Neighbor-cell Assisted Error Correction for MLC NAND Flash Memories

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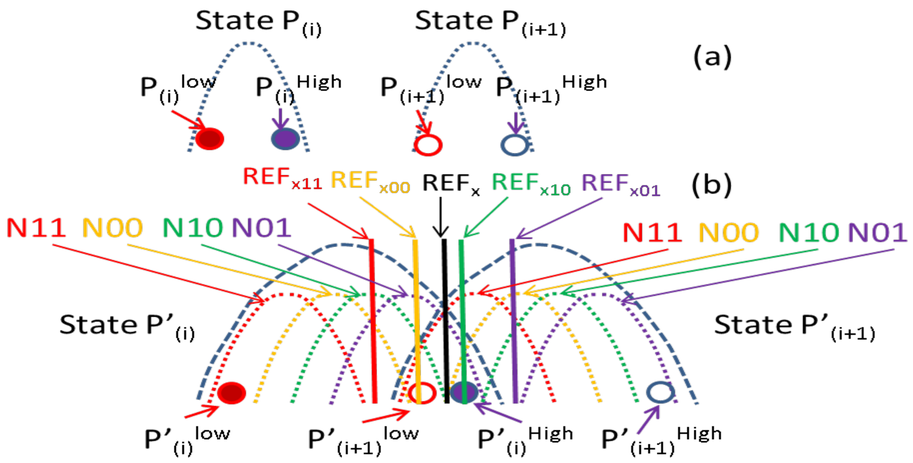
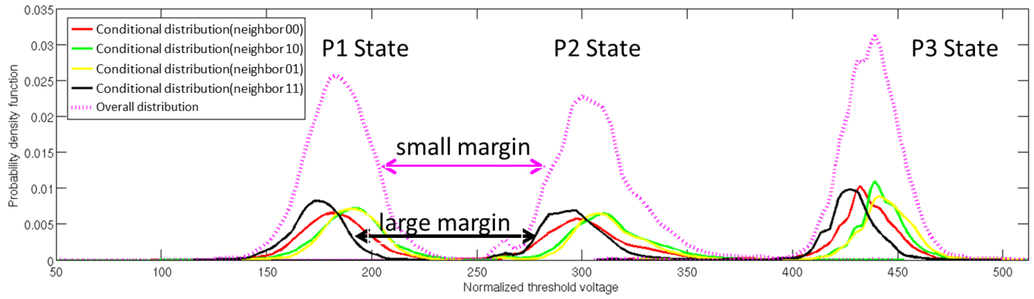
Motivation & Background



Measurement and Analysis

1. **Optimum read reference voltage at cross point of neighbor states**
2. **Minimum BER can be achieved with optimum reading**
3. **Conditional distribution has similar distance but smaller variance than overall reading**
4. **Read with conditional distribution achieves smaller minimum raw BER than read with overall distribution**



Distribution distance

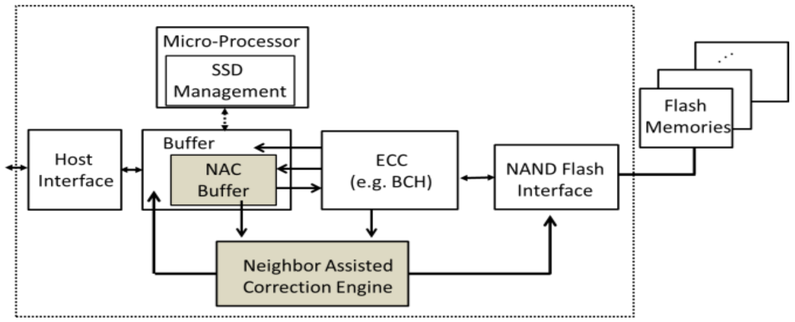
$$E(X^{P(i+1)}) - E(X^{P(i)}) = \frac{1}{N}\sum (E(x_m^{P(i+1)}) - E(x_m^{P(i)}))$$

Distribution variance

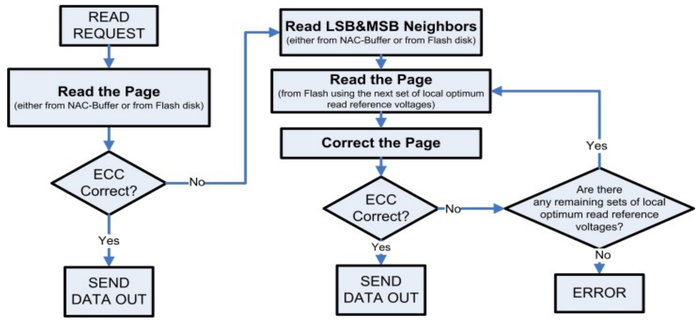
$$Var(X) = \frac{1}{N}\sum Var(x_m) + \frac{1}{N^2}\sum\sum (E(x_m) - E(x_n))^2$$

	Overall	x_{11} (ER)	x_{10} (P1)	x_{00} (P2)	X_{01} (P3)
Distance	65.4	65.4	64.7	66.4	65.8
Variance	385.9	286.2	256.7	242.8	252.1
SNR	3.4	3.8	3.9	4.2	4.1
BER	$3x10^{-4}$	$7x10^{-5}$	$5x10^{-5}$	$2x10^{-5}$	$3x10^{-5}$

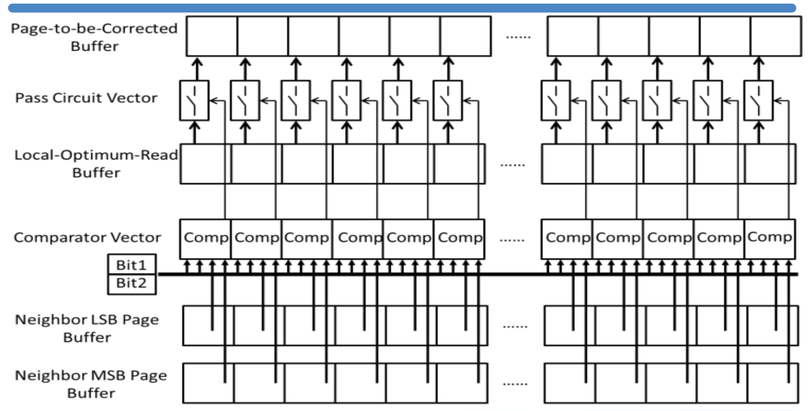
NAC inside SSD



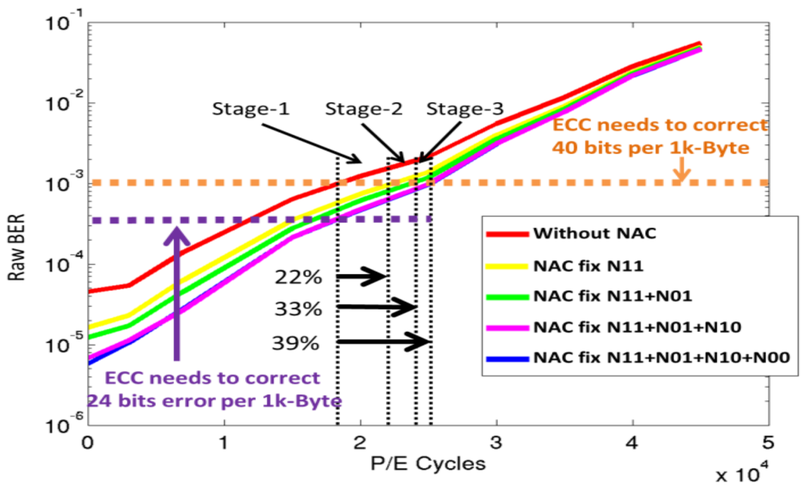
Flow of NAC



NAC Microarchitecture

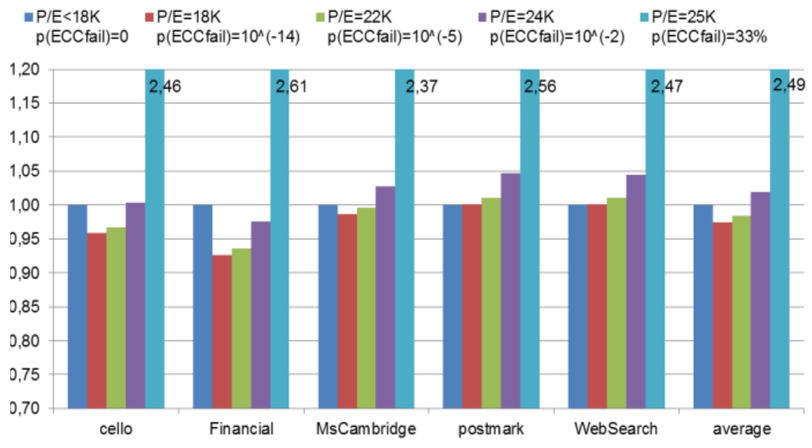


Key Results: Lifetime extension and performance evaluation



Lifetime extension: up to 39%

ECC relaxation: reduce cost by 40%



Within nominal lifetime: **No performance degradation**

Extended lifetime: **Less than 5% performance overhead**