Long-Term Information Technology Research

Meeting the PITAC Challenge

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http://www.cs.rice.edu/~ken/Presentations/SIAMPITAC.pdf

PITAC Charter

- The Committee shall provide an independent assessment of:
  - Progress made in implementing the High-Performance Computing and Communications (HPCC) Program;
  - Progress in designing and implementing the Next Generation Internet initiative;
  - The need to revise the HPCC Program;
  - Balance among components of the HPCC Program;
  - Whether the research and development undertaken pursuant to the HPCC Program is helping to maintain United States leadership in advanced computing and communications technologies and their applications;
  - Other issues as specified by the Director of the Office of Science and Technology.
    - Review of the entire IT investment strategy — is it meeting the nation's needs

PITAC Membership 97–99

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  - Ken Kennedy, Rice
- **Members:**
  - Eric Benhamou, 3Com
  - Ching-chih Chen, Simmons
  - Steve Dorfman, Hughes
  - Bob Ewald, SGI
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  - Danny Hillis, Disney, Inc
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  - David Farber, Penn
  - Hector Garcia-Molina, Stanford
  - Jim Gray, Microsoft
  - Robert Kahn, CNRI
  - David Nagel, AT&T
  - Ted Shortliffe, Stanford
  - Joe Thompson, Miss. State
  - Andy Viterbi, Qualcomm
  - Irving Wladawsky-Berger*, IBM

* = current co-chair

Methodology

- Evaluation of Federal Research Investment Portfolio
  - —Plans reviewed for each of the major areas:
    - High End Computing and Computation
    - Large Scale Networking
    - Human Centered Computer Systems
    - High Confidence Systems
    - Education, Training, and Human Resources
- Review of Balance in Federal Research Portfolio
  - —Fundamental versus Applied
    - Based on our own definition of these terms
  - —High-Risk versus Low-Risk
  - —Long-Term versus Short-Term

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  - —Agencies pressed by the growth of IT needs
    - IT R&D budgets have grown steadily but not dramatically
    - IT industry has accounted for over 30 percent of the real GDP growth over the past five years, but gets only 1 out of 75 Federal R&D dollars
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- This Trend Must Be Reversed
  - —Continue the flow of ideas to fuel the information economy and society

Remedy

- Increase the Federal IT R&D Investment by 1.4 billion dollars per year
  - Ramp up over five years
  - Focus on increasing fundamental research
- Invest in Key Areas Needing Attention
  - Software
  - Scalable Information Infrastructure
  - High-End Computing
  - Social, Economic, and Workforce Issues
- Develop a Coherent Management Strategy
  - Establish clear organizational responsibilities
  - Diversify modes of support

Software

- Recommendations
  - Make fundamental software research an absolute priority
  - Invest in key area needing attention
    - Improving programmer productivity
      - Ameliorate the shortage of IT professionals
    - Improving reliability and robustness of software
    - Improving usability through human interface innovations
    - Improving capabilities for information management
  - Make software research a substantive component of every major information technology research initiative.

Scalable Information Infrastructure

- Research Needed:
  - Understanding the behavior of the global-scale network.
  - Physics of the network, including optical and wireless technologies such as satellites, and bandwidth issues.
  - Scalability of the Internet.
  - Information management, Information and services survivability
  - Large-scale applications and the scalable services they require.
    - National digital library, Next-generation world-wide web
  - Fund a balanced set of testbeds that serve the needs of networking research, research in enabling information technologies and advanced applications, and Internet research.

High–End Computing

- Findings:
  - High-end computing is essential for science and engineering research
  - High-end computing is an enabling element of the United States national security program
  - New applications of high-end computing are ripe for exploration
  - Suppliers of high-end systems suffer from difficult market pressures
    - High-end market not large
  - Advances in high-end computing eventually find their way to desktop
- Recommendation
  - Fund high-end computing research (architecture, software, and applications, and testbeds) because it is important to the government and the health, welfare, and security of the population

Social, Economic, Workforce Issues

- Invest in Four Areas:
  - —IT-literate population
  - —IT workforce
    - More workers, more underrepresented groups
  - —Use of IT in education
  - —Understanding economic and policy implications of technology
- An Observation on IT Workforce
  - —Research investment in universities is critical
    - Without it, faculty leave
    - Without it, grad students do not go —> no new faculty
    - Without faculty, we cannot produce more BS graduates

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  - Industry is not good at funding and developing disruptive technologies
  - Federal Government funding creates fuel for the venture capital system

Good News

- Administration Budget
  - Proposed additional $366 million in FY 2000
    - Appropriated: $226 million
  - Proposed $605 million increase for FY 2001
  - Successive years unclear
- Congress
  - Sensenbrenner NITR&D Act from House Science Committee
    - 5 years of funding at PITAC-recommended levels
    - Permanent R&D investment tax credit
    - Passed with near-unanimous support
    - Only partially reflected in the Senate authorization bills
  - Appropriations are year-to-year

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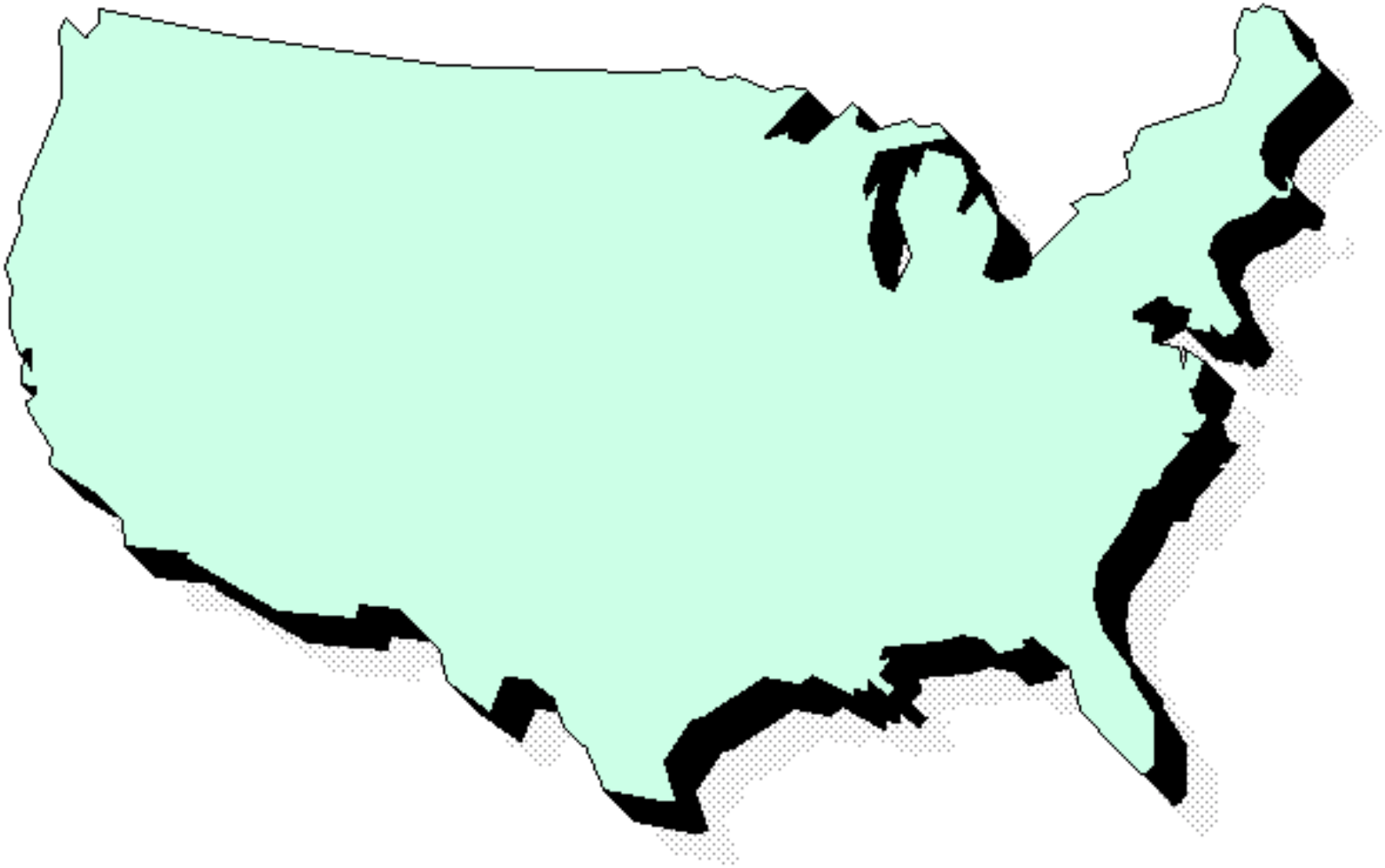
- Software Productivity*
  - Workforce shortage
  - Idea: make it possible for end users to be application developers

National Distributed Computing



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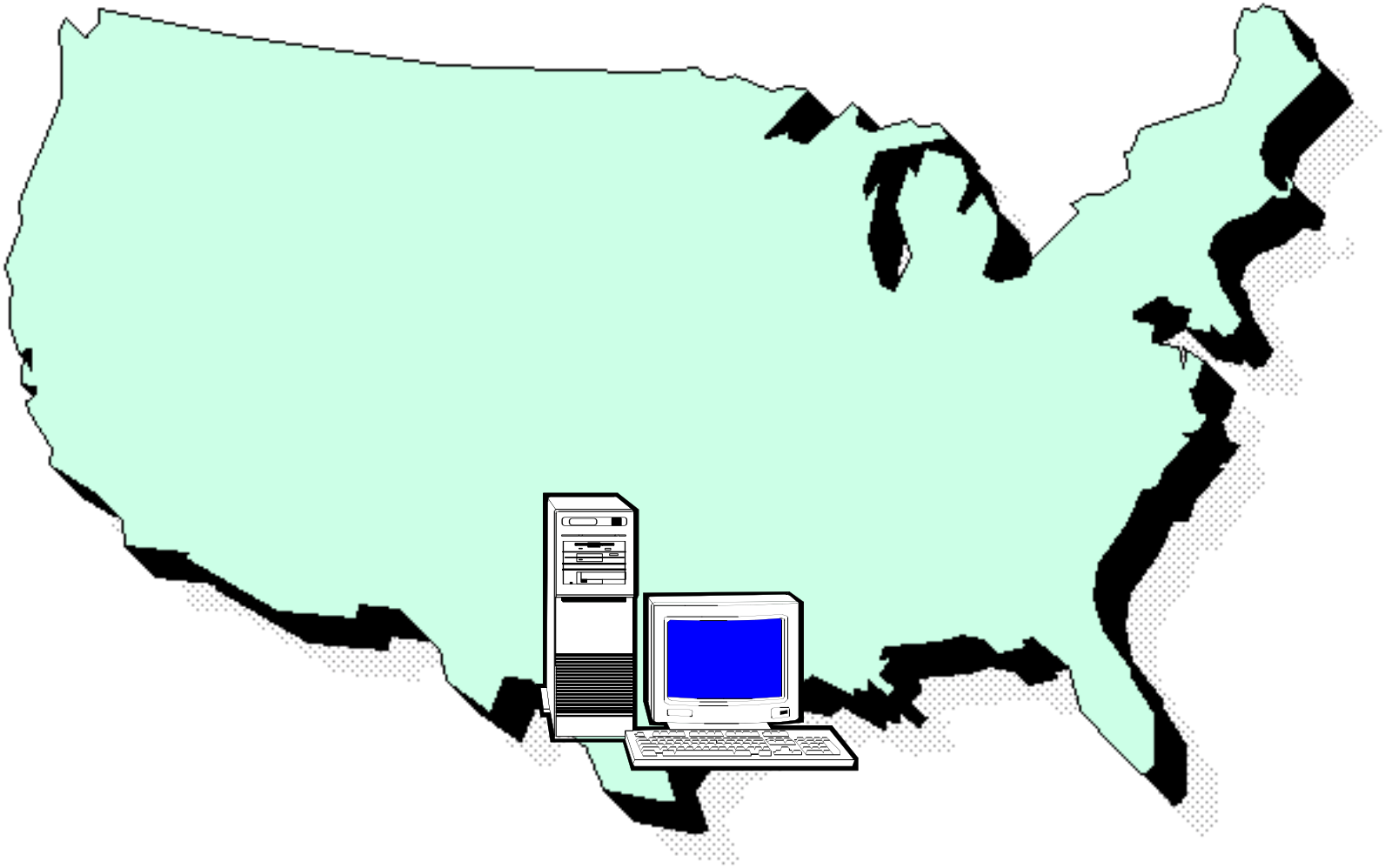

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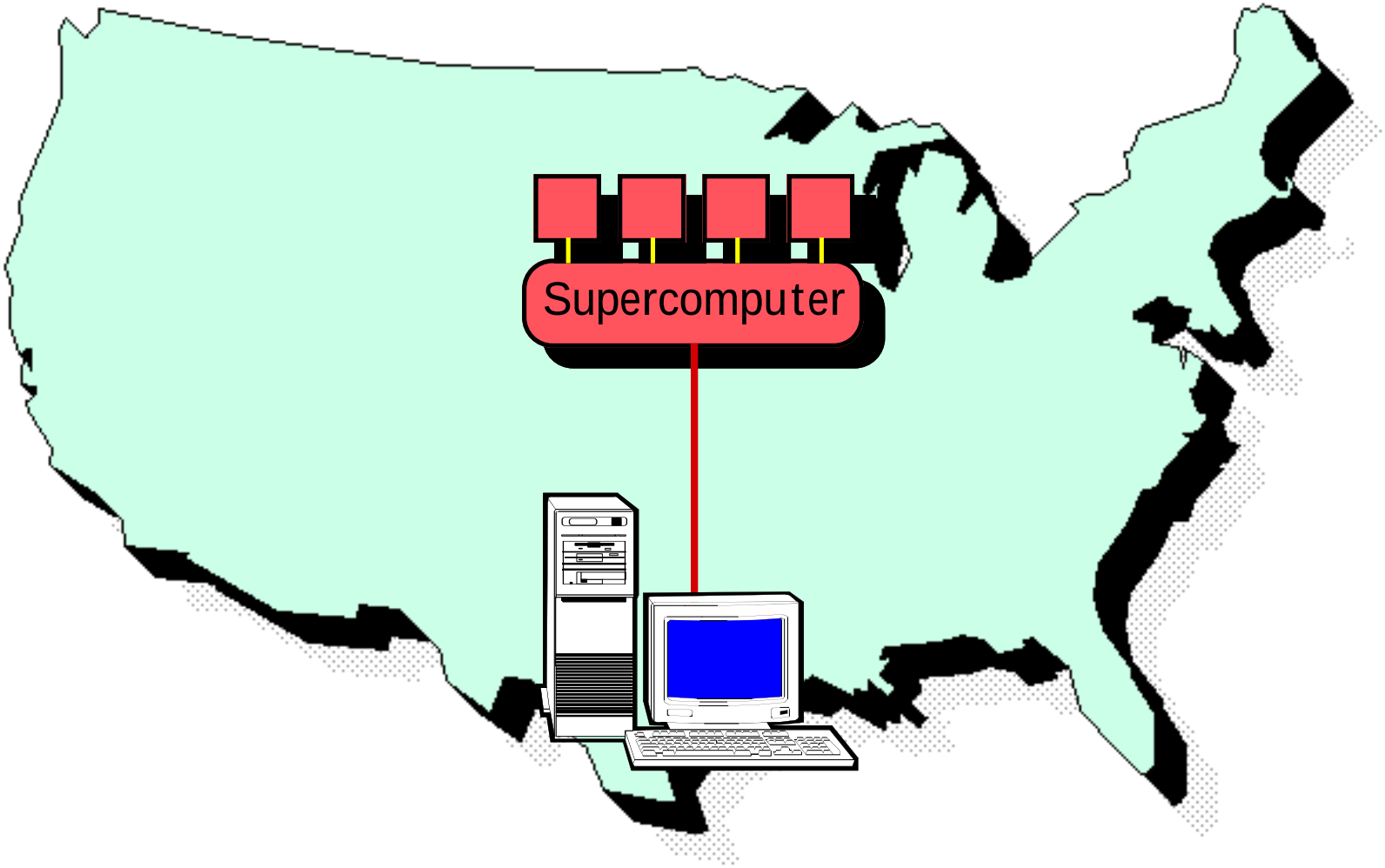

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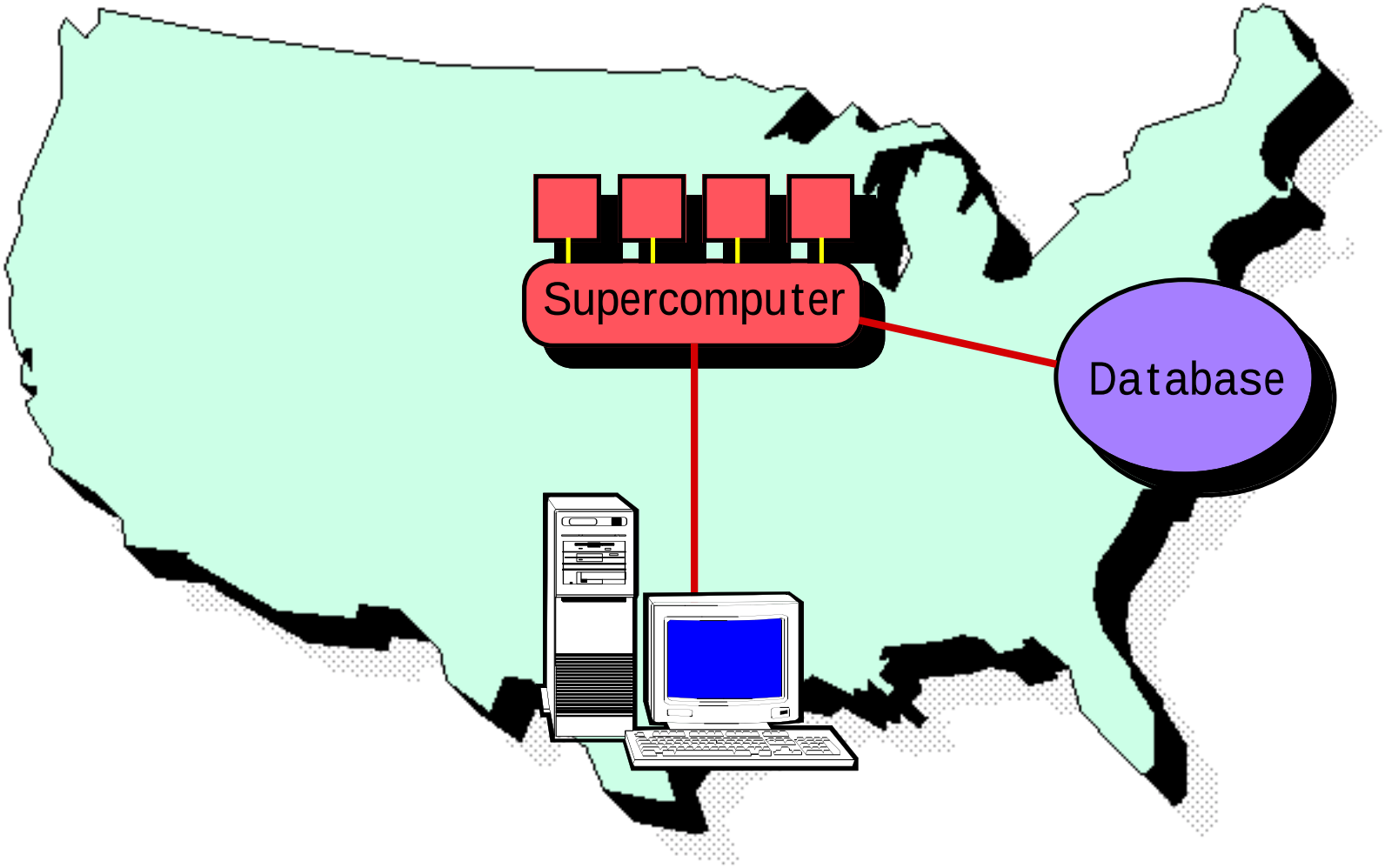

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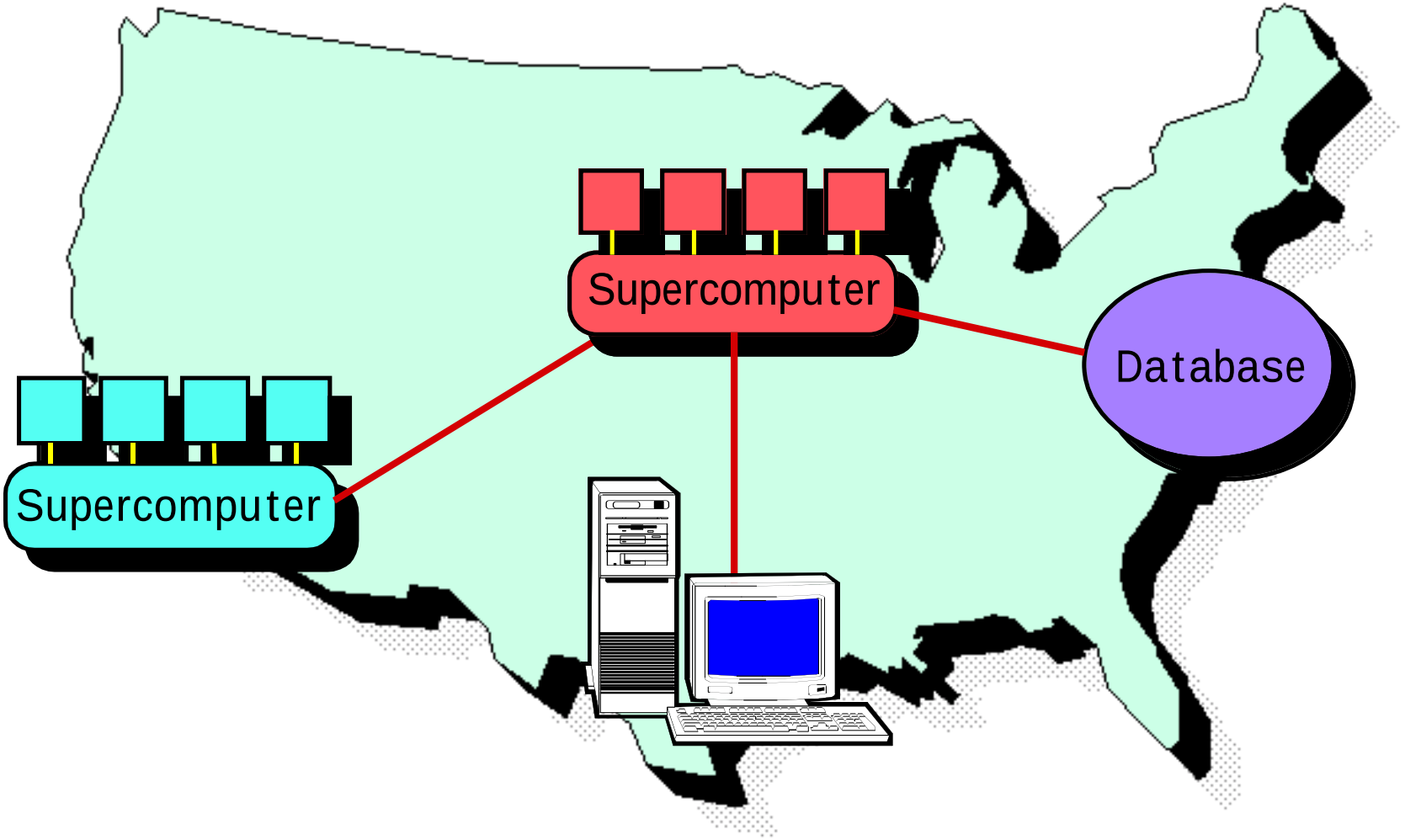

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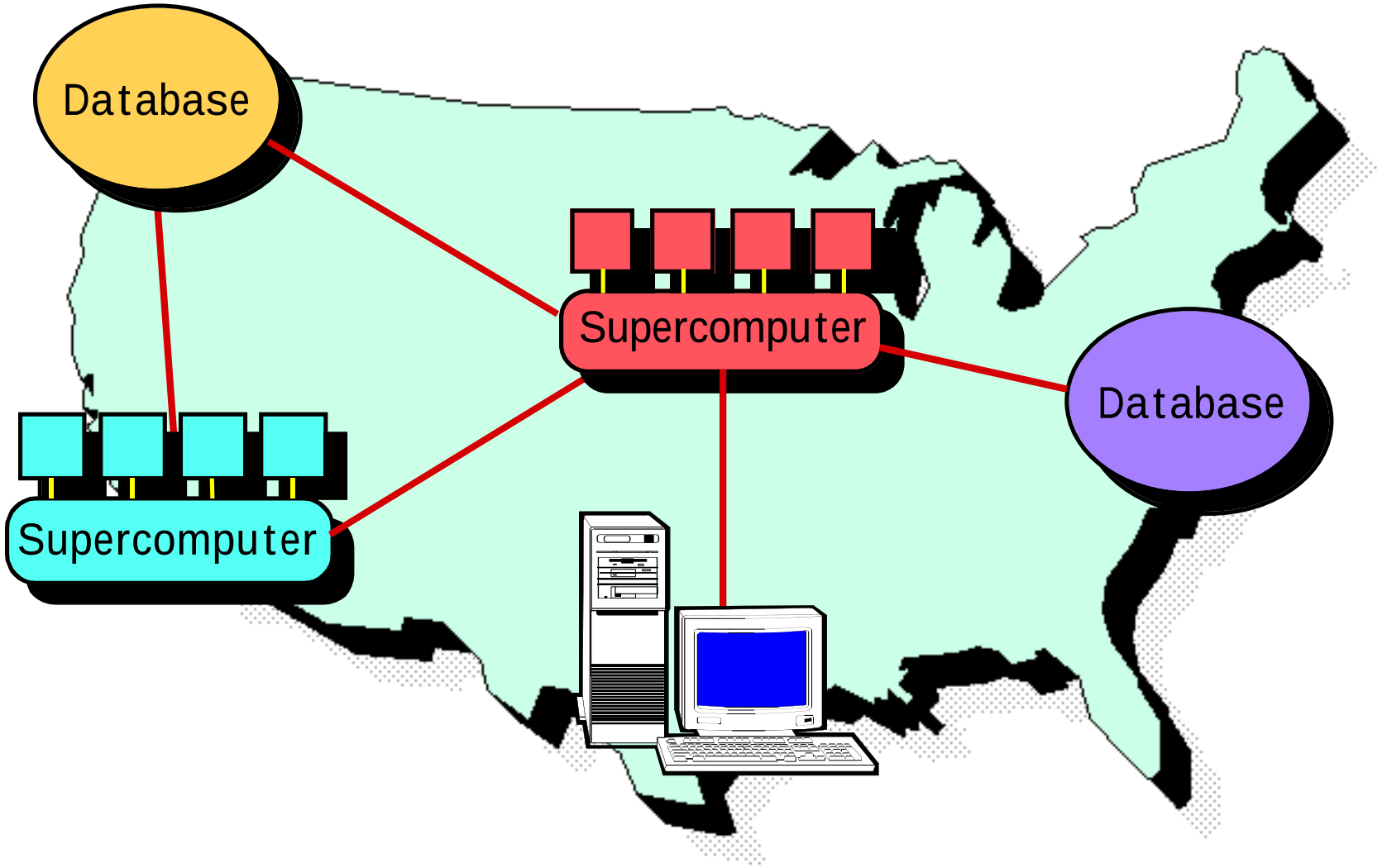
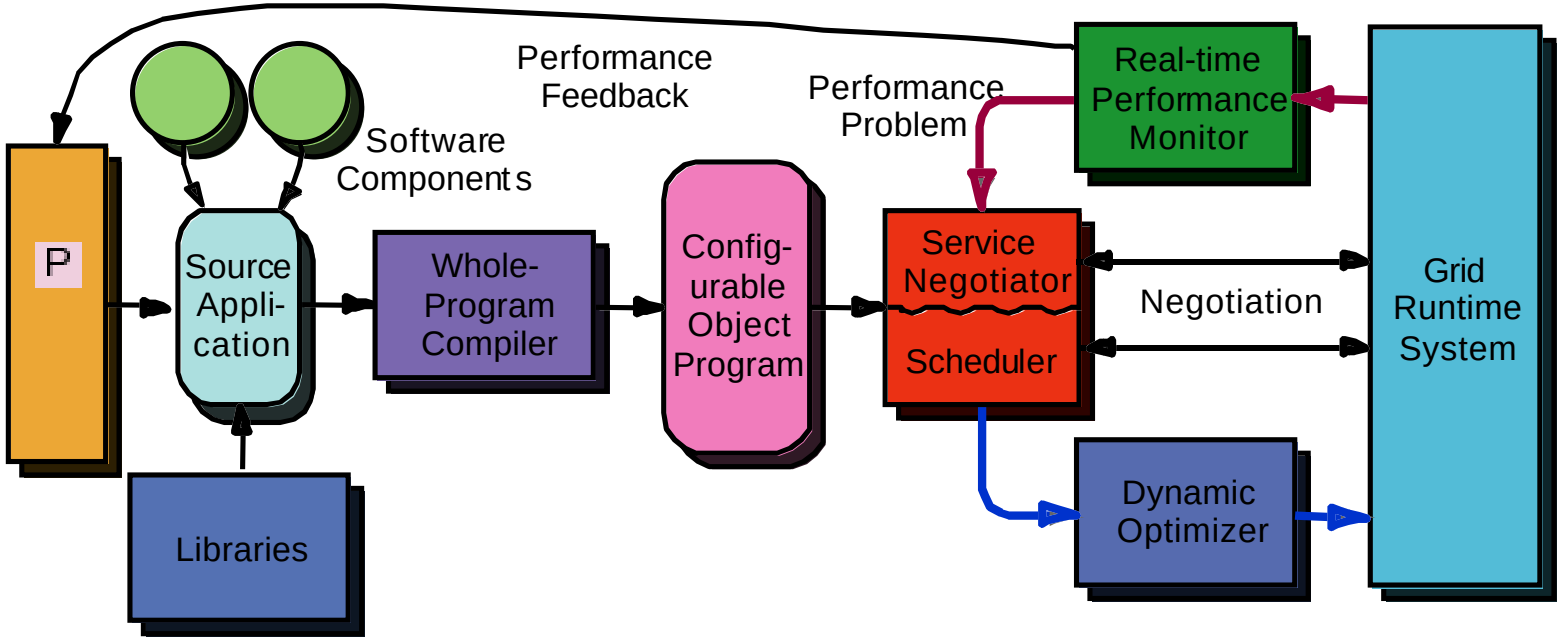


Grid Compilation Architecture

- **Goal:** reliable performance under varying load



GrADS Project (NSF NGS): Berman, Chien, Cooper, Dongarra, Foster, Gannon, Johnsson, Kennedy, Kesselman, Mellor-Crummey, Reed, Torczon, Wolski

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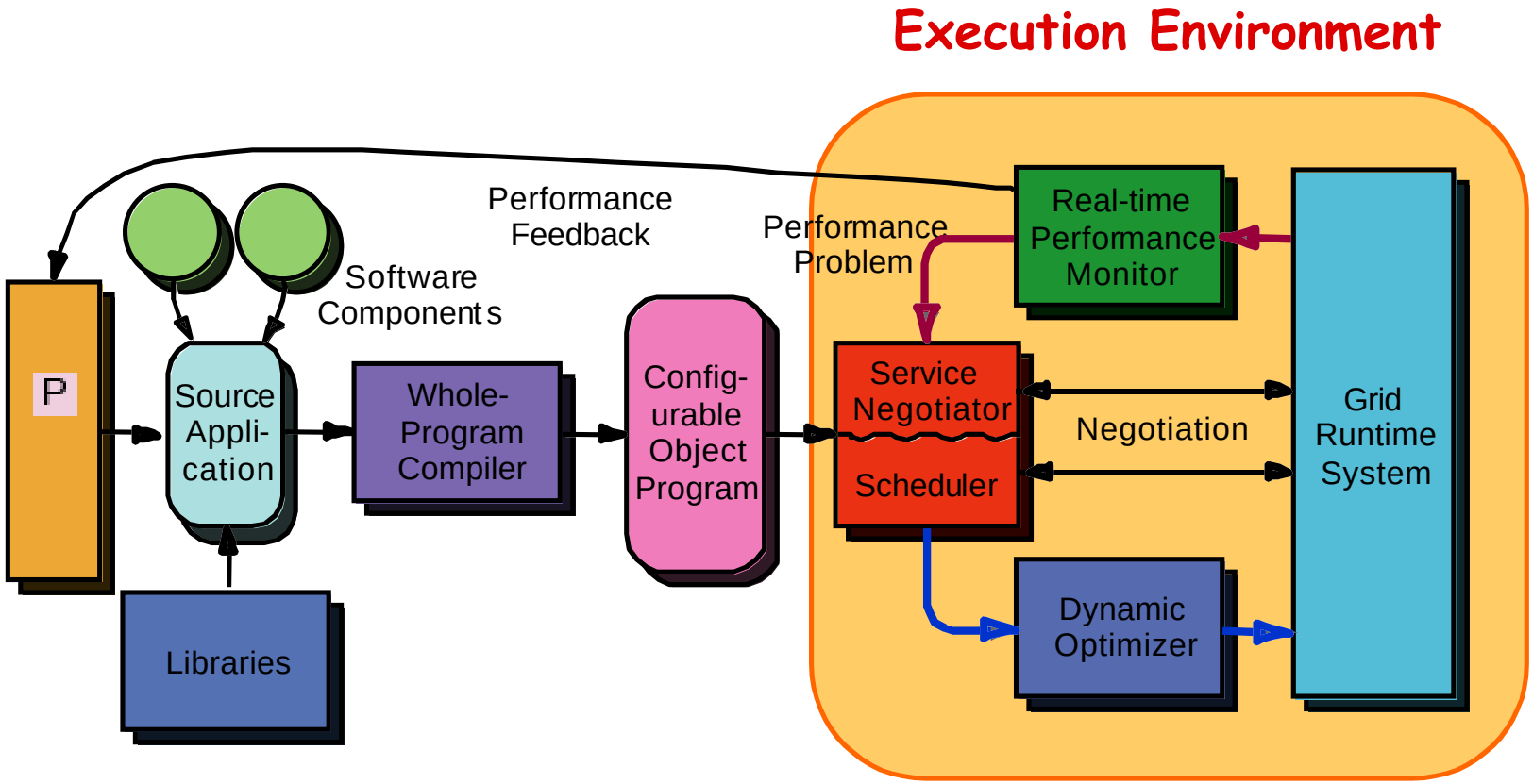

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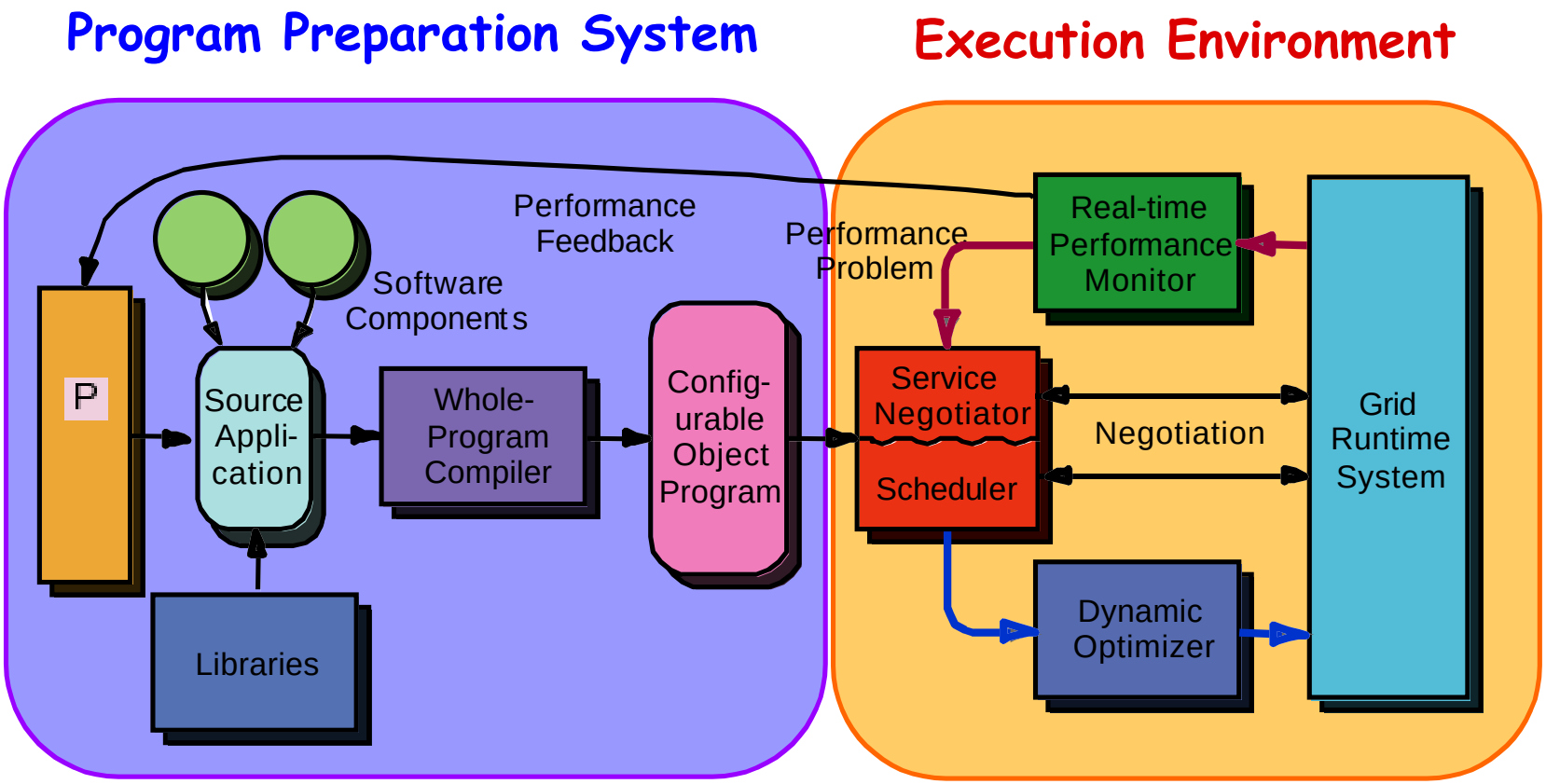

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- One Strategy: Make the End User a Programmer
  - —professional programmers develop components
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    - problem-solving environments (PSEs)
    - scripting languages (possibly graphical)

      examples: Visual Basic, Tcl/Tk, AVS, Khoros

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- Compilation for High Performance
  - —translate scripts and components to common intermediate language
  - —optimize the resulting program using interprocedural methods

Telescoping Languages

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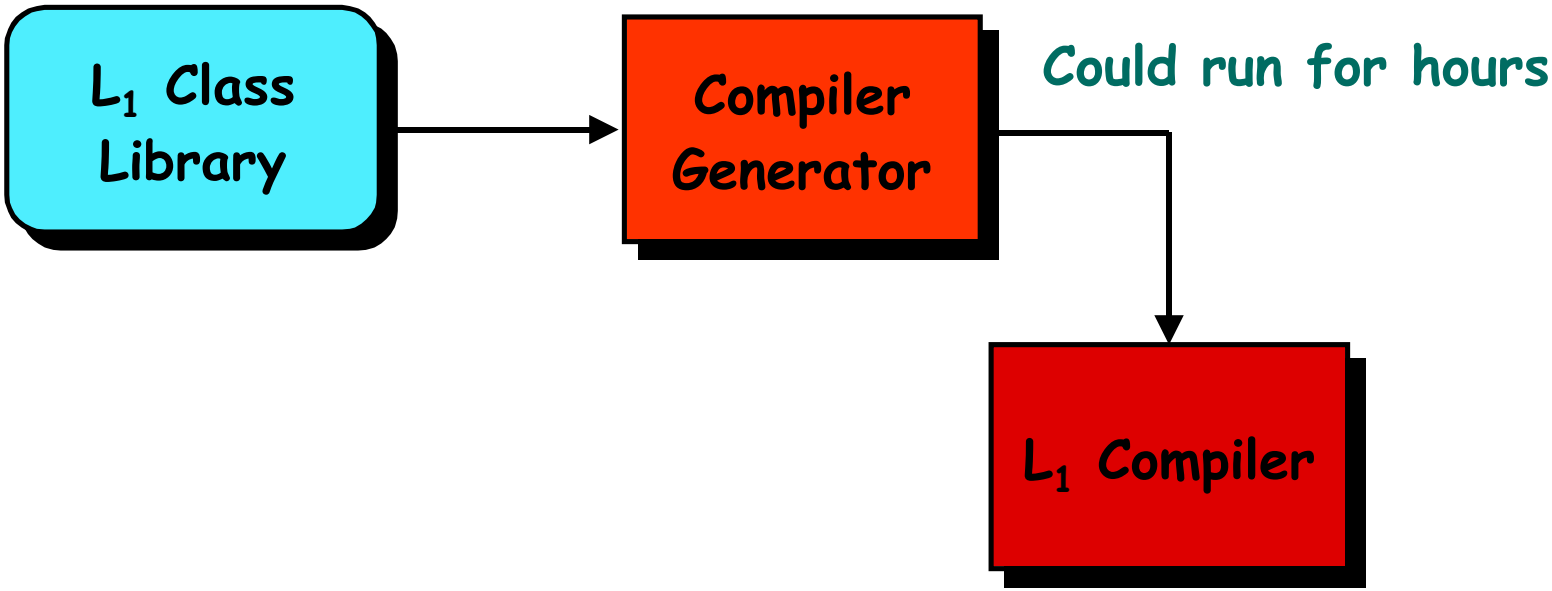

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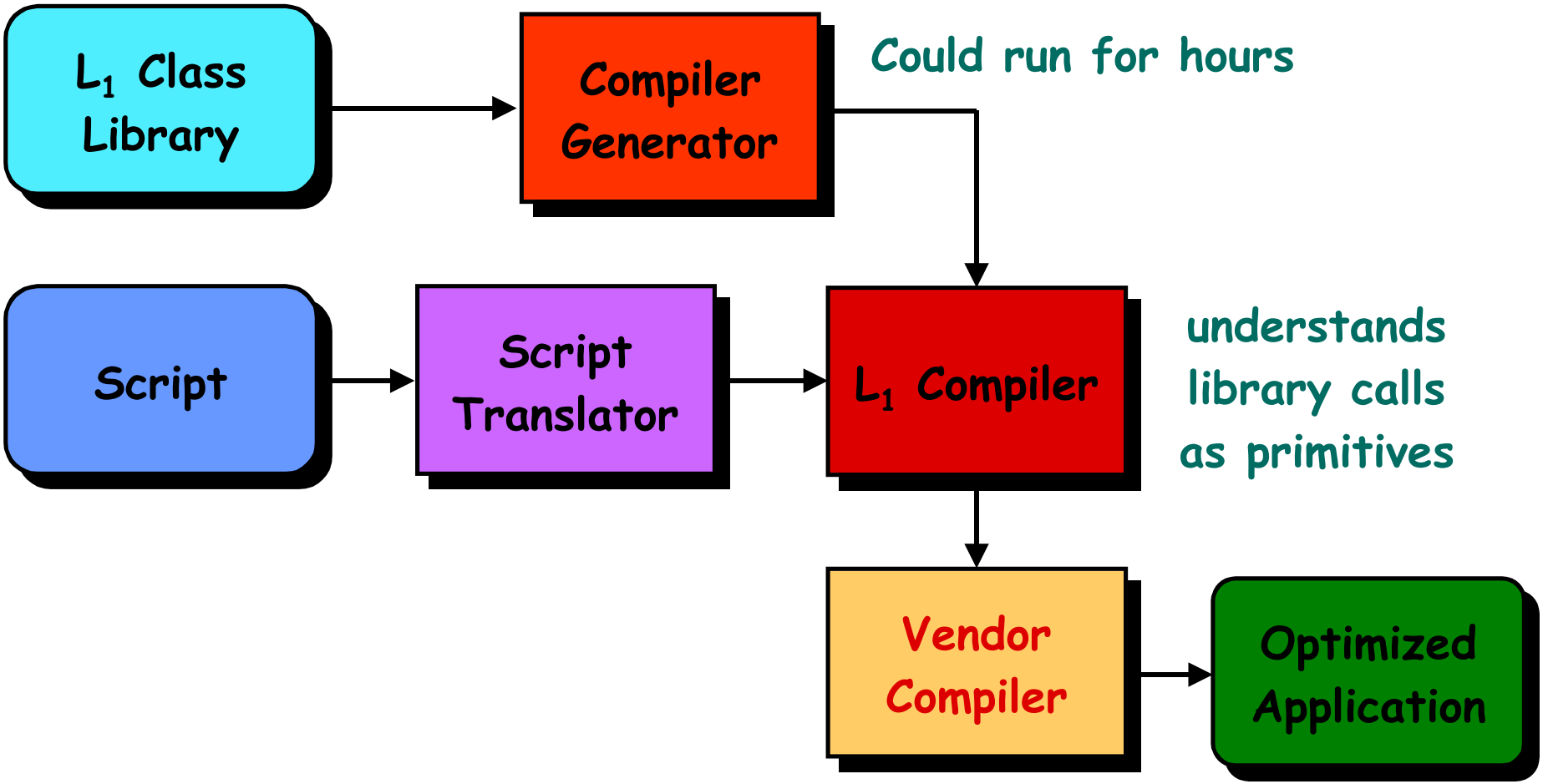

Telescoping Languages: Advantages

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- User retains substantive control over language performance
  - Mature code can be built into a library and incorporated into language

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- Transmission of high-quality video
  - Compression, compression, compression

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