

Update on Testbeds at ADAC Partners ORNL Experimental Computing Laboratory

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With many, many contributions from workshop participants, FTG Group, ExCL team, and colleagues

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ORNL is managed by UT-Battelle, LLC for the US Department of Energy



Time for a short poll...



History

Q: Think back 10 years. How many of you would have predicted that many of our top HPC systems would be GPU-based architectures?





Future

Q: Think forward 10 years. How many of you predict that most of our top HPC systems will have the following architectural features?

General purpose multicore CPU

GPU

FPGA/Reconfigurable processor

Neuromorphic processor

Deep learning processor

Quantum processor

RISC-V processor

Some new unknown processor

All/some of the above in one SoC





ADAC Emerging Technologies



ADAC Emerging Technologies Charter

- Goal: create collaborative testbed environments where emerging technologies can be investigated to inform future architectures and software and applications development
- Motivation
 - Need very early access to technologies in this age of Extreme Heterogeneity
 - Investigating testbeds is different than using HPC production systems
 - Usage models
 - software development
 - exclusive access benchmarking
 - Privileges
 - Constantly (re)install software environment from hardware up including OS
 - Reconfigure firmware
 - Configure hardware
 - Immature software and hardware
- Share

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- Lessons
- Software (e.g., containers, drivers, fixes)
- Operations
- Hardware
- Security

Extreme Heterogeneity 2018

PRODUCTIVE COMPUTATIONAL SCIENCE IN THE ERA OF EXTREME HETEROGENEITY



Report for DOE ASCR Workshop on Extreme Heterogeneity January 23–25, 2018 Version August 27, 2018



https://doi.org/10.2172/1473756

	Progress Echnolo TRL 1-3 Basia • Examples: nanotube memristor- neuromorp chip-level photonics, quantum o	ion of Experimer ogies Concepts Carbon- computing, based ohic computing, silicon universal computing Computing	TRL 4-6 Emerging • Examples: FPGAs in HPC, TrueNorth, SpiNNaker, D- Wave, Emu, many SoC- based systems, TPU, Gen-Z, NoCs, near-memory • Experimental Prototype • Experimental Prototype • Access Testbed CS & Math Research	TRL 7-9 Operational • Examples: Titan, Cori, Mira, Summit, BlueWaters, Keeneland, Stampede, Tubame2.5 Belect, and Improve Belect, a
	Programming	Assembly language, or less	Few, if any, development tools	Language support and compilers.
	OS-R	Manual	Specialized programming environments and OSs	Commodity OS & runtime systems
	Scale	Small collections of devices	Single to hundreds of engineered processing elements	>10,000 processing elements
	Performance	Analytical projections based on device empirical evaluation.	Analytical projections or simulation based on component or pilot system empirical evaluation.	Empirical evaluation of prototype and final systems.
	Apps	Small encoded kernels	Architecture-aware algorithms; Mini-apps; Small applications	Numerical libraries; Full scale applications
44	Example	GPUs invented in 1999	OpenGL in 2001; CUDA in 2007; OpenCL in 2008; OpenACC in 2010; DB in 2010; ECC in 2012	GPUs are a fully supported compute

Levels of Privileged Access



ORNL Experimental Computing Laboratory (ExCL)

ExCL Common Infrastructure Project and User management Community •Accounts Workshops • Projects and Proposals •Online discussions forums and issues •Help Consolidated •News Shared Login and Gateway Nodes Authentication and Authorization •Gateway nodes •Secure operations •Data transfer nodes •Partition access to specific compartments Consistent and secure access to private •System and account lifecycles network compartments •Experience with management of export controlled and proprietary systems Shared Filesystems and Databases Monitoring and control systems •Secure access to filesystems across pillars •Manage access to shared resources Manage privileged access levels • Lights out operation Source Code and Data sets Web Source Code repos Educational and reference materials • Performance databases for applications •Outreach and architectures Both Open and Controlled access

ExCL Technology Pillars



ExCL 2.0 (ORNL)





ORNL Experimental Computing Laborato (ExCL)

Pathfinding the future of computing

Welcome

Welcome to ExCL! We are excited to collaborate with users exploring emerging c technologies.

The Experimental Computing Lab (ExCL) is a laboratory designed for computers a time where heterogeneity defines the path forward, this system offers heteroge that researchers can use in their work. The computational resources provided by diverse technologies in terms of chips, memories, and storage. ExCL will also ac changing computing ecosystem and will incorporate the latest technology and r its users.

ExCL User Account Request

Please enter information about the specific user requesting the ExCL account.

If you are not an ORNL employee, please use your primary external email address here. This address will be used for ExCL announcements.

xCL Systems – ORNL Experimenta 🗙 🕂

and issues to excl-help@ornl.gov.

Resource Type

CPU CPU CPU

CPU-GPU

C 🏠 🛛 🔏 excl.ornl.gov/excl-systems

If submission of this request is successful, you will receive a copy of the request to your email address listed below.

Email address

Valid email address

This form is collecting email addresses. Change settings

Last Name*

Short answer text

First Name

Short answer text

		:	Search:		
\$	Resource	Description	¢ Host ¢	Comments 🗢	
	Intel Broadwell		Oswald[00-03]	In service	
	Intel Skylake 4114		Utility[00-03]	In service	
	ThunderX2 Server	2x 28-core 2GHz Cavium ARM TX2; 128GB DDR4	Thunder	In service	
	Summit node	One node of DOE Summit: 2 POWER9 CPUs 6 NVIDIA Voltas (Tesla V100 SXM2 16GB) NVLINK AC922 Witherspoon	Leconte	In service	
G	IU-Chick	512GB NCDIMM 128 Gossamer cores 8 Nodes, 64 Nodelets	emu	In service	
ExCL	era Stratix V		Newark	In service	
	era Arria 10		Oswald[00-03]	In service	
	el/Altera Stratix 10		Pcie	In service	
	ID Radeon VII GPU	Vega 20, GCN 5 on TSMC 7FF process	radeon	In service	

ExCL Systems

Our emerging computing systems and expertise define ExCL. The following table lists our current resources that are available for use. Please send questions



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Summit (IBM POWER9+NVIDIA Volta) Node installed Experimental Computing Lab (ExCL) managed by the ORNL Future Technologies Group

IBM Summit Node with 6 Nvidia Tesla V100 GPUs (8335-GTX)

- Same CPU/GPU/Memory as nodes in OLCF Summit
 - 2 Power9 CPUs (IBM 02CY209)
 - 22 Cores each, 4 threads/core
 - 606GiB main memory
 - 6 Tesla V100 SXM2 16GB GPUs
- Provides a development and evaluation environment for Power9/V100 GPUs
- Tracks (as closely as possible) the software stack in use on Summit
- Shared / Queued / Single User availability modes will be available



AMD Radeon VII Available

Experimental Computing Lab (ExCL) managed by the ORNL Future Technologies Group

- AMD Radeon VII, Vega 20 Architecture
 - GCN 5 on TSMC 7FF process, 13.2B transistors
 - 60 Compute Units with 3.4 DP peak TF
 - 16 GB HBM2 with 4096-bit width for ~1TBps bandwidth
 - TBP 300W
 - PCle 3.0 x16
- Intel Xeon Skylake Host
 - HP Z4 G4 Workstation w/ PCIe 3.0 x16
 - W-2123 / 64Gb host
 - 1 CPU * 4 cores * 2 threads/core
 - 512 GB SSD uncommitted/available
- Software
 - AMD ROCm development tools
 - HIP (Heterogeneous Compute Interface for Portability) available
 - OpenCL 2.1
- Additional Details
 - https://www.anandtech.com/show/13832/amd-radeon-viihigh-end-7nm-february-7th-for-699
 - https://en.wikipedia.org/wiki/AMD_RX_Vega_series#cite note-anand radeon vii



- request



- 4X Tesla V100 GPUs
- TFLOPS (Mixed precision) 500
- GPU Memory 128 GB total system
- NVIDIA Tensor Cores 2,560
- NVIDIA CUDA® Cores 20,480
- CPU Intel Xeon E5-2698 v4 2.2 GHz (20-Core)
- System Memory 256 GB RDIMM
- Full NVIDIA stack
- · Other compilers/tools installable on





ARM ThunderX2 Node Available

Experimental Computing Lab (ExCL) managed by the ORNL Future Technologies Group

ThunderX2 Workstation

· Cavium (Marvell) ThunderX2 with ARMv8.1 instruction set.



- 2 Cpus, each with 28 Cores with 4 threads/core
- 128 GiB Main Memory
- Gigabyte MT91-FS1-00 motherboard
- · Multiple access levels available to researchers investigating ARM8v1 performance
- Traditional ARM/Linux software stack available





Apache Pass Optane-based Memory System

Experimental Computing Lab (ExCL) managed by the ORNL Future Technologies Group

- Intel OPTANE Memory
 - 1.5 TB of OPTANE Memory (Persistent)
 - 12 * 126 GiB NV DIMMS (2666 MHz)
 - 384 GiB of DRAM (Volatile)
 - 12 * 32 GiB DRAM (2933 MHz)
- Accessed as filesystem or memory access mode / configurable at boot time
 - Most recent Linux Kernel deployed (5.2.0)
 - Intel PMM drivers and PMM tools deployed
 - Newer kernels built and deployed on request
 - Kernel-matched perf command to read memory performance and health instrumentation
- Supermicro X11DPU-Z+ motherboard
 - Intel Gold 6248
 - 2 CPUs * 20 cores/socket * 2 threads/core
 - Mellanox ConnectX-4 networking
 - 12 NVMe SSDs







Intel Stratix 10 FPGA

Experimental Computing Lab (ExCL) managed by the ORNL Future Technologies Group

- Intel Stratix 10 FPGA and four banks of DDR4 external memory
 - Board configuration: Nallatech 520 Network Acceleration Card
- Up to 10 TFLOPS of peak single precision performance
- 25MBytes of L1 cache @ up to 94 TBytes/s peak bandwidth
- 2X Core performance gains over Arria® 10
- Quartus and OpenCL software (Intel SDK v18.1) for using FPGA
- Provide researcher access to advanced FPGA/SOC environment







For more information or to apply for an account, visit https://excl.ornl.gov/

NVIDIA Jetson AGX Xavier SoC

Experimental Computing Lab (ExCL) managed by the ORNL Future Technologies Group

- NVIDIA Jetson AGX Xavier: High-performance system on a chip for autonomous machines
- Heterogeneous SoC contains:
 - Eight-core 64-bit ARMv8.2 CPU cluster (Carmel)
 - 1.4 CUDA TFLOPS (FP32) GPU with additional inference optimizations (Volta)
 - 11.4 DL TOPS (INT8) Deep learning accelerator (NVDLA)
 - 1.7 CV TOPS (INT8) 7-slot VLIW dual-processor Vision accelerator (PVA)
 - A set of multimedia accelerators (stereo, LDC, optical flow)
- Provides researchers access to advanced highperformance SOC environment











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Qualcomm 855 SoC (SM8510P)

Experimental Computing Lab (ExCL) managed by the ORNL Future Technologies Group



Kyro 485 (8-ARM Prime+BigLittle Cores)

Prime Core	175				А55 128 КВ					
А76 512 КВ	А76 256 КВ	А76 256 КВ	А76 256 КВ	A55 128 KB	A55 128 KB					
	DSU		2048KB							

Hexagon 690 (DSP + AI)

- Quad threaded Scalar Core
- DSP + 4 Hexagon Vector Xccelerators
- New Tensor Xccelerator for AI
- Apps: AI, Voice Assistance, AV codecs

Adreno 640

• Vulkan, OpenCL, OpenGL ES 3.1

CAK RIDGE

- Apps: HDR10+, HEVC, Dolby, etc
- Enables 8k-360° VR video playback
- 20% faster compared to Adreno 630



- Snapdragon X24 LTE (855 built-in) modem LTE Category 20
- Snapdragon X50 5G (external) modem (for 5G devices)
 Qualcomm Wi-Fi 6-ready mobile platform: (802.11ax-ready,
- 802.11ac Wave 2, 802.11ay, 802.11ad)

• Qualcomm 60 GHz Wi-Fi mobile platform: (802.11ay, 802.11ad)

- Bluetooth Version: 5.0
- Bluetooth Speed: 2 Mbps
- High accuracy location with dual-frequency GNSS.

Spectra 360 ISP

- New dedicated Image Signal Processor (ISP)
- Dual 14-bit CV-ISPs; 48MP @ 30fps single camera
- Hardware CV for object detection, tracking, streo depth process
- 6DoF XR Body tracking, H265, 4K60 HDR video capture, etc.

Qualcomm Development Board connected to (mcmurdo) HPZ820



- Connected Qualcomm board to HPZ820 through USB
- Development Environment: Android SDK/NDK
- Login to mcmurdo machine
 - \$ ssh –Y mcmurdo
- Setup Android platform tools and development environment \$ source /home/ngx/setup android.source
- Run Hello-world on ARM cores
 - \$ git clone <u>https://code.ornl.gov/nqx/helloworld-android</u>
 \$ make compile push run
- Run OpenCL example on GPU
 - \$ git clone https://code.ornl.gov/nqx/opencl-img-processing
 - Run Sobel edge detection
 - \$ make compile push run fetch
- Login to Qualcomm development board shell

```
$ adb shell
```

\$ cd /data/local/tmp

For more information or to apply for an account, visit <u>https://excl.ornl.gov/</u>

Created by Narasinga Rao Miniskar, Steve Moulton

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- Tactical Overview																			
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DevOps and CI/CD Tools Available

CI/CD Builder Envs

- GitLab Auto DevOps
- AWS Code Pipeline
- Circle Cl





Containers / Orchestration

- FTG Kuber in AWS
- Docker in ExCl & CADES
- OpenShift support in process







Work in Progress

- Procure and deploy relevant AI testbeds
- Finalize container strategy
- Add users



National Laboratory