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 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, etc. 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:
  - 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.
4. 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:
  - Testbed 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.

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

Kubernetes Cluster

Node 1

Node N

Persistent Storage

EPICS based control system:
• e-logbook
• EPICS Archiver Appliance
• EPICS base
• EPICS virtual IOCs: soft IOCs + network devices.

EPICs based control system:
• open LDAP
• BEAST alarm handler
• Other services

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