Stochastic Approach to CSP's in the Hardware Verification Domain

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Simulation Based Methods, Systems and Modeling

Constraints in test case generation

- Verification task: Real address in some corner memory space, Effective address aligned to 64K.
- Testing knowledge: Reuse cache row.
- Architecture: Effective address translates into real address in a complex way.

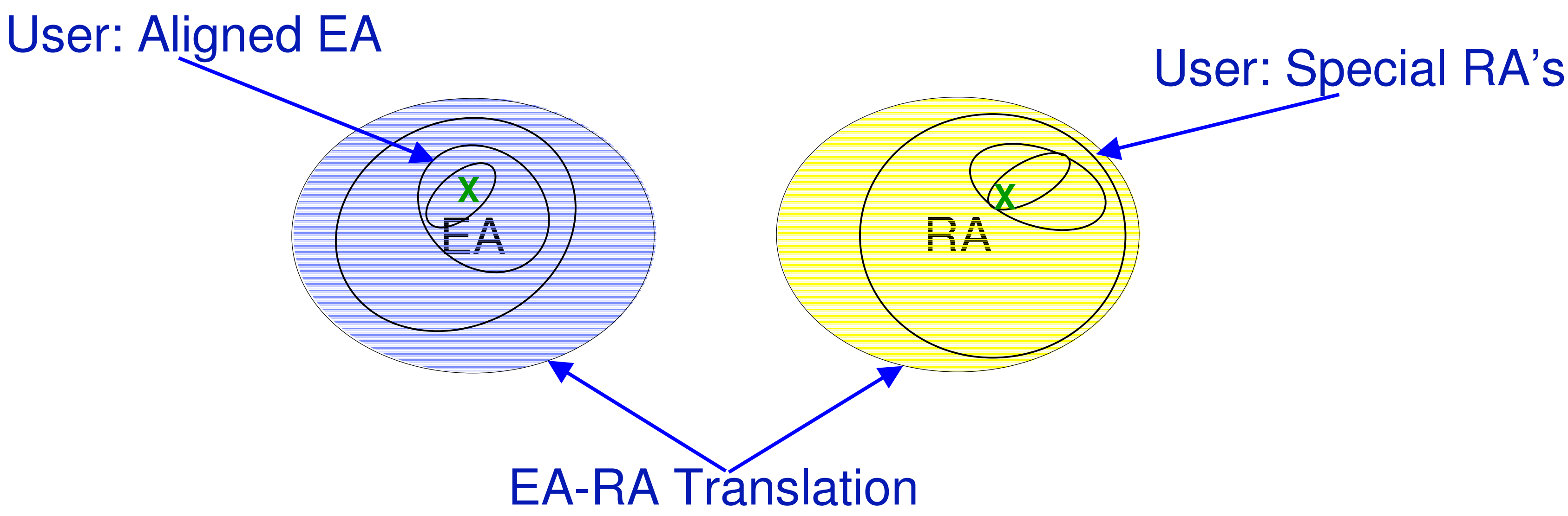
EA: 0x0B274FAB_0DBC0000
RA: 0x0002FFC5_90A4D000

Huge Domains (2^{64})
Quality of solution: Random uniformity

EA: 0x0002FF00_00000000
RA: 0x0002FF00_00000000

Correct, but worthless!

Deterministic Methods (DPLL, MAC, k-consistency, …)



1. Reach a level of consistency through successive reductions of sets
2. Choose a random assignment for a variable, and maintain the consistency

Limitations of Deterministic Methods: An example

$$a, b, c \in \{0, \ldots, N\}, \quad N = 2^{64}$$

$$\left.\begin{array}{l} 1.\ a \neq 0 \Rightarrow b = 0 \\ 2.\ a = 0 \Rightarrow c = 0 \\ 3.\ b = 0 \Rightarrow c = 0 \\ 4.\ c = 0 \Rightarrow a = 1 \end{array}\right\rangle$$

Only solution: $a = 1, b = c = 0$

Local consistency at onset: Choose randomly with probability 1/N of being correct

(Solution reached at 600 million years)

Limitations of Deterministic Methods: Another example

$$a, b, c \in \{0, \ldots, N\}, \quad N = 2^{64}$$

$$\left.\begin{array}{l} 1.\ \ a * b = c \\ 2.\ \ a, b, c \text{ each have five 1's in their binary representation} \end{array}\right\rangle$$

Already a single reduction of domains is hard

Stochastic approaches: defining the metrics

- State: a tuple representing a single assignment to each variable
- Cost: A function from the set of states to {0} U R^+
  - Cost = 0 iff all constraints are satisfied by the state.

$$a * b = c \qquad \text{Cost} = (c - a * b)^2$$

$$a = 0 \Rightarrow b = 0 \quad \text{Cost} = \begin{cases} b & a = 0 \\ 0 & a \neq 0 \end{cases}$$

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