The Program Preparation System

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http://hipersoft.rice.edu/stc_site_visit/talks/PPS.pdf

Preparing Programs for the Grid

State of practice today

- Use Python & Perl to write top-level scripts
- Lash together libraries, communications code, …
- Obtain efficiency from hand-tuned libraries
- Involves much trial and error
- Grid programming is only for a specialist
  (or team of specialists)
- Reasonable results, unless something goes wrong at run-time

If programming is hard, the Grid will not reach its potential

— Mainstream scientists & engineers will remain out of the loop

Preparing Programs for the Grid

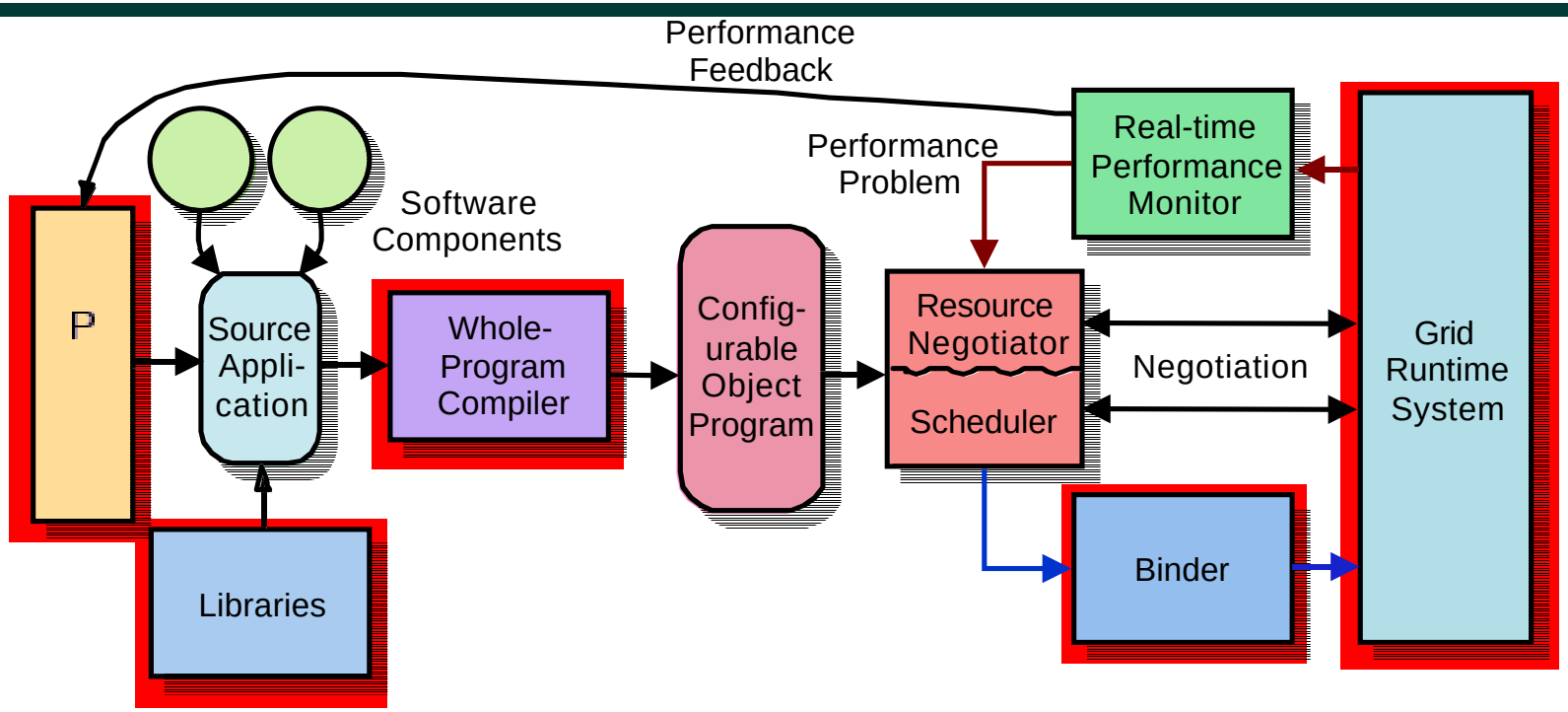
The future

- Domain-specific languages that generate efficient code
- Adaptive, Grid-aware libraries that provide performance
- Automated generation of mapping strategies
- Load-time mapping,binding & optimization
- Run-time monitoring (& remediation) of actual behavior
- Support for checkpoints, replication, and migration

The goal

- Make Grid programming accessible to a broad range of applications and users

The PPS Vision

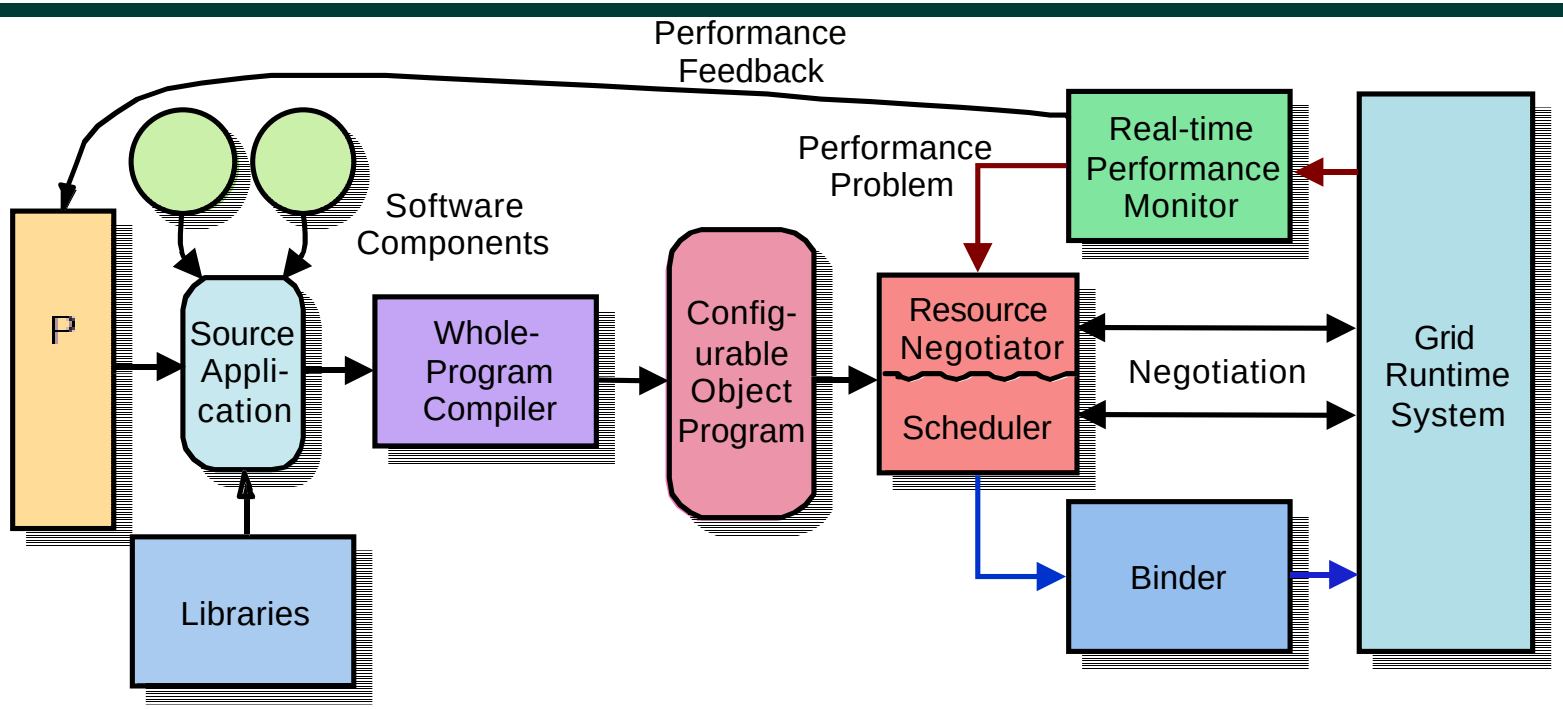


Deliver ease of programming + performance

- Requires cooperation from a broad set of tools
- Requires big team with diverse skills & perspectives

GrADS
Grid Application Development Software Project

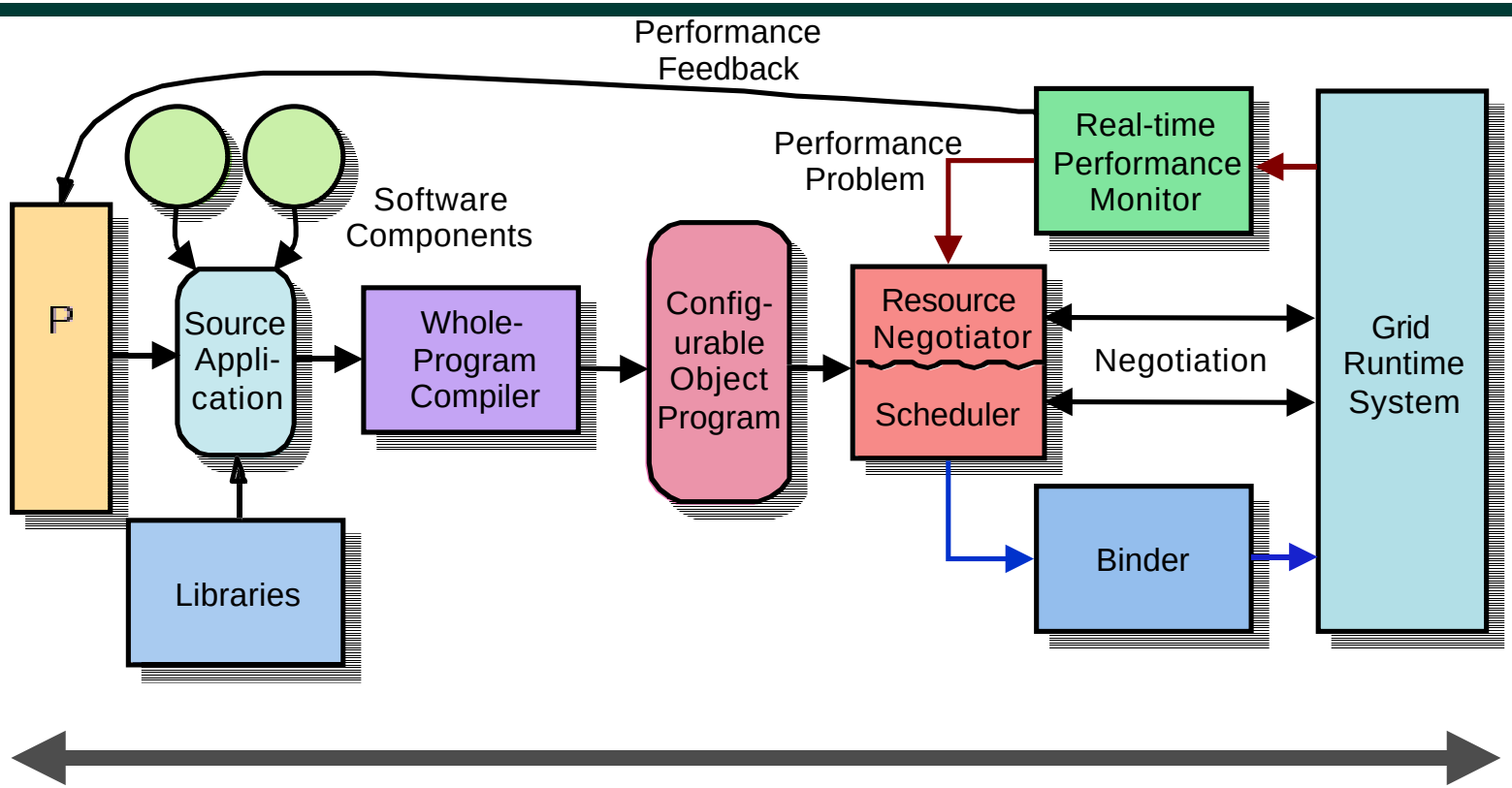
The PPS Vision



Methodology

- Study applications & applications development
- Codify and automate the parts that are common or difficult

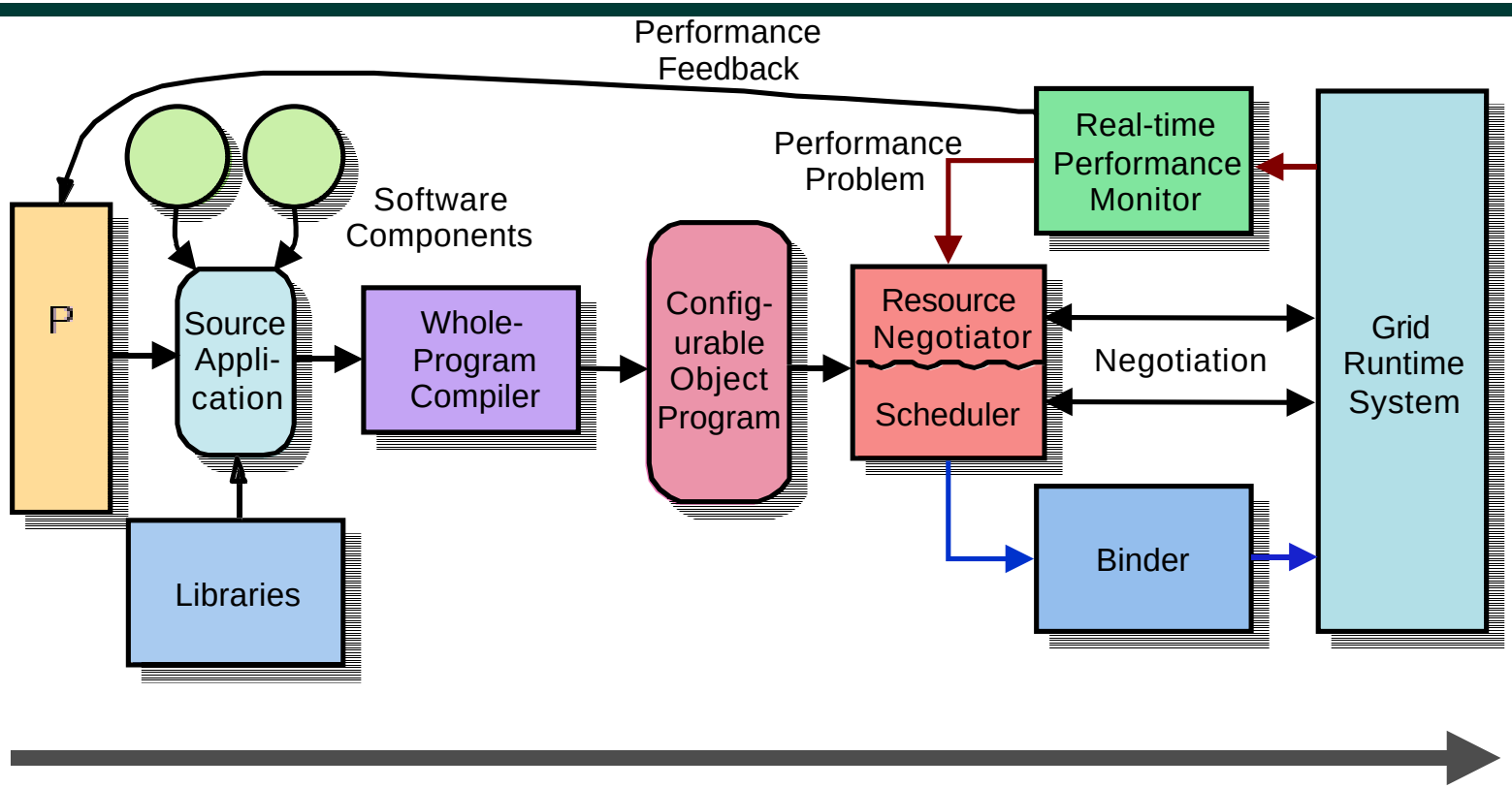
The PPS Vision



Theme

- Use performance models throughout the process & the system

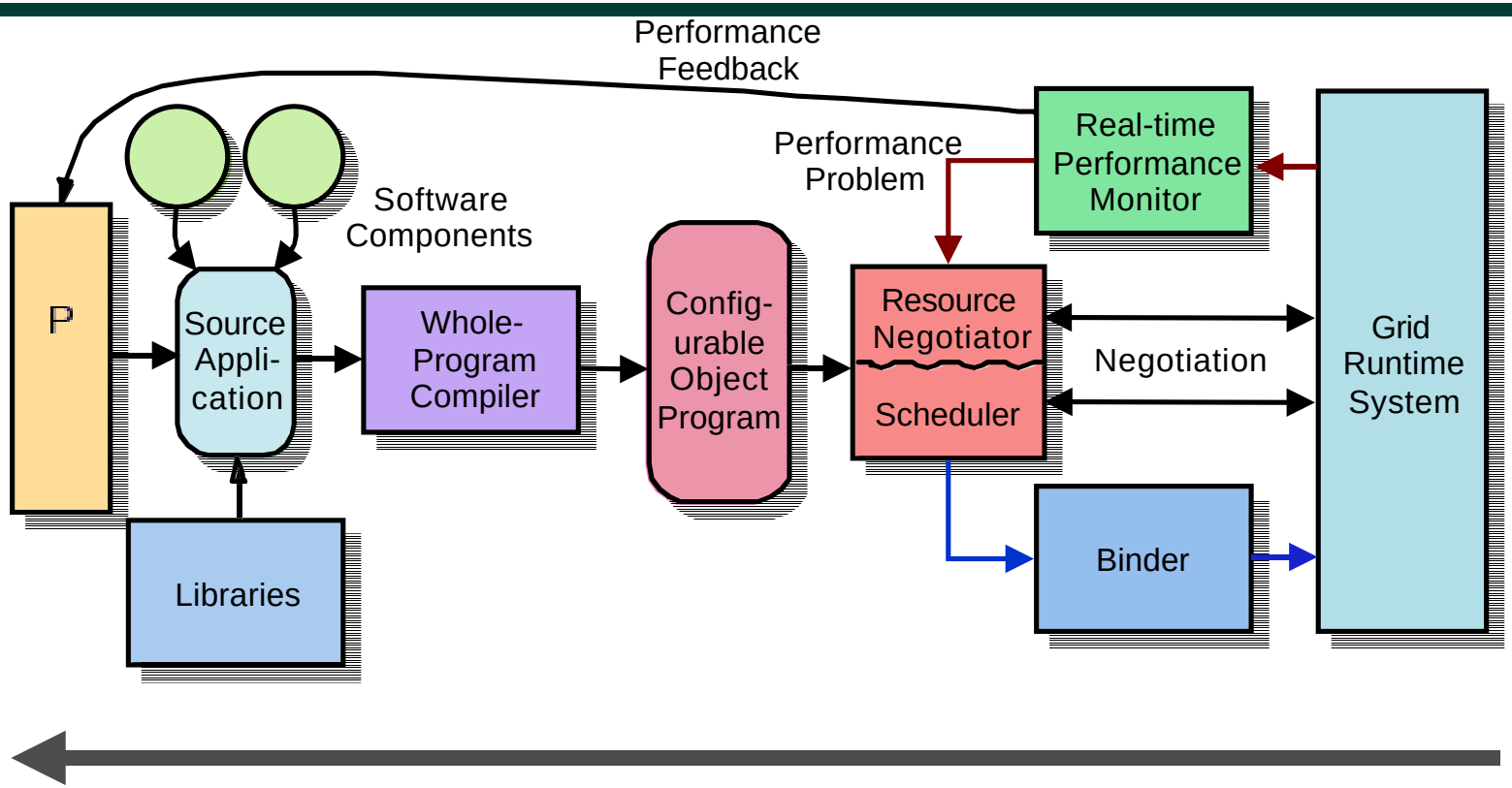
The PPS Vision



Theme

- Move mapping, binding, and code tailoring later in the process

The PPS Vision



Theme

- Move analysis earlier, where we can invest more time in it

Telescoping Languages

A strategy for generating domain-specific languages (DSL)

Vision:

- Collection of libraries + syntax + mapping $\Rightarrow$ efficient DSL
- Use analysis to simplify and automate DSL generation

Principles:

- Axioms & annotations about operators/library entries
  - Let the system reason at a higher level
- Analyze axioms, algebra, & code
  - Generate high-level optimization schemes
  - Synthesize specialized entry points that capitalize on context

See http://hipersoft.rice.edu/grads/publications_reports.htm

Telescoping Languages

Community codes to domain specific languages

Users want both simplicity & performance (favor simplicity)

- Codes developed with scripting languages or Matlab-like tools
- Automatically turn these codes into DSLs
  - —Use extensive analysis to obtain performance

Example: Signal Processing Codes built on Matlab

- Small toolkits built on top of Matlab for exploration
- Must be recoded in C for communications devices
- Exploratory study of Telescoping Language mechanics
  - —Looking at libraries & applications
  - —Developing analyses & transformations (procedure strength reduction)

Dynamic Optimizer/Binder

Original name was misleading

Binder — load-time code tailoring

- Implements mapping for Compiler/Negotiator/Scheduler
  - —Tailor for local resources and machine parameters
- Inserts probes & actuators for monitor and dynamic optimizer
- Final optimization and tailoring for target machine

Dynamic Optimizer — software moderated execution

- Optimize executing program in response to actual behavior
  - —Hot paths, placement, specialization to run-time constants
- Validate performance model and report emergencies
  - —Local fixes for minor problems, report big problems to monitor

Our Plan

Area	Short Term (2 years)	Medium Term (3-5 years)	Long Term (5-10 years)
Domain-specific languages	Langs built on Matlab or Python	Initial telescoping languages	Higher levels of algebraic optimization
Whole Program Compiler	Vendor compiler + perf. models	Gen. variants Gen. COPs T.L. support	Filters to Binder Hints for DO
Builder	x86→x86 Mapping Local opt'n	> 1 target Pick variants Late xlation	Use filters Hints for DO
Dynamic Optimizer (DO)	All work done by Binder	Hot paths Placement Check model	Use hints Remapping New features