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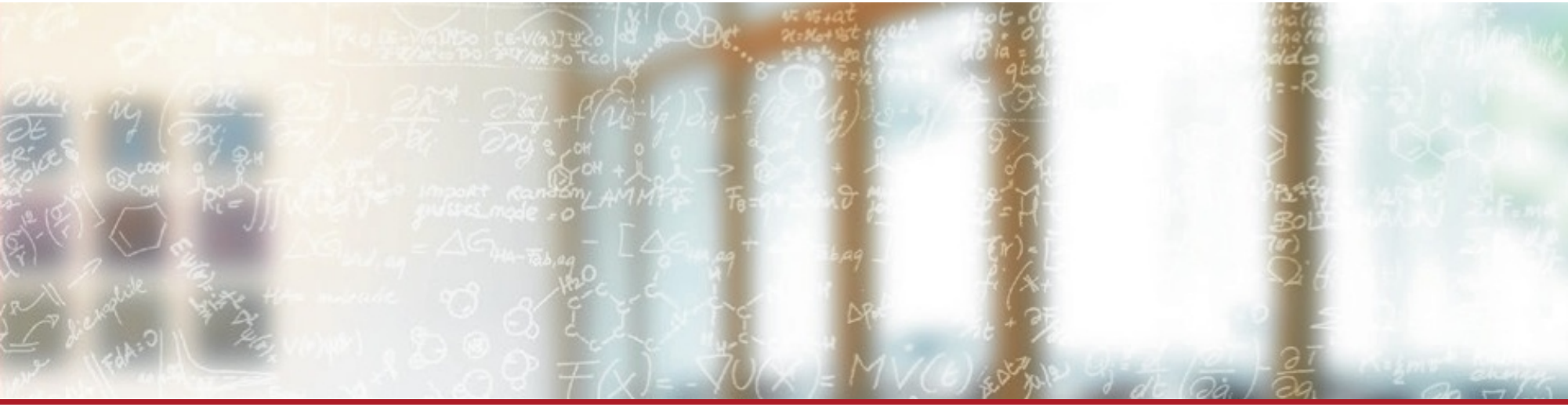


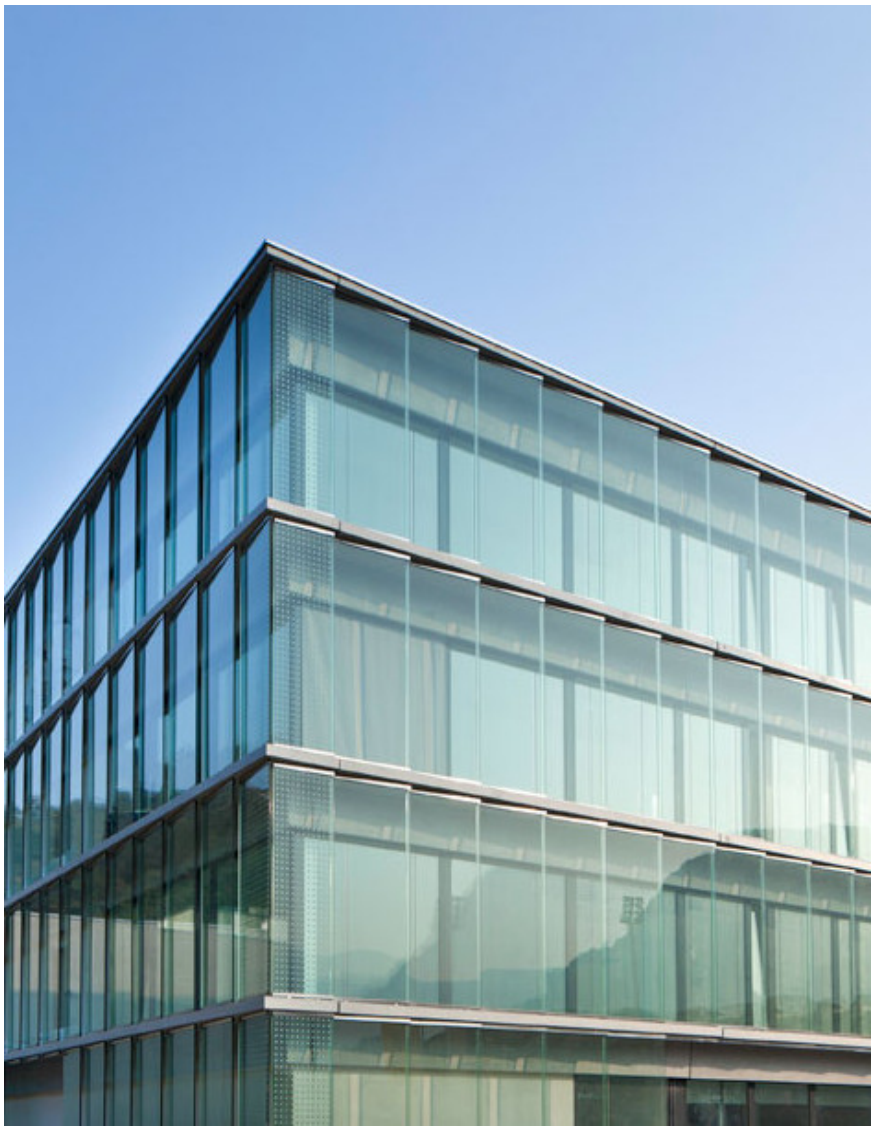
Shifter: Containers in HPC Environments

Second ADAC Workshop, Lugano, June 2016

Lucas Benedicic, CSCS

June 14th 2016

Agenda

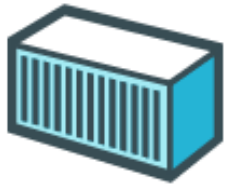


- Background
- Implementation
- Use Cases
- Security

Background

Docker overview

Build



Ship

Run

- Build an image capturing all application requirements
- Commit the image or use a recipe file

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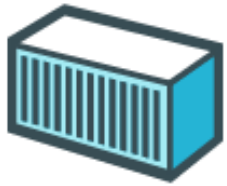

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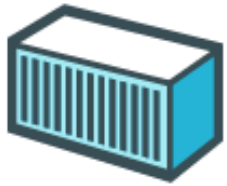

Ship

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Run

- Pull the image from DockerHub or a private Registry
- Launch the image as a container

Docker drawbacks

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- **Integration**
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- **Complexity**
  Docker uses a client/daemon architecture

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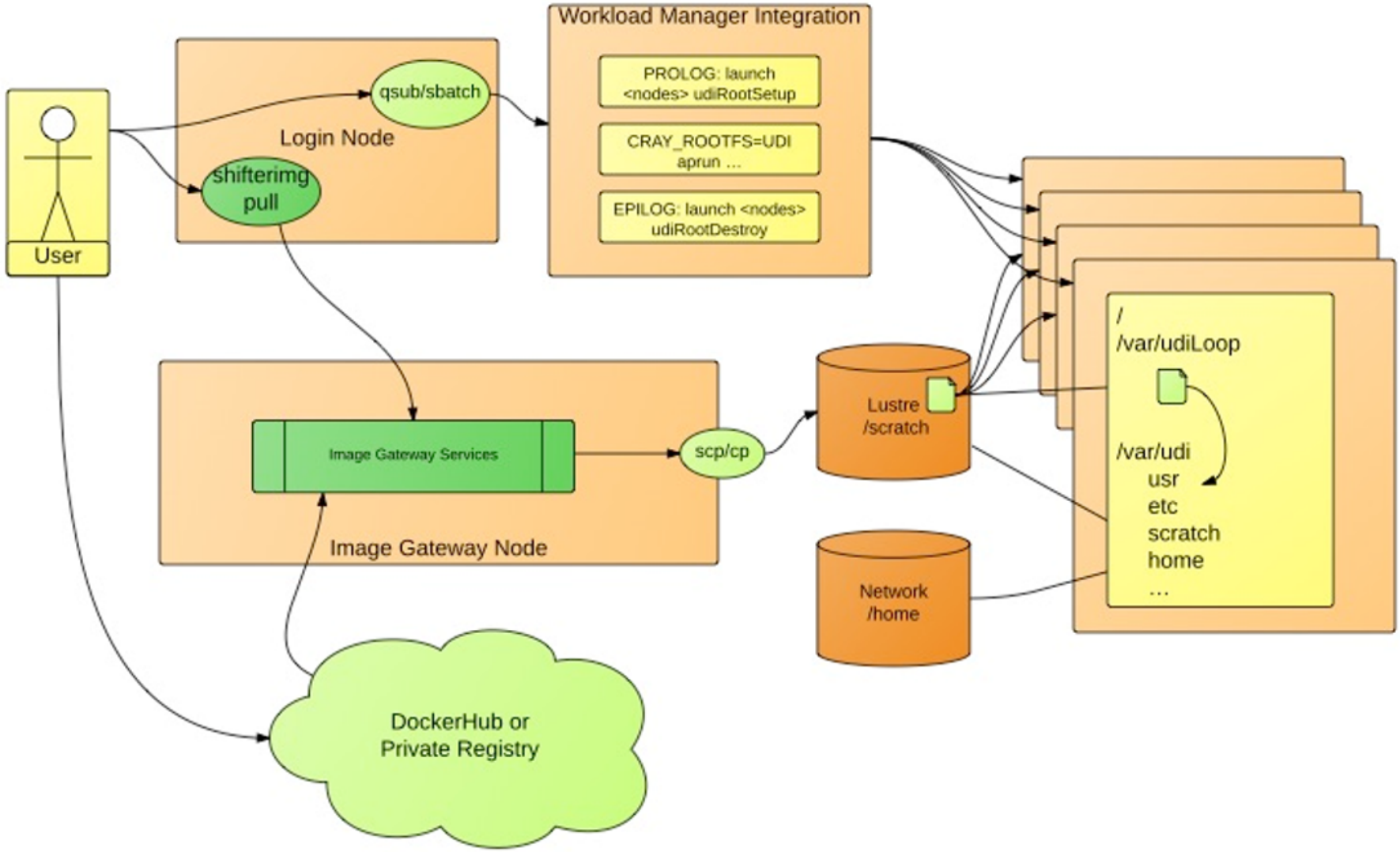
  - **Security** stripped-down version of the original image is deployed in read-only mode

Implementation

Shifter Architecture



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- Instantiate multiple containers on the same compute node

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- Images are read-only on the compute node
- Shifter does not use `cgroups` directly
  - Resources are handled by the workload manager (e.g., SLURM)

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Use Cases

Creating a Docker image

Dockerfile

```
FROM ubuntu:14.04
# Update packages and install dependencies
RUN apt-get update -y &&
apt-get install -y build-essential
# Copy in the application
ADD . /theapp
# Build it
RUN cd /theapp &&
make &&
make install
```

Use the image with Shifter

SLURM batch job

```
#!/bin/bash
#SBATCH -N 16 -t 20
#SBATCH --image=docker:ubuntu:14.04
#SBATCH --volume=/scratch/user/data:/data

module load shifter
srun -n 16 shifter /theapp/app
```

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- Improves reproducibility
- Improves sharing (e.g., Dockerfile, DockerHub)

Atlas and LHC

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- Jobs expect a RHEL-compatible OS and a precompiled software stack
- Shifter reproduces the complete software stack on the Cray XC
- Job efficiency is comparable on both systems

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- Shifter minimizes the metadata overhead
- Tested on NERSC's Cori up to 1600 nodes

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- This is not the case when using GPUs
  - it uses specialized hardware, and
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- Shifter approach (CSCS + NVIDIA)
  - direct access to device characters
  - the required libraries are dynamically discovered at runtime

Accessing GPUs

- The Stream benchmark within a Shifter container shows native performance!
- NVIDIA's DGX-1 software stack is based on this solution

GPU: Stream benchmark

```
lucasbe@santis01 ~/shifter-gpu> sbatch ./nvidia-docker/samples/cuda-stream/benchmark.sbatch
Submitted batch job 496

lucasbe@santis01 /scratch/santis/lucasbe/jobs> cat shifter-gpu.out.log
Launching GPU stream benchmark on nid00012 ...
STREAM Benchmark implementation in CUDA
Array size (double precision) = 1073.74 MB
using 192 threads per block, 699051 blocks
Function      Rate (GB/s)  Avg time(s)  Min time(s)  Max time(s)
Copy:         184.3169     0.01167758   0.01165104   0.01170397
Scale:        183.1849     0.01175387   0.01172304   0.01178598
Add:          180.3075     0.01790012   0.01786518   0.01792288
Triad:        180.1056     0.01790700   0.01788521   0.01794291
```

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- Dynamic-linking at runtime
  - user's application built with ABI compatibility
  - system-specific implementation dynamically mounted at runtime

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- Look at what RedHat did

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- User-provided data are verified and filtered if needed, e.g., sudo

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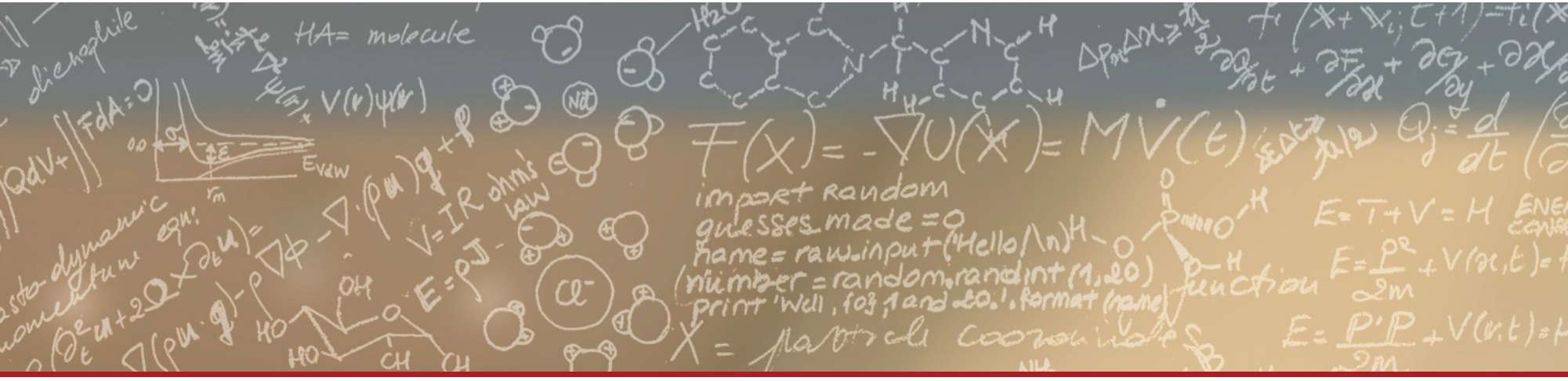
- **We haven't even scratched the surface of the possibilities**



Thank you for your attention.