On the Applicability of Virtualization in an Industrial Environment

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Context

Compute systems for product design in industry

- allow to simulate different designs
- need large systems & parallelization
- are essential today
- example at ABB: electric field simulation
  - in-house parallel PVM/MPI code POLOPT
  - since early 1990s, still in production use
  - cooperation with TUM: optimization/porting
  - different geo-located systems & engineers' workstations
  - maintained for Linux/Windows, Client/Server etc.

Motivation

High maintenance / development efforts

- change to 3rd-party simulation codes?
- unify runtime environment by virtualization
  - remove dependence to target environments
  - only one version to maintain, easy deployment:
    64-bit x86, Linux, single MPI implementation
  - multiple virtualization solutions required on different target systems

Objectives

For each different target system:
what is the best virtualization solution?

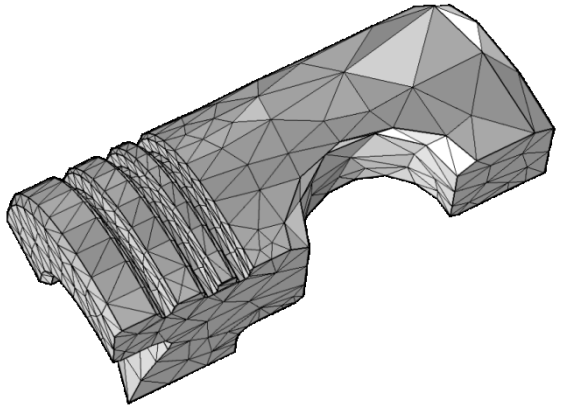
- importance of performance
  (on cluster: essential, on workstation: nice)
- permissions required
  (on cluster: root not available, on WS: fine)
- setup costs: software/adaptation scripts
  (once / regularly e.g. for security updates)

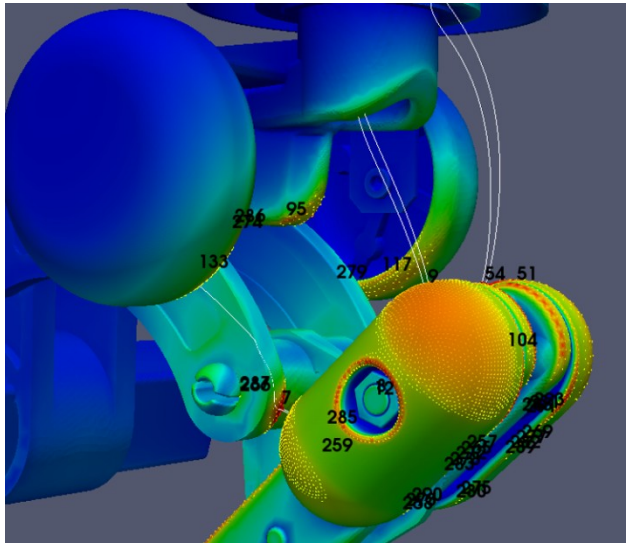
Outline

- POLOPT
- Virtualization Solutions
- Proposed Solution
- Measurements

POLOPT

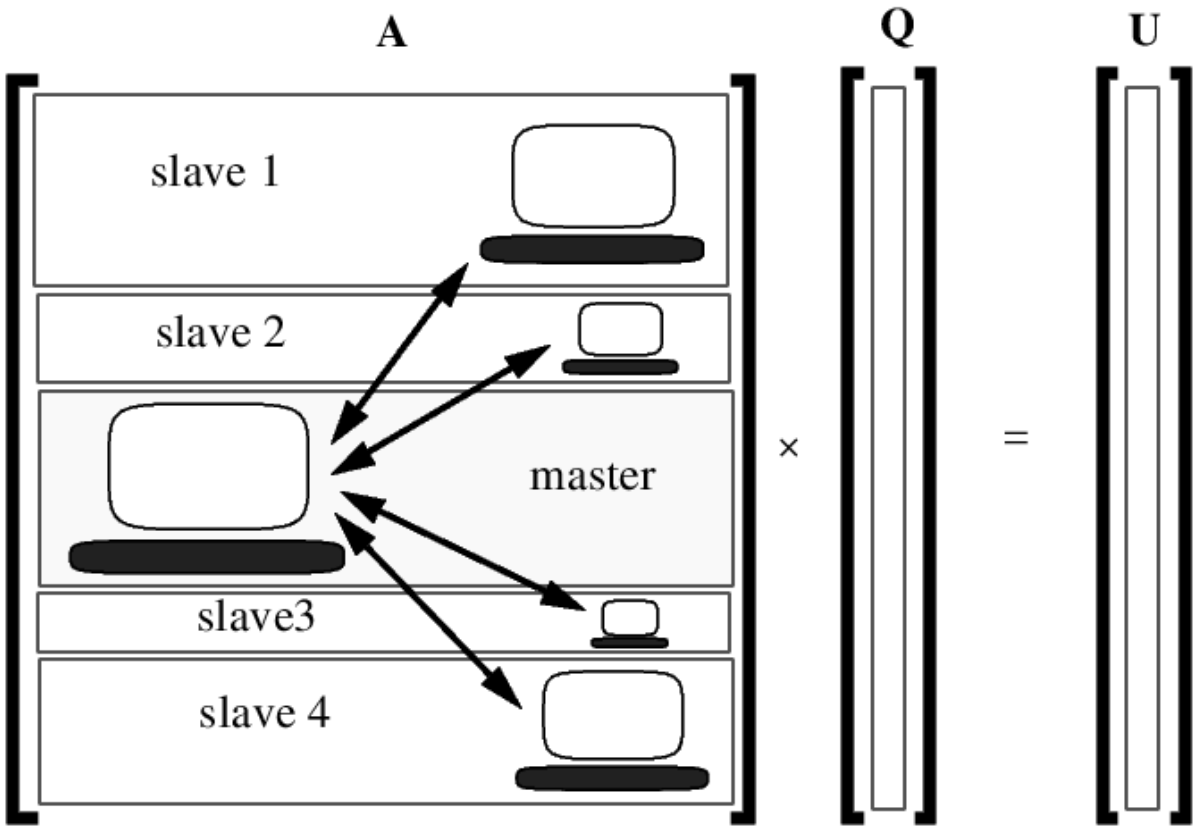
- Boundary Element Method (BEM)
- Unknowns (N): Electric charges on surface elements
- Two phases
  - matrix setup
    (size N^2, complexity: N^2)
  - iterative solver: GMRES
    (complexity: #iter * N^2)
  - both phases relevant
  - mostly streaming over data





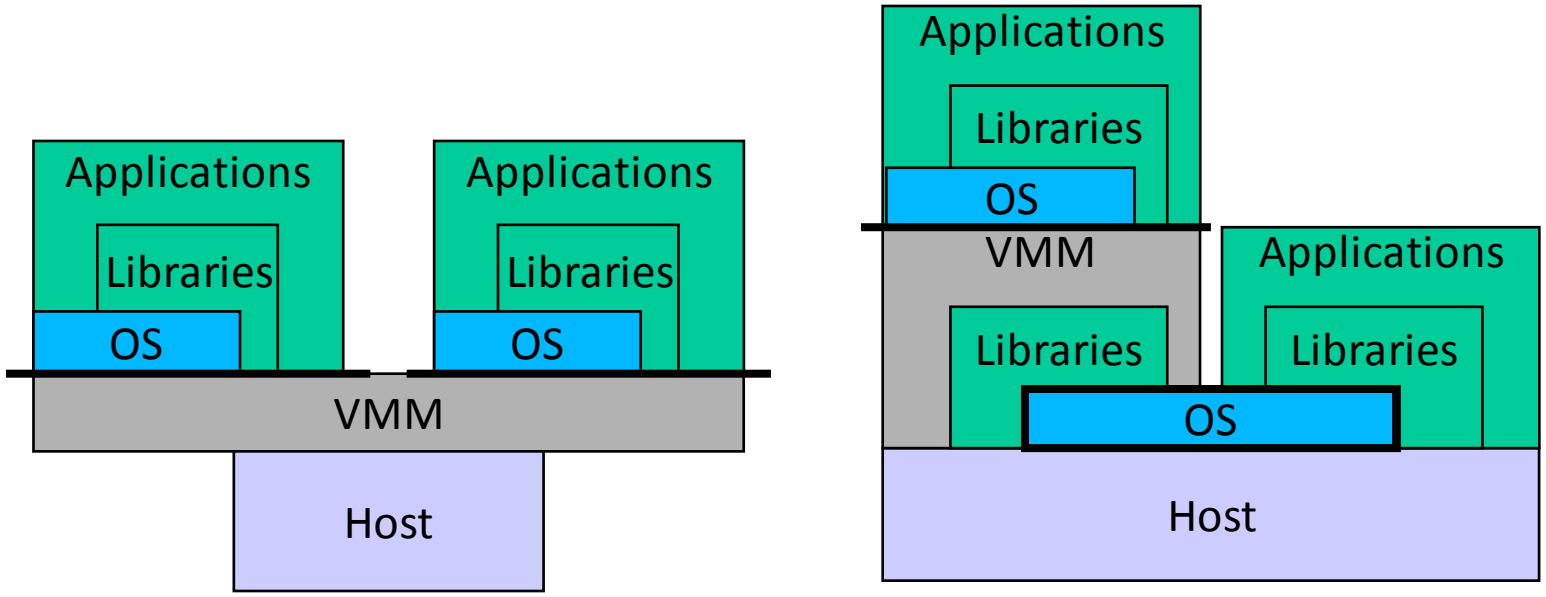
Parallelization

- Fix partitioning of matrix for parallelization
- Load balanced (static)
- Master also participates in computation



Virtualization Solutions

- System-VMs (VMWare, Xen, VirtualBox, KVM)



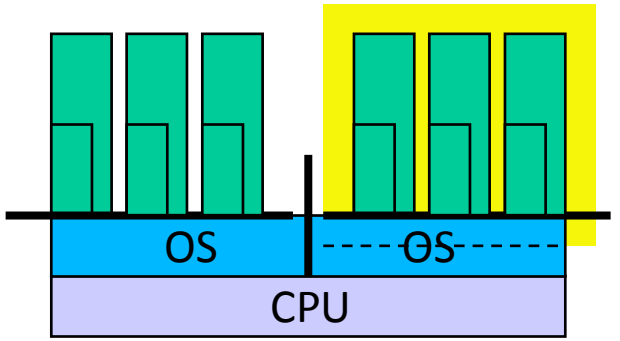
Native / Type-I

Hosted / Type-II

- different guest vs. host OS, often used in cloud
- typically non-negligible overhead (5-10 %)

Virtualization Solutions (2)

- OS-level virtualization = container (Solaris Zones, Jails, Docker)
  - indirection for OS-controlled resources (file system, net,…)
  - no inherent overhead (but: TCP)
  - needs root for creation (Linux: CGroups)
- lightweight: only chroot (preferred by LRZ)
  - Singularity: SUID binary, drops priveledges after chroot
  - PRoot: chroot emulation via PTrace hooks (slow!)

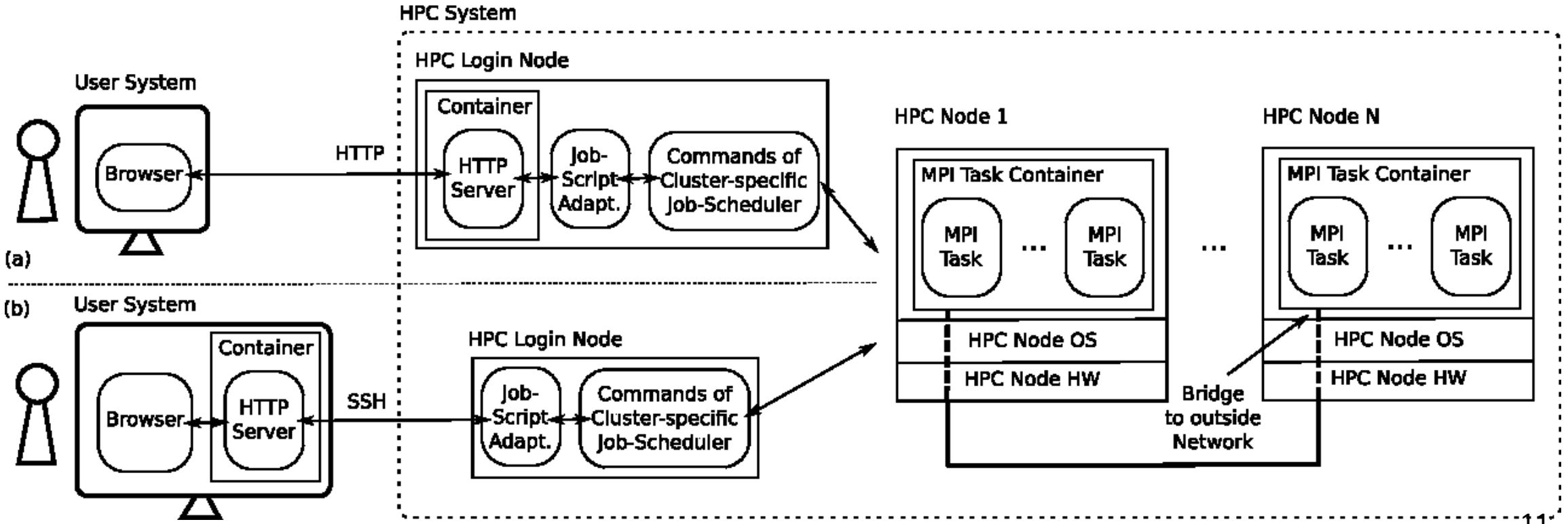


Our Solution

- identical container image for **all** target platforms
- web user interface for
  - input / output
  - progress report

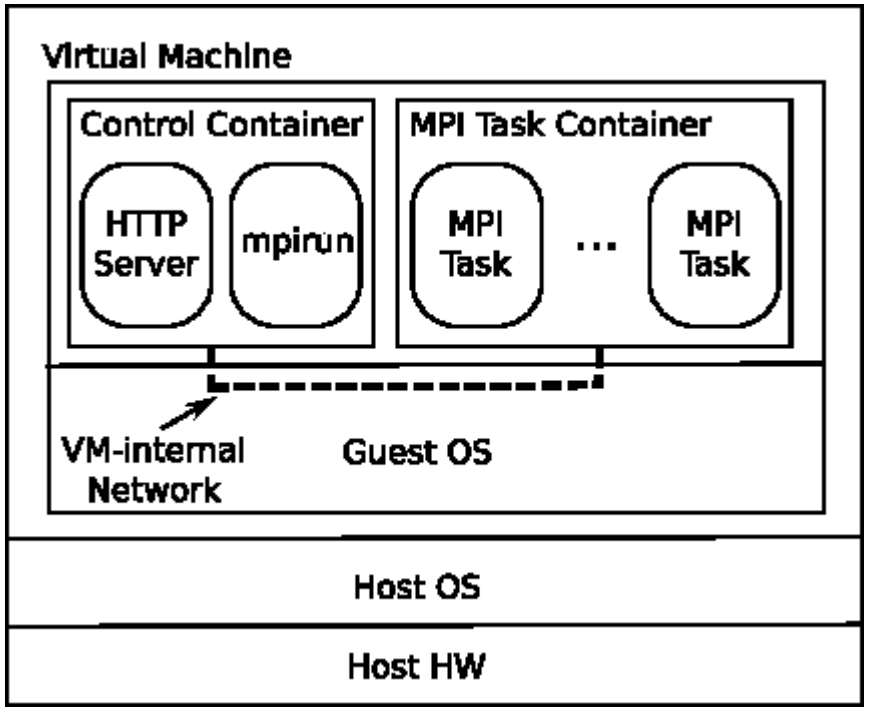
Target Platform: HPC Cluster

- use regular job-scheduling system
- dedicated containers: setup/cleanup part of job script



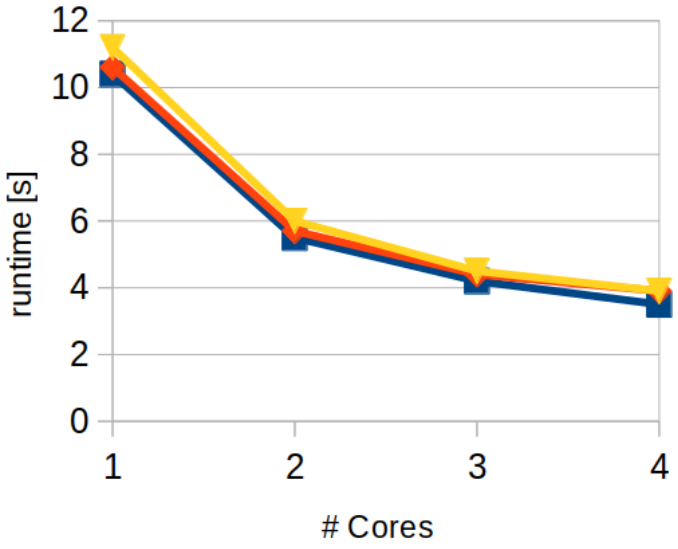
Target Platform: Workstation

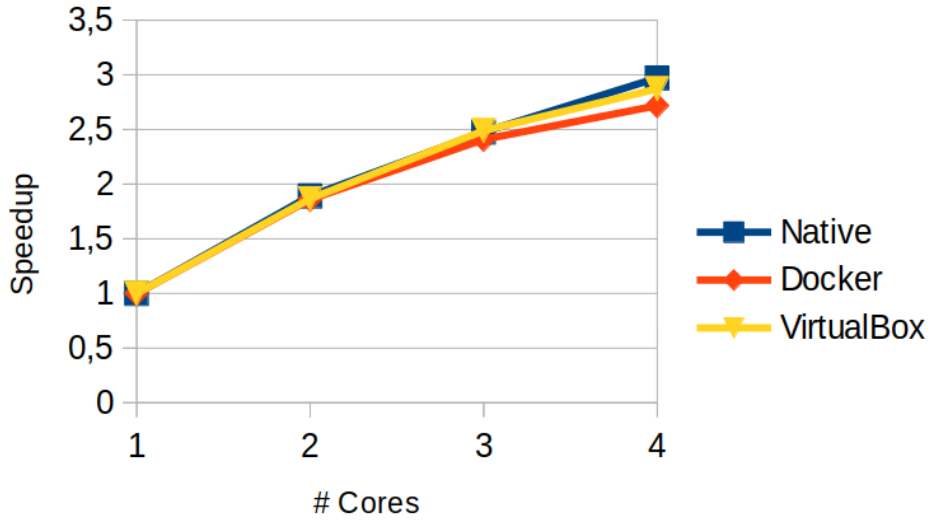
- VM + Container
  - host can be Windows, slowdown acceptable



First Measurements: Native vs. Docker vs. VM

- quad-core Xeon i5-3450 (Ivy Bridge): 3.1GHz, 6MB L3, VTX
- container based on Debian 8, Docker 1.12 (here: multiple containers)
- POLOPT: Intel compiler 17.0.0, Intel MPI 2017
- Small model (~ 1700 unknowns)





Conclusion

Virtualization

- helps reducing costs by allowing single target
- reduces maintenance cost of in-house code
- eases deployment to different target systems
- enables future commercial cloud usage
  (needs risk analysis for sensitive data)

Outlook

- measurements for multi-node