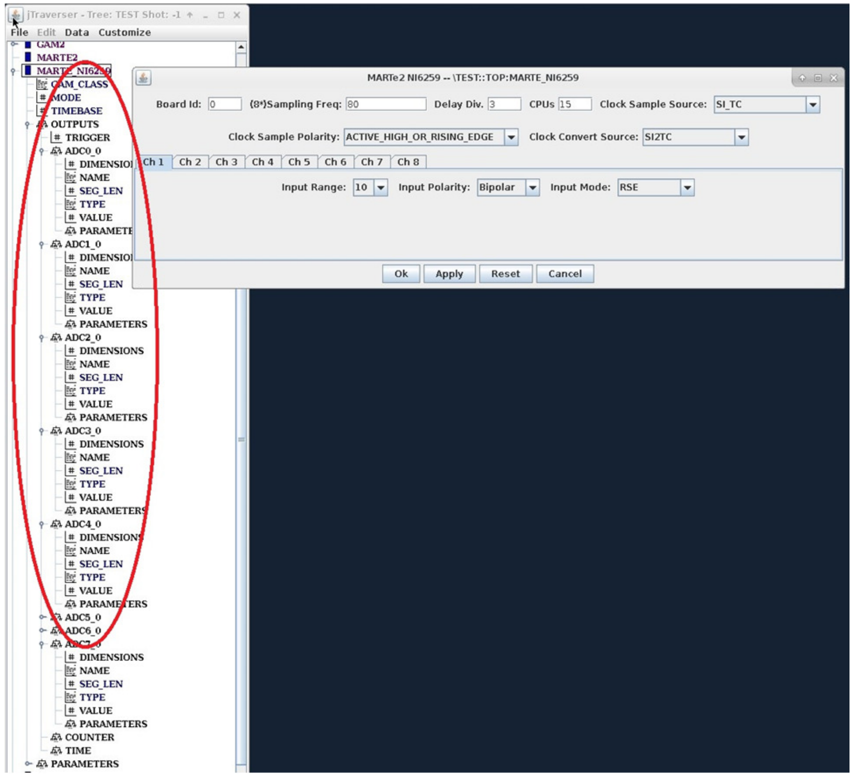
- The answer is definitely: **NO**
- Three logical components each mapping an activity in real-time control
  - GAM => The ***Algorithm***
  - DataSource => The management of ***Data***
  - Broker => The management of ***Data Flow***
- Data flow can be (among others):
  - ***Plain***, i.e. just copy in memory. In this case Data Source implements just the buffer and the broker the copy
  - ***Synchronized***, where the broker triggers some action like ADC sampling, DAC output.
  - ***Decoupled***, to handle non real-time storage of real-time data stream. The broker will handle buffering and the management of a separate thread

# MDSplus Data Plumbing in MARTe2

- Carried out by two DataSource implementations: **MDSReader** and **MDSWriter**
  - ***MDSReader*** will load reference waveforms in memory and will return appropriate sample whenever the corresponding broker (*MemoryMapSynchronizedInputBroker*) is executed
  - ***MDSWriter*** receives data decoupled from real-time threads thanks to the associated Data Broker (*MemoryMapAsynchOutputBroker*)
- Nevertheless the two systems are still mostly independent, and two different configurations must be provided
  - MDSplus experiment model for Data Acquisition configuration
  - MARTe2 configuration file for the definition of the real-time components (GAMs, Data Sources, Threads)

# MDSplus Devices

- Model the different object instances in the experiment database
- A ***Device*** is the container of set of related data (e.g. to describe a piece pf HW)
  - A subtree in the data hierarchy associated with every device instance
- Devices are similar to classes and bring a data structure (a subtree) and a set of methods
- A constructor method will instantiate the corresponding data set when the experiment database is built
- A Setup Method will be invoked by the graphical browser to show the content of the corresponding instance
- Other methods will carry out device specific functions (INIT, STORE)



# Adding a new device in MDSplus

- MDSplus devices are mapped against ***python classes***
- Developing a new device means developing a new python class that inherits fro ***class Device***

- All the required interaction with MDSplus is carried out by the superlass. The new device has to:
  - Declare the structure of the underlying subtree by means of a ***python dictionary***
  - Implement device specific methods. Associated data items are available as instance fields

- **It is therefore natural to import MARTe2 configuration as a set of devices**

# Mapping MARTe2 components into MDSplus devices

- A straight mapping is not the best approach.
- It is possible to provide a high level view of the system, including all the required information, and then generating on the fly the corresponding MARTe2 configuration
- The system can be described by the following devices:
  - MARTE2_GAM: describing a computation carried out in the system
  - MARTE2_IN: describing an input device
  - MARTE2_OUT: describing an output device
- Data flow will be specified by input/output node references in the associated device fields
  - Naturally expressed in MDSplus by means of ***Expressions***
- All data handled by the system will be stored in the pulse file, providing a complete picture of the system behavior.

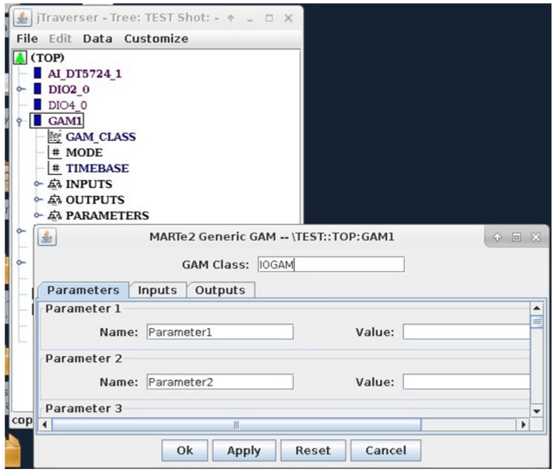
# Use case: A simulation program

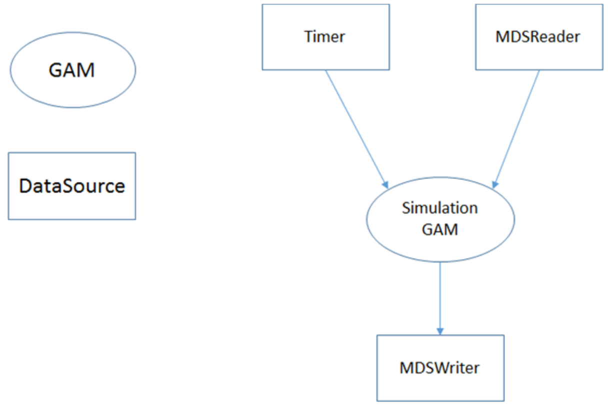
- Implemented by a (subclass of) MARTE2_GAM device

- It specifies the Parameters, the Inputs and the Outputs

- Input fields refer to stored input signals that are read from the pulse file by means of the generated Data Source instance

- The generated MARTe2 components include a MDSWriter instance to store results in the pulse file



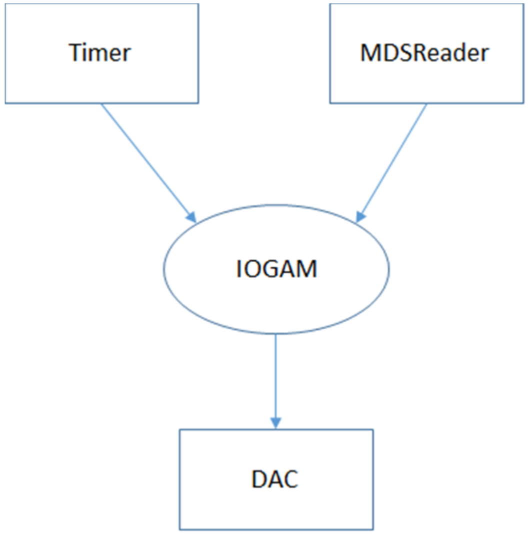
# Use case: Waveform generation

- Implemented by a (subclass of) MARTE2_OUT

- It specifies the Parameters and the Inputs.

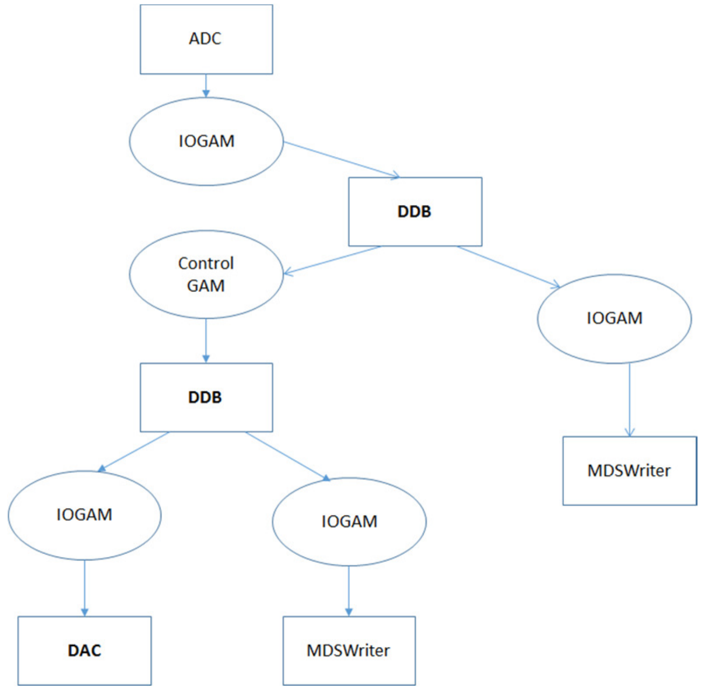
- Input fields refer to stored input signals that are read from the pulse file by means of the generated Data Source instance

- The generated MARTe2 components include a MDSReader instance to read data from the pulse file, and a specific DAC DataSource for waveform generation.



# Use case: Control Loop

- Implemented by a set of MARTE2_IN, MARTE2_GAM and MARTE2_OUT instances
- Input fields of MARTE2_GAM instance will contain a reference to output fields of MARTE2_IN
- Input fields of MARTE2_OUT will refer to output fields of MARTE2_GAM
- The generated MARTe2 components include two MDSWriter instances to write data into the pulse file, one DAC DataSource for waveform generation, and one ADC DataSource for Data Acquisition.



# Conclusions

- The proposed approach provides a full integration of MARTe2 and MDSplus
- A subset of the possible MARTe2 configurations can be described in this way
  - However it covers the use cases of interest
- A real world MARTe2 configuration file is composed of many thousands of lines, and editing it manually is impossible
- Users do not need a detailed MARTe2 knowledge for system configuration
- Developers can easily wrap MARTe2 DataSources and GAMs into MDSplus devices by inheriting from the python superclasses MARTE2_GAM, MARTE2_IN and MARTE2_OUT.
- The final target will be the generation of MARTe2 GAM and MDSplus MARTE2_GAM device directly from Simulink.

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