The University of Reading

Design and Development of Prototype Components for the Harness High-Performance Computing Workbench

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Contents

Introduction – Overview

- Parallel computing is used to solve large-scale problems
- Enormous amounts of computational performance for simulations and modeling in aerospace, medicine, nanotechnology and material science
- Development of parallel algorithms and software
- Software organizes the resources and handles the communication of application components
- Two well-known parallel computing packages, Parallel Virtual Machine (PVM) and Message Passing Interface (MPI)

Introduction – Previous Work

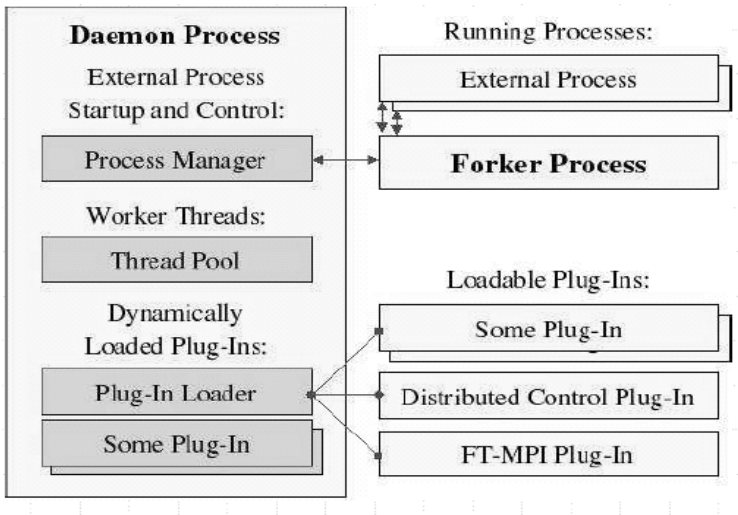
- Harness is a follow-on to PVM
- An ongoing, collaborative work between the Oak Ridge National Laboratory (ORNL), University of Tennessee Knoxville (UTK), and Emory University
- Provides a pluggable, heterogeneous Distributed Virtual Machine (DVM) environment
- Organizes programs and services by using plug-in software modules
- Consists of a lightweight kernel (runtime environment)

Introduction – Requirements and Objectives

- Parallel plug-ins assemble applications and provide services
- The main objectives of this Master thesis project were
  - Gaining experiences in the research area of parallel plug-ins
  - Using the available functions provided by Harness
  - Exploring the new aspects of fault tolerance that arise from the use of dynamic parallel plug-ins.
- Plug-ins must meet different requirements, such as inter plug-in communication, plug-in (un)loading and fault tolerance

Definition of Parallel Plug-ins

Harness



Today's plug-in technology

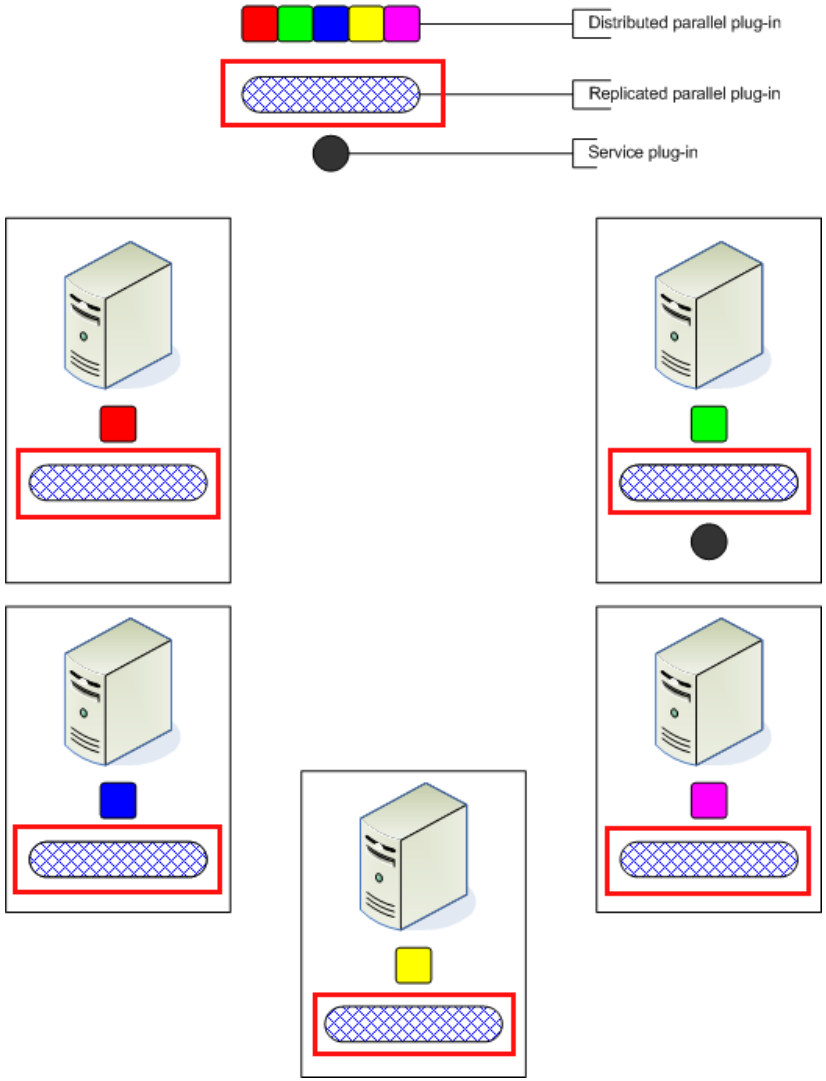
- Plug-ins interact with other programs providing certain, specific functions
- Extends software to provide new features
- Usually integrated over a well-defined interface
- Possible way to overcome bulky software

Parallel Plug-ins

Motivation and Features

- New design attempts to use the advantages of both technologies
- Providing a design pattern for parallel plug-ins and basic parallel plug-in frames
- Parallel plug-ins build up entire, modularized, pluggable applications
- Facilitating the modularization of huge and complex software systems
- Parallel plug-ins are independent from other modules of the complete system
- Benefits: code reuse and lightweight software

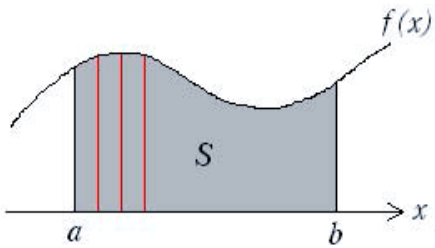
Types of Parallel Plug-ins



- Distributed parallel plug-in
- Replicated parallel plug-in
- Service plug-in

Parallel Plug-ins and Scientific Applications

Monte Carlo Integration



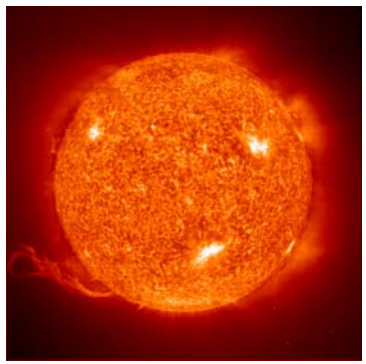
$$I = \int_a^b g(x)\mathrm{d}x$$

$$I \approx I_{MC} = \frac{b-a}{n}\sum_{i=1}^{n} g(x_i)$$

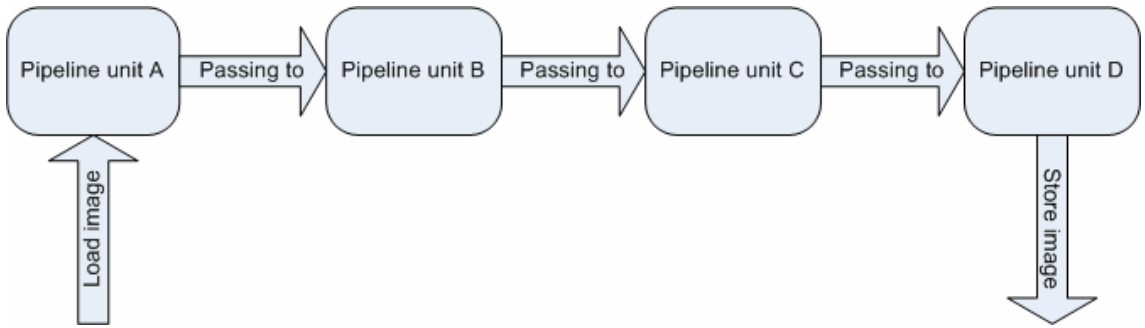
- Used in many simulations in physics or other scientific disciplines
- Based on numerically generated pseudo random numbers
- Simplifies the calculation of complex integrals

Parallel Plug-ins and Scientific Applications

Image Processing Pipeline

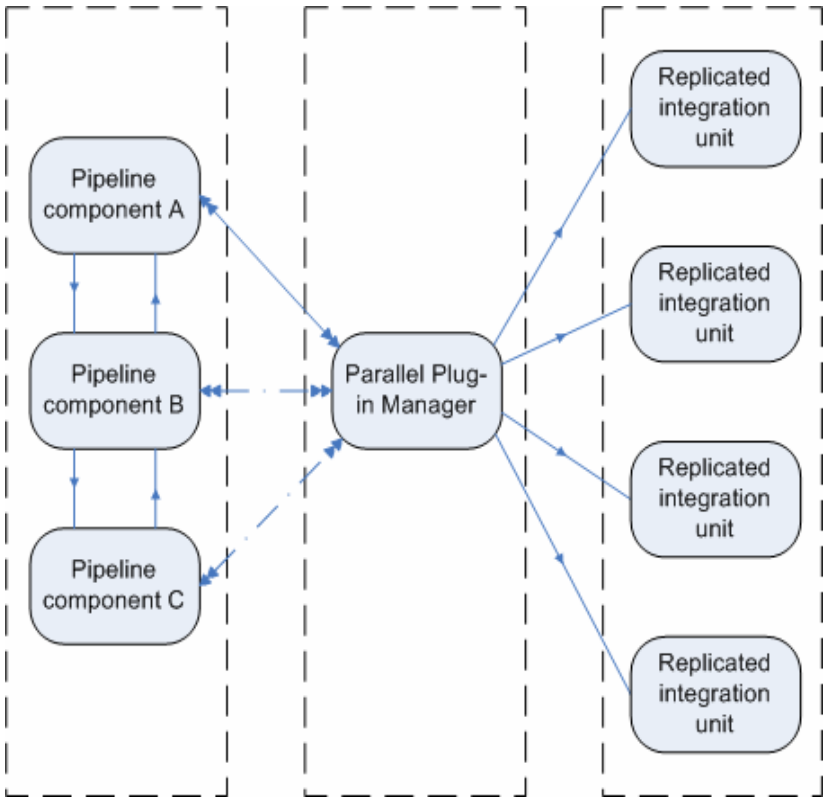


- Needs a lot of processing power for the calculation of certain filter functions
- Mostly, images are processed with a variation of filters

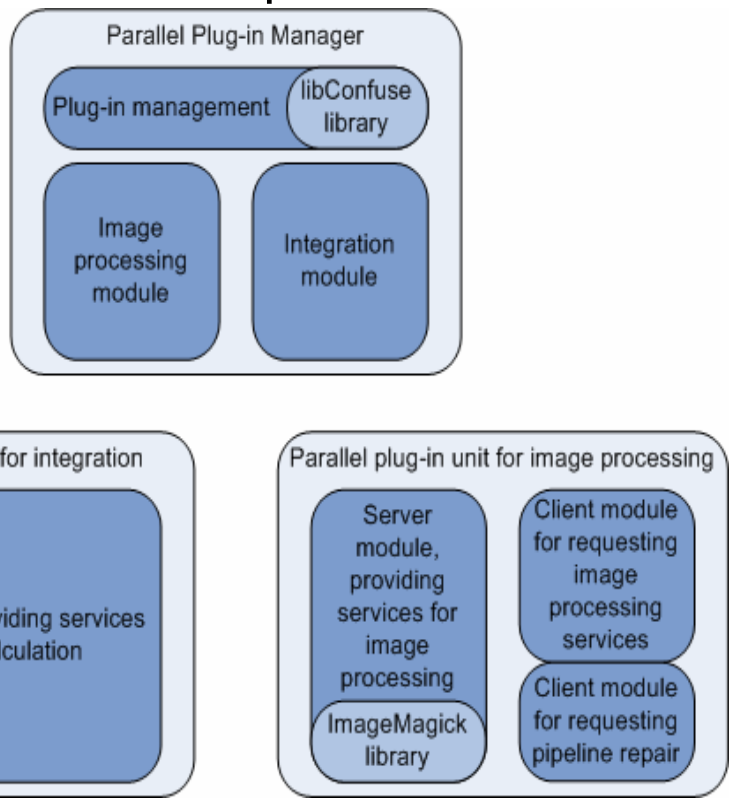


System Design of a Prototype Parallel Plug-in Suite

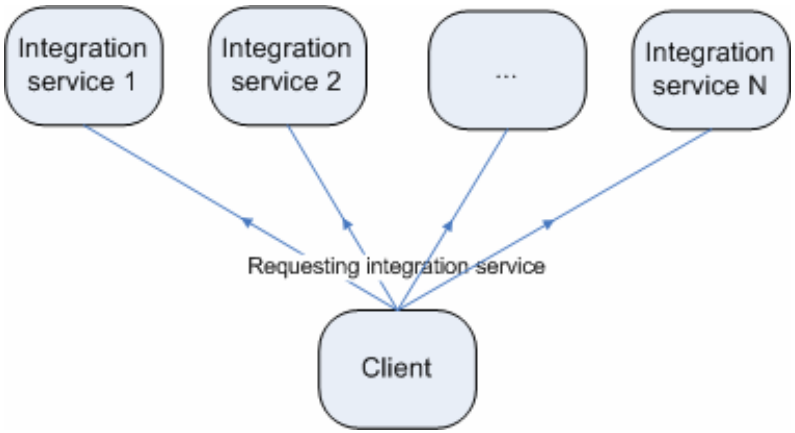
Architecture of the Parallel Plug-in Prototype Suite



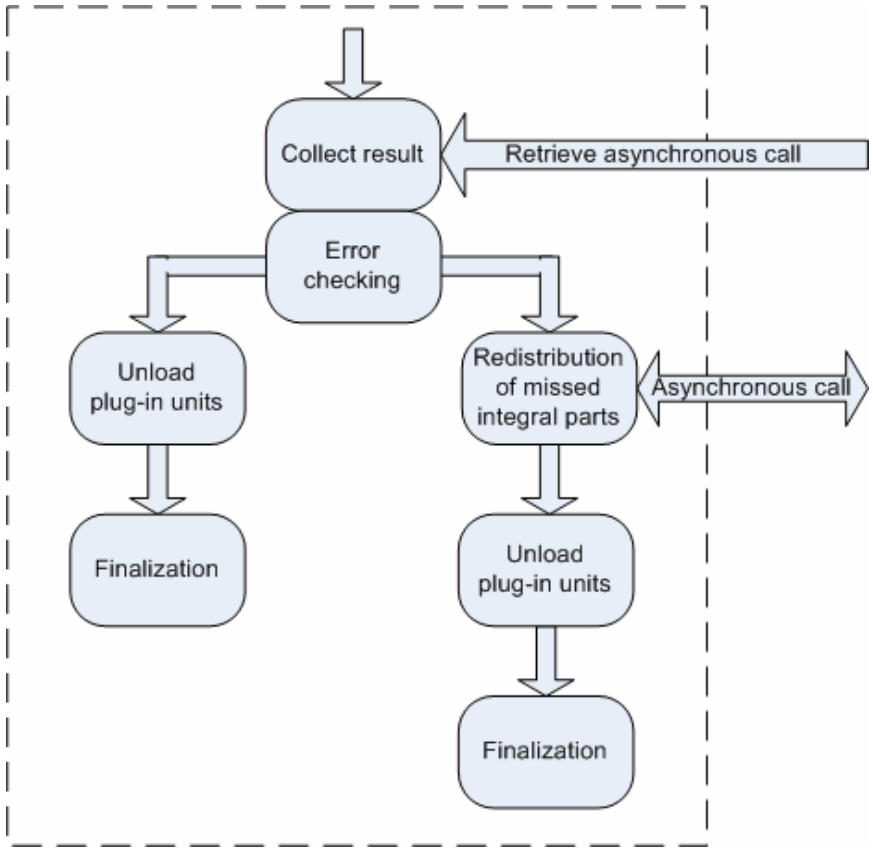
Design of the Prototype Suite Components



System Design – Parallel Plug-in for Integral Computation

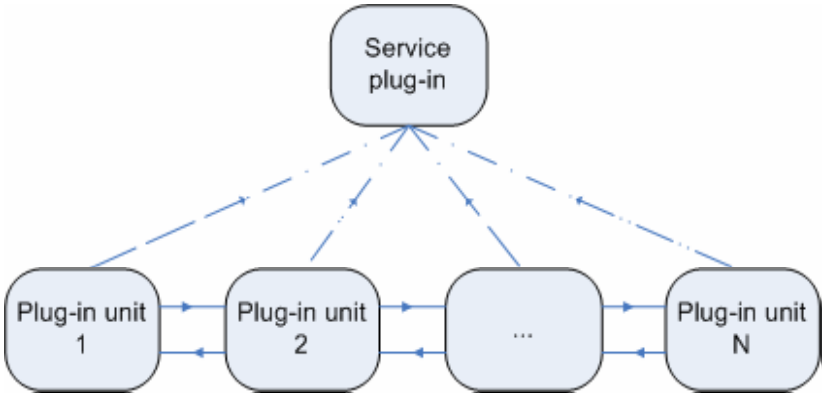


Integration Application

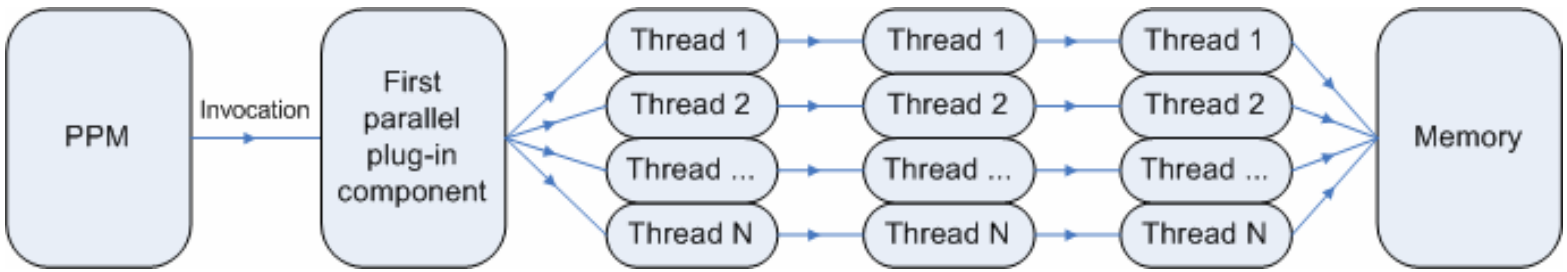


Fault-tolerant Design

System Design – Parallel Plug-in for Image Processing



Multiple
Image Processing Pipeline
with Acknowledgment
and Error-Handling



Fault-Tolerant Design

- Continue the operation of a system after a failure occurred
- Partial success: not all parallel plug-in components were loaded
- PPM handles partial success depending on the loaded parallel plug-in
- Redistribution of missed integral intervals
- Restoration of a broken image processing pipeline

Conclusions

- Plug-in technology was successfully joined with Harness
- Various facets of parallel plug-in technology were presented
- Three major problems or features of parallel plug-ins were investigated and realized
  - (Un)loading of parallel plug-ins
  - Inter plug-in communication
  - Fault-tolerant design
- Scalability and reliability through fault-tolerant design, including partial success
- The final version of the paper draft is sent to the HPCC 2006 in Munich