Comparative Analysis of EPICS IOC and MARTe for the Development of a Hard Real-Time Control Application

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Going to develop a Real-Time Control Application?

Hard or Soft Real-Time? Which latency is acceptable? What about jitter?

Strict determinism or occasional event loss are tolerated?

What about exploiting the last hardware technologies on the market?

- Both are programming environments to code a **real-time control system** suited for **scientific experiments**.
- Both are **portable** on different operating systems and architectures.
- Both are written in **C/C++ language**.

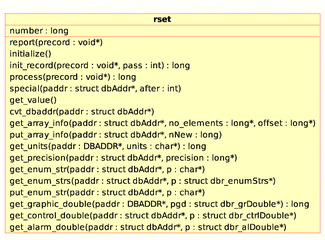
- Both are **component based** (components can be connected to carry out the required control algorithm).
- Both are **configurable at initialization** and **reconfigurable at runtime**.
- Both create during **initialization** all data **structures** that are **required at runtime**.

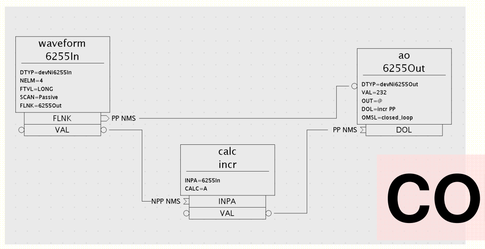
EPICS IOC
EPICS version 3.14.11

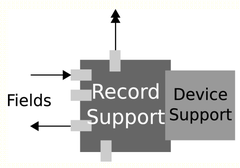
MARTe
MARTe/BaseLib CVS June 2011

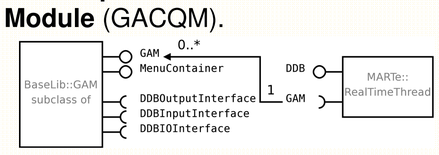
COMPONENT BASED APPROACH

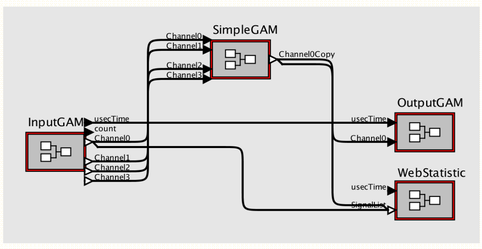
- Components are implemented by **records.**
- Records are logically grouped in **databases**.
- New record types (called **Record Support**) can be created by providing a set of routines and data structures.
- For **every record** type it is possible to define a new **Device Support** that enables the record to interact with an I/O device.

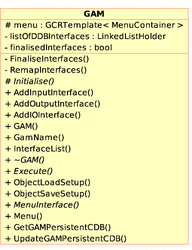












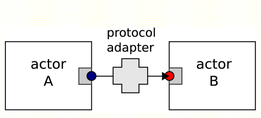
CONFIGURATION CAPABILITY

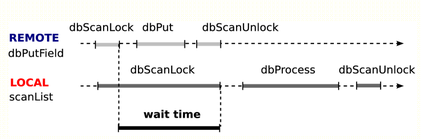
- The configuration of an EPICS IOC application spans across **different files.**
- The database configuration file is populated by **a list of records**.
- In EPICS a configuration file is used to **generate IOC source code** before compilation.
- When a new record is ready to be tested the developer has to **create** a new project, **insert** the record with ancillary files in the project, **create** the configuration files **compile all** and **run** the project.
- Value and compound data of a record can be **tuned at runtime**.
- To load or remove a record a user has to **change the configuration** files and **recompile** all the application from scratch before **running** it again.

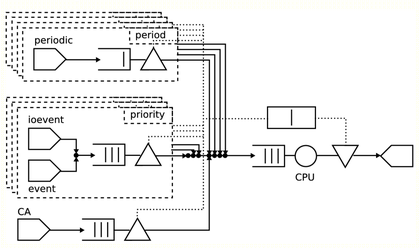
- The configuration of a MARTe application is held by a **single file**.
- A configuration file contains **different lists of GAMs** and **instance descriptors** of C++ classes.
- In MARTe a configuration file **is loaded** by a running MARTe system.
- When a new GAM is ready to be tested the developer has to **compile it**, **write** a test configuration file (modifying a template) and **run** the project.
- In order to change a GAM parameter it is necessary to **stop the execution** of every MARTe activity and **reload** the framework.
- To load or remove a GAM just **reload** the configuration file: it is not necessary to recompile the application.

CONCURRENT MODELS OF COMPUTATION

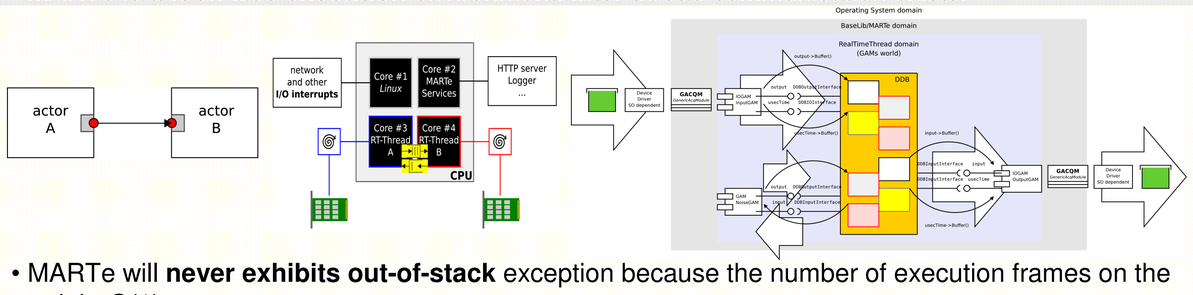
- A single record in an EPICS IOC can be **accessed concurrently** for **reading**, **writing** or **processing**. Reading and writing can trigger processing, before fetching a value (**demand-driven**) and after updating a value (**data-driven**).
- The processing of a chain of records takes place within a **scan** (an Operating System's thread).
- A scan can be locally triggered periodically (**periodic scan**) or by software and hardware events (**event scan**, **IO event scan**); remotely by **caGet** or **caPut** operations.
- After the processing has been triggered on the first record of a chain those records that have to be executed next are determined by the **associated link** in the database. A link can carry data and processing (INLINK, OUTLINK) or simply processing (FWDLINK).
- Since a single record can be concurrently accessed by different scans, **per-record locks exist**.







- A long EPICS' chain of passive records with many links can produce an **out-of-stack exception**, the number of execution frame on the stack is *O(n)* where *n* is the number of passive chained records.



- MARTe will **never exhibits out-of-stack** exception because the number of execution frames on the stack is *O(1)*.

- EPICS supports data diversity by means of a rich set of **protocol adapters**.
- In EPICS it is possible to have many INLINKs to the same record's field but it is **not possible** to have an OUTLINK or a FWDLINK **connected to more than one** record's field.

- MARTe does **not support data diversity**: two GAMs can communicate only if they both adhere to the same data interface.
- In MARTe one output signal from a GAM can be connected to as **many** GAMs as needed.

CONCURRENT MODELS OF TIME

- **No time model** can be assumed, a record can be processed at any time by different (concurrent) scans.
- A discrete algorithm will be executed in a non-uniform sampling environment. The smart way choosen in the PID record is to define a **minimum amount of time between record processings**.

- Each GAM is triggered **once per period** and the time elapsed between calls to GAMs is equivalent to period *T*.
- **Periodic timing** is provided by a GACQM interfaced with a TimeInput GAM. Algorithmic GAMs are aware of the absolute time and of the execution period T (via ExternalTimeTriggering service).

REAL-TIME SUPPORT

- The developer can not choose how to wait for an event, it fully **depends** on the **device driver**.
- Every event is **queued** for execution and **never lost**. There are different queues of execution and the execution policy is FIFO. One queue handles CA requests; three queues (low, medium, high priority) are shared between events and IO events and there is one queue per periodic scan.
- The EPICS Operating System Interface (OSI) layer does **not support multiprocessor environments**. A static set of queues is defined for each instance of EPICS IOC.

- The way in which a device driver (GACQM) waits for a hardware event is **selectable** (polling or interrupt) and defined in the **configuration file**.
- MARTe does not queue any event: events can be lost but there is **no jitter due to events enqueuing**.
- MARTe allow the developer to **assign** threads and IRQs to specific processors. The **affinity mask** of threads and IRQs on the processors is a parameter in the MARTe **configuration file**.

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