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Unintrusive Aging Analysis based on Offline Learning

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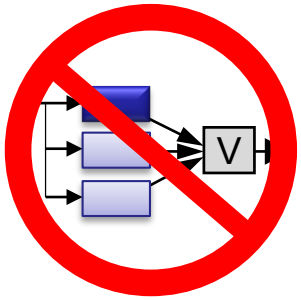
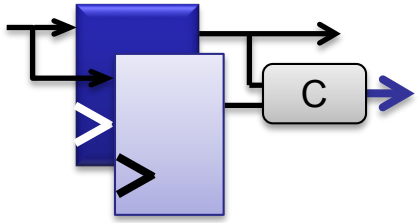
Motivation

- Aging of integrated systems of rising importance
- But:
  - (Still) less critical for customer applications
  - Interest in low weight solutions (S.M.A.R.T. for HDDs, …)
- This work:
  - Low-weight aging monitoring / remaining lifetime prediction
  - Based on (offline) learning

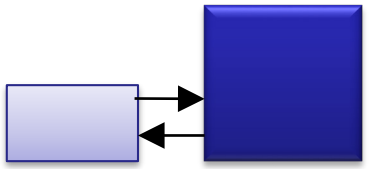


Aging Monitoring

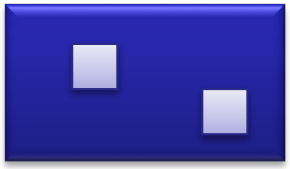
- **In-situ slack sensors**
  - Detection / preview of failing timing
  - Added invasively to (selected) critical paths



- **Online self-testing**
  - Built-In Self-Test (BIST) during test mode
  - Additional circuitry (Scan chains, …)

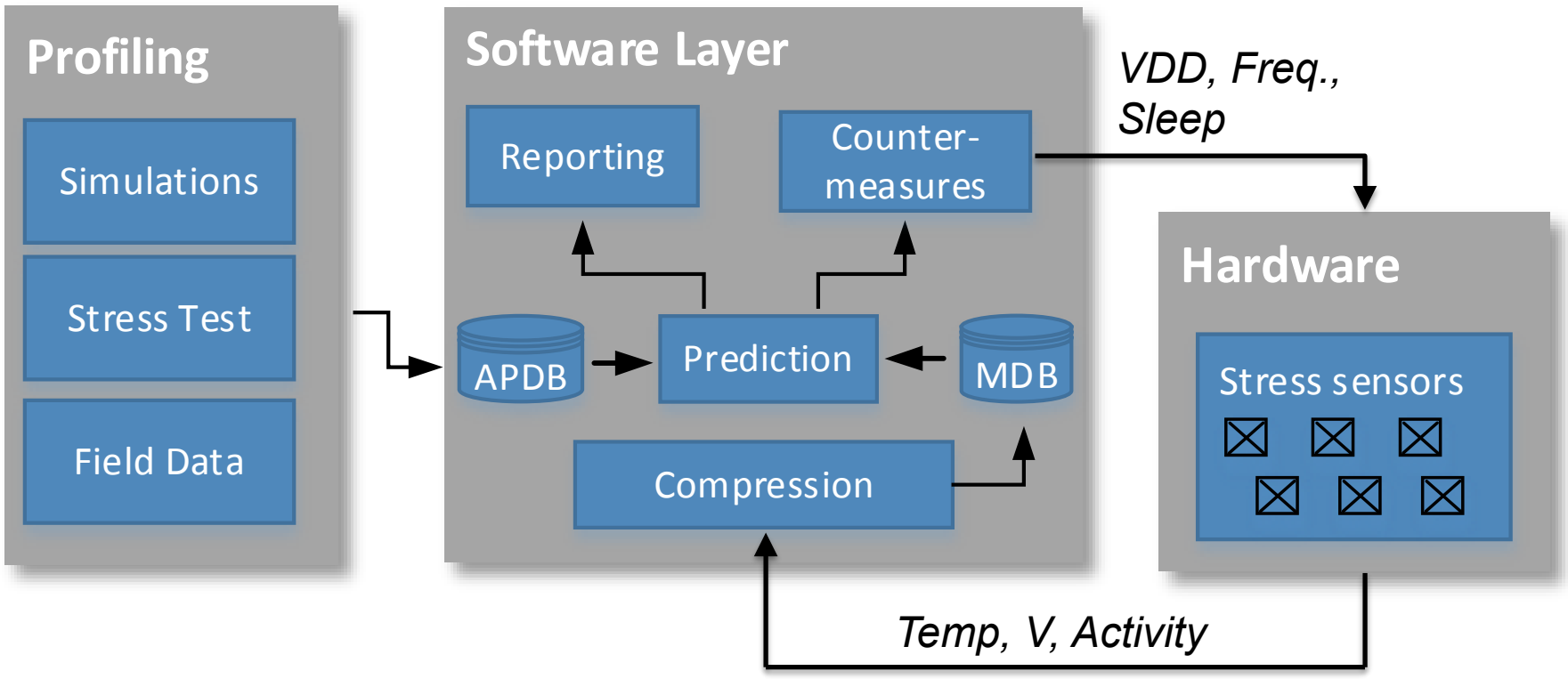


- **Aging sensors**
  - Report experienced aging
  - Ignores system's activity



Unintrusive Aging Analysis

Architecture

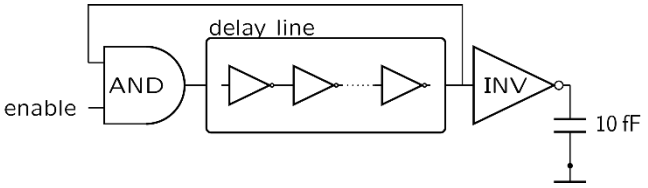


- APDB, MDB: Databases

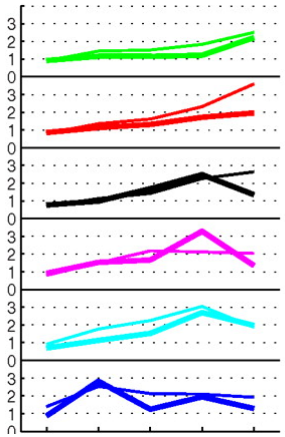
Unintrusive Aging Analysis

Profiling

- **Sensors**
  - Temperature, voltage, activity, …
  - Low area offset, unintrusive



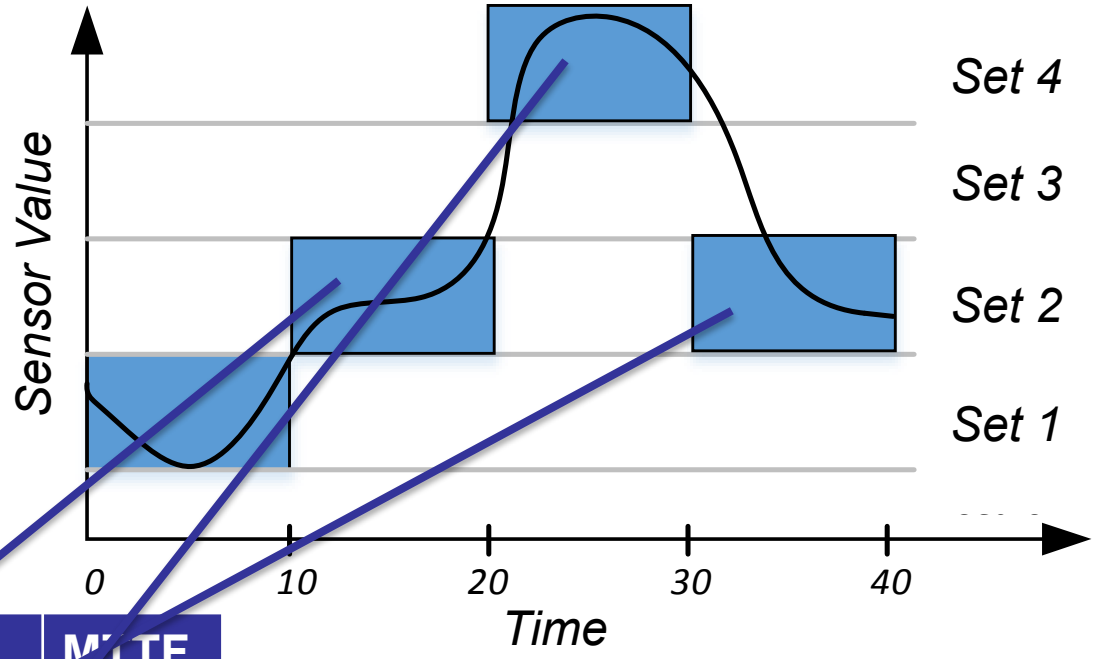
- **Profiling**
  - Simulations
    - Aging characterization at design time
    - Various scenarios (Temp, VDD, activity, …)
    - Parameter can vary
  - Also possible: Data from stress test / field



Unintrusive Aging Analysis

Compression and Profile Storage

- Compression of simulated / measured data
- Insertion in Databases



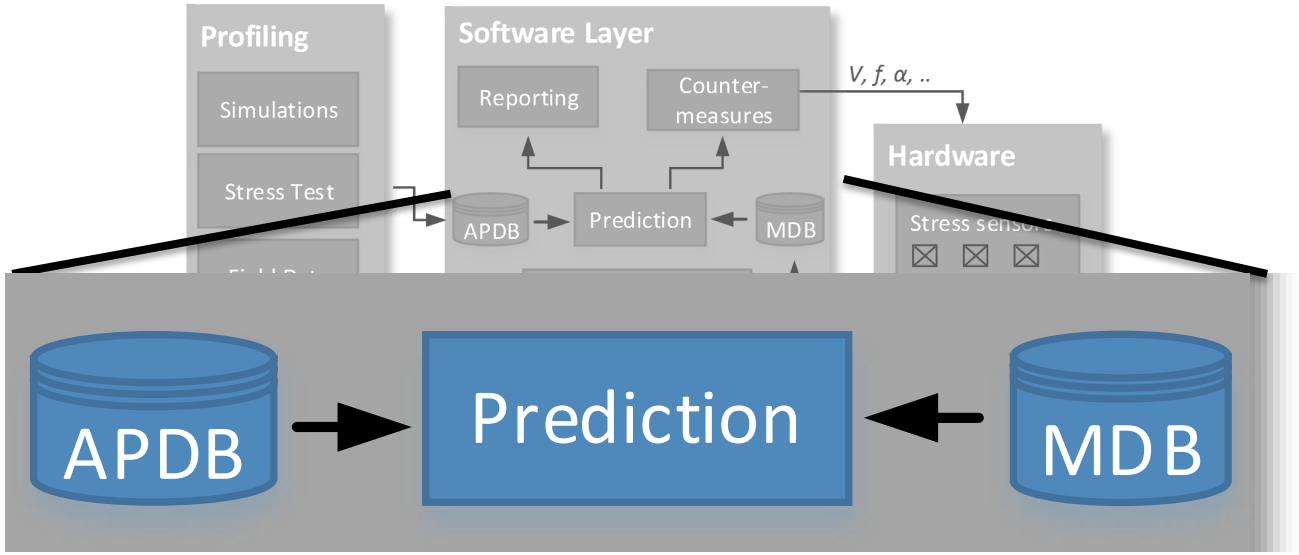
…	Sensor $S_{T,4}$			…	MTTF
	in Set 0 [%]	…	in Set 4 [%]		
	20 %		32 %		2e2 h

- Data bases for
  - Profile Data (APDB)
  - Measured Data (MDB)

MTTF – Mean Time To Failure

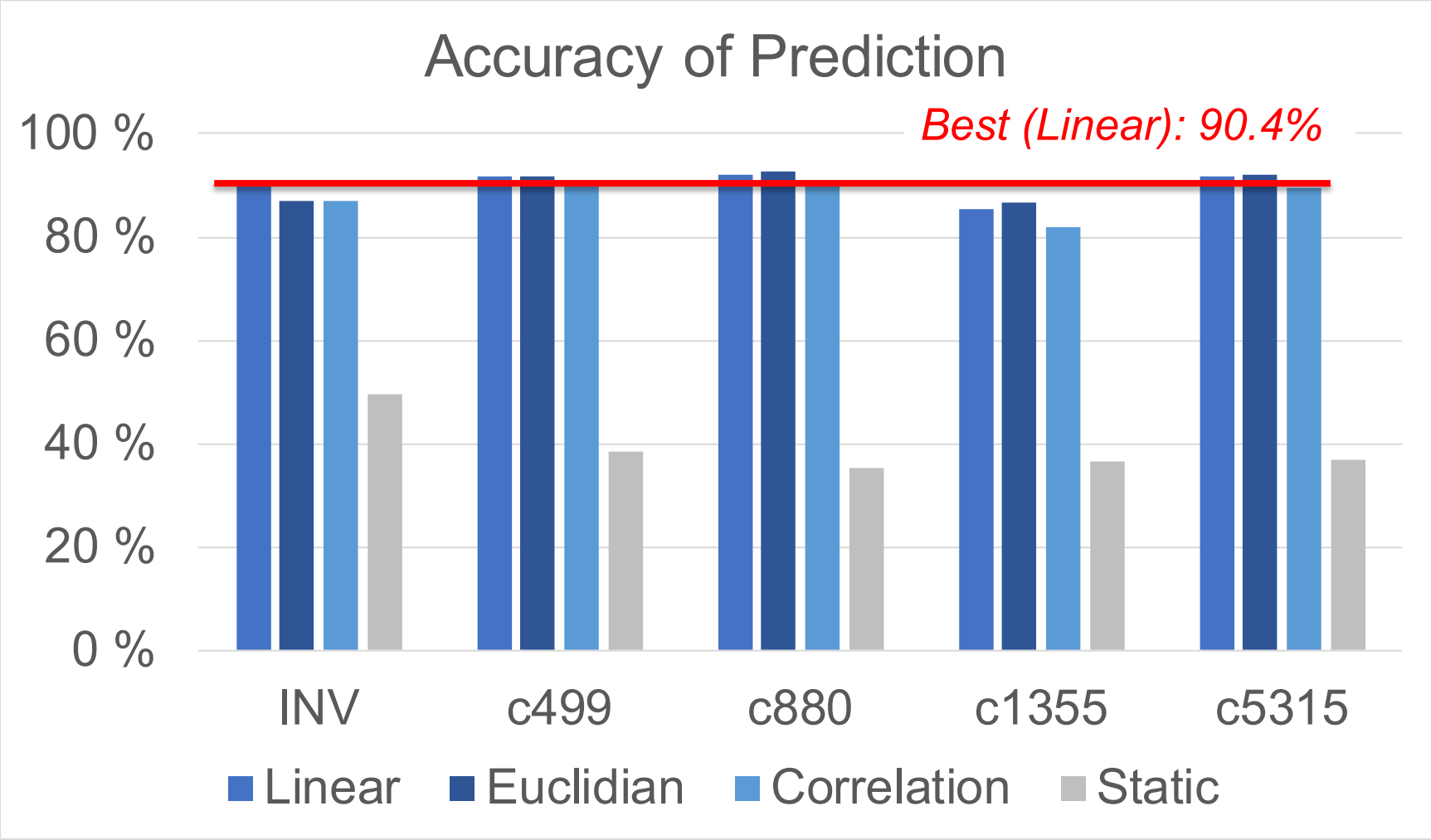
Unintrusive Aging Analysis

Prediction Models



- **Prediction**
  - Relate Measured data (MDB) to Profiling Data (APDB) for prediction of current Remaining Useful Lifetime (RUL)
  - Three Models (Linear, Euclidean Distance, Correlation)

Results


Accuracy of Prediction
Best (Linear): 90.4%
100 %
80 %
60 %
40 %
20 %
0 %
INV
c499
c880
c1355
c5315
Linear
Euclidian
Correlation
Static

Conclusions

- Methodology for low weight prediction of aging of integrated systems
- Application of profiling data
- Consideration of varying parameters
- Simulation results: Prediction accuracy ca. 90 %
  → Not exact but
  - Enables proactive counter measurements
  - User can be warned

Unintrusive Aging Analysis based on Offline Learning

Thank you!

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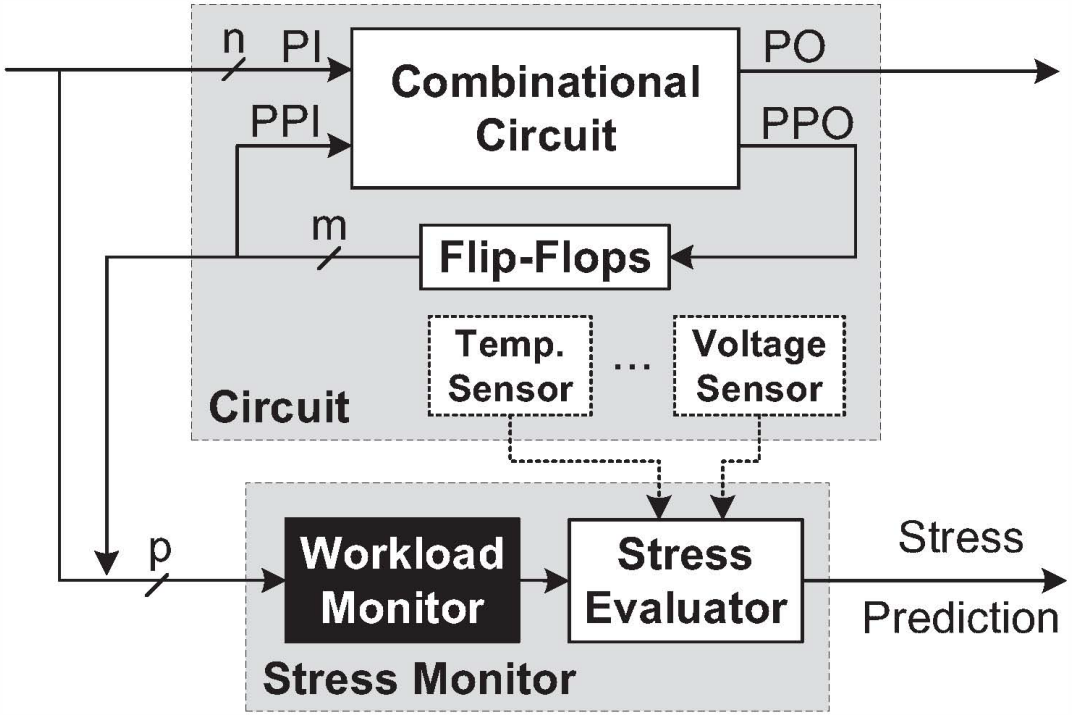
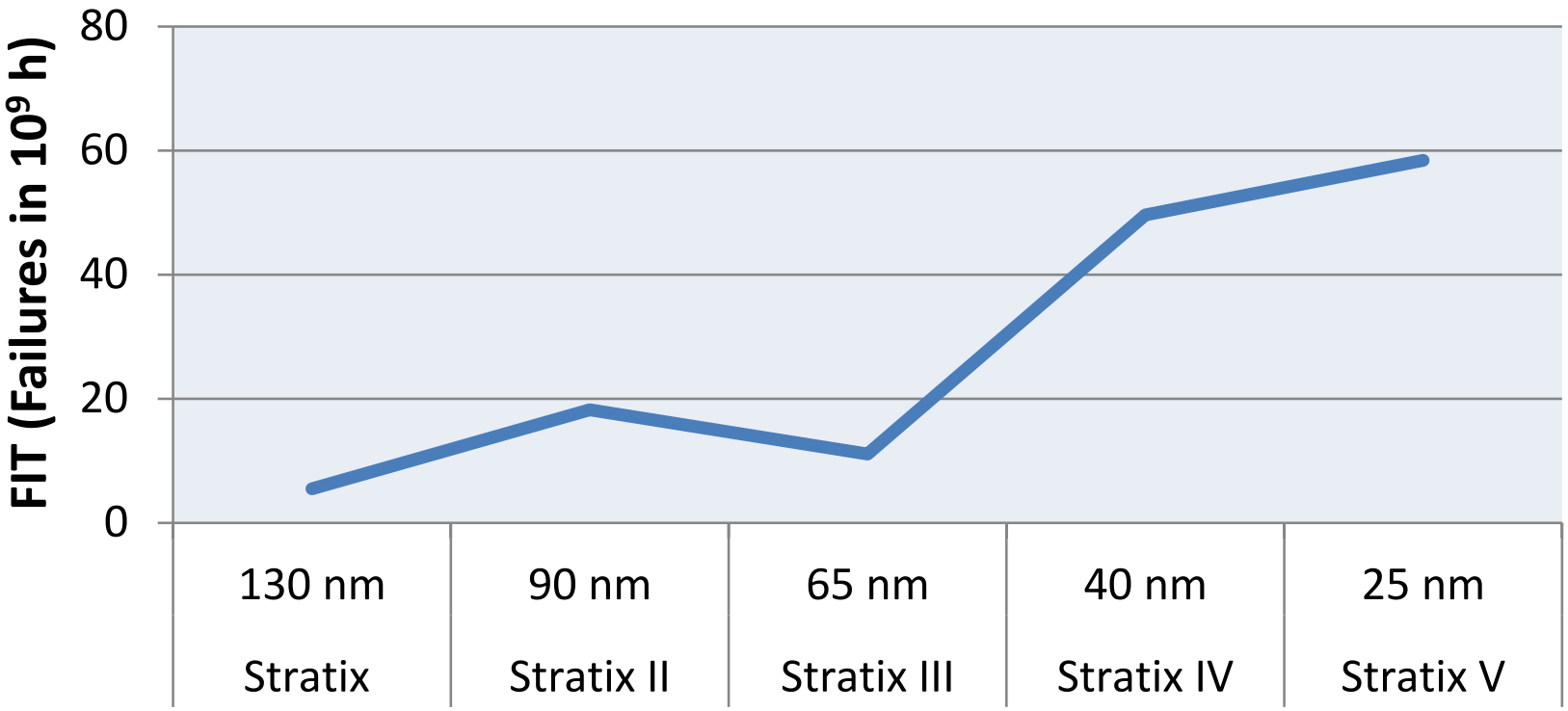
Activity Sensor

- [7] R. Baranowski, et al., "On-line prediction of NBTI-induced aging rates," in DATE 2015, pp. 589-592.
- Monitoring of switching activity of the circuit's primary inputs (PI) or pseudo-primary inputs (PPI)



Aging



Altera, RELIABILITY REPORT 56, 2013