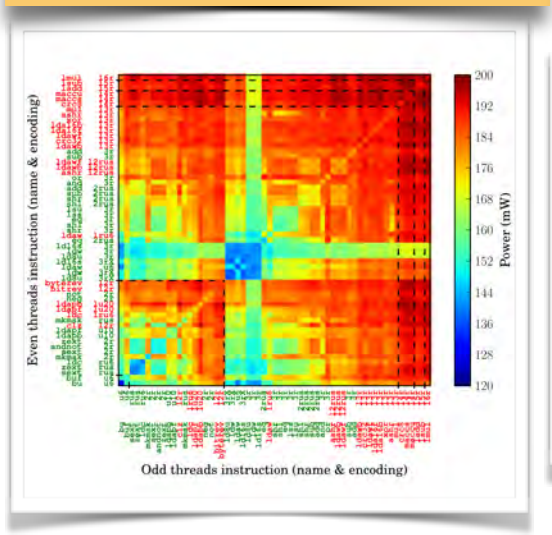
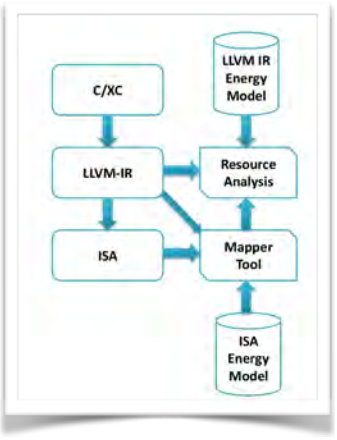
A low-level energy model gives estimates for energy consumption of individual machine instructions (ISA level).

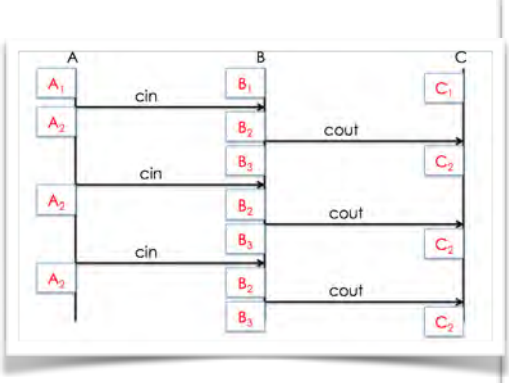
Higher-level energy models are derived by mapping low-level models to intermediate code (e.g. LLVM) or source code.

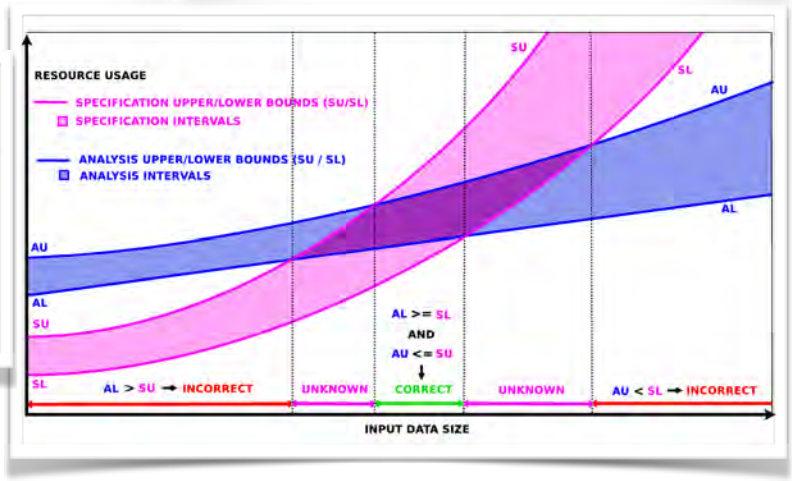
Analysis of resource usage involves control-flow, data-flow and parallelism

Energy *specifications* of programs can be verified automatically before execution by analysing code with respect to an energy model.

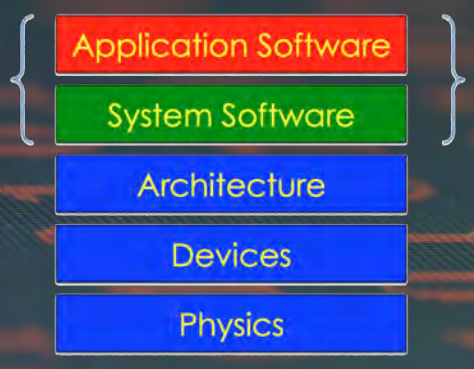



# The ENTRA project promotes "energy-aware" software development using advanced program analysis and modelling of energy consumption in computer systems




The greatest energy savings are available by optimizing the higher levels of the system stack

Advanced tool support is needed since most application developers have no idea of energy consumption at the level of code

## Achievements to date

### Models

- Low-level ISA models including multi-threaded execution
- Mapping of ISA to intermediate level code
- Direct construction of source energy model

### Tools

- energy analysis at LLVM and ISA level
- verification of energy specifications
- energy model mapping ISA to LLVM
- worst-case energy analysis
- generic verification and flow analysis
- XC compiler incorporating energy optimizations
- analysis of communication in multi-threaded programs

### Requirements

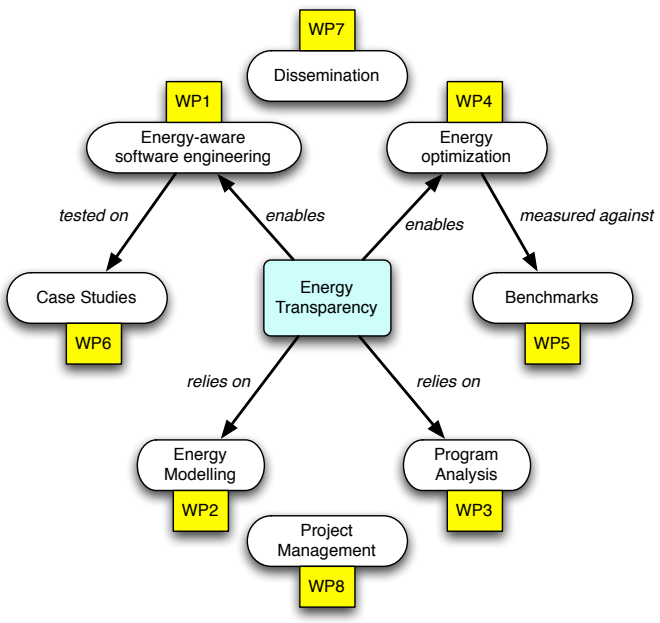
- functionality for tool support for energy-aware software engineering

### Theory

- optimization techniques for energy-aware dynamic allocation and scheduling
- framework for probabilistic resource analysis

# ENTRA

# Whole-Systems Energy Transparency

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