Medical Image Processing with OpenShift and OpenStack

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The Landscape

Medical image processing research happens in relative isolation
The focus is on the output
Everyone invents their own platform
ChRIS (ChRIS Research Integration System) is a web-based medical image platform that allows for various forms of medical image (Ex: MRIs) processing.

ChRIS itself is comprised of multiple open source projects (https://github.com/FNNDSC/) and the intention is to make the research and capabilities available to other hospitals.
Massachusetts Open Cloud (MOC)

Collaborative effort bw/ 5 research universities, government, and industry

Unlike Amazon/Microsoft/Google an open ecosystem of cloud services

Research and innovation over a production-scale public cloud

- Operating over a 15MW datacenter
- Backed by OpenStack and OpenShift
Combined Goal

Improve the scale and efficiency of healthcare image processing applications using various Red Hat technologies

- Today image processing takes ~10 hrs for certain apps. Ideally we can get that down to a few mins.

Democratize medical image application development

- Standardize healthcare application development (docker/OCI)
- Provide a platform that enables testing over real data (OpenShift+OpenStack)
The Technology
OCI / docker

- Standardizes image processor development
  - Portability
  - Dependency isolation
OpenShift / Kubernetes

- Provides scaled job framework for running image processors
- Resource Management
  - CPU/Memory/Network/GPU
- Easy to operationalize (logging/metrics/Ansible/etc.)
OpenShift: Optimizing for Density

Utilize slack resources with QOS Tiers

MASSACHUSETTS OPEN CLOUD (MOC)
OpenShift - AI/ML

- Spark
- Tensorflow
- ...

![OpenShift - AI/ML Image]
OpenStack

- OpenShift/Kubernetes doesn’t solve the infrastructure problem
- Containers need a unifying story for the private cloud
- On-premises IaaS
  - Compute (GPU and CPU)
  - Networking
  - Storage (Ceph)
  - Scale & on-demand access
Medical Processing

- Registration
  - "morph" one image onto another
  - Used for:
    - localization
    - "difference"
    - typical first step
Medical Processing

- Classification (AI/ML)
  - Identification and pointing out abnormalities
  - Complex contrasts

- Metabolism
  - Monte Carlo simulation of photon propagation through brain tissue
  - Multiple wavelengths, scattered based on tissue properties and local metabolism of $O_2$
Medical Processing

- Tractography
  - acquire multiple image volumes
  - solve diffusion equation for water movement based on image contrast
    - mapping fiber paths through the brain for surgical planning
ChRIS Detail

- Store
- Compute Environment
- Compute Environment
- Compute Environment
- Data Source
- Data Source
- Data Source
Parallelizing Plugins
Image Processing

- Parallel Processing with Kubernetes Job Framework
- N workers run until worker 1-N completes (fixed completion count)
- Communication through FS or Network
Parallel Example - Advanced Normalization Tools

- Among the highest quality algorithms for non-rigid registration
  - [https://github.com/stnava/ANTs](https://github.com/stnava/ANTs)
  - [https://github.com/FNNDSC/pl-antsreg](https://github.com/FNNDSC/pl-antsreg)
- Used as prototype for scaling image plugins
- Lessons Learned
  - Most existing image processing applications weren’t written to scale horizontally
  - Performance gains dependent on how much of the algorithm is parallelizable

| Setup | Parallelizable Processing | Coalesce |
GPU Enabled Plugins
GPU Topology

MOC (OpenStack)

HOST X

VM 1
- CONTAINER 1
- CONTAINER 2
- CONTAINER N

VM 2
- CONTAINER 1
- CONTAINER 2
- CONTAINER N
GPU Details

Plugins register themselves with ChRIS as requiring or desiring a GPU.

OpenShift/Kubernetes schedules plugins onto nodes with available GPUs.

- Device Plugins
GPU Example - Prostate Segmentation

https://github.com/FNNDSC/pl-neuproseg/
GPU Example - Monte Carlo

Scalable and massively parallel Monte Carlo photon transport simulations for heterogeneous computing platforms
Leiming Yu; Fanny Nina-Paravecino; David R. Kaeli; Qianqian Fang
J. of Biomedical Optics, 23(1), 010504 (2018). doi:10.1117/1.JBO.23.1.010504
Demo
Take Aways

Choosing the right open source solutions is essential to every project’s success.

OpenShift on OpenStack solved our processing and data management challenges and let us focus on the specific problem at hand.