Accessing GPUs from Containers in HPC

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Overview

1. Build an image capturing all application requirements
2. Push the image to DockerHub or a Private Registry
3. Launch the image as a Container

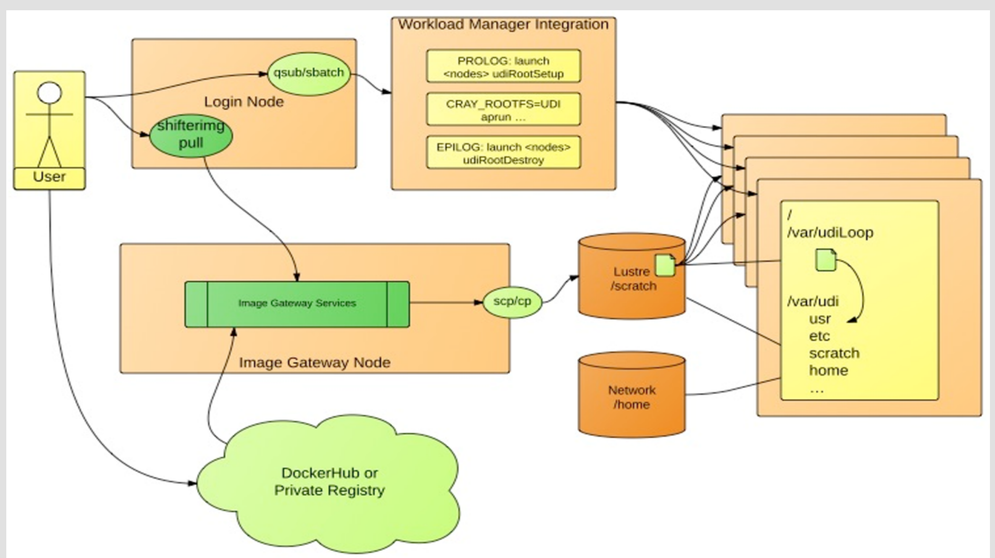
Docker drawbacks in HPC

- **Architecture** assumes a local disk
- **Security** users can easily escalate privileges on the host
- **Integration** not designed to work with batch systems
- **Complexity** uses a client/daemon architecture

Solution: Shifter

- **Flexibility** no administrator assistance to launch a container
- **Security** stripped-down version of image deployed in read-only mode
- **Integration** workload-manager integration, .e.g., SLURM
- **Compatibility** full integration with public repositories, e.g., DockerHub

Shifter Architecture

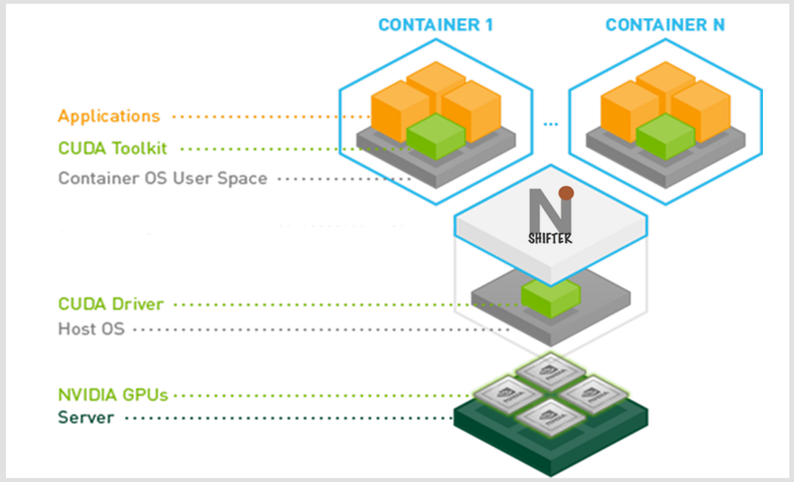


GPU Support

- Containers are hardware- and platform-agnostic
- Support for GPUs requires:
  - specialized hardware, and
  - specific software on the host, e.g., Nvidia driver

Shifter approach

- **Flexibility** required libraries discovered at runtime
- **Security** access to character devices with user's UID
- **Integration** direct access to character devices
- **Compatibility** works with any CUDA SDK v6.0 or later



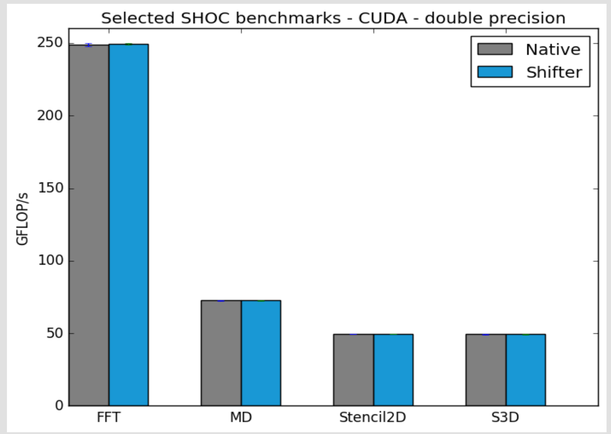
Implementation

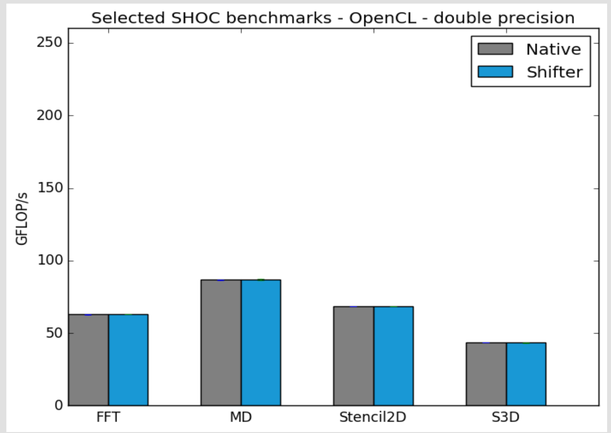
- CUDA requires access to the kernel driver and the corresponding CUDA runtime libraries.

1. Mount the character devices of the available GPUs (e.g., /dev/nvidia0).
2. Mount the user-space libraries on the host system at deployment time.
3. Reflect the mounted paths, e.g., using *ldconfig*, within the container runtime.

- The procedure is executed automatically as part of the workload-manager integration hooks, e.g., SLURM

Shifter Performance





Conclusion

- Seamless execution of CUDA- and OpenCL-enabled containers achieving native performance.
- Support for different CUDA toolkit versions on the host and on the container.
- Directly leverage GPU resources on a Cray XC30 like Piz Daint from within a container.

References

[1] W. Felter, A. Ferreira, R. Rajamony, and J. Rubio, “An updated performance comparison of virtual machines and linux containers,” in Performance Analysis of Systems and Software (ISPASS), 2015 IEEE International Symposium On. IEEE, 2015, pp. 171–172.
[2] D. M. Jacobsen and R. S. Canon, “Shifter: Containers for HPC," in Cray Users Group Conference (CUG'16), 2016.
[3] L. Benedicic, M. Gila, S. Alam, and T. Schulthess, “Opportunities for container environments on Cray XC30 with GPU devices,” in Cray Users Group Conference (CUG'16), 2016.
[4] A. Danalis, G. Marin, C. McCurdy, J. S. Meredith, P. C. Roth, K. Spafford, V. Tipparaju, and J. S. Vetter, “The scalable heterogeneous computing (SHOC) benchmark suite,” in Proceedings of the 3rd Workshop on General-Purpose Computation on Graphics Processing Units. ACM, 2010, pp. 63–74.