The Virtual Grid Application Development Software (VGrADS) Project

Overview

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http://vgrads.rice.edu/



The VGrADS Team

• VGrADS is an NSF-funded Information Technology Research project



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• Plus many graduate students, postdocs, and technical staff!



Vision: Global Distributed Problem Solving

- Where We Want To Be
 - Transparent Grid computing
 - Submit job
 - Find & schedule resources
 - Execute efficiently
- Where We Are
 - Low-level hand programming
 - Programmer must manage:
 - Heterogeneous resources
 - Scheduling of computation and data movement
 - Fault tolerance and performance adaptation
- What Do We Propose as A Solution?
 - Separate application development from resource management
 - Through an abstraction called the Virtual Grid
 - Provide tools to bridge the gap between conventional and Grid computation
 - Scheduling, resource management, distributed launch, simple programming models, fault tolerance, grid economies





VGrADS Big Ideas

- Virtualization of Resources
 - Application specifies required resources in Virtual Grid Definition language (vgDL)
 - Give me a loose bag of 1000 processors, with 1 Gb memory per processor, with the fastest possible processors
 - Give me a tight bag of as many Opterons as possible
 - Virtual Grid Execution System (vgES) produces specific virtual grid matching specification
 - Avoids need for scheduling against the entire space of global resources
- Generic In-Advance Scheduling of Application Workflows
 - Application includes performance models for all workflow nodes
 - Performance models automatically constructed
 - Software schedules applications onto virtual Grid, minimizing total makespan
 - Including both computation and data movement times



Virtual Grids (VGs)

- A Virtual Grid (VG) takes
 - Shared heterogeneous resources
 - Scalable information service
- and provides
 - An hierarchy of applicationdefined aggregations (e.g. ClusterOf) with constraints (e.g. processor type) and rankings
- Virtual Grid Execution System (vgES) implements VG
 - VG Definition Language (vgDL)
 - VG Find And Bind (vgFAB)
 - VG Monitor (vgMON)
 - VG Application Launch (VgLAUNCH+DVCW)
 - VG Resource Info (vgAgent)



VGrADS Tool Research

- Scheduling of workflow computations
 - Off-line look-ahead scheduling dramatically improves in total time
 - Accurate performance models significantly affect quality of scheduling
 - Batch queue behavior can be predicted accurately enough for scheduling decisions
- Fault tolerance
 - Diskless checkpointing for linear algebra computations (application-specific)
 - Temporal reasoning for fault prediction
 - Optimal checkpoint frequency for iterative applications

Online vs. Offline - Heterogeneous Platform (Compute Intensive Case)



VGrADS Virtual Grid Application Development Software Project

VGrADS: What's New

- SC'04
 - Scheduling EMAN application
 - Aware of performance models
- SC'05
 - Find and Bind (FAB) for resource selection
 - Scheduling EMAN application
 - Aware of batch queue predictions (and performance models)

• SC'06

- Virtual Grid "slots" for resource availability
 - Start time + duration
 - Uses advance reservations where available
 - Uses batch queue prediction elsewhere
- Scheduling LEAD application
 - Aware of reservations and batch queue predictions (and performance models)



The LEAD Vision: A Paradigm Shift



The CS challenge: Build cyberinfrastructure services that provide adaptability, scalability, availability, useability, and real-time response.

End Users NWS Private Companies



LEAD Portal – Experiment Builder

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VGrADS Application Collaboration





Some Future Challenges

- Parallelism in the LEAD workflow manager
 - Parallel steps in different slots or within one slot
- Accurate Slot Requests Through Preliminary Scheduling
 - Minimization of wasted slot time
 - Accurate scheduling, better queue prediction
 - Dynamic adaptation of slot reservations
 - Requires some form of resource equivalence:
 - For step B, I need the equivalent of 200 Opterons, where 1 Opteron = 3 Itanium = 1.3 Power 5 (from perf models)
- Increased Schedule Robustness
 - Minimizing variation along the critical path
- Scheduling to Minimize Cost
 - In the presence of cycle exchange rates
 - Get the minimum-cost resources to solve the problem by the given deadline



VGrADS at SC'06

- Booth Talks and Demos
 - Tuesday, noon GCAS booth (1825)
 - Tuesday, 2:30 USC booth (2246) [Not live]
 - Wednesday, 1:00 SDSC booth (1915)
 - Thursday, 10:30 RENCI booth (1143)
 - What you'll see
 - LEAD running on several clusters
 - Scheduler mapping LEAD components to slots
 - vgES managing slots via batch queue prediction
- Papers
 - "Improving Grid Resource Allocation via Integrated Selection and Binding" by Kee, et al. - Wednesday, 10:30
 - "Toward a Doctrine of Containtment: Grid Hosting with Adaptive Resource Control" by Ramakrishnan, et al. - Wednesday, 11:00
 - "Evaluation of a Workflow Scheduler Using Integrated Performance Modeling and Batch Queue Wait Time Prediction" by Nurmi, et al. - Thursday, 2:00



Launching from the LEAD Portal

• Work in Progress



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Scheduling with Batch Queues

- Last Year: VGrADS supported scheduling using estimated batch queue waiting times
 - Batch queue estimates are factored into communication time
 - E.g., the delay in moving from one resource to another is data movement time + estimated batch queue waiting time
 - Unfortunately, estimates can have large standard deviations
- This Year: limiting variability through two strategies:
 - Resource reservations: partially supported on the TeraGrid and other schedulers
 - In advance queue insertion: submit jobs before data arrives based on estimates
 - Can be used to simulate advance reservations
- Exploiting this requires a preliminary schedule indicating when the resources are needed
 - Problem: how to build an accurate schedule when exact resource types are unknown



Preliminary Scheduling Solution

- Use performance models to specify alternative resources
 - For step B, I need the equivalent of 200 Opterons, where 1 Opteron = 3 Itanium = 1.3 Power 5
 - Equivalence from performance model
- This permits an accurate preliminary schedule because the performance model standardizes the time for each step
 - Scheduling can then proceed with accurate estimates of when each resource collection will be needed
 - Makes advance reservations more accurate
 - Data will arrive neither too early or too late
- It may provide a mixture to meet the computational requirements, if the specification permits
 - Give me a loose bag of tight bags containing the equivalent of 200 Opterons, minimize the number of tight bags and the overall cost
 - Solution might be 150 Opterons in one cluster and 150 Itaniums in another

