



# NAND Flash Considerations for Consumer Applications

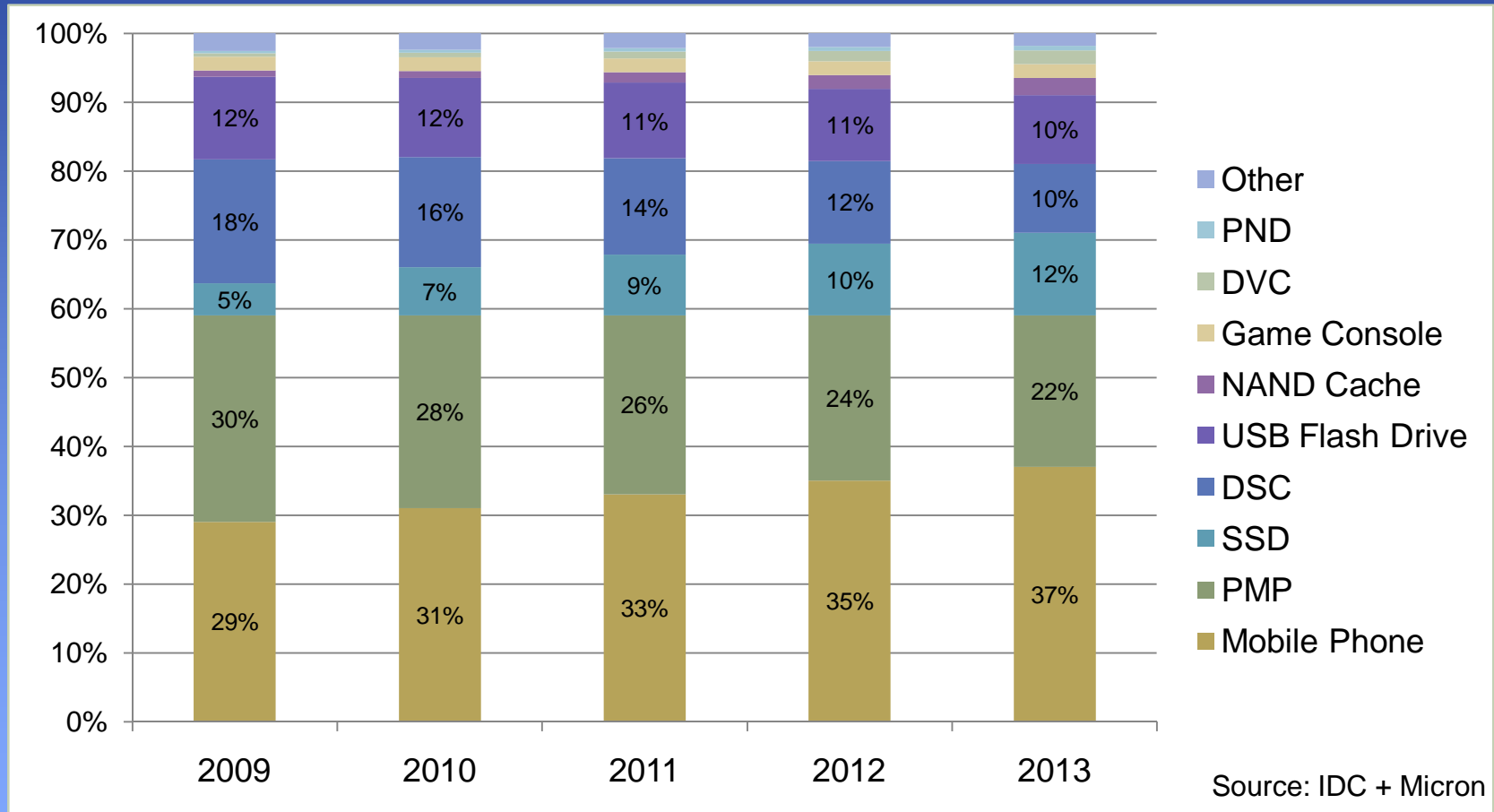
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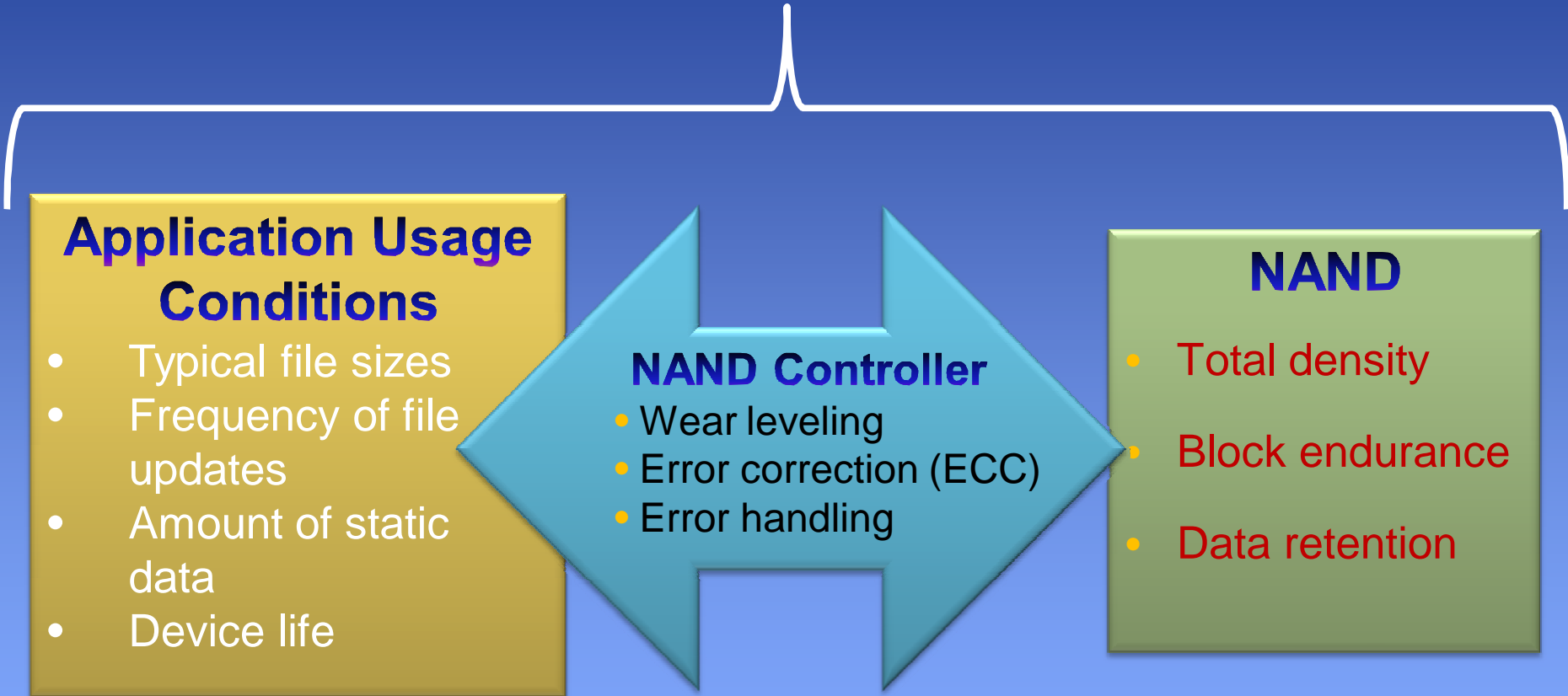
## Agenda

- NAND in consumer applications
- Overall system reliability
- NAND requirements
- MP3/PMP example
- Summary

# NAND Bit Share by Application



# Overall System Reliability



NAND Plays a Limited Role

## System Reliability: Application Usage Conditions

- *How* the system is used significantly impacts overall system reliability
- Primary contributor is frequency of file updates (workload)
  - Heavier workloads require more NAND endurance
  - File sizes, required device life, amount of static data also contribute
- Consider *worst-case* usage

## System Reliability: NAND Controller Factors

- Wear leveling:
  - Improves device life
  - Reduces NAND endurance requirements
- Static wear leveling is typically most effective (though rarely used!)
- Error correction code (ECC) reduces uncorrectable bit error rate
- Error handling – bit errors should not result in system-level fails



## System Reliability: NAND Flash

- NAND is adapting to meet application requirements
- Many consumer applications accept:
  - Low endurance
  - Consumer-level reliability
  - Moderate data retention
- What are adequate NAND requirements for consumer applications?

## NAND in Consumer Applications

- Application requirements should match consumer expectations
- NAND controller provides the link
  - Allows lowest-cost NAND to be used in consumer applications
  - Compensates for reduced NAND capability
- Determine actual NAND requirements



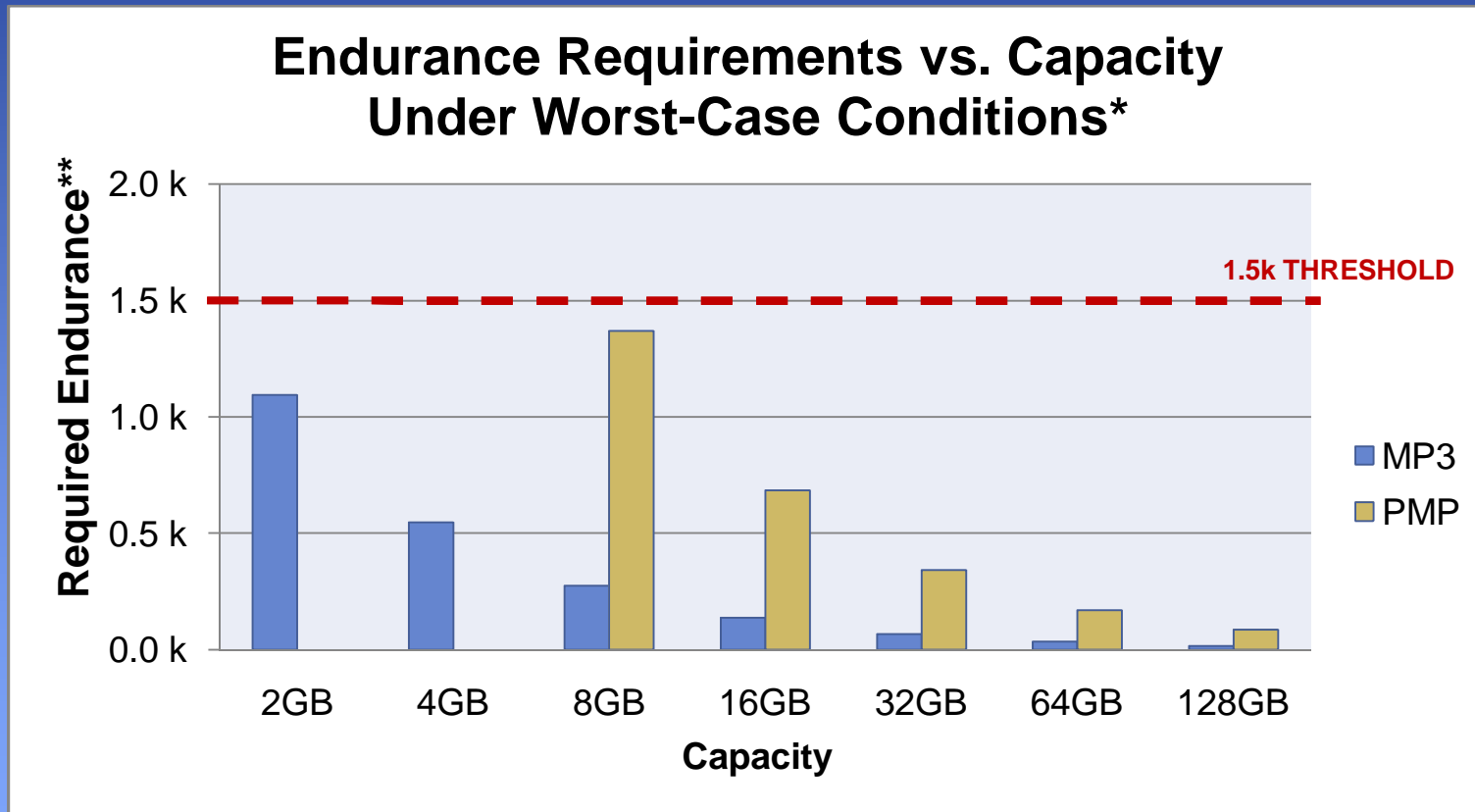
## Consumer Application Example: MP3/PMP Worst-Case Usage Condition

- 90% static data
  - Small amount of “free” capacity
- Dynamic wear leveling
  - Only “free” capacity is included in wear leveling
- “Very heavy” daily workload
  - MP3: end-user updates 30 songs (~2 CDs) per day for 5 years
  - PMP: end-user updates 35 songs per day + 7 movies per month for 5 years

# MP3/PMP NAND Endurance

	Usage Scenario (Static data + dynamic data)	Capacity	Life	Daily Workload (Dynamic data: user data + FAT, etc.)	Required Endurance (with worst-case wear leveling)
<b>MP3</b>	<b>Static (90%):</b> 3.6GB (~950 songs, 4MB/song) + <b>Dynamic (10%):</b> 20/60/120MB per day	4GB	5 year	20MB (moderate usage, 5 songs per day)	<b>91 cycles</b>
				60MB (heavy usage, 15 songs per day)	<b>274 cycles</b>
				120MB (very heavy usage, 30 songs per day)	<b>548 cycles</b>
<b>PMP</b>	<b>Static (90%):</b> 7.2GB (~500 songs, 4MB/song + 2 movies, 2GB/movie) + <b>Dynamic (10%):</b> 100/300/600MB per day	8GB	5 year	100MB (moderate usage, 9 songs per day + 1 movie per month)	<b>228 cycles</b>
				300MB (heavy usage, 25 songs per day + 3 movies per month)	<b>684 cycles</b>
				600MB (very heavy usage, 35 songs per day + 7 movies per month)	<b>1369 cycles</b>

# MP3/PMP: Endurance vs. Capacity



\* Conditions: 90% static data, dynamic wear leveling, very heavy workload, 5-year life

\*\* Calculation used:  $\text{endurance} = (5 \text{ years} \times 365 \text{ days/year}) \div ([\text{Capacity} \times 10\%] \div \text{Daily workload})$

## Summary

- Consumer applications drive NAND technology
- Controller helps compensate NAND capabilities
- NAND generally meets or exceeds requirements for consumer applications