Software Challenges of Heterogeneity

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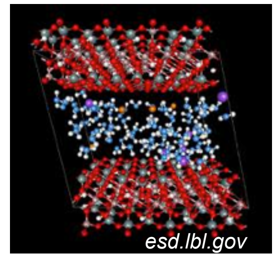
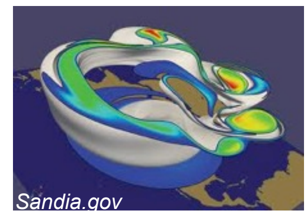
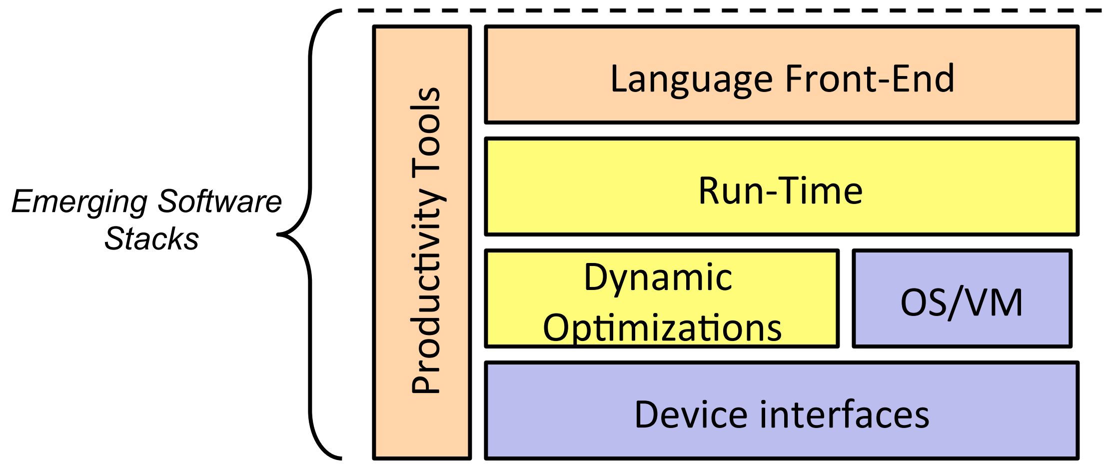
System Software Challenges of Heterogeneity





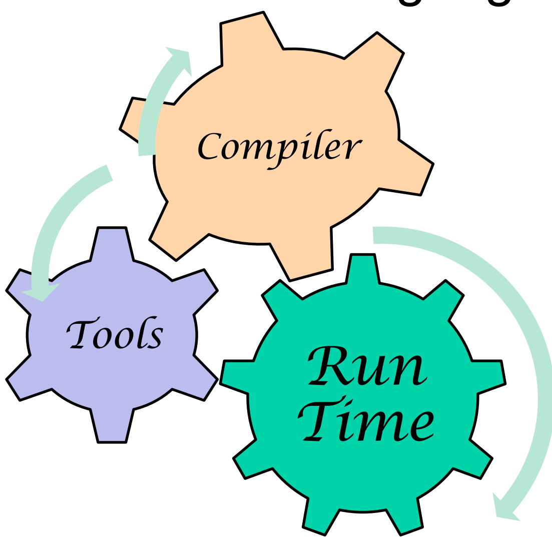
- Execution Portability
  - –Systems evolve over time
  - –New systems
- Performance Portability
  - New algorithms
- Introspection
  - Productivity tools
- Application Migration
  - –Protect investments in existing code bases



Need for Execution Model Translation

CUDA C/C++ Datalog Haskell C++AMP OpenCL

Languages: Designed for Productivity



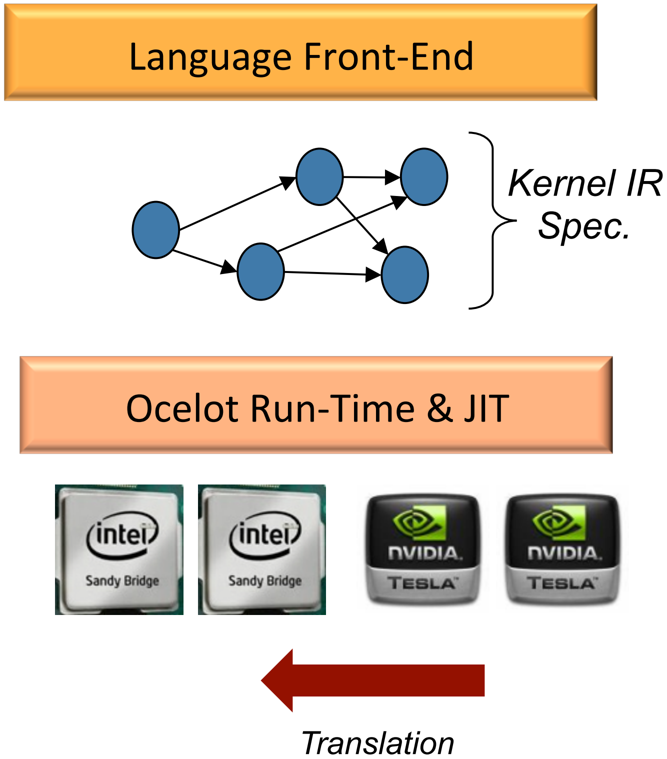
Execution Models (EM):
Dynamic Translation of EMs to bridge this gap

Hardware Architectures – Design under speed, cost, and energy constraints

Execution Portability: Raise the Level of Abstraction

G. Diamos, A. Kerr

- Application portability as the system evolves
  - On-line customization to meet application & architecture diversity
- Refactoring and re-tuning of applications is expensive and impractical for many applications
  - Need to protect software investments
- Side effect free kernels
  - Analogy with assembly instructions



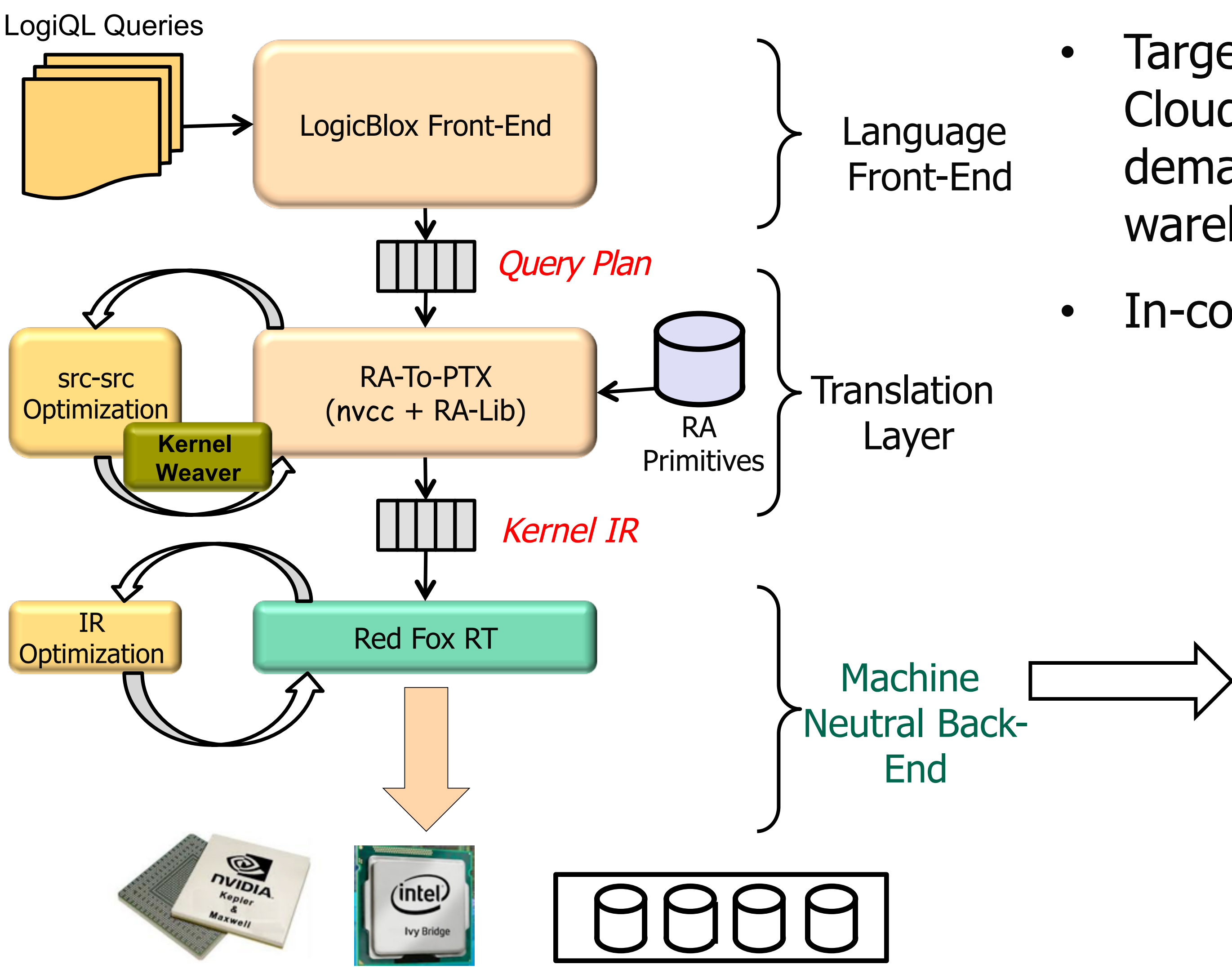
Kernels execute anywhere → Key to portability!

Domain Specific Compilation: Red Fox

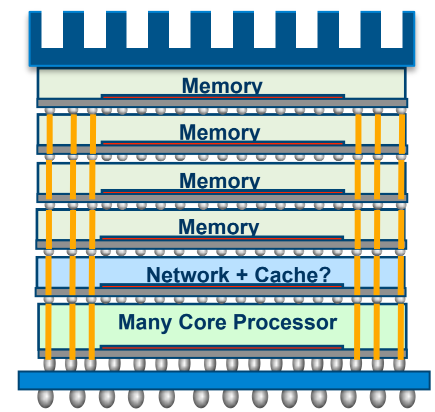
Joint with LogicBlox Inc.

H. Wu, G. Diamos

```
tr(x,y,z) ← E(x,y),E(y,z),E(x,z),x<y<z.
```

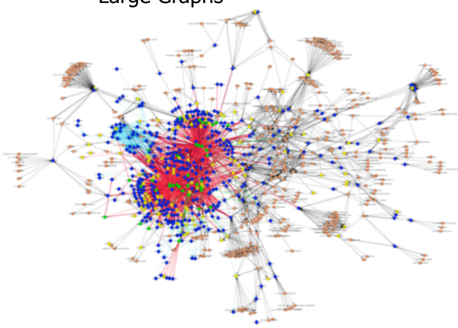


- Targeting Accelerator Clouds for meeting the demands of data warehousing applications
- In-core databases



System Model

Large Graphs



Programming Models

Data Movement Optimizations

System Abstractions
e.g. GAS, Virtual DIMMs, etc

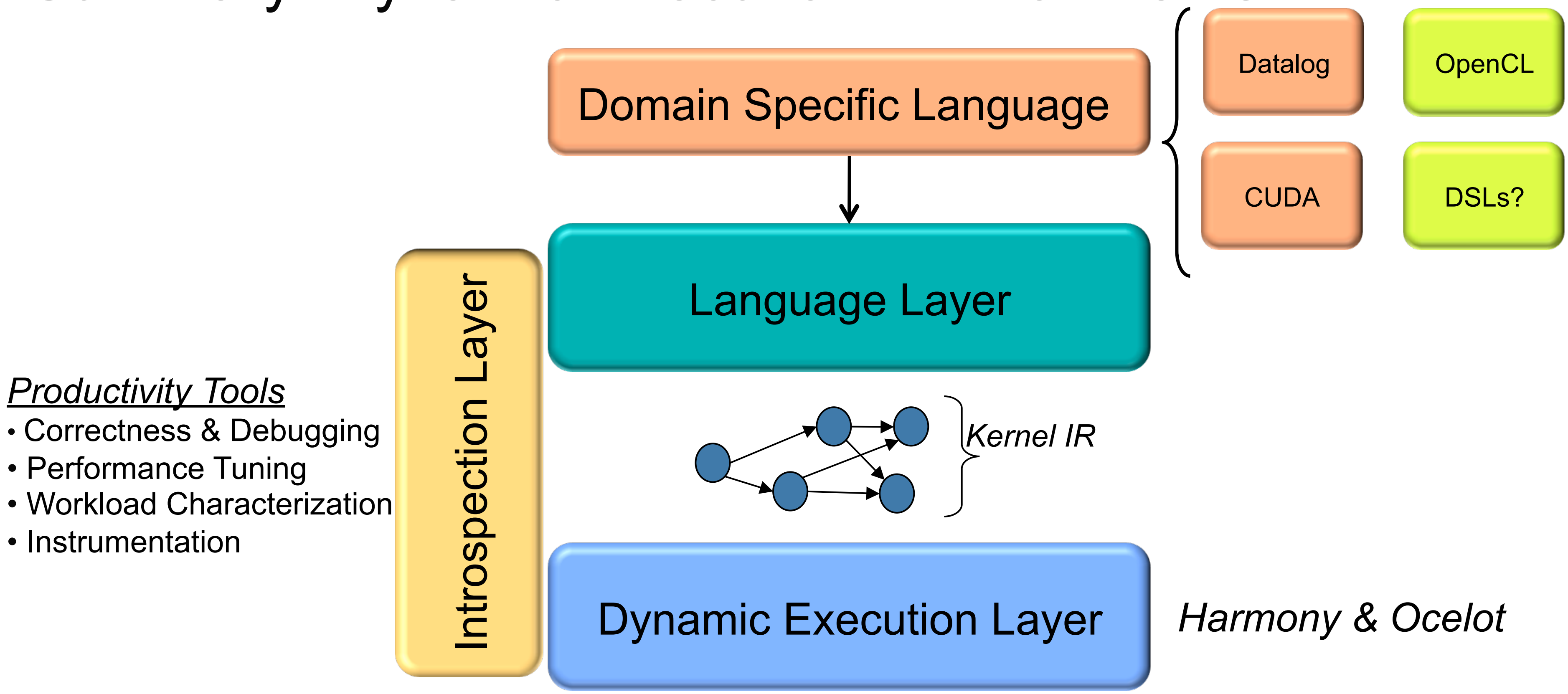
Domain Specific Languages

Compiler and Run-Time Support

Cluster Wide Hardware Consolidation

Hardware Customization

Summary: Dynamic Execution Environments



- Core dynamic compiler and run-time system
- Standardized IR for compilation from domain specific languages
- Dynamic translation as a key technology

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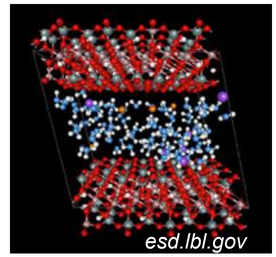
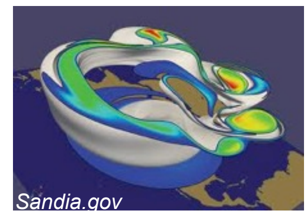
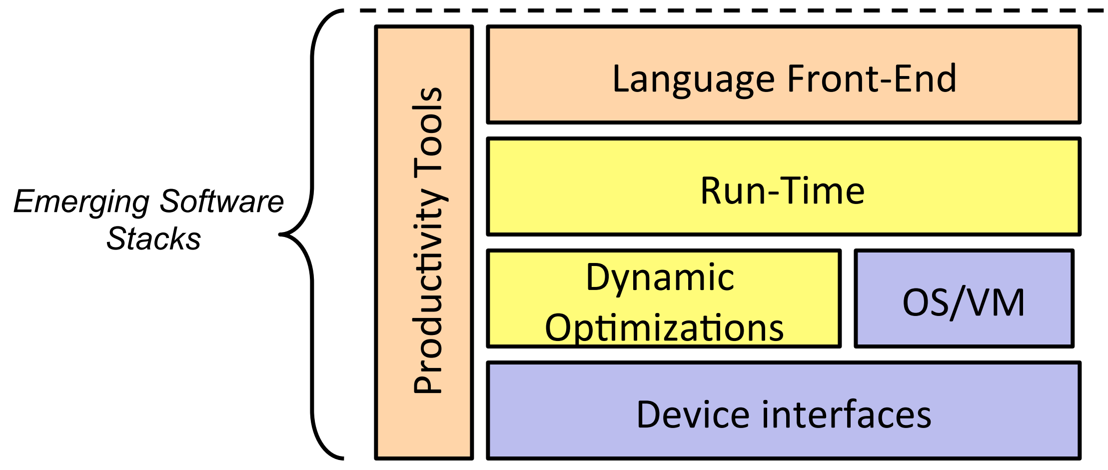




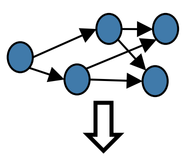


Motivation

C/C++ OpenCL CUDA Python

- *Application Validation*
- *Maintenance and Update*
- *Phase Behavior*
- *Impact of Deployment Environment*

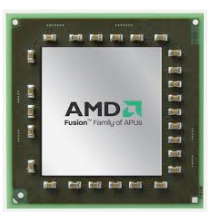
Language Front End

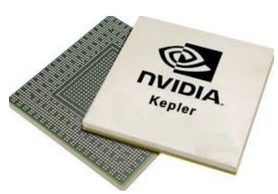


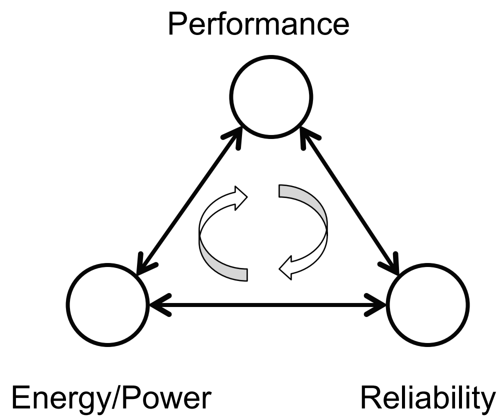
LLVM IR

Optimization

Virtual ISA, e.g., HSAIL, PTX



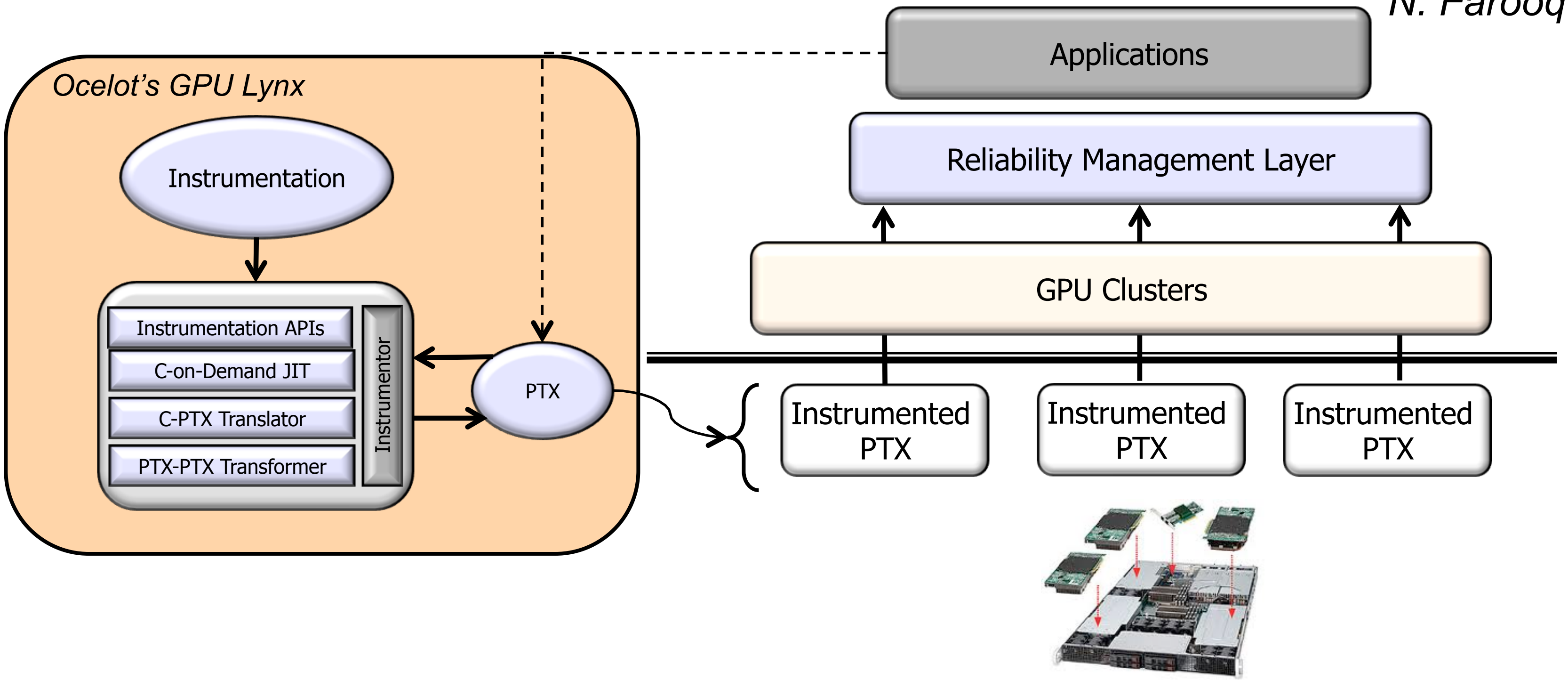




Key Idea: Code injection and JIT Compilation

Software Reliability Enhancement Framework

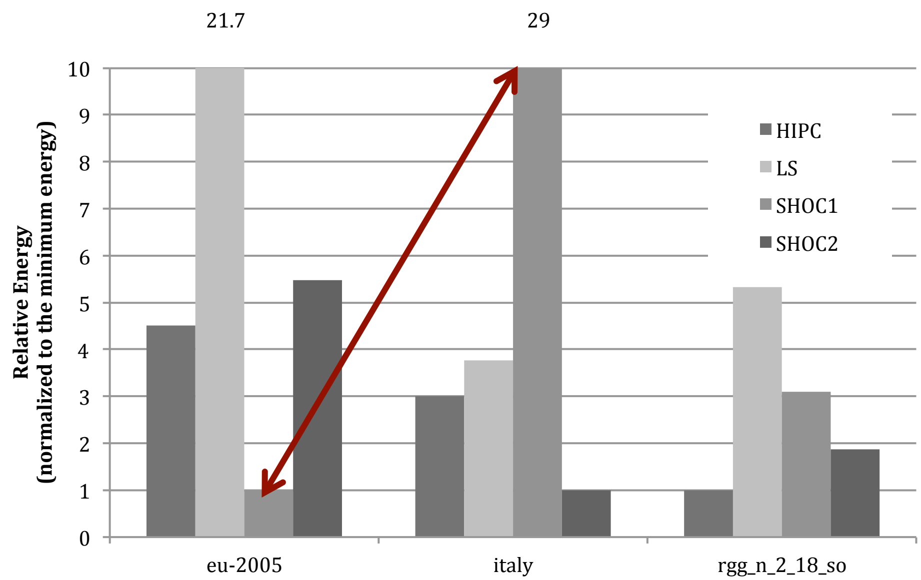
N. Farooqui, S. Li



- Real time customized information available about GPU usage
- Use this information to drive SRE decisions

Framework: On demand, customizable, transparent, and extensible, software reliability enhancement (SRE)

Challenge of Application-Level Energy Modeling



Different implementations of BFS on different input data sets

Courtesy H. Kim

- Note the variance of energy dissipation across different implementations of the same function

- Challenge: How do we understand the energy implications of our decisions? Algorithms, data structures, etc.

Thank You

Questions?