CONTAINERIZED CONTROL STRUCTURE FOR ACCELERATORS

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Nowadays, modern accelerators are starting to use virtualization to implement their control systems. Following this idea, one of the possibilities is to use containers. **Containers are highly scalable, easy to produce/reproduce, easy to share, resilient, elastic and low cost in terms of computational resources. All of those are characteristics that fit with the necessities of a well defined and versatile control system**. In this paper, a control structure based on this paradigm is discussed. Firstly, the technologies available for this task are briefly compared, starting from containerizing tools and following with the container orchestration technologies. As a result, Kubernetes and Docker are selected. Then, the basis of Kubernetes/Docker and how it fits into the control of an accelerator is stated. Following the control applications suitable to be containerized are analyzed: electronic log systems, archiving engines, middleware servers,... Finally, a particular structure for an accelerator based on EPICS as middleware is sketched.

Control Systems and Virtualization

Control System Characteristics:

- *Maintainable*:
  - Easy to describe and deploy automatically.
  - Based on few standards.
  - Based on reliable technologies:
    - + Proven/Tested.
    - + Supported and maintained (vendor, community). Easy to share.
    - + Being developed to fit new challenges.
    - + Better if open source: Particular necessities.
- *Robust*: Early error detection and fast recovery.
- *Easy to scale*: To accomplish upgrades.
- *Efficient*: Use the resources efficiently and maintain low energy consumption.

Virtualization fits very well with the most of the control system needs

As reported by J-Parc, HZB, DELTA, NIF, CERN,... the main uses of virtualization are:

1.- Add High Availability.
2.- Resources optimization.
3.- Improve maintainability: Easy backup and upgrades/changes.
3.- Software standardization and maintaining.

They state also two main **drawbacks**:

1.- A host crash implies several services malfunctioning.
2.- Large system recovery time.

Containers Orchestration

Orchestrators offer:

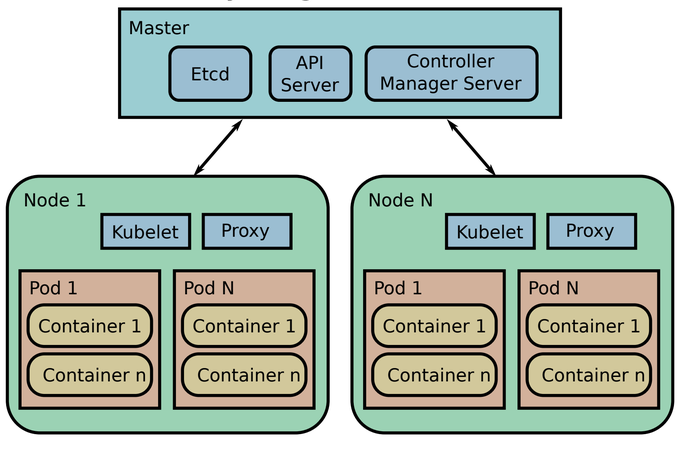
- *Provisioning*: Provide and launch containers efficiently.
- *Configuration-as-text*: For easy edition, versioning and sharing.
- *Monitoring*: Check the health of the containers in the cluster.
- *Rolling Upgrades and Rollback*: Incremental upgrading.
- *Policies for Placement, Scalability etc.*: Load balancing, HA.
- *Service Discovery*: Container placement agnosticism.
- *Easy Administration*: Integration with the IT infrastructure.

Orchestration tools solve the main drawbacks of the virtualization in control systems

Orchestration tool selection

- *Kubernetes*:
  - Tested tool for medium-large clusters.
  - Large and active community.
  - Managed by the Cloud Native Computing Foundation (CNCF): Amazon, CoreOS, Mesosphere, Samsung, Microsoft, Red Hat, IBM, Intel, Oracle, Docker, Cisco, Google,...
- *Swarm*: The best Docker compatibility and it is easy to use. It is preferred for no very large clusters.
- *Mesos*: Well proven tool (Twitter, eBay, Netflix,...). Designed and tested for very large clusters.

Selected: **Kubernetes**



Containerization

Nowadays, there are two alternatives for virtualization: Virtual Machines (VMs) and Containers.

Containers vs Virtual Machines

- Benefits of containers:
  - Fast application delivery: Maintenance and update.
  - Better scaling: In case of more resources need. About 22 times better than VMs.
  - More rapid spawning and termination.
  - Better resource utilization (lightweight).
    - + Higher workloads with grater density.
    - + Containers are able to run multiple isolated processes in a host without the overhead caused by the hypervisor layers introduced by VMs.
- Benefits of VMs:
  - Better compatibility and isolation.
  - More robust that containers.

Containerization fits better than VMs for a control system services

Container selection

Main container Alternatives on Linux: *LXC, rkt, Docker*.
- Based on their capabilities they are similar.
- rkt and Docker are the ones with the largest inertia.

Focused on non critical services the election is based on:

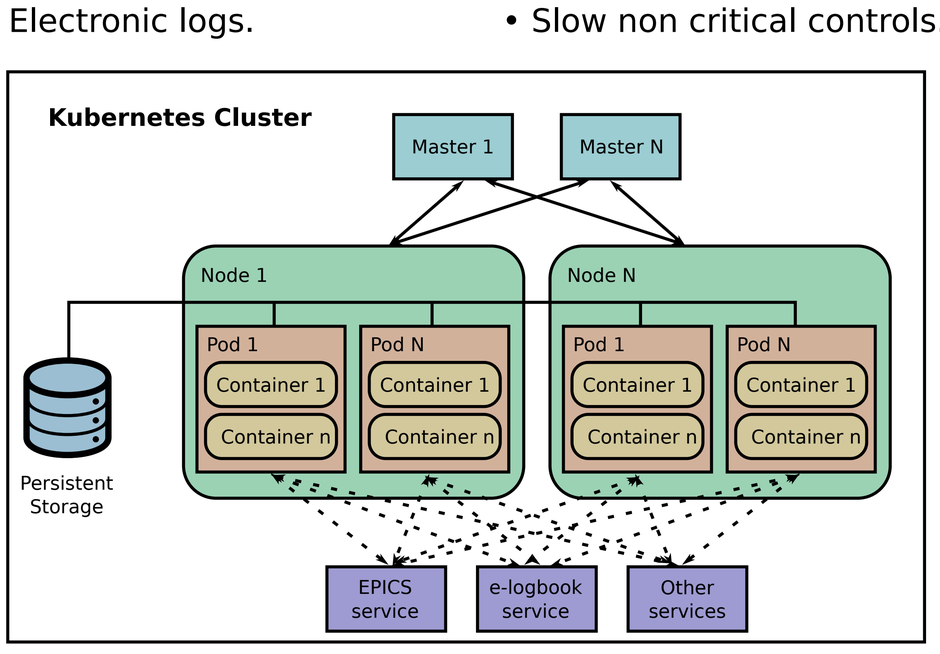
- Ease of utilization
- Support
- Active development
- Compatibility with orchestration tools, etc.

Selected: **Docker**

Container based control architecture

Manage non critical services of the control system.

- Alarm handlers.
- Data archivers.
- Electronic logs.
- LDAP services.
- User interface managers.
- Slow non critical controls.



EPICS based control system:

- e-logbook
- EPICS Archiver Appliance
- EPICS base
- EPICS virtual IOCs: soft IOCs + network devices.
- open LDAP
- BEAST alarm handler

Measured less than 10 seconds from an EPICS virtual IOC crash to its recover