The Virtual Grid Application Development Software (VGrADS) Project

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http://www.hipersoft.rice.edu/vgrads/

VGrADS
Virtual Grid Application Development Software Project

The VGrADS Team

- **VGrADS is an NSF-funded Information Technology Research project**

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- **Plus many graduate students, postdocs, and technical staff!**

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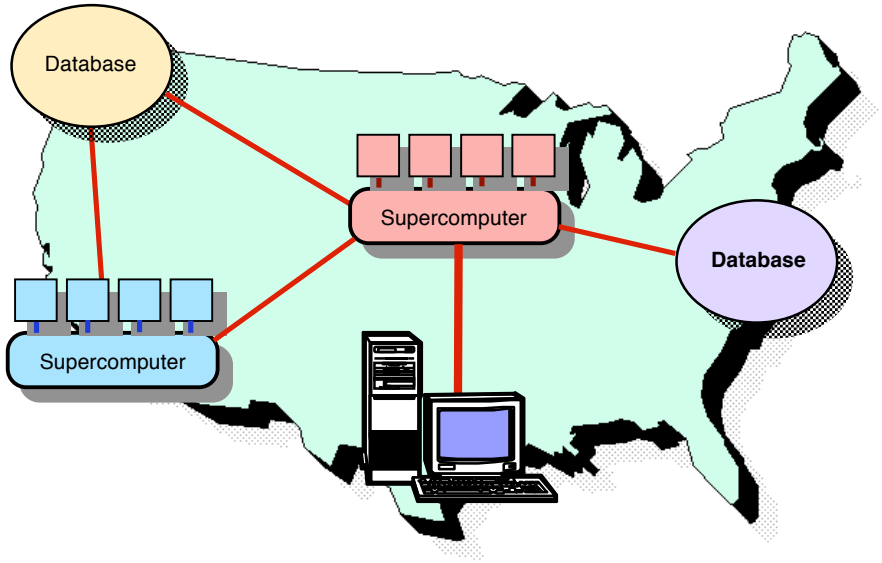
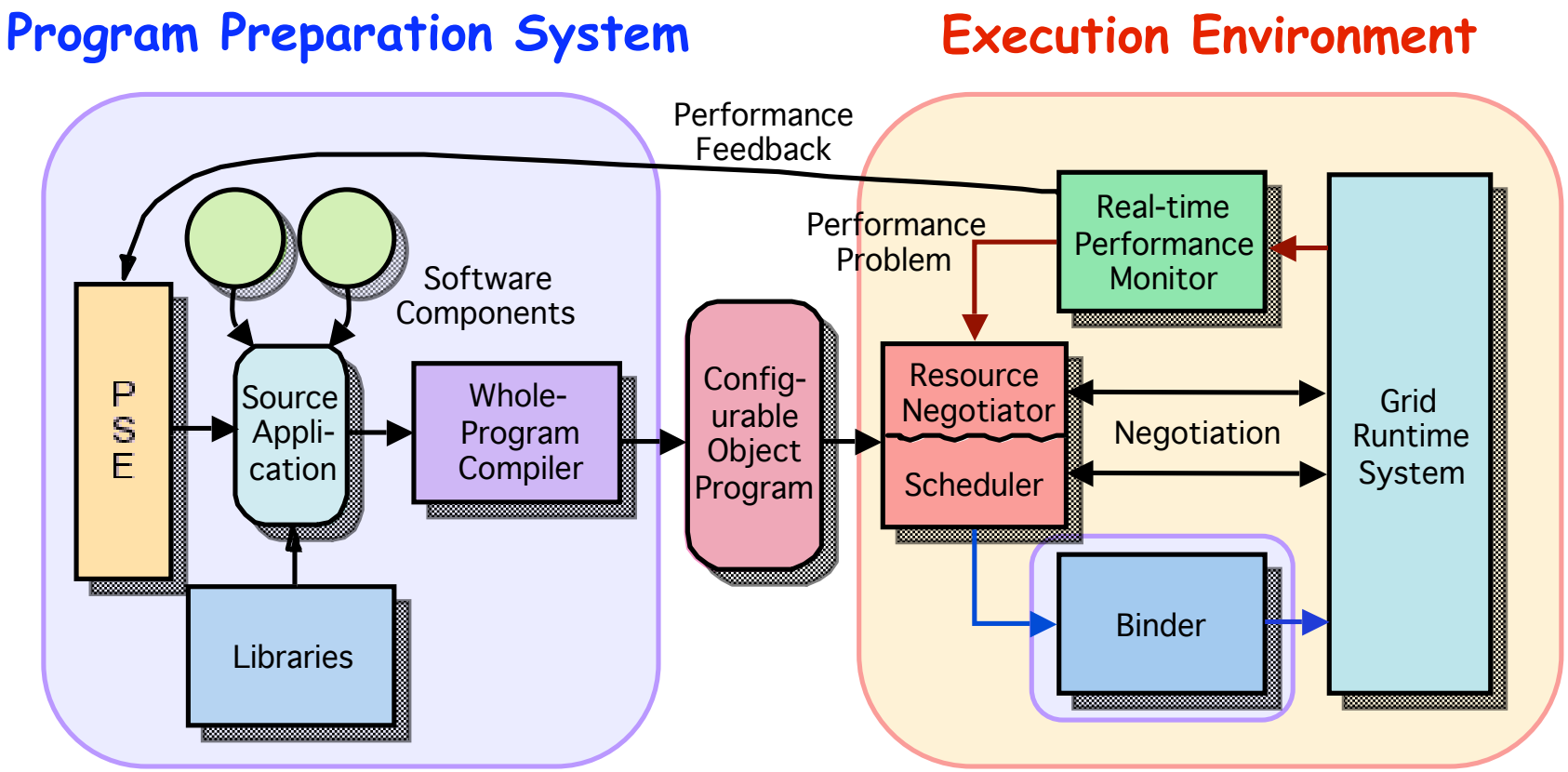
The VGrADS Vision: National Distributed Problem Solving

- **Where We Want To Be**
  - —Transparent Grid computing
    - Submit job
    - Find & schedule resources
    - Execute efficiently
- **Where We Are**
  - —Low-level hand programming
- **What Do We Need?**
  - —A more abstract view of the Grid
    - Each developer sees a specialized "virtual grid"
  - —Simplified programming models built on the abstract view
    - Permit the application developer to focus on the problem



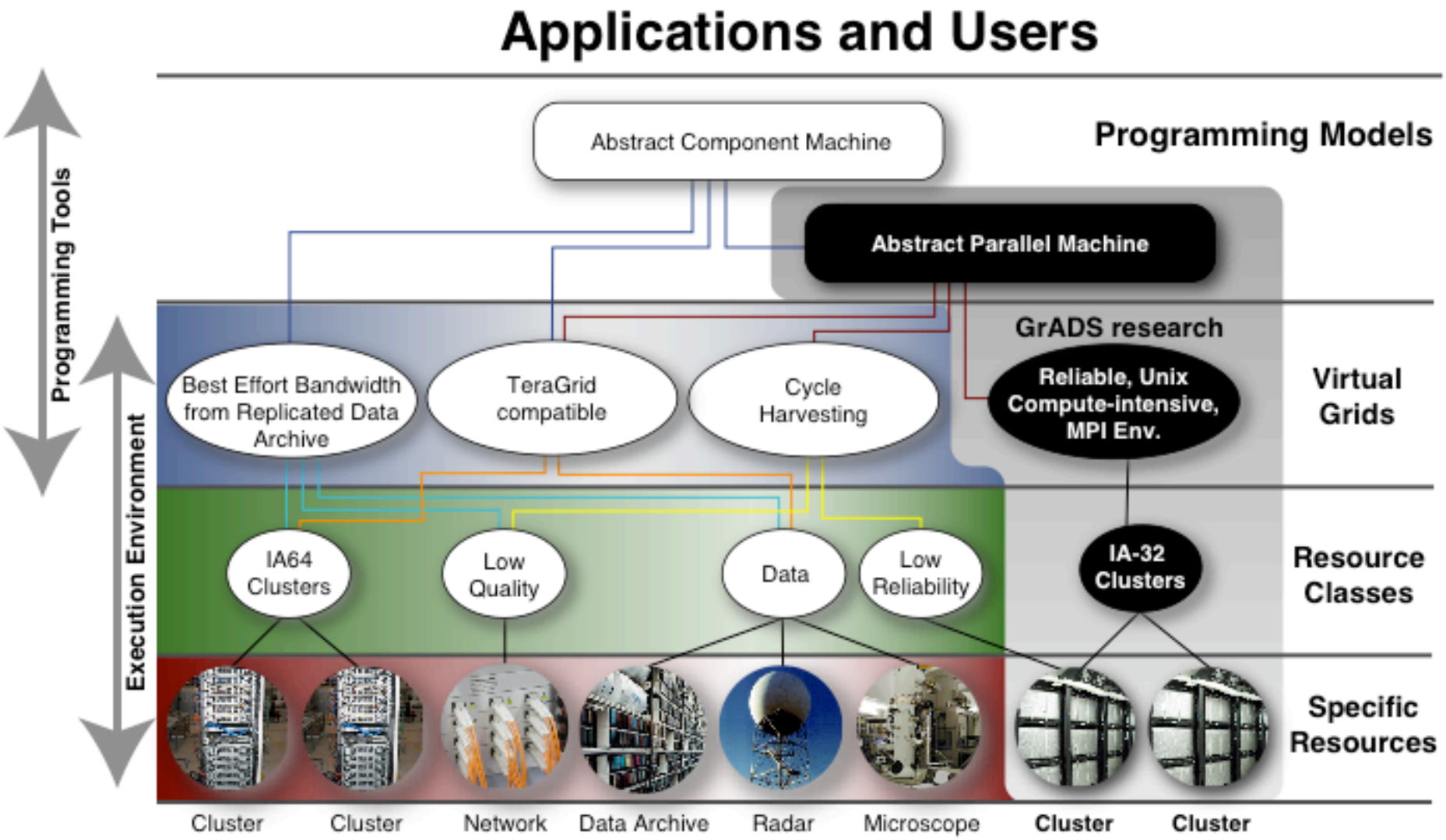
The Original GrADS Vision



Lessons from GrADS

- Mapping and Scheduling for MPI Jobs is Hard
  - Although we were able to do some interesting experiments
- Performance Model Construction is Hard
  - Hybrid static/dynamic schemes are best
  - Difficult for application developers to do by hand
- Heterogeneity is Hard
  - We completely revised the launching mechanisms to support this
  - Good scheduling is critical
- Rescheduling/Migration is Hard
  - Requires application collaboration (generalized checkpointing)
  - Requires performance modeling to determine profitability
- Scaling to Large Grids is Hard
  - Scheduling becomes expensive

VGrADS Virtual Grid Hierarchy



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Virtual Grids and Tools

- **Abstract Resource Request**
  - Permits true scalability by mapping from requirements to set of resources
    - Scalable search produces manageable resource set
  - Virtual Grid services permit effective scheduling
    - Fault tolerance, performance stability
- **Look-Ahead Scheduling**
  - Applications map to directed graphs
    - Vertices are computations, edges are data transfers
  - Scheduling done on entire graph
    - Using automatically-constructed performance models for computations
    - Depends on load prediction (Network Weather Service)
- **Abstract Programming Interfaces**
  - Application graphs constructed from scripts
    - Written in standard scripting languages (Python,Perl,Matlab)

Virtual Grids

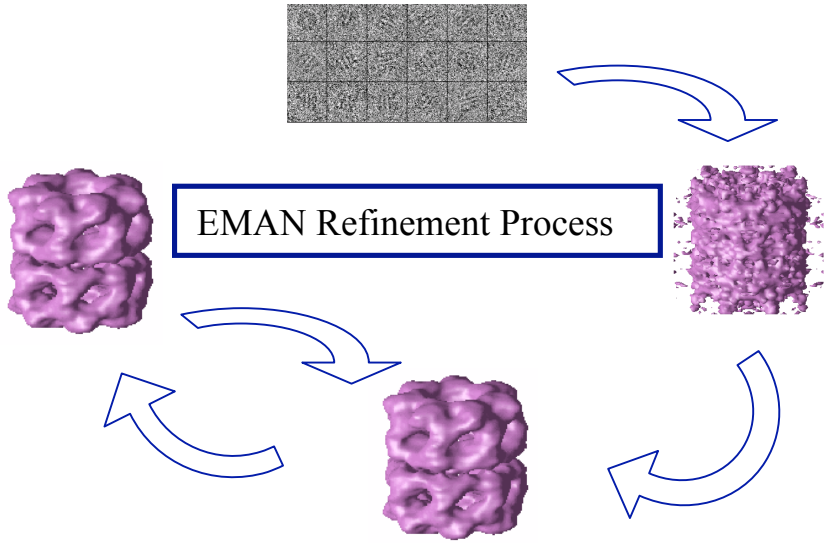
- Goal: Provide abstract view of grid resources for application use
  - Will need to experiment to get the right abstractions
- Assumptions:
  - Underlying scalable information service
  - Shared, widely distributed, heterogeneous resources
  - Scaling and robustness for high load factors on Grid
  - Separation of the application and resource management system
- Basic Approach:
  - Specify vgrid as a hierarchy of …
    - Aggregation operators (ClusterOf, LooseBagOf, etc.) with …
    - Constraints (type of processor, installed software, etc.) and …
    - Application-based rankings (e.g. predicted execution time)
  - Execution system returns (candidate) vgrid, structured as request
  - Application can use as it sees fit, make further requests

Programming Tools

- Collaborating on definition of the Virtual Grids interface
  - Initial experiments based on GrADS infrastructure
- Focus: Automating critical application-development steps
  - Building workflow graphs
    - From Python scripts used by EMAN
  - Scheduling workflow graphs
    - Heuristics required (problems are NP-complete at best)
    - Good initial results *if* accurate predictions of resource performance are available (see EMAN demo)
  - Constructing of performance models
    - Based on loop-level performance models of the application
    - Requires benchmarking with (relatively) *small* data sets, extrapolating to larger cases
  - Initiating application execution
    - Optimize and launch application on heterogeneous resources

VGrADS Demos at SC04

- **EMAN - Electron Microscopy Analysis [Rice, Houston]**
  - 3D reconstruction of particles from electron micrographs
  - Workflow scheduling and performance prediction to optimize mapping
- **GridSAT - Boolean Satisfiability [UCSB]**
  - Classic NP-complete problem useful in circuit design and verification
  - Performance-based dynamic resource allocation and scheduling



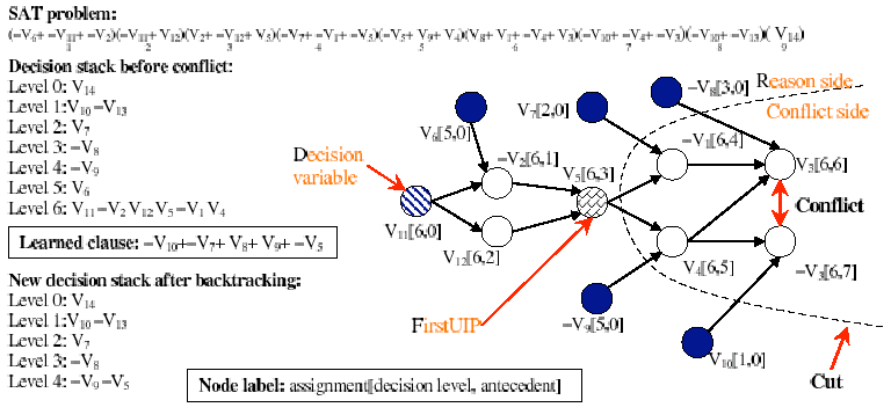


Figure 1: Example of conflict analysis with learning and non-chronological backtracking