Model Checking in the Cloud

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Daryl Stewart

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EDA in the Cloud at ARM

- ARM runs LSF clusters for design and verification
  - Capacity for expected peak + safety margin
  - Idle time not a problem – we can always run maturity (soak) test
  - Reduce maturity test load for burst provision
- Successful experiments deploying workloads into Cloud
  - But Cloud providers unwilling to provide acceptable level of liability
  - AWS: waive right to patent infringement claims on Amazon or *any of their suppliers*
- Working on utility cloud
- Hybrid cloud? (colocated storage)
- Can use machine clusters – rebuild our LSF for burst provision

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New Tier 3 Cluster

- Greenest Data Centre in Europe - PUE 1.05
    - Winner European award for a New Data Centre Facility (2012)
    - 200 TFlops, 93 TBytes DRAM

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Model Checking at ARM

- Sequential-X verification of whole-processors
  - Deterministic behaviour despite non-reset flops

- Verification at block level, functional unit level
  - From low level to end-to-end properties

- Protocol validation
  - System coherency, deadlock...

- Designers encouraged to write properties in preference to test benches

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Issues

- Range of proof engines to select
    - Can race multiple engines
    - Sharing partial results (assert becomes assume)

- Intelligent regression tests
    - Remembering previous successful proof to guide search?

- Manual generation of invariant "helpers"
    - Reducing week long proofs to minutes through ingenuity, not brute force

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Scaling power, or just cost?

- Some proofs take days
  - Invariants can reduce this to minutes or seconds
- If massive parallelism reduces time to minutes at the cost of a large number of compute nodes, is it more useful?
  - Analogous to Simulation vs. FPGA vs. Emulation?
  - Is there value in being forced to confront "harder" properties?
- The cost of traditional verification is becoming prohibitively expensive
  - Do we need more brute force, or smarter solutions?

	Cycle cost	Speed	Observability
Emulation	1,000,000	0.1MHz	high
Simulation	100,000	1KHz	high
CA models	10,000	10KHz	high
FPGA	1,000	10MHz	medium
Silicon	1	1GHz	low

Fifty years of progress

The experiences of various groups who work on problem solving, theorem proving and pattern recognition all seem to point in the same direction: These problems are tough. There does not seem to be a royal road or a simple method which at one stroke will solve all our problems. My discussion of ultimate limitations on the speed and amount of data processing may be summarized like this: Problems involving vast numbers of possibilities will not be solved by sheer data processing quantity. We must look for **quality**, for **refinements**, for **tricks**, for every **ingenuity** that we can think of. Computers faster than those of today will be a great help. We will need them. However, when we are concerned with problems in principle, present day computers are about as fast as they ever will be.

Bremermann, H.J. (1962)

End

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Abstract

- Cloud computing where computing is provided as a utility is finally a reality. This new paradigm is shaping the way hardware and software is designed. One of the main attractions of the cloud is its elasticity. This empowers users with the ability to dynamically change their hardware requirements by paying for resource usage by the hour. Compute-intensive applications such as model checking can potentially benefit from such an infrastructure. In this panel, we will address the following questions:
    - How can model checking leverage the advantages of distributed and multi-core systems in the cloud?
        - Is this new paradigm suitable for model checking?
        - What are possible solutions beyond an "embarrassingly parallel" approach of running a single property per core?
        - Is there a specific subset of properties that might be more suitable to this form of analysis?
    - What is needed from the research and engineering community to achieve adoption within the next 5 years?
    - Would a drive to model checking in the cloud increase the industry's adoption of formal technology?
    - What issues need to be addressed for design houses to adopt this technology and will the current license model of EDA tools change to adapt to the new requirements?

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