RACR - MQUAT

The journey has just begun

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Agenda

**1 The past**

2 The present

3 The future

Where we started in Phase I

- MQuAT concept [GKP+14]
    - Self-adaptive system optimizing for multiple qualities
    - Component-based design for both hardware and software
    - Quality contracts capturing requirements and guarantees of components

- THEATRE [GWC+10] as a Java-based implementation of MQuAT
    - Knowledge represented using EMF-(Meta)Models
    - Optimization problem solved by transformation to ILP
    - Designed for distributed operation (see HAECubie) using Master-Slave-Pattern [Sah96]

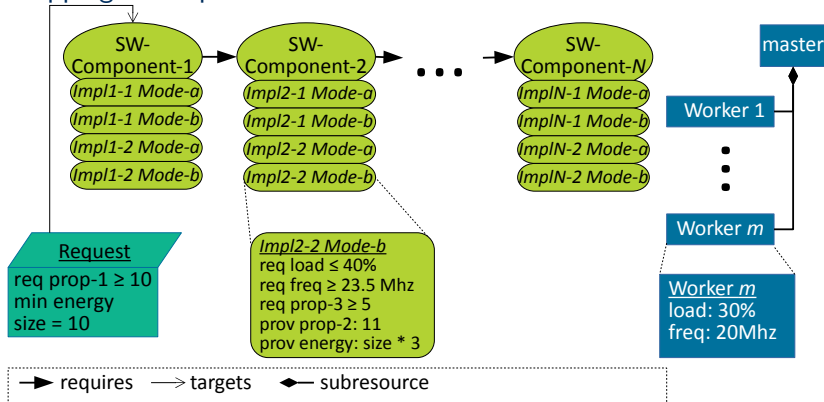# Structure and variant model
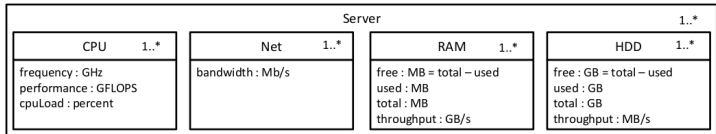
(a) CCM Structure Model for Hardware Landscapes.
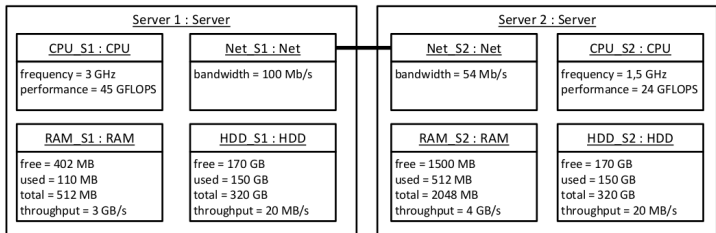
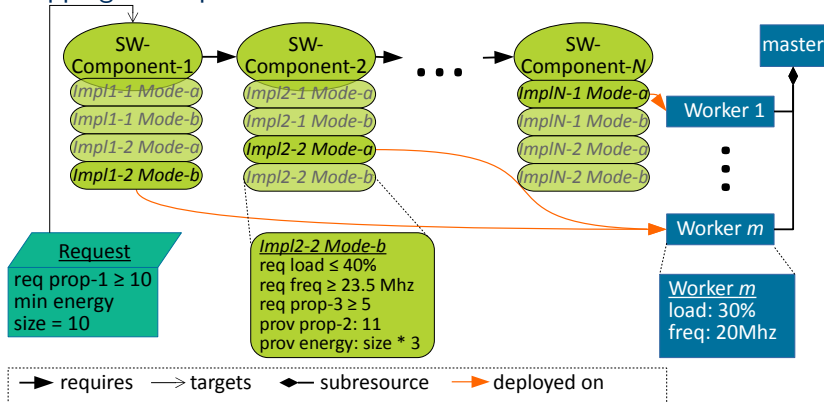(b) CCM Variant Model of a Hardware Landscape Comprised of 2 Servers.

The optimization problem

Mapping n components on m resources

The optimization problem solved

Mapping *n* components on *m* resources

What was the problem

- Usage of ILP thought *unusable* for bigger systems
  - Current measurements disprove this, see slides 11 – 13

- EMF-Models and some of their elements ambiguous or redudant
  - Component requirement possible on both, component- and mode-level
  - Structure and variant model contain similar information
  - Approach of structural model not easy to use (especially for ILP-Generation)

- Currently, ILP generated from scratch for each request

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How we want to achieve scalability

- Use RACR [Bür12]
  - **R**eference **A**ttribute Grammer **C**ontrolled **R**ewriting
  - Specify knowledge as an ASG[1] whose structure is defined by a RAG[2]
  - RAG is a combination of structural and variant model, avoiding duplicate information
  - Analyses run on ASG now run inherently **incremental** and are defined **declaratively**

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[1]Abstract Syntax Graph, i.e. an Abstract Syntax Tree with references
[2]Reference Attribute Grammar

Test setup
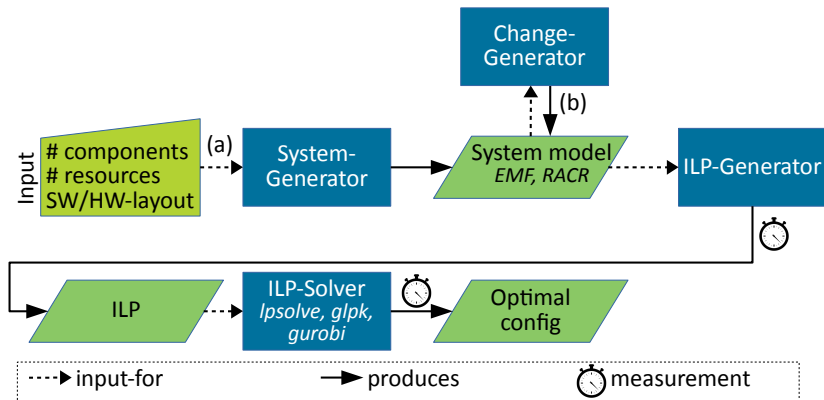
(a) Initial creation, (b) HW changes

Measurements

- Setup
    - System Generator to generate ILP for increasing size of systems
    - 23 different sizes of systems
    - ILP-Solving with 40sec timeout

- ILP-Solving using existing Java/EMF-based, old ILP format
    - Timeouts: glpk 10/23, lpsolve 8/23

- ILP-Solving using Scheme/RACR-based, enhanced ILP format
    - All but one systems solved within 5sec (outlier 12sec)

Measuring generation times

- Not quite there yet:
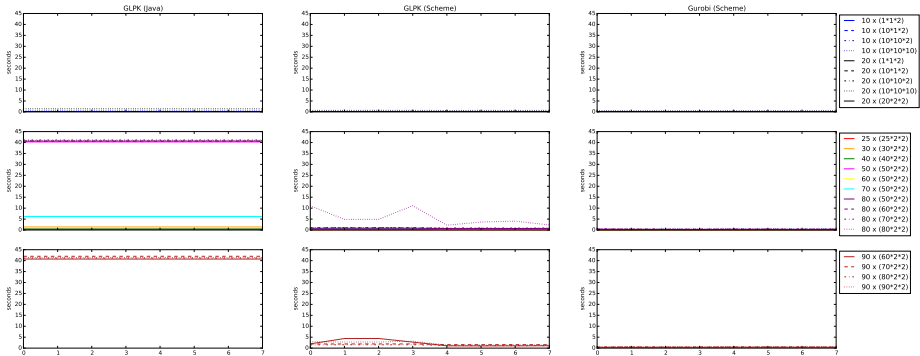

ILP Generation Time
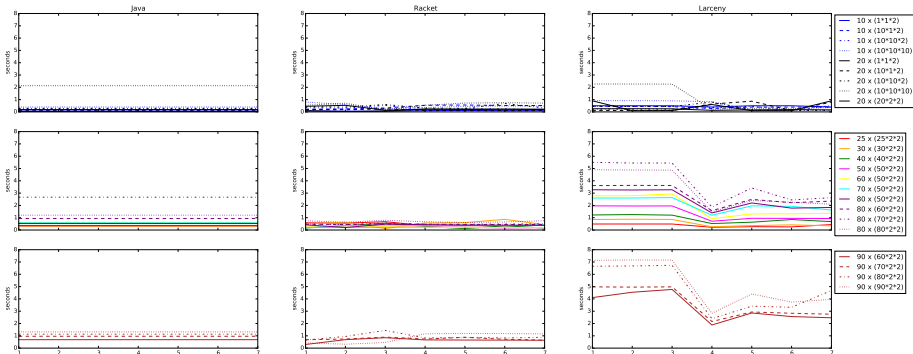
Measuring solving times

- Promising results

ILP Solving Time

Measuring solving times (Detailed)

ILP Solving Time - Comparison

Legend:
- 10 x (10*10*10)
- 50 x (50*2*2)
- 70 x (50*2*2)
- 90 x (60*2*2)
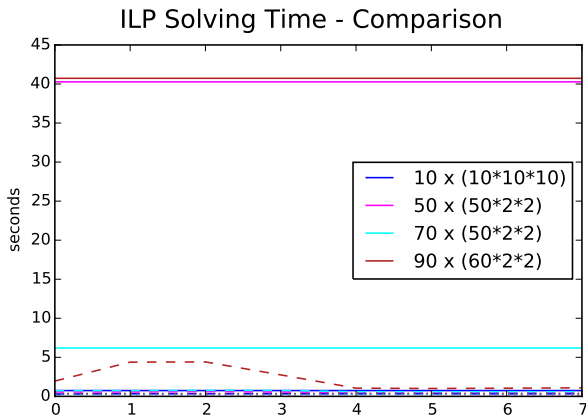
- solid = GLPK, old format, dashed = GLPK, enhanced format
- dotted = Gurobi, enhanced format ($\leq$ 1sec)

Current pitfalls

- Different input formats accepted by lp_solve and glpk
    - Transformation (mostly syntactical) needed
- Slow running Larceny
    - Unexpected as Larceny compiles to machine code
- Caching not fully exploited
    - Some constraints still unnecessarily recomputed

General Facts

- https://bitbucket.org/rschoene/racr-mquat
- Main language: Scheme

Language	files	blank	comment	code
Scheme	12	159	168	1222
Python	6	49	16	284
SUM:	19	212	185	1546

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Where we should go next

- Do not transform to ILP
  - Implement a heuristic similar to RACRtune demo[3] of Daniel Langner and Johannes Mey

- Apply static analysis where appropriate, e.g.
  - Abstract Interpretation [CC77, Ros90] to estimate energy consumption [JM06, RMM03]
  - Describe decisions [Dan15]
  - Eliminate unreachable configurations
  - Unify constraints (in contracts) of modes

- Extend AG
  - Describe multiple systems and their interaction, e.g. [WSG+13]
  - Include behavior model for more fine grained description

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[3]Shown at HAEC review and OUTPUT'15, paper in progress

An example application of static analysis

Worst Case Execution Time (WCET) squeezing [KKZ13]

- Combines ILP solving with Symbolic Execution (SE) [Kin76]
- Iterative, alternating, automatic approach
- SE either tightens found bound – or proves it precise

Application to HAEC use case

- Do Worst Case Energy Consumption (WCEC) squeezing
  - based on energy contracts

References I

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References II

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[RMM03]   Cosmin Rusu, Rami Melhem, and Daniel Mossé. Maximizing rewards for real-time applications with energy constraints. *ACM Transactions on Embedded Computing Systems*, 2(4):537–559, November 2003.

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