Injecting Software Architectural Constraints into Legacy Scientific Code

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Problem

- Legacy scientific code represents a significant investment

- Scientific understanding has not changed - *sometimes*
- Complexity of implementation (exotic scientific expertise)
- Length of development (20-25 years in some cases)

How do we use this software on the latest generation of infrastructure?

Observations

- Basic software engineering principles like separation of concerns and layers of abstraction are important
- Monolithic scientific code should be modularized
  - Leads to better understanding
  - Supports distributed deployment and replication
- Deployment to modern infrastructure – e.g. Grids and Clouds – requires both scientists and engineers
  - Scientists must validate the scientific veracity of the system
  - Engineers are required to understand technology, manage throughput, robustness, etc. (*non-functional properties*)

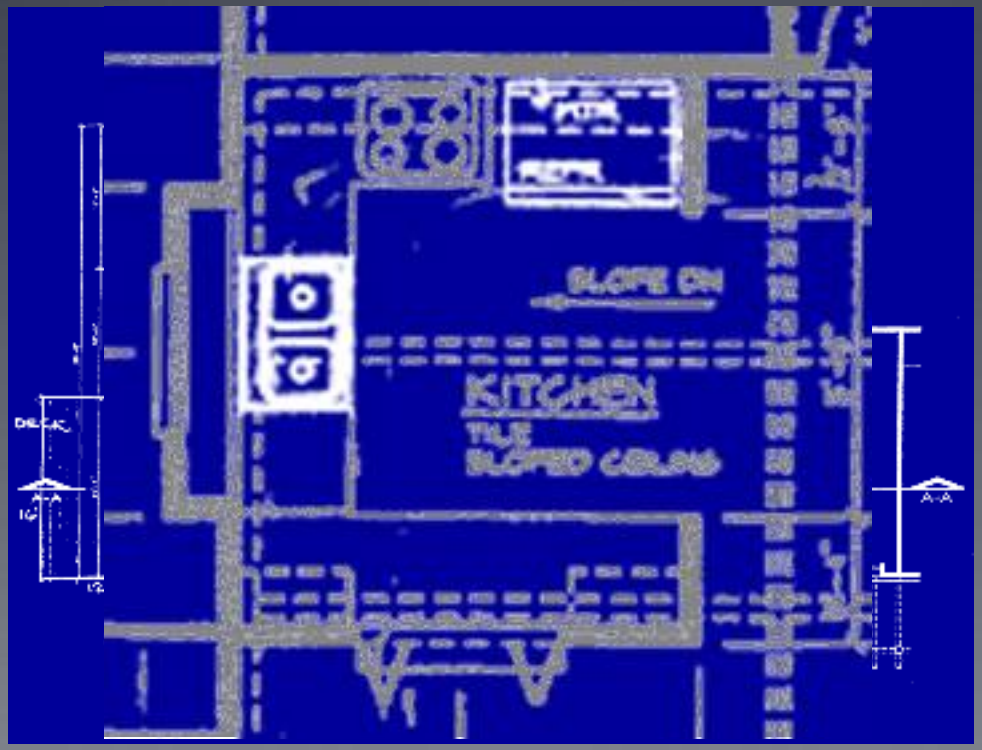
Hypothesis

Software Architecture is poised to aid scientific software developers by:

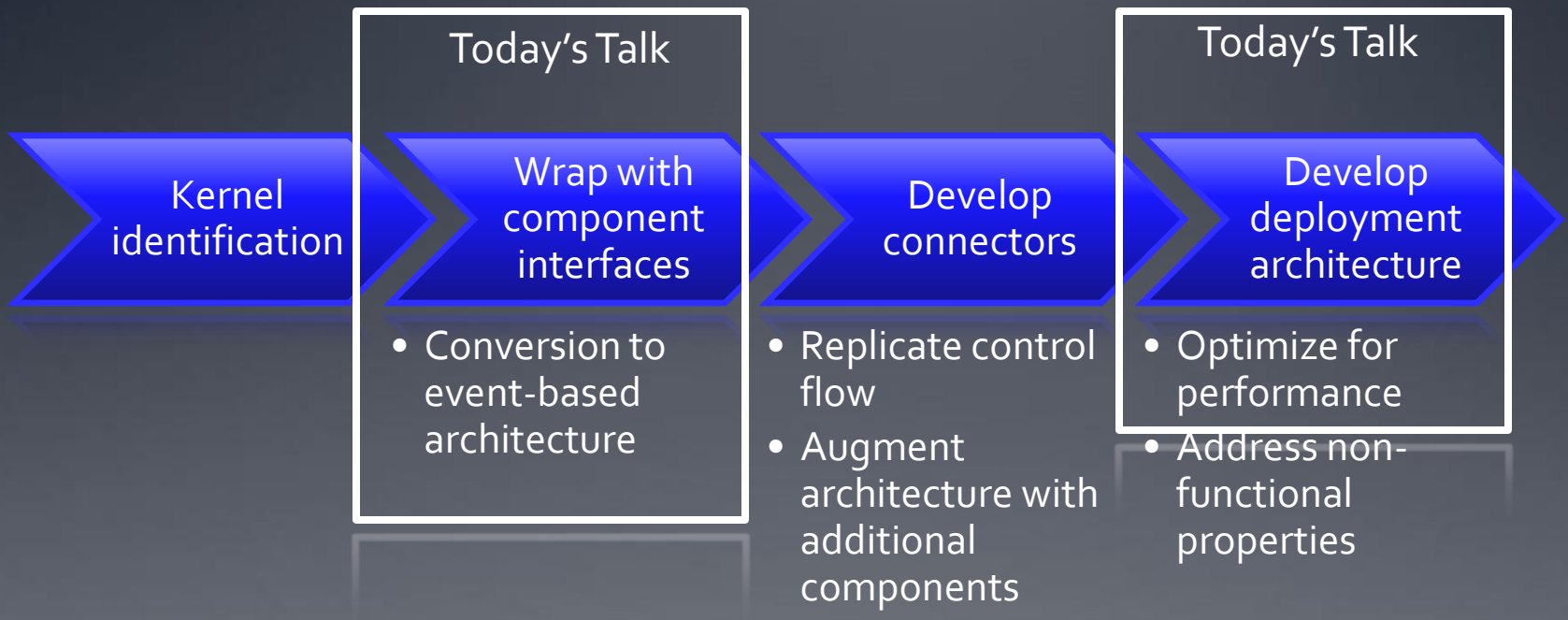
- Managing separation of concerns
- Modularizing monolithic software into components
- Treating deployment separately from functionality
- Allowing engineers to reason about non-functional properties

What is Architecture?

- Components – Connectors – Configurations
- Form & Rationale
- Behavior & Topology (or *Constraints*)



Methodology



Why Architectural Wrappers?

Well, I'm an architect…

But more seriously…

Architecture provides:

Separation of Concerns

- Scientists can validate and improve the science
- Engineers focus on developing "production" properties

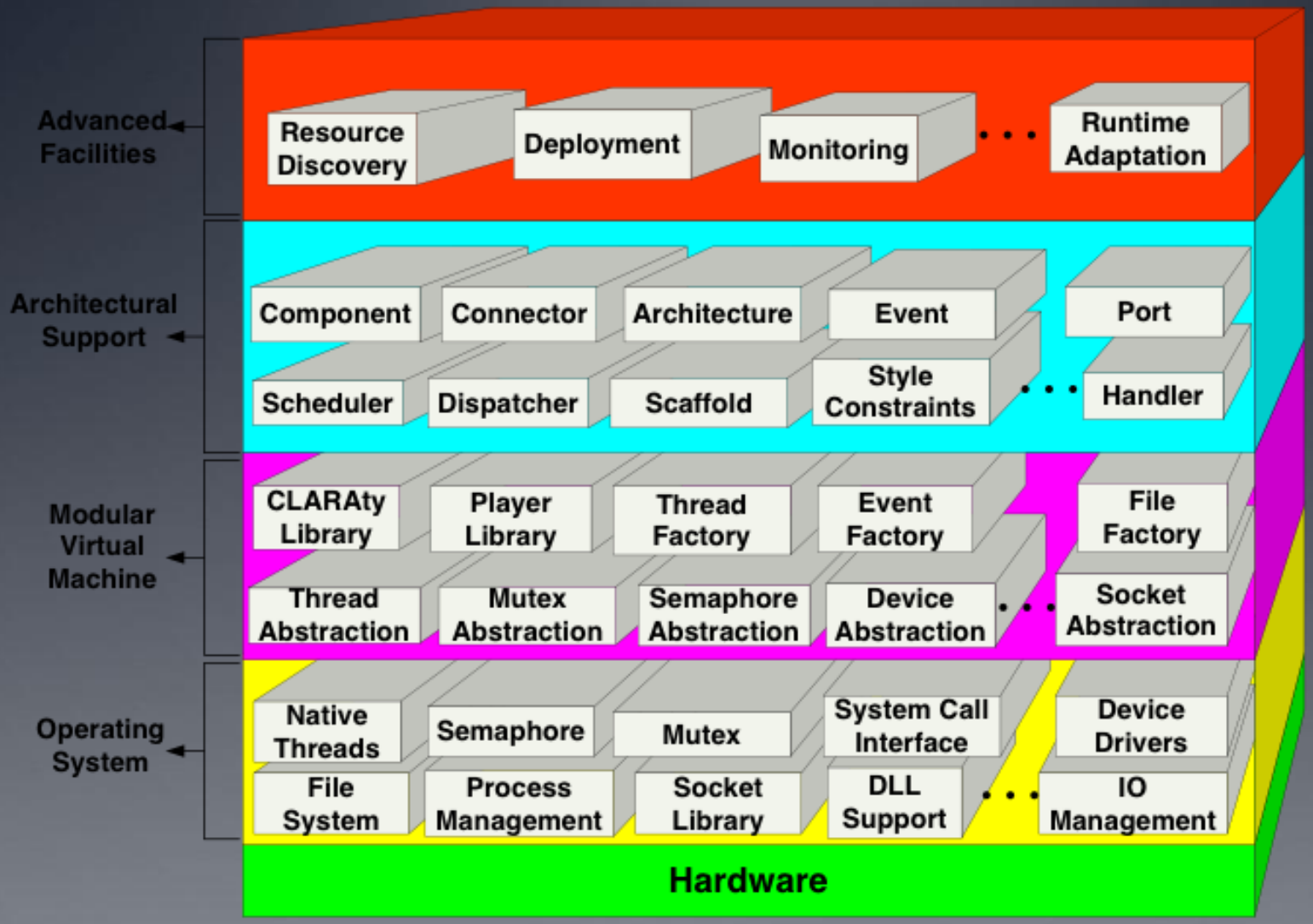
Full Lifecycle Support

- Common artifact with which to make joint design decisions
- Direct path to implementation

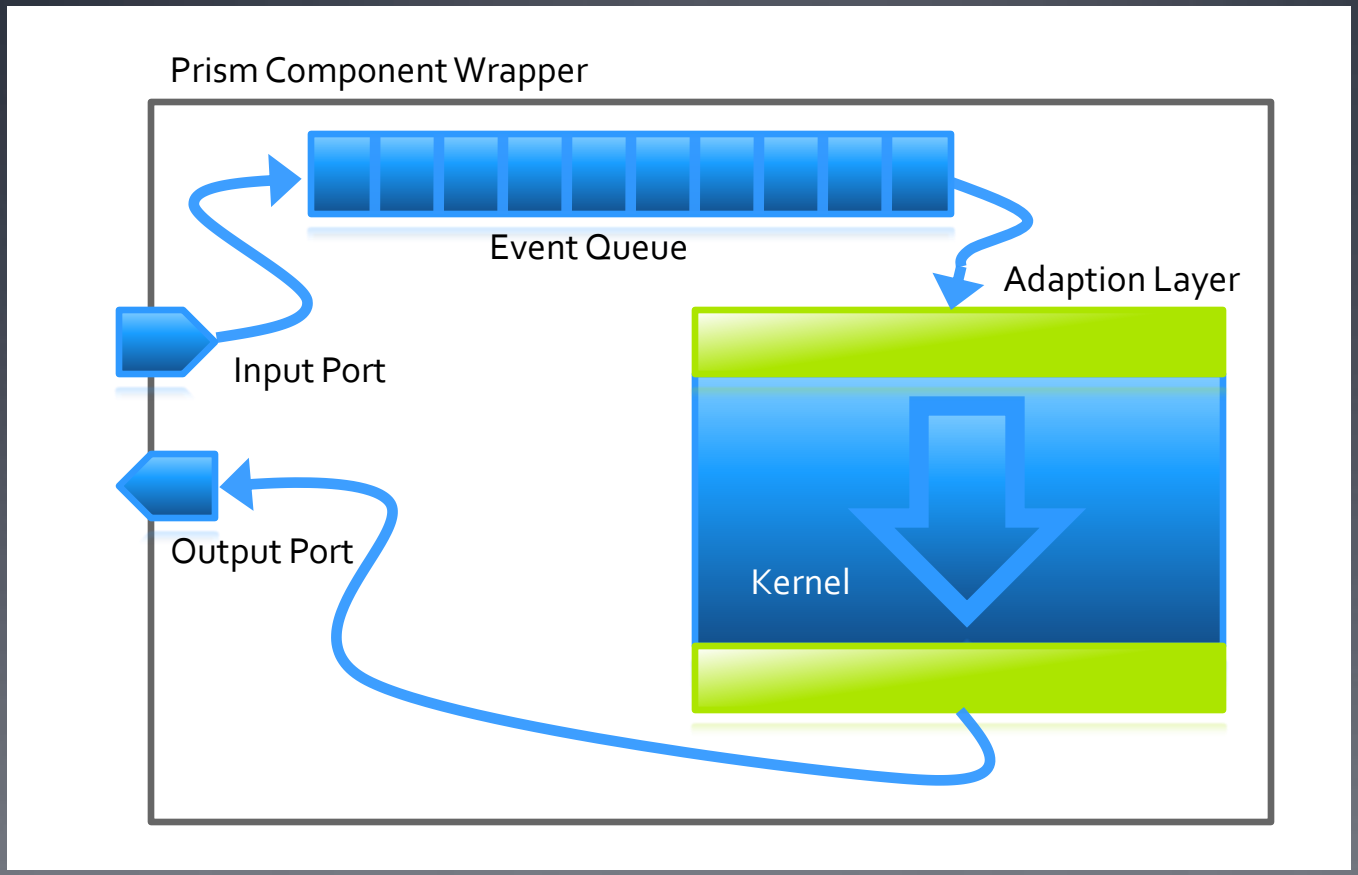
Related Work

- Wrappers have been proposed before
  - [Mehta, Medvidovic, and Phadke, 2000]
  - [Muslea, Minton, and Knoblock, 2001]
  - [Spitznagel and Garlan, 2003]
- Architecture reified in code
  - [Aldrich, Chambers, and Notkin, 2002]
  - [Malek, Mikic-Rakic, and Medvidovic, 2005]
- CBSE efforts in Scientific Software
  - [Allen, et al., 2006]

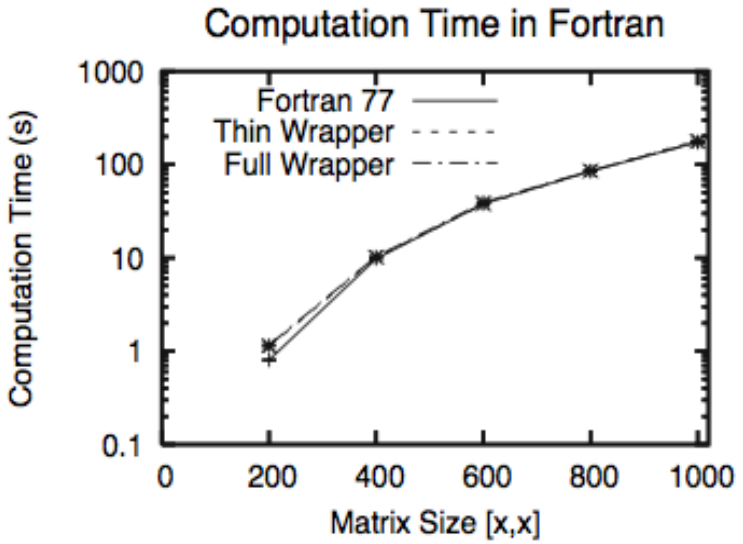
Implementation Support

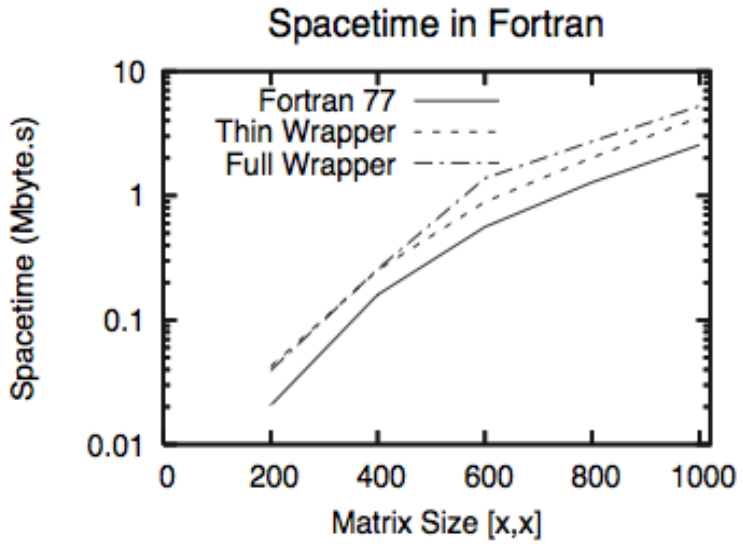


Wrapped Components



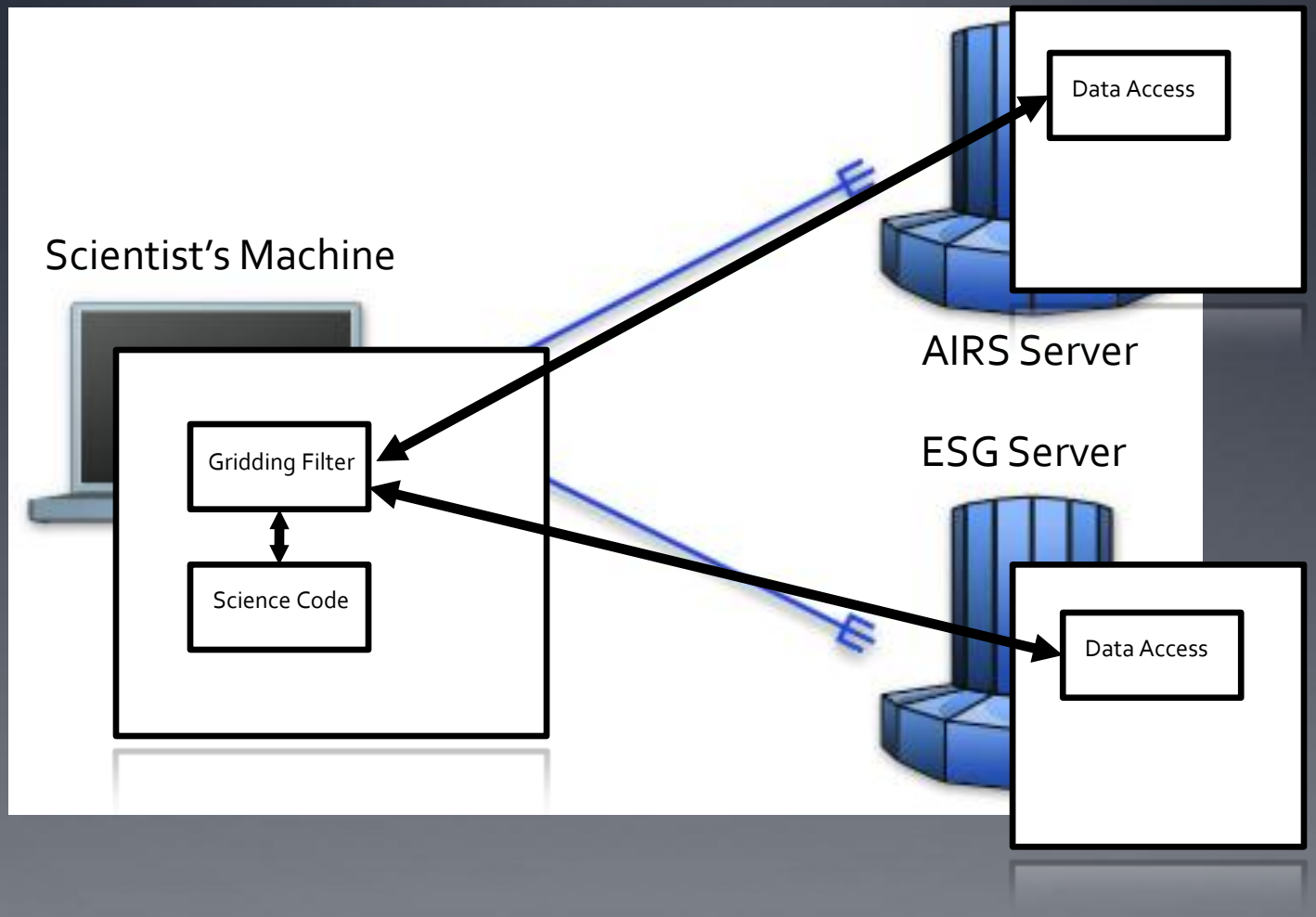
Performance Overhead





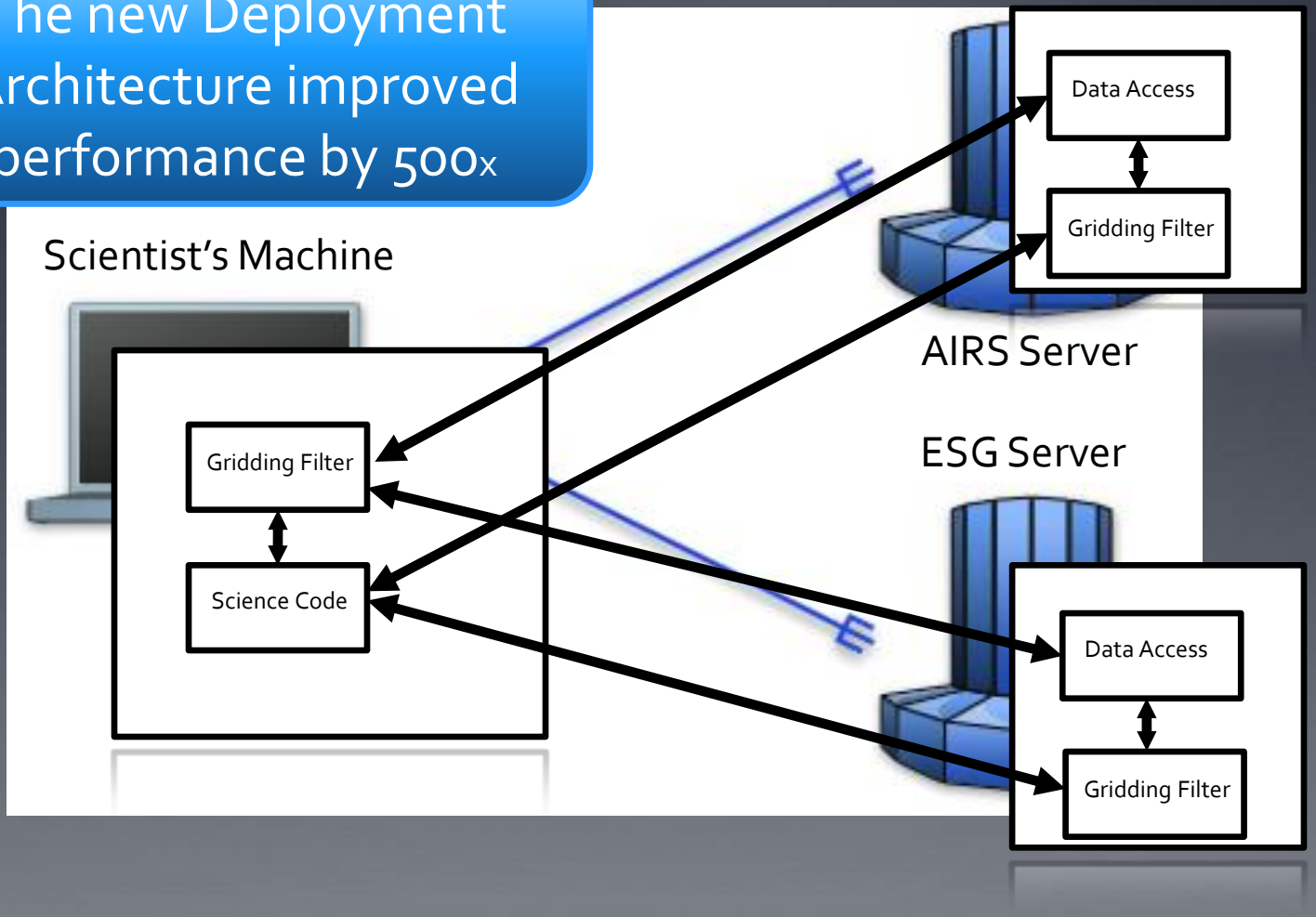
- Computation time overhead was negligible
- Memory footprint overhead was 1.5x-2x

Deployment Architecture Experiment



Deployment Architecture Experiment

The new Deployment Architecture improved performance by 500x



What's Next?

What we are working on now:

- Kernel-based decomposition
- Domain-specific software architecture & support for this architecture in Prism.

Future work:

- Use architectural deployment analysis (and tool support) to improve QoS/non-functional properties [Mikic-Rakic, Malek, and Medvidovic, 2008].
- Relationship between connector-based control flow and workflow modeling.

Thanks!

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