The Virtual Grid Application Development Software (VGrADS) Project

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http://vgrads.rice.edu/
The VGrADS Team

- VGrADS is an NSF-funded Information Technology Research project

- Plus many graduate students, postdocs, and technical staff!
Vision: Global Distributed Problem Solving

• **Where We Want To Be**
  - Transparent computing
    - In an increasingly distributed space
    - Applications to cloud computing
    - Applications to HPC

• **Where We Are**
  - Low-level hand programming
  - Programmer must manage:
    - Heterogeneous resources
    - Scheduling of computation and data movement
    - Fault tolerance and performance adaptation

• **How Do We Get from Here to There?**
  - Separate application development from resource management
    - Through an abstraction called the Virtual Grid
  - Provide tools to bridge the gap
    - Scheduling, resource management, distributed launch, simple programming models, fault tolerance, grid economies
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VGrADS Big Ideas

• **Virtualization of Resources**
  - Application specifies required resources in Virtual Grid Definition language (vgDL)
    - *Give me a tight bag of as many Opterons as possible*
  - Virtual Grid Execution System (vgES) produces specific virtual grid matching specification
    - *May involve adding layer of capabilities*
    - vgES also reports properties of the virtual grid to application

• **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
  - A hierarchy of application-defined aggregations with constraints and rankings
  - E.g. Cluster of Opteron nodes
- Virtual Grid Execution System (vgES) implements VG
  - Brings order out of chaos
- Can be implemented on multiple platforms
  - Grids
  - Compute clouds
  - HPC
  - Manycore chips
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Successfully Bound Candidates

Resource Universe

Virtual Grid
VGrADS Tool Research

• Scheduling of workflow computations
  o Off-line look-ahead scheduling dramatically improves total time
  o Accurate performance models significantly affect quality of scheduling
  o Batch queue behavior can be predicted accurately enough for scheduling decisions

• Fault tolerance
  o Diskless checkpointing for linear algebra computations (application-specific)
  o Qualitative performance analysis for fault detection
  o Optimal checkpoint frequency for iterative applications
  o Availability prediction

![Graph showing time in minutes for different scheduling methods](image)
VGrADS: Application-driven Research

- **SC04**
  - Executing the EMAN application
    - Incorporated performance models

- **SC05**
  - Executing the EMAN application
    - Used batch queue predictions (and performance models)

- **SC06**
  - Executing the LEAD application
    - Scheduled to vgES virtualized resource reservation slots (leveraging queue predictions and performance models)

- **SC07:** *Fault tolerance through virtual grid abstractions*
  - Executing the LEAD application
    - Incorporates reliability information (and above features)
    - Combine replication and migration of workflow nodes
Overview of SC07 Demo

• Demonstrate fault-tolerance *on top of vgES*
  - Scheduler
  - Fault Tolerance & Recovery (FTR)
  - Workflow Planner (WP)

• Fault tolerance mechanisms
  - Scheduler, FTR, WP communicate during planning to decide *over-provisioning*
  - Scheduler, FTR, EM, vgES communicate during execution for *rescheduling*
  - FTR uses availability prediction service for reliability estimates

• vgES
  - Management of multiple copies
  - Passive and application agnostic

• LEAD - the driving application
The LEAD Vision: A Paradigm Shift

Dynamic Observations

Analysis/Assimilation
- Quality Control
- Retrieval of Unobserved Quantities
- Creation of Gridded Fields

Prediction/Detection
- PCs to Teraflop Systems

Product Generation, Display, Dissemination

Models and Algorithms Driving Sensors

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

End Users

NWS

Private Companies

Students

Virtual Grid Application Development Software Project
VGrADS at SC07

• Booth Talks and Demos
  o When and where
    - Tuesday, 4:00-5:00pm, GCAS booth (789)
    - Wednesday, 10:30-11:30am, RENCI booth (3215)
    - Wednesday, 3:00-4:00pm, SDSC booth (561)

• Other talks and posters
  o Poster: “Performability Modeling for Scheduling and Fault Tolerance Strategies for Grid Workflows” by Lavanya Ramakrishnan & Dan Reed
    - All Week (Reception, Tuesday 5:15-7:00pm), Ballroom Lobby
    - Tuesday, 1:30-2:00pm, room A1/A6
  o Doctoral Showcase Presentation: “Qualitative Performance Analysis for Large-Scale Scientific Workflows” by Emma Buneci
    - Wednesday, 3:45-4:00pm, room A10/A11
  o Presentation: “A Framework for Qualitative Performance Analysis of Large-Scale Scientific Applications” by Emma Buneci and Dan Reed
    - Wednesday, 10:00-10:30, SC07 Education Booth (L1)