LifeSciHealth

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Virtualization for Desktop Grid Clients

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MTA SZTAKI

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"Using Virtual Machines in Desktop Grid Clients for Application Sandboxing"

- Joint work with Gilles Fedak (INRIA) and Oleg Lodygensky (IN2P3)
- Carried out in the frame of a *CoreGRID Researcher Exchange Programme*
- Idea came after the 3rd BOINC Workshop (BOF on virtual machines
- Work was done in November-December 2007
  - 5 weeks total at INRIA, Orsay, France
- A technical report was published with the results in June 2008
- Was a long time ago, but I think it might be still interesting…

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Goals 1/2

- "Provide a checkbox in the BOINC Manager which enables the execution of any application inside a Virtual Machine (sandbox)."
  - Usable by any deployed application
  - Should not require to install any additional libraries
  - Should be integrated with the client
  - Should not interfere with the daily work of the user
- "Should be a general solution that can be integrated with different DG middlewares."
  - In our case at least with XtremWeb (INRIA, IN2P3) and BOINC (SZTAKI)

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Goals 2/2

- "The solution should be primary aimed at Volunteer Computing projects."
  - Applications with little or no external dependencies (when possible)
    - To avoid large VM images
  - CPU intensive applications
  - Most likely Windows hosts, but should run also on Linux and Mac OS X
  - These characteristics can be also true for some commercial applications…
    - E.g. the applications of CancerGrid

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Benefits - motivation

- Simplified application development
  - A binary for a single platform (preferably Linux) is enough
  - Applications with many dependencies can be run
- Legacy applications
  - Applications without source code can be run on BOINC
- System-level checkpoint
  - VMs can be suspended, checkpointed, resumed
  - No need to implement it at the application level
- Enforce resource limits
- Isolation

Considered virtualization tools

- Bochs
  - Emulator implemented in C++
- QEMU
  - Processor emulator
- KQEMU
  - Extension for QEMU to improve performance
- VMWare Player
- VirtualBox

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Requirements for virtualization tools 1/4

- Transparency for the system
  - Should work "out of the box" with already deployed Desktop Grids
  - Should not constrain any restrictions to applications when using the VM
    - Checkpoint and resume, suspend and continue, measure and report the used CPU time and fraction done
- Transparency for the user
  - No special knowledge or preparation should be required for deployment
  - Should not interfere with the daily routine of the volunteer

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Requirements for virtualization tools 2/4

- Isolation
  - Applications running in the VM should not have any possibility for outside contact
    - Network access, accessing the files on the host, etc.
- Backdoor
  - Should be a method for accessing files inside the VM
  - Still no access to outside world for the guest
  - e.g. QEMU allows to forward a port from the guest to a socket at the host (without networking at the guest)
- Cross-platform
  - Should run on Windows, Linux, Mac OS X

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Requirements for virtualization tools 3/4

- Instantiation
  - More than one VM could be running at a time
  - Duplicate images for each VM should be avoided
    - *Using overlay images*
- Failure-tolerant (“bullet-proof”)
  - No malicious application or task may render the VM unusable for future tasks
    - Creating and reverting to snapshots
    - *Using overlay images*
- Performance
  - Performance penalty for using the VM should be low

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Requirements for virtualization tools 4/4

- Background (“headless execution”)
  - Should not present windows, pop-ups or a graphical display, should run in the background
- Licensing
  - Should be open source e.g. GPL, LGPL, BSD, Apache, etc.

Comparison

	Bochs	QEMU	QEMU + KQEMU	VMware Player	VirtualBox
virtualization method	emulation	emulation	virtualization	virtualization	virtualization
1. *transparency for the user*	√	√	×	×	×
a. deployment	√	√	× (KQEMU)	×	×
b. slowdown	×	√	√	√	√
2. *transparency for the system*	×	√	√	×	×
a. checkpoint and resume	√	√	√	√	√
b. suspend and continue	√	√	√	√	√
c. remote control	×	√	√	×	√
d. backdoor	×	√	√	×	×
3. isolation	√	√	√	√	√
4. cross-platform	√	√	×	×	√
5. performance	×	×	√	√	√
6. instantiation	×	√	√	×	×
7. background	×	√	√	×	√
8. licensing	LGPL	GPL	GPL	Proprietary	Proprietary/ GPL

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Comparison

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a. deployment	√	√	× (KQEMU)	×	×
b. slowdown	×	√	√	√	√
2. *transparency for the system*	×	√	√	×	×
a. checkpoint and resume	√	√	√	√	√
b. suspend and continue	√	√	√	√	√
c. remote control	×	√	√	×	√
d. backdoor	×	√	√	×	×
3. isolation	√	√	√	√	√
4. cross-platform	√	√	×	×	√
5. performance	×	×	√	√	√
6. instantiation	×	√	√	×	×
7. background	×	√	√	×	√
8. licensing	LGPL	GPL	GPL	Proprietary	Proprietary/ GPL

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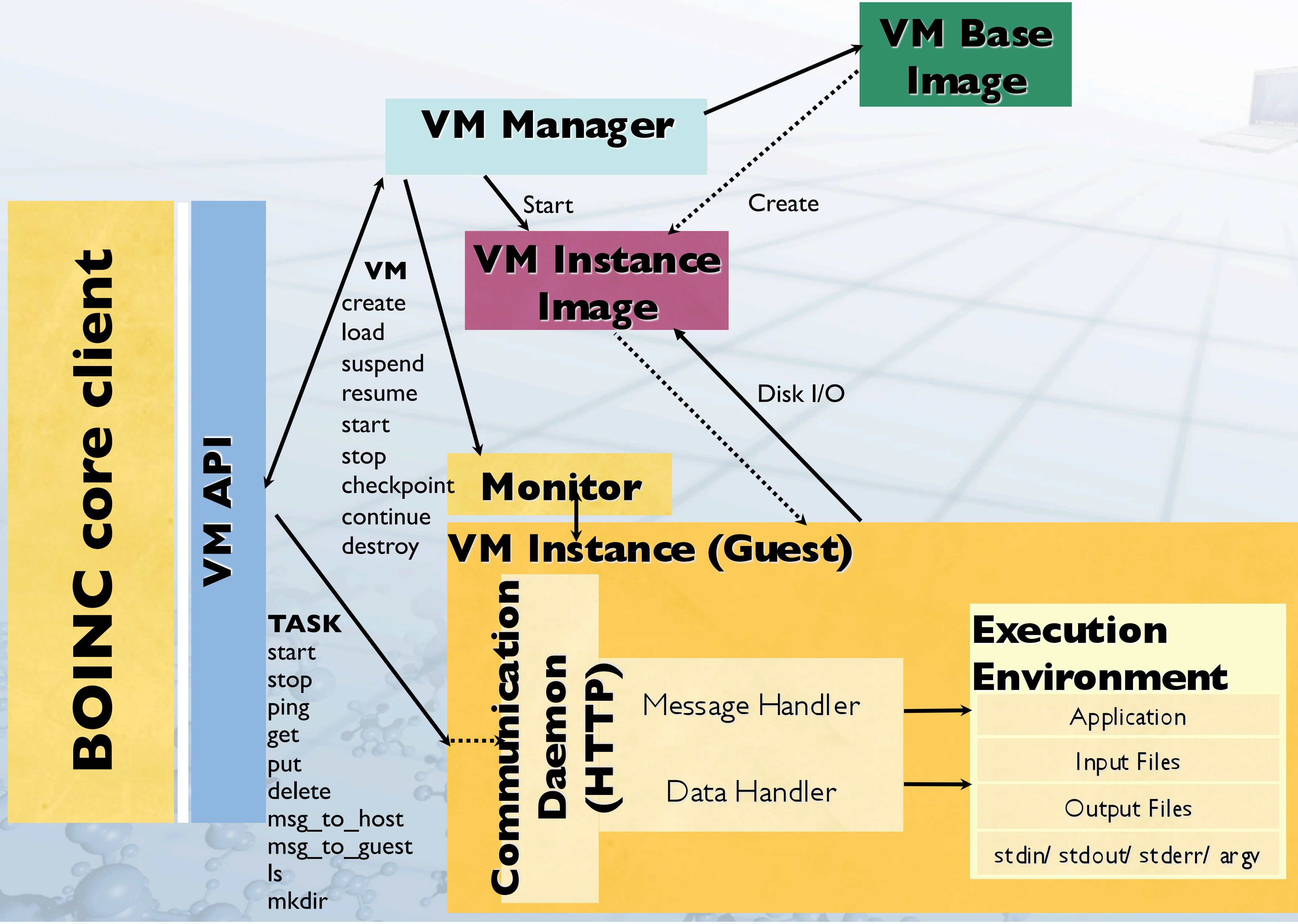
General ideas

- VM images are big – create them on the spot
  - Distribute a base image, and inject the input files on the client
  - Use overlay images for fault tolerance
- Define and use atomic commands for VM control and task execution
  - *libvirt* was considered, too complex, functionality was missing
  - Use an existing protocol, e.g. **http** or **ssh**
    - **http** already has PUT, GET to store and retrieve files

Architecture – with BOINC



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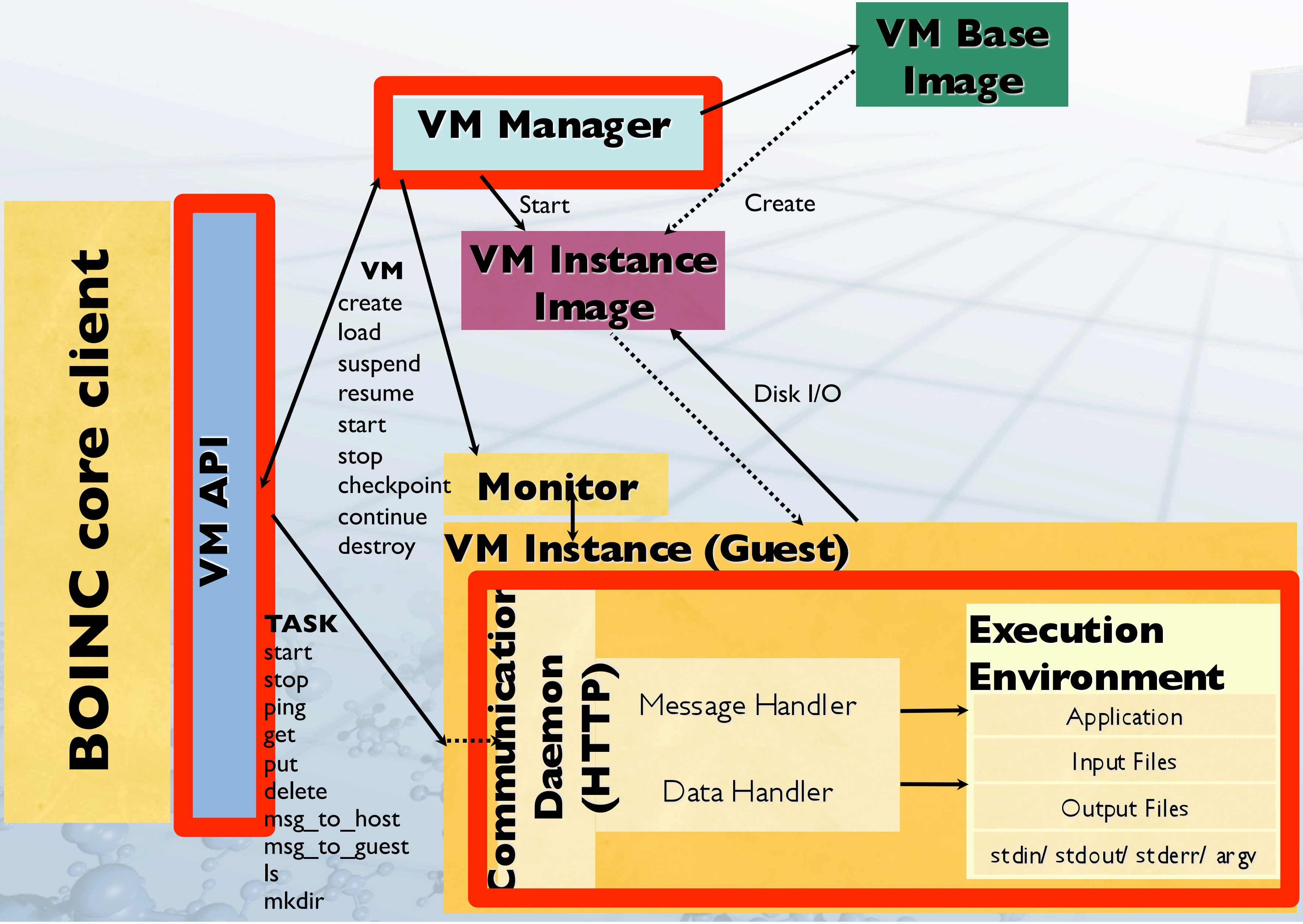
Architecture – with BOINC



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Architecture - VM API

- “High-level” C/C++ API to control task execution and VMs
- `vm_sb_*` functions for task execution
  - `start, stop, put, get, ping, delete, msg_to_host, msg_to_guest, ls, mkdir`
  - *Communication daemon* on the guest side
- `vm_*` functions for VM control
  - `create, load, suspend, resume, start, stop, checkpoint, continue, destroy, get_status`
  - *VM Manager* provides these functions

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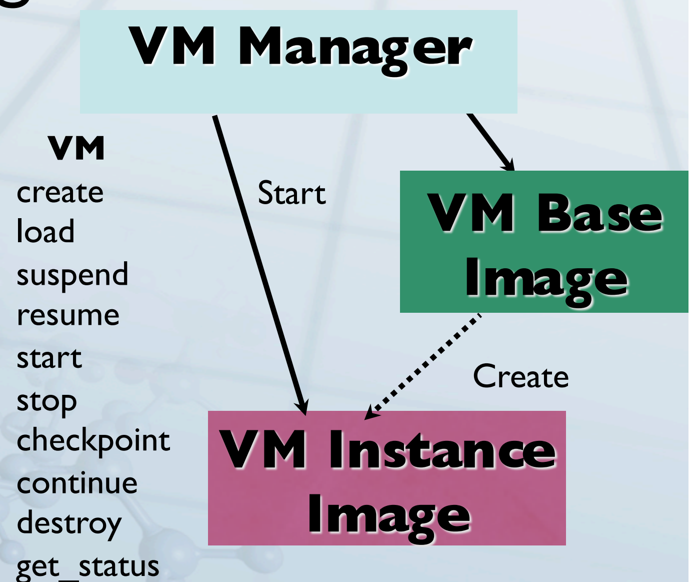
Architecture - VM Manager 1/2

- "Low-level" component for managing VM images
- Performs operations requested by the VM API
  - `create, load, suspend, resume, start, stop, checkpoint, continue, destroy, get_status`
- VM Base Images store default Linux OS and components that are required to run by the guest OS
  - Communications Daemon, * Handler, Execution Environment
- Overlay images are created for VM instances – all disk I/O goes here
  - Thrown away after task finishes
- Metadata stored in a SQLite database



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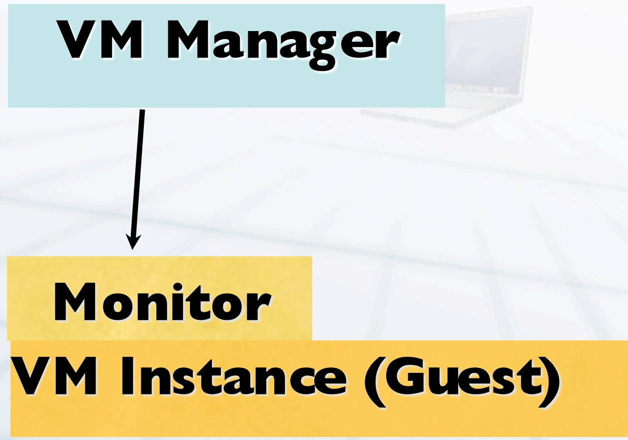
Architecture - VM Manager 2/2

- Controls the VM via the monitor of QEMU (concept from libvirt)
  - monitor is bound to a socket
  - works like a terminal
    - send a command
    - if we get a prompt success
- VM Base image
  - Debian Linux
  - Compressed QCOW2 format
  - ~350MB
- Instance image ~50-150MB



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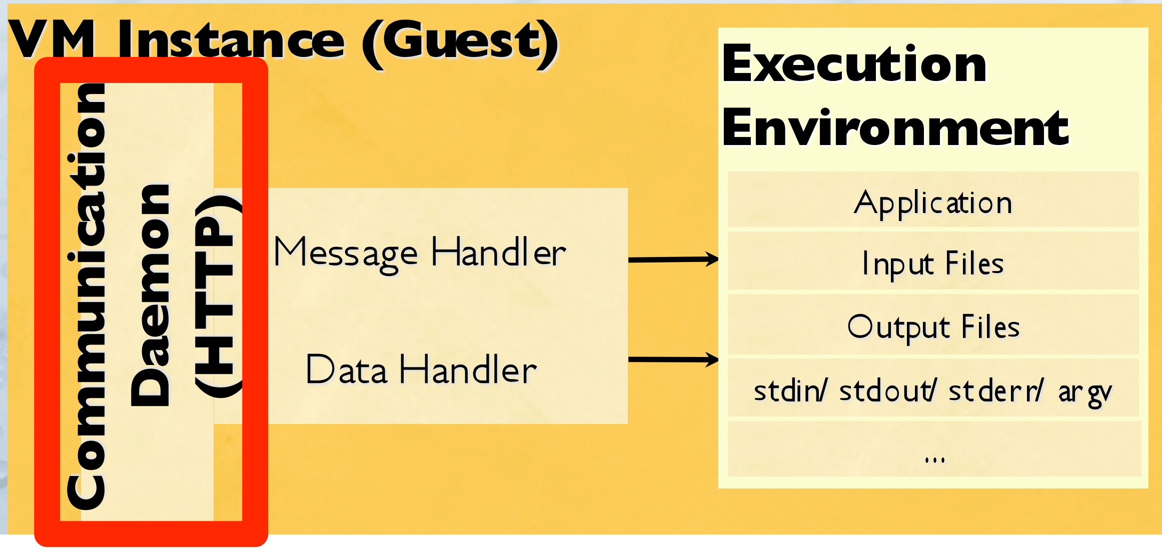
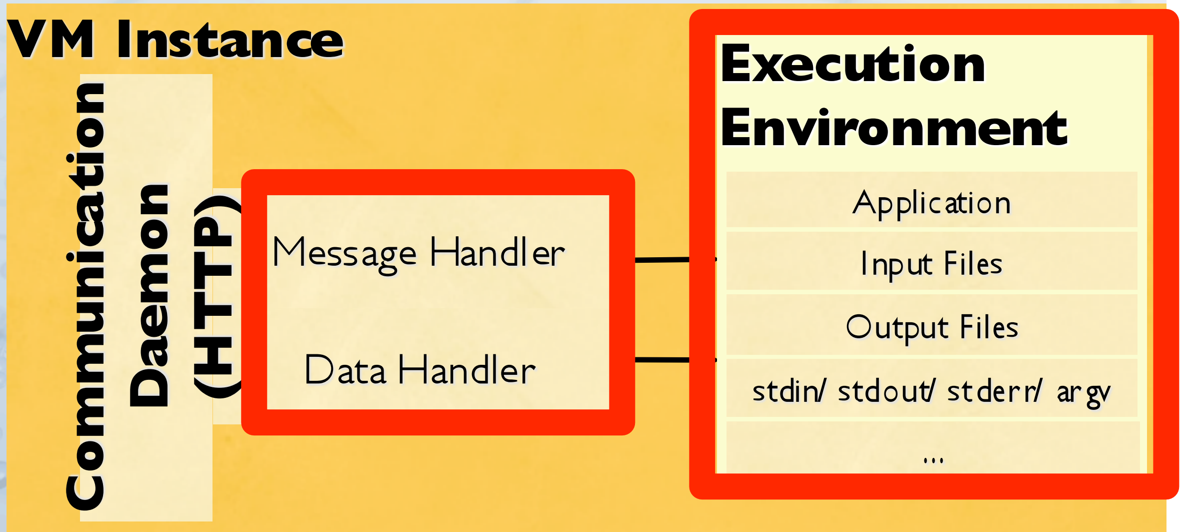
Architecture – Communication Daemon

- Handles task specific commands
  - Embedded HTTP server, receives messages from host
  - `start, stop, put, get, ping, delete, msg_to_host, msg_to_guest, ls, mkdir`
    - implemented over HTTP PUT/ GET/ POST
- QEMU allows to forward a TCP port in the guest to a TCP port on the host – modified QEMU to map to a socket on the guest when available
- All communication is initiated by the host, guest only responds



Architecture – Message Handler, Data Handler, Execution Environment

- Execution Environment
  - Starts application in a work directory - can be removed and recreated at the end of each task
  - Environment variables set
  - Command line parameters
- Data Handler, Message Handler
  - Implement functionalities for the available commands



How to Implement BOINC functionalities ?

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- Checkpoint/ Resume
  - Provided by the VM (QEMU)
  - Multiple checkpoints can be stored in a single overlay image
- Suspend/ Continue
  - Provided by the VM (QEMU)
- Measure CPU time
  - QEMU instance is a single process, we can measure its used CPU time directly (**is not implemented**)
- Report fraction done
  - Using `msg_to_host` (**is not implemented**)
- Enforce resource limits (CPU, disk)
  - Provided by the VM (QEMU)

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Performance – Intrusiveness 1/2

- We wanted to know
  - How big is the CPU overhead of the virtualization (QEMU)
  - How does lowering the priority of the VM instance process affects performance and responsibility of the host system
- We run a test – execute a work unit in the VM while performing daily routine-work on the host
  - Was editing a PowerPoint presentation
  - Each part of the test was run 20 times
  - Application “BinSYS” from SZTAKI Desktop Grid
  - Host: Pentium IV 2.53GHz CPU, 1GB RAM, Windows XP
  - Guest: 160MB RAM, Debian Linux

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Performance – Intrusiveness 2/2

Type	Slowest	Fastest	Average
Native Linux	711.06 sec	708.17 sec	710.20 sec
Windows host, Linux guest, QEMU normal priority, with KQEMU	747.56 sec	744.21 sec	745.12 sec
Windows host, Linux guest, QEMU below normal priority, with KQEMU	759.76 sec	757.60 sec	758.71 sec

- "*Normal priority*" – Noticeable slowdown in the host, especially when disk i/o
- "*Below normal priority*" – No slowdown
- Without the KQEMU component, the execution was extremly slow

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Status and future work

- “Prototype” - It works, but…
  - Parts of the High-level VM API are missing
  - Integration with the BOINC Client is missing
- Part of a proposal for an EU funded project due to start in 2010
- Technical report available at http://boinc.berkeley.edu/trac/wiki/VmApps

Usage in the CancerGrid project

- Workflows are executed
  - Consist of legacy applications using GenWrapper (BOINC)
  - CPU intensive applications
- Consortium of academic and industrial partners
  - Consortium members donate CPU time
  - Office computers running Windows
  - Increased security would be more than welcomed by Administrators…

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If you need more detailed (technical) information,
email to desktopgrid@lpds.sztaki.hu or
visit www.desktopgrid.hu

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Thank you for your attention!

Questions?

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http://www.cancergrid.eu