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A Lightweight Kernel for the Harness Metacomputing Framework

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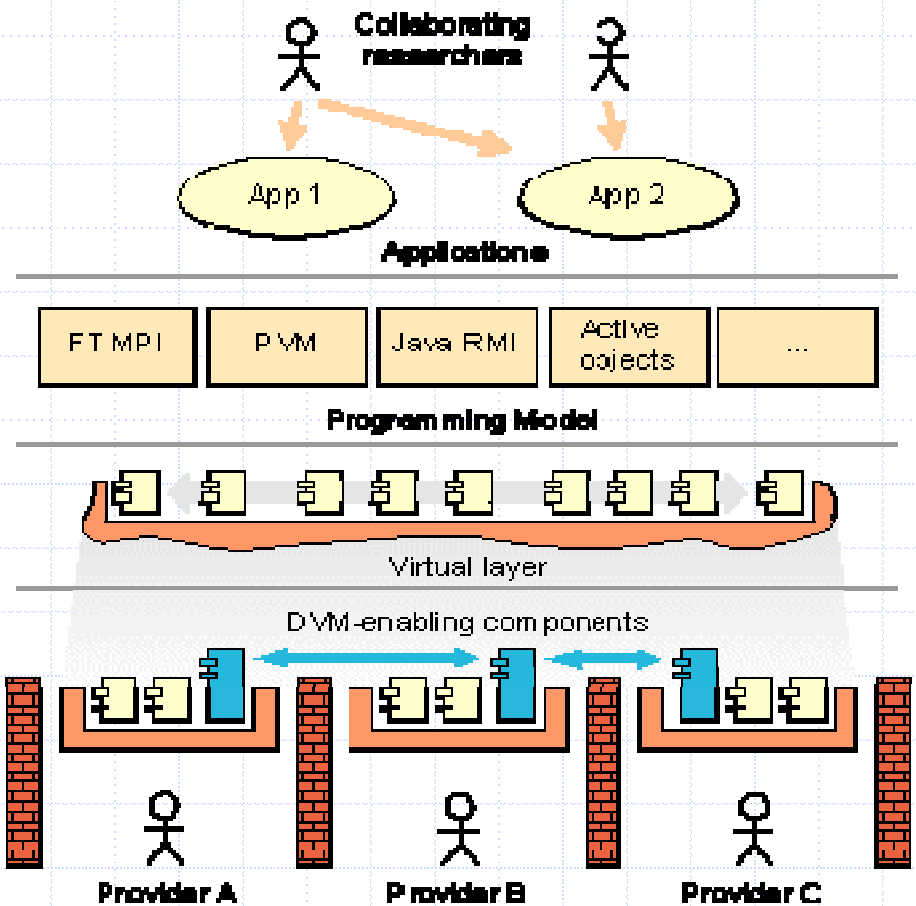
What is Harness

ICL UT Innovative Computing Laboratory

Emory University

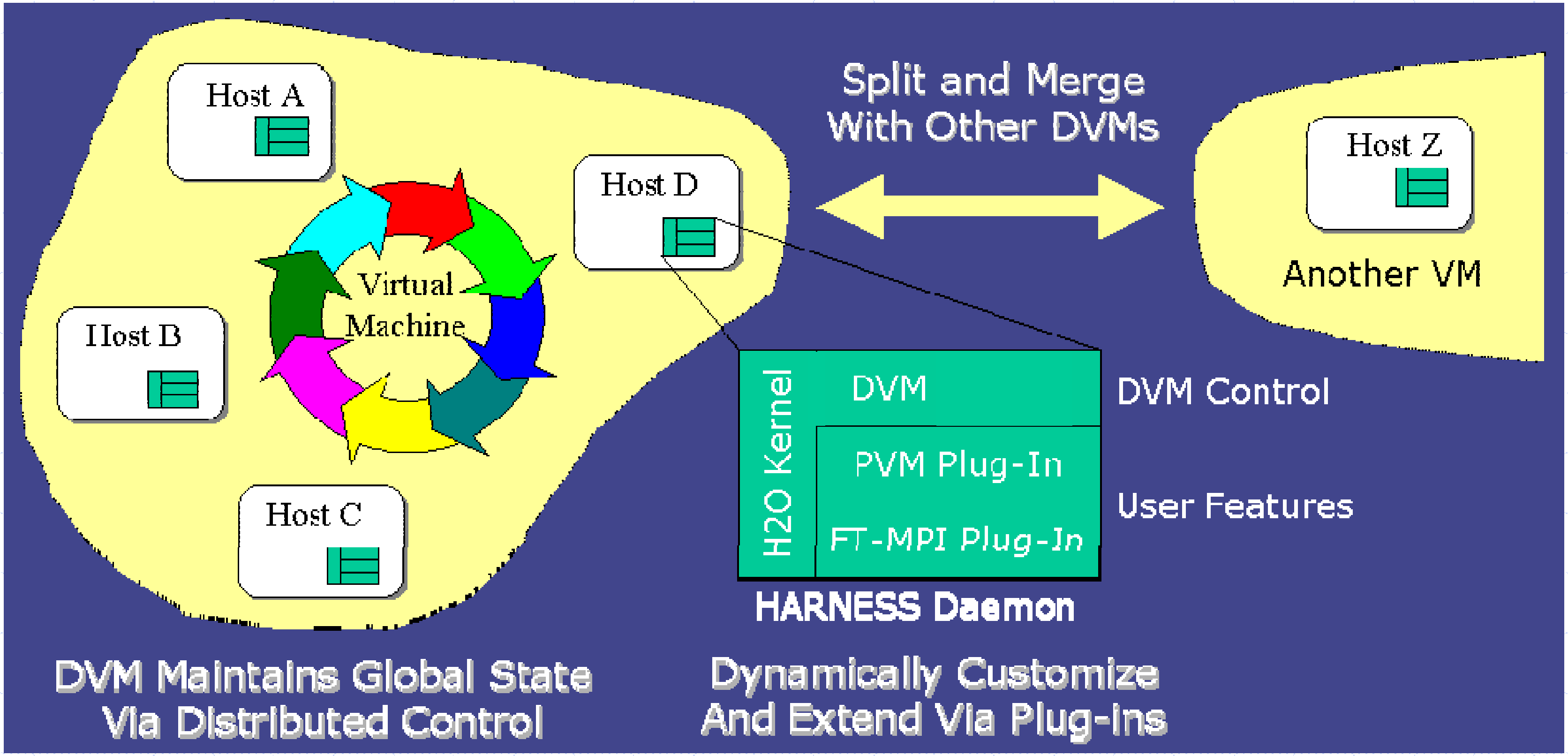
- A pluggable, reconfigurable, adaptive framework for heterogeneous distributed computing.
- Allows aggregation of resources into high-capacity distributed virtual machines.
- Provides runtime customization of computing environment to suit applications needs.
- Enables dynamic assembly of scientific applications from (third party) plug-ins.
- Offers highly available distributed virtual machines through distributed control.
- Various experiments and prototypes (C/Java).

Harness Architecture

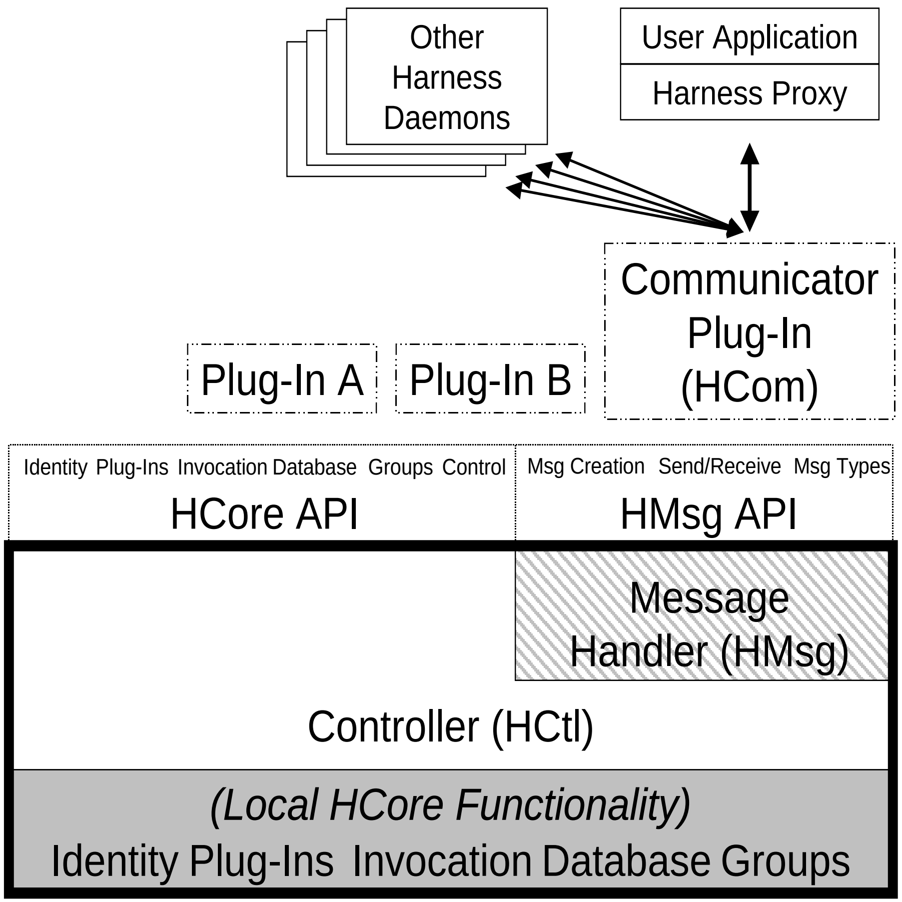


- Light-weight kernels share their resources.
- Plug-ins offer services.
- Support for diverse programming models.
- Distributed Virtual Machine (DVM) layer.
- Highly available DVM using distributed control.
- Highly available plug-in services via DVM.

Harness DVM Architecture



Original Harness Kernel Design



/I inside kernel (HCtl)
ı ring-based peer-to-
r distributed control.

abases inside kernel
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r-to-peer messaging
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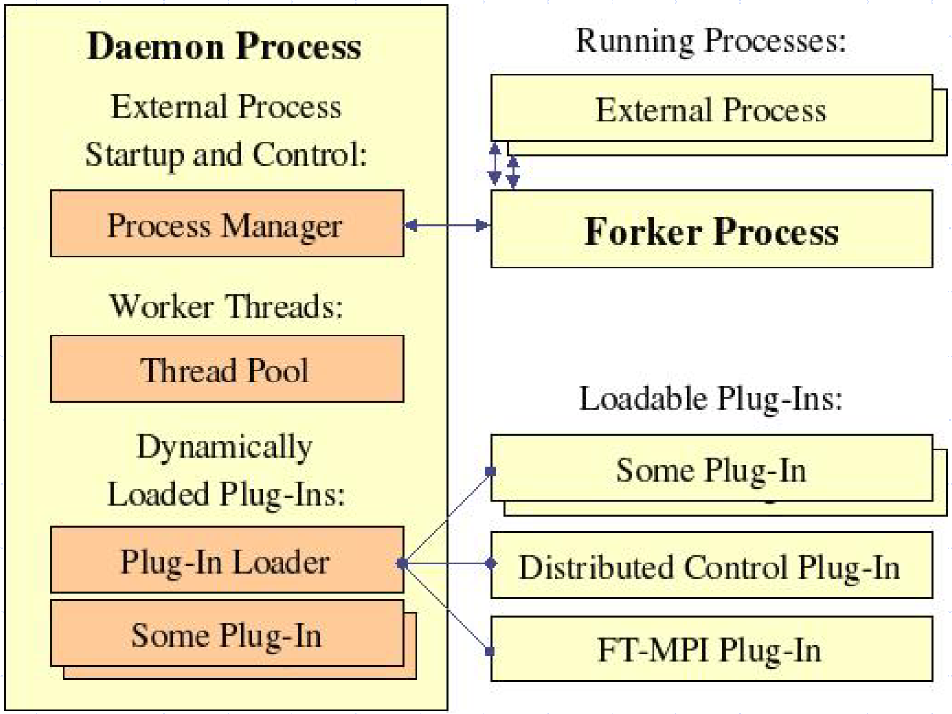
ced/Hidden DVM
gramming model.

Improved Lightweight Kernel

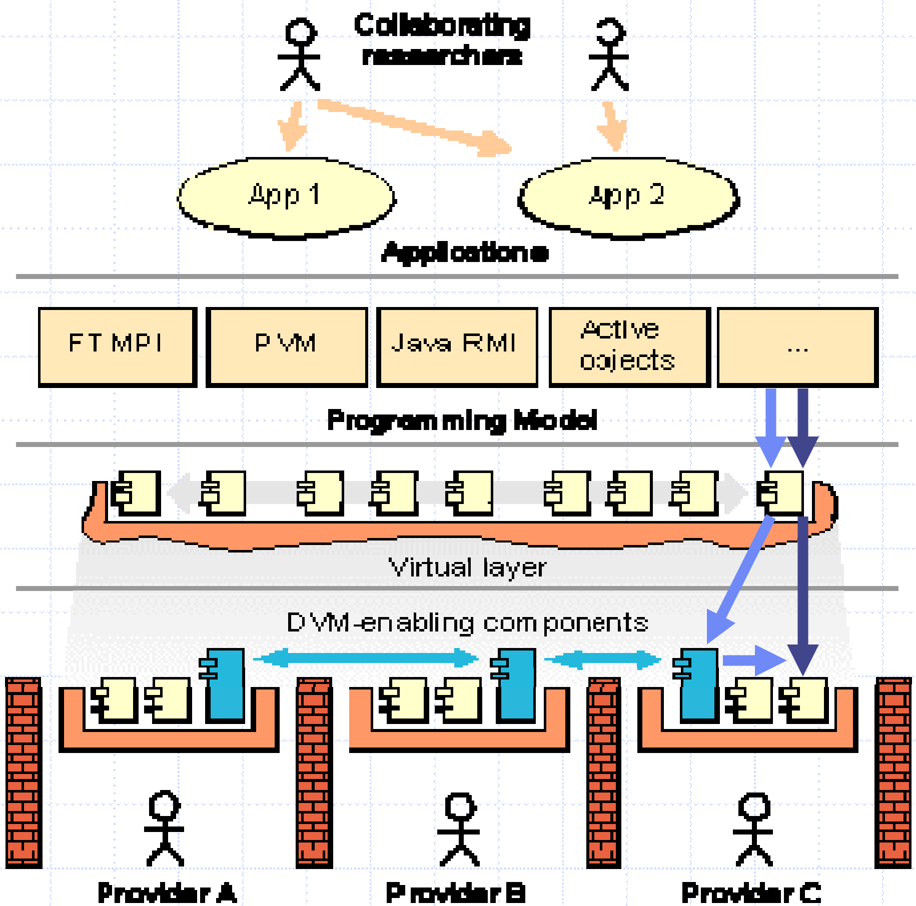


- Optional Distributed Control plug-in (DVM).
- Only local information stored inside kernel.
- Enhanced process and plug-in management.
- Thread management.
- RMI/RPC messaging through RMIX plug-in.

- User is able to choose programming model based on actual needs: DVM, PVM, FT-MPI, client-server, etc.

- Plug-in access via DVM
- Direct plug-in access

Optional Distributed Control Plug-in



- Not all plug-ins need to be part of the DVM.
- User chooses if high availability is needed.
- Avoids unnecessary DVM use and associated performance impact.
- Allows loosely coupled peer-to-peer paradigms.
- Improves adaptability, versatility and usability.

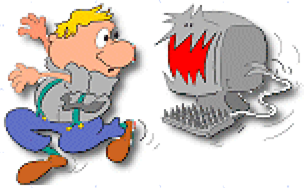
Improved Process Manager

- Capable of controlling child processes via a separate kernel child process (forker) spawned at startup.
- Allows creation and destruction of child processes.
  - Relays input to stdin of child processes.
  - Optionally captures and buffers child process stdout.
  - Supports sending of signals to child processes.
  - Harness kernel threads may wait for child process exit.
- Typically used for remote kernel startup using ssh and for external application runs.

Enhanced Plug-in Loader

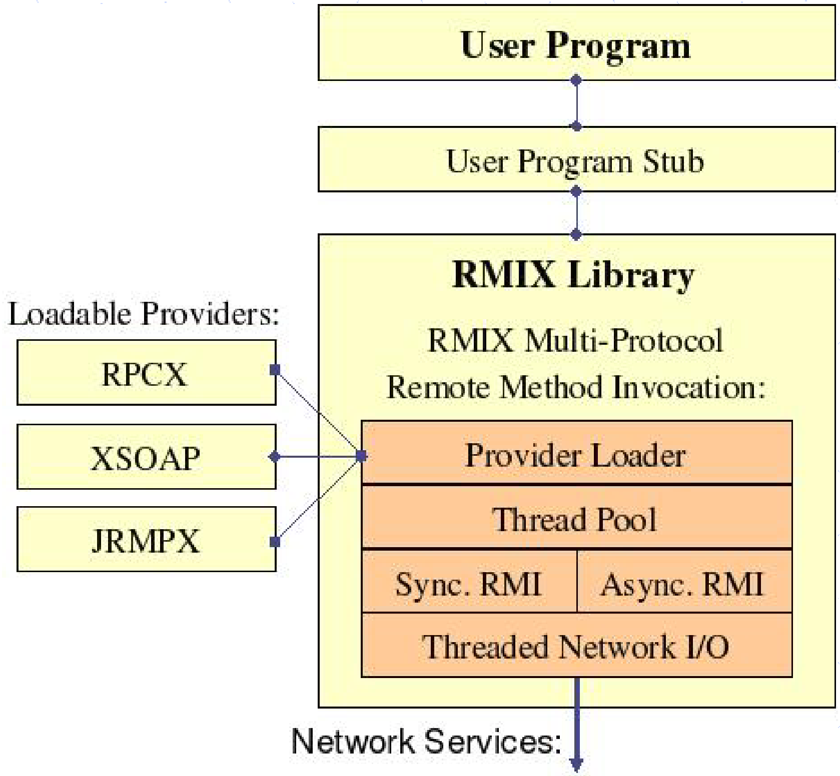
- Loads and unloads shared libraries (dlopen/dlclose).
- Initializes after loading. Finalizes before unloading.
- Allows multiple loading using unique handles.
- Offers recursive dependent plug-in (un)loading.
- Provides global symbol export or lookup (dlsym) of table with global data and function pointers.
- Supports optional plug-in versioning scheme: <version>.<age>.<revision>
- Capable of managing different plug-in versions loaded into the same kernel (without global export).

Added Thread Pool



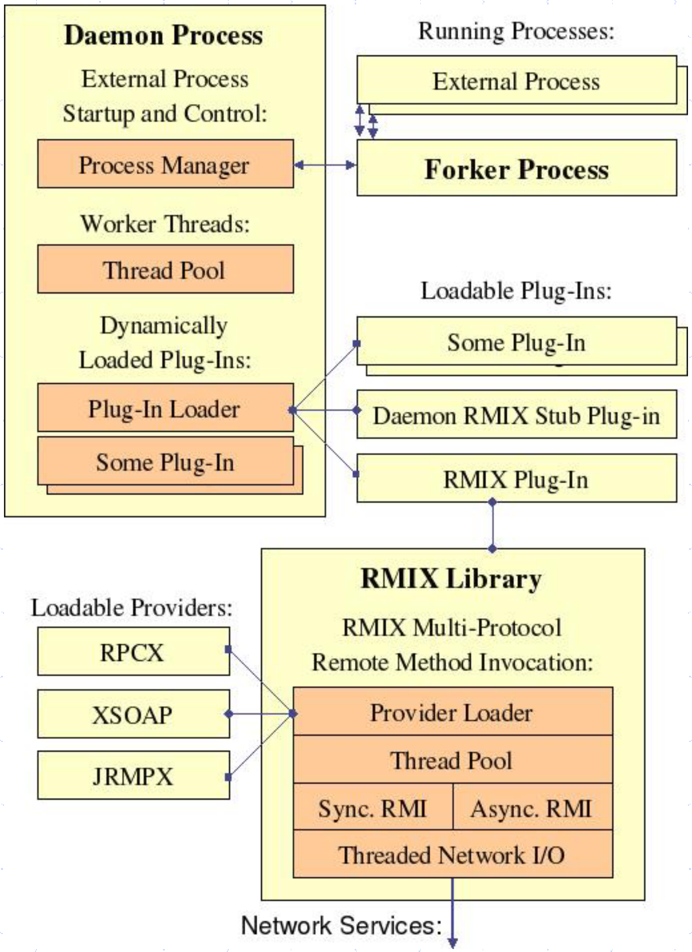
- Allows to change minimum/maximum thread count.
- Supports variable timeouts for idle threads.
- Offers configurable kernel shutdown thread timeout.
- Capable of adjusting the maximum job queue length.
- All maximums, minimums and timeouts are reconfigurable before kernel startup and at runtime.
- Simplifies task execution in the multi-threaded kernel.
- Increasing the maximum thread count is typically used for persistent threads, like servers.

RMIX Framework



- Originally developed in Java at Emory University.
- Dynamic, heterogeneous, RMI/RPC framework.
- Pluggable providers: Sun RPC, Java RMI and SOAP.
- Support for asynchronous and one-way invocations.
- Stand-alone C variant and Harness plug-in currently in development at ORNL.

RMIX Harness Plug-in



- Reuse of Harness plug-in and thread management.
- RMIX Harness plug-in wraps RMIX base library.
- Harness plug-ins provide client and server stubs.
- Kernel stub plug-in.
- Harness plug-ins are able to communicate via RMIX.
- Further improves flexibility and heterogeneity.

Conclusions

- Improved adaptability, versatility and usability by changing to a lightweight Harness kernel design.
- Moved previously integrated distributed control service (DVM) into an optional Harness DVM plug-in.
- DVM is only used when high availability is needed.
- Improved performance by bypassing the DVM.
- Enhanced process manager to provide remote kernel startup using ssh and external application runs.
- Introduced an optional plug-in versioning scheme.
- Added thread pool to simplify task execution in the multi-threaded kernel environment.

Future Work

- Finishing the development of RMIX stand-alone C variant and RMIX Harness plug-in to further improve flexibility and heterogeneity.
- Service-level high availability features for applications, as well as for typical operating system components, such as schedulers.
- Virtualization of different underlying platforms to present a uniform programming and deployment interface.

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Questions or comments?

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