Introduction to Embedded Systems Research: Notes on Reliability

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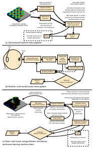
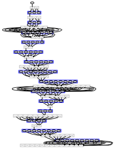
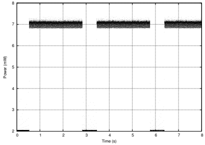
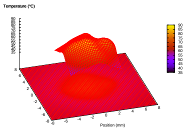
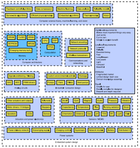










Outline

1. Action items
2. Reliability

Action items I

17 Oct: R. P. Dick, L. Shang, M. Wolf, and S.-W. Yang, "Embedded Intelligence in the Internet-of-Things," *IEEE Design & Test of Computers*, Dec. 2019.

22 Oct: Start B. Widrow and M. A. Lehr, "30 years of adaptive neural networks: Perceptron, Madaline, and backpropagation," *Proc. IEEE*, vol. 78, no. 9, Sept. 1990.

24 Oct: Finish and present B. Widrow and M. A. Lehr, "30 years of adaptive neural networks: Perceptron, Madaline, and backpropagation," *Proc. IEEE*, vol. 78, no. 9, Sept. 1990.

25 Oct: Project checkpoint 1.

29 Oct: Y. Zhu, A. Samajdar, M. Mattina, and P. Whatmough, "Euphrates: Algorithm-SoC co-design for low-power mobile continuous vision," arXiv, Tech. Rep., Apr. 2018.

Action items II

5 Nov: B. Chatterjee, D. Das, S. Maity, and S. Sen, "RF-PUF: Enhancing IoT security through authentication of wireless nodes using in-situ machine learning," *IEEE Internet of Things J.*, vol. 6, no. 1, Feb. 2019.

7 Nov: S. Kato, S. Tokunaga, Y. Maruyama, S. Maeda, M. Hirabayashi, and Y. Kitsukawa, "Autoware on board: Enabling autonomous vehicles with embedded systems," in *Proc. Int. Conf. on Cyber-Physical Systems*, Apr. 2018.

14 Nov: Project checkpoint 2.

Outline

1. Action items
2. Reliability

Testing

- 64-bit adder $\rightarrow 2^{128}$ input vectors.
- Coverage is imperfect.
- Control inputs.
- Observability via outputs / probe points.
- Single stuck-at fault model.
- Scan chain.

Formal Methods and Model Checking

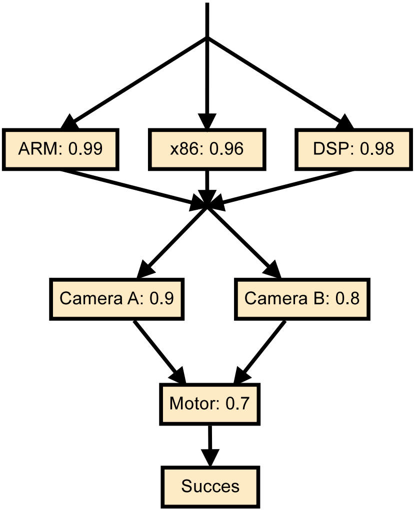
Requires formal specification and property descriptions.

Exhaustively prove that certain properties hold for all input vectors.

Theorem providing, SAT solving, etc.

Computatuonally expensive.

Reliability modeling



General reliability calculations

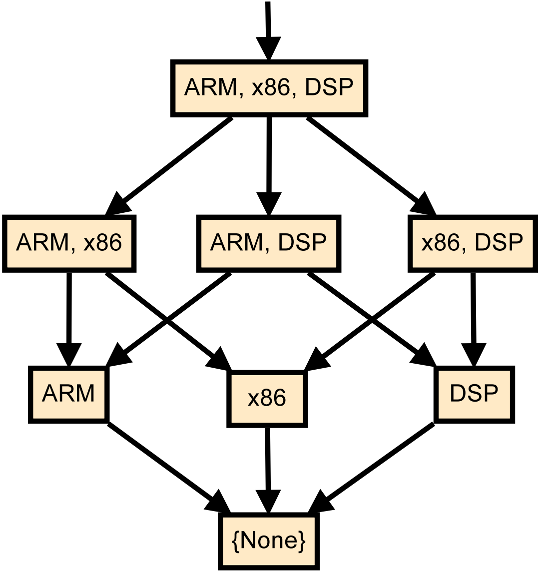
ARM 0.99	x86 0.96	DSP 0.98	Stage success	Probability
0	0	0	0	$0.01 \cdot 0.04 \cdot 0.02 = 8 \times 10^{-6}$
0	0	1	1	$0.01 \cdot 0.04 \cdot 0.98 = 0.00039$
0	1	0	1	$0.01 \cdot 0.96 \cdot 0.02 = 0.00019$
0	1	1	1	$0.01 \cdot 0.96 \cdot 0.98 = 0.0094$
1	0	0	1	$0.99 \cdot 0.04 \cdot 0.02 = 0.00079$
1	0	1	1	$0.99 \cdot 0.04 \cdot 0.98 = 0.039$
1	1	0	1	$0.99 \cdot 0.96 \cdot 0.02 = 0.019$
1	1	1	1	$0.99 \cdot 0.96 \cdot 0.98 = 0.93$

Shortcuts for parallel and series

Parallel: $P_{succeed,sys} = 1 - \prod_{i \in N} (1 - P_{succeed,i})$.

Series: $P_{succeed,sys} = \prod_{i \in N} P_{succeed,i}$.

Fault lattice



Fault lattice exploration

Fault lattice size in number of components?

Exhaustive exploration often computationally intractable.

Monte Carlo variants.