A Look at Computer Architecture Methodologies

Mario Badr and Natalie Enright Jerger
Why evaluation methodologies?

1. Is computer architecture an art or a science?
   - Experimental Data
   - Reproducibility

2. How have evaluated metrics changed over the years?
Scope of the Survey

• 44 ISCA Proceedings
  • 1973-2017
  • Too many papers (over 1600)

• Select papers from each proceeding across topics
  • Bias selection to impactful papers
  • 4-7 papers per proceeding
  • 222 papers total
## Paper Topics

<table>
<thead>
<tr>
<th><strong>Axis #1</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Core</td>
<td>A conventional general purpose processor with one core</td>
</tr>
<tr>
<td>Multiple Core</td>
<td>More than one conventional processor</td>
</tr>
<tr>
<td>Specialized Architecture</td>
<td>An unconventional processor (e.g., accelerator, GPU)</td>
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<table>
<thead>
<tr>
<th><strong>Axis #2</strong></th>
<th><strong>Description or Examples</strong></th>
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<tbody>
<tr>
<td>Microarchitecture</td>
<td>e.g., branch prediction, simultaneous multithreading</td>
</tr>
<tr>
<td>Memory</td>
<td>e.g., cache replacement, phase change memory, cache coherence, memory consistency</td>
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<tr>
<td>Networks</td>
<td>e.g., bus, crossbar, network-on-chip, network interface</td>
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<tr>
<td>Organization</td>
<td>The overall design of multiple components</td>
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<tr>
<td>Coordination</td>
<td>The management of multiple components to achieve a goal</td>
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Surveyed Papers Along Both Axes

![Bar chart showing paper counts for different topics under different architectures:]

- **Specialized Architecture**
  - Memory: 10
  - Microarchitecture: 20
  - Networks: 30
  - Organization: 40
  - Coordination: 10

- **Single Core**
  - Memory: 20
  - Microarchitecture: 40
  - Networks: 10
  - Organization: 20
  - Coordination: 10

- **Multiple Cores**
  - Memory: 60
  - Microarchitecture: 20
  - Networks: 40
  - Organization: 60
  - Coordination: 20

*Paper Count*
Types of Evaluations

• None

• Qualitative

• Theoretical

• Quantitative
  • Experimental data
We Focus on Quantitative Evaluations

• None

• Qualitative

• Theoretical

• Quantitative
  • Experimental data

• Analytical Model

• Prototype

• Simulation
  • Architectural
  • Circuit-level
  • Other
The 1970s – 27 papers

• Quantitative Evaluations: 40%

• Evaluated Metrics
  • Performance
  • Proxies for area

• Analytical Models
  • e.g., assume ideal parallelism
  • e.g., performance projections
The 1980s – 46 papers

- Quantitative Evaluations: 60%
- Reduced costs of memory and CPU
  - Single core processors
  - Prototyping
- Trace-driven simulation
The 1990s – 47 papers

• Quantitative Evaluations: 85%

• Introduction of many simulators
  • SimpleScalar

• Introduction of CACTI
  • Catches on in the next decade

• Power/energy is considered
A Brief Interlude: Evaluated Metrics

1973 – 1995

1996 – 2017
The 2000s – 50 papers

• Quantitative Evaluations: 98%

• Models for power, energy, thermal
  • Wattch, HotSpot, Orion, McPAT
  • CACTI gains popularity

• More simulator options
  • Pin, Simics

• Tools to reduce simulation time
  • SimPoint, PinPoint, SMARTS
The 2010s – 52 papers

• Models and prototypes used more

• More tools
  • Raised levels of abstraction
  • Design space exploration
Summarizing Tool Use – 1973 - 2017

- Analytical Model
- Architectural Simulation
- Prototyping
Computer Architecture: Art or Science?

• Strong push to quantitative evaluations

• Designs are evaluated with more metrics

• Many tools developed to generate data

• Reproducibility?
The Increasingly Complex “Methodology”

• Methodology section prominent in mid-to-late 90s

• Methodologies grow very complex
  • More tools are used

• Page real estate
  • Less used for methodology
  • More used for experimental data

• Methodologies do not provide enough information
Conclusion: Towards a Scientific Method

Architects
• Better methodology section
• Relevant experimental data
• Release your evaluation
  • Docker
  • GitHub
  • Other technologies

Tools Developers
• Caution against limitations
• Output ‘artifacts’ that
  • Can be redistributed
  • Can be re-used as inputs
  • Can be analyzed
Our Data is Open Source

https://github.com/mariobadr/survey-wp3

License: Apache 2.0

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