Parallelization by Simulated Tunneling

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Pick one master node: straightforward x86 simulator

Machine model: master node queries cache, “tunnels” to new state if match
Deterministic programs: input allowed, but up front

\[ \text{state} = \text{registers} \times \text{instructions} \times \text{heap} \times \text{stack} \]
\[ = \text{registers} \times \text{memory} \]
\[ = (00000100010101111101010\ldots)_{11111110101101010101)
\[ x_0 = (00000000000000000000000000000000, 00000000000000000000000000000000, \ldots, 00000000000000000000000000000000, \ldots, 11010101, \ldots, 11110111) \]
$x_0 = (00000000000000000000000000000000,...,00000000000000000000000000000000,...,11010101,...,11110111)$

Fetch + Decode + Execute

$x_1 = (11111111111111111111111111111111,...,00000000000000000000000000000000,...,00000000000000000000000000000000,...,11010101,...,11110111)$
A dynamical system is a state space $\mathcal{X}$ and an evolution rule $f$.

$$x \in \mathcal{X}$$

$$f : \mathcal{X} \rightarrow \mathcal{X}$$
A dynamical system is a state space $X$ and an evolution rule $f : X \rightarrow X$.

In every dynamical system, the evolution rule is associative under composition.
If initial point of tunnel matches master’s current point (up to symmetries) -- tunnel immediately to final point

The crucial role of symmetries
E.g. translation on non-causal bits
Symmetries again
E.g. only have to get 10% bits right
E.g. function memoization
Time evolution of $L_1$-norm of state vector $x_t$
Log-log plot of run time scaling

- **Our scaling**
- **Perfect linear scaling**
- **Bare metal**

Run time in seconds vs. Number of 850 MHz Blue Gene cores
Status

- Deterministic computation (for now)
  - All I/O up front
- Experimental infrastructure
  - Restricted x86 simulator
  - MPI on laptop / Blue Gene
- Search programs
- Simple Bayesian predictor