Christopher M. Sullivan
Porting from x86 to OpenPOWER made easy
CGRB - Oregon State University
Back in the day….
The term **processing** meant working on materials and other physical items…
Processing Today
Back in the day....

Data **storage** meant putting something into a large box or unit.
Data Storage Today
Back in the day…

The term **memory** meant trying to remember how you did something…
Memory Today
Researchers Need Computers To Help Answer Questions!
• What is the CGRB at Oregon State

• How do computational methods and tools fit into use of OpenPOWER systems.

• Choosing the proper operating system.

• Building tools to run on OpenPOWER systems.

• Problems with compiling software and tools.

• Examples of building tools on OpenPOWER based systems.
CGRB at Oregon State & Computational Science

• Building infrastructure for Researchers
• Tools for Data Mining & Data Processing
• Building New Algorithms / New Tools
• Creating Deliverables for Publications
• Ways to Reduce Cost and Increase Scope
CGRB Infrastructure

- GENOME Cloud
  - ~20,000 Jobs / Day
  - 4100 Processors
  - 3.5+ PB Redundant Usable Storage
  - 10 machines with greater then 1TB of memory
  - 6x POWER8 Systems
  - Increase access to resources
  - Decrease analysis time
  - Increase Network Speed
How Do Computational Methods and Tools Fit into Use of OpenPOWER Systems.
Why So Many Processors

• Increase scope of data that can be included in analysis.
  • POWER8 has ability to manage a large number of threads per socket.

• Reduce processing time from months to weeks.
  • Start more jobs with access to more threads.

• Allow for multiple tools to be done at the same time and converge into an answer.
  • Scientific processing requires use of more than one tool. Running this on a limited number of cores/threads increase total time of analysis.
Why So Much Storage

• Experiments generally have multiple samples

• Each sample should have replicates

• Each needs to be processed through multiple tools
  • Around three independent algorithms
  • Each tools has parameters to change as well

• Multiple steps within a total analysis pipeline
Why Large Memory Machines

• Different features of a genome or transcriptome can change the amount of memory used in analysis.
  • Repeats

• More data taken into an analysis means more memory needed for the analysis.
  • Different types
  • Increase sequence depth

• Different algorithms use different amounts of memory for analysis.

• Process is repeated changing parameters until the best results are achieved.
Data Mining & Data Processing

- High Throughput Sequencing
- Image Analysis
- Simulations
- Microscopy Analysis
- Citizen Science / Public Data
- IoT Data from Multiple Sources
Tools for Data Mining & Data Processing

1. CGRB maintains many of the software tools.
   - There are currently over **4000 programs accessible (2000 working on POWER8/9)** to all users.
   - CGRB **donates one hour of time** to compile tools needed by researchers.

2. CGRB has computational staff available to help.
   - **Available hourly** or allocated FTE.
   - Help manage graduate students through projects.
   - **Develop courses** to teach methods used by many groups.

3. CGRB helps build new tools for data processing.
   - Help **remove limits** associated to current tools.
   - Deal with **new data sets** with new formats.
   - **Create pipelines** used by groups to process data.
Choosing the Proper Operating System
Linux!

Linux support for POWER

- Same source and distribution release schedules as x86
- Simplified x86 application migration with little endian distributions
- Enterprise support for all three from IBM or distributors.
Little Endian vs Big Endian

• In the beginning...
  – IBM was Big Endian
  – Intel was Little Endian

• Linux and x86
  – Intel based machines took over due to low cost of ownership and replaced traditional UNIX based servers.
  – Use of Linux based OS increased access to tools and lower costs.

• Code created on one system would not compile on the other.
Little Endian vs Big Endian

• Now OpenPOWER machines with the POWER8/9 processor using Little Endian.

  • This means tools that run on the x86 based machines can now be compiled to run on OpenPOWER.

  • Tools that take advantage of lots of threads per core have the best performance increase (1 Socket has 10 Cores each with 8 Threads).
CGRB Looks at POWER8

• We were familiar with AIX but felt that it was getting harder and harder to compile scientific software.

• Since we could run a standard flavor of Linux (CentOS) on the POWER8 and it was Little Endian we could easily test the systems with our tools.

• Increase access to hardware resources like CAPI and NVLink could change how data is processed.
Building tools to run on OpenPOWER systems
Jump Right In...

• Since we manage tools for our users every time we brought down a tool to compile for x86 we compiled it for POWER8.

• Remember to start at the beginning

• Don’t be afraid to contact developers with problems
Compiling Tools

• Autoconf
  • Start at the beginning with “autoconf”. This command will setup all the architecture dependent paths needed to successfully compile a tool.
  
  • GCC is the same on both the x86 and POWER8 when using Linux Operating Systems like CentOS.
Problems with compiling software and tools
Operating System and Library Problems

- x86 Specific Library Problems
  - SSE, SSE2, SSE3 Memory Libraries
  - There are IBM Libraries to Replace Them

- Autoconf Problems with Build Type
  - Sometime configure command can not figure out what operating system build type to use for “ppc64le”.
  - Just use “build=ppc64” as a configure option and many time it will find all the correct paths.
Example Compile

```
[root@neo data]# tar -xzvf /local/downloads/PPC64LE/tiff-4.0.6.tar.gz
```

```
[root@ibm-power1 data]# tar -xzvf /local/downloads/PPC64LE/tiff-4.0.6.tar.gz
```
Is it really just that easy...?
Compile Software

• Is it really that easy...?
  • Yes in many cases!
    • Compile using all standard options. You may need to add a build type of “ppc64” to some software.

• Most tools will compile (over 70%)

• Ones that will have a problem have x86 specific libraries that are used for memory or other architecture specific problems.

• Some tools will compile but will not perform as well. Generally we found that using the IBM compilers resolve this issue.

• Other tools that will not compile we can ask the developers to help.
CGRB Collaboration with IBM

• CGRB Worked with IBM to Create Build Scripts for Power8
  • For the over 2000 programs currently working on Power8.
    • https://github.com/ppc64le/build-scripts
  • Internship to student provided by IBM to create build scripts for important code used by the scientific community to compile on the POWER8 systems.
  • All new tools will be compiled and deployed with IBM help to ensure open access to all build scripts.

• OpenPOWER at CGRB
  • Deploy POWER8 to users in CGRB at Oregon State
  • Users submit jobs to either x86 or POWER8 and environment variables determine the path based on architecture.

• OpenPOWER Continuous Development Environment
  • New continuous development environment for developers to move code to POWER8
  • New CAPI interconnect to move data at 80GB/s.
  • NVLink Pascal GPGPU processors.
OpenPOWER Development Environment with GPU Support

- Free Open Access Development Environment for porting code to POWER8
  - Access to several OpenPOWER servers
  - Each Server with the following configuration:
    - 2x 10 Core POWER8 Processors
    - 1 TB Onboard RAM
    - 2x NVIDIA P100 Pascal GPU (NVLink)
    - 40Gbps Network
    - 2x 3.2 TB NVMe FLASH (CAPI)
    - CAPI Bus
    - Onboard NVLink

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<th>Compute</th>
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How To Get Access

• OSU Open Source Lab
  • http://osuosl.org

• Look under services for free access to different OpenPOWER resources.

• Minsky/GPU Access to machines with NVIDIA P100 and NVMe Flash memory
  • http://osuosl.org/services/powerdev/request_gpu
Creators of Tools Use New OpenPOWER Development Environment

• Provide access to creators of tools to build on Power8 platform.

  • **Julia** - The CGRB granted access to a container on one of the donated IBM development machine for the Julia developers. Julia group was also able to have there code work with the new NVIDIA GPU technology changing their pathway forward on deeplearning.

  • **GeneMark** – Mark Borodovsky worked with the CGRB to re-compile GeneMark onto the Power8 platform. This was initially done for eukaryotic genomes but was later done for prokaryotic genomes as well.

  • **Diamond Aligner** – Benjamin Buchfink was provided access to the Power8 systems within the CGRB and was able to port the diamond aligner to work with the better performance then the current x86 version.
Summary

• Computational Science is used in a gamut of research and clinical areas.
• Many times new technologies change the way computational science can be done.
• New technologies can generate magnitudes of order greater precision, change the scope of work or reduce bias.
• New technologies many times require changes in tools and hardware.
• Using computational methods can be accessible through web interfaces and command line.
## Acknowledgements

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<tr>
<td>Ryan Kitchen</td>
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<td>Shawn O’neil</td>
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