Intelligent Secure Storage for Industrial IoT
Creating Reliable Embedded Systems with Flash Memory

Design Tools for IoT Storage

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The Market / Challenge
Industrial IoT Use Cases
25B+ connected devices by 2020, many generating a data package every millisecond

- **Transportation / Aviation**
  2.5PB of data per flight

- **Industrial Automation**
  10 Billion samples per day

- **Energy (Oil & Gas, Metering)**
  2-8TB of data per day

- **Asset Tracking / Supply Chain**
  4 Billion data messages per day

- **IoT Storage Capacity**
  87 exabytes shipped by 2021
NAND Flash Landscape
An arms race (that may not benefit Industrial IoT)

- Big move to 3D with many transitions on horizon
  - 64L $\rightarrow$ 96L $\rightarrow$ 128L
  - MLC $\rightarrow$ TLC $\rightarrow$ QLC
- Primary focus on capacity, enterprise/client data
- TBW typically decreases
- Offerings short-lived

<table>
<thead>
<tr>
<th>Manufacturers</th>
<th>2014</th>
<th>2015</th>
<th>1H16</th>
<th>2H16</th>
<th>1H17</th>
<th>2H17</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
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</thead>
<tbody>
<tr>
<td><strong>SAMSUNG</strong></td>
<td>18nm</td>
<td>16nm</td>
<td>14nm</td>
<td>16nm</td>
<td>14nm</td>
<td>128L</td>
<td>256L / Stack</td>
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<tr>
<td><strong>3D V-NAND</strong></td>
<td>32L</td>
<td>48L</td>
<td>64L</td>
<td>64L</td>
<td>96L(or 128L)</td>
<td>256L</td>
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<tr>
<td><strong>TOSHIBA</strong></td>
<td>18nm</td>
<td>9nm</td>
<td>12nm (2)</td>
<td>12nm (2)</td>
<td>12nm (2)</td>
<td>256L</td>
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<tr>
<td><strong>Western Digital</strong></td>
<td>16nm</td>
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<td><strong>Micron</strong></td>
<td>32(Gen1)</td>
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<tr>
<td><strong>NAND</strong></td>
<td>64(Multi-Stack, QuantM, Micron)</td>
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<tr>
<td><strong>SK hynix</strong></td>
<td>15nm</td>
<td>16nm</td>
<td>14nm</td>
<td>12nm (2)</td>
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<td>256L</td>
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<tr>
<td><strong>3D NAND</strong></td>
<td>38L(V2)</td>
<td>48L(V3)</td>
<td>72L(V4)</td>
<td>128L</td>
<td>256L</td>
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</tbody>
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Industrial Embedded Technology for Our Interconnected World
3D NAND Attributes
Improvements over 2D but with some challenges

➢ 3D NAND’s charge trap has it’s advantages
  • Scalable to larger capacities
  • Faster read/write operations
  • Lower energy consumption

➢ But…some disadvantages
  • Charge loss issues can result in lower data retention, especially at temperature

Visibility to workload and temp effects on data retention important
Data Retention & Temperature
A persistent problem getting worse?

- 2D MLC exhibits significant data retention loss at higher temps
- Will 3D TLC be better, same or worse?
  - Charge loss an inherent issue that increases with temp
  - Can cause a large increase in RBER unless controller can shift read voltage to compensate for charge loss

Visibility to data retention critical for reliable SSD deployment
Characteristics of Industrial IoT

Industrial IoT is different

- IoT workloads very demanding
- Capacity requirements lower
- Service life / availability 5+ years
- Subjected to extreme temps
- Monitoring & predictive maintenance provide high ROI

SSD selection is key!
Industrial IoT Impact on Storage
Premature wear-out a concern, visibility key to addressing

- IoT data is demanding
  - Typically small-sector, random, and unaligned
  - Coming 24/7/365, often milliseconds at a time
  - Stored locally for years at a time, often at high temp

- Can drive write amplification up by factor of 8 (or more)

Monitor and Adapt
- Increase overprovisioning
- Block vs. Page mapping
- Data alignment
- Use more durable NAND
Visibility to affects on SSD gives some control
• Adapting to workloads can increase endurance
• Optimizing software may be best overall solution

If all else fails….
• Model application affects during qualification
• Predict when maintenance is needed
Common SSD attributes worth monitoring

- Temperature (junction and ambient)
- Data Retention (how long, unpowered and at temperature)
- How changes in software / workload can affect endurance

Tools should be easy to use for quick evaluation

- APIs for integration into existing software
- Open source for monitoring/mgt of any SSD
vtView Monitoring & Management
Good tools make for good decisions

Engineering
- Visualize workload and software impacts on endurance
- Visualize advanced features (TRIM) effects on endurance

Test Automation & System Regression
- Automate SSD testing and perform in-system regression analysis
- Compare effects of software / firmware changes to workload and endurance (don’t be surprised)

Field Service
- Provide historical data for understanding of field usage (workload, temp, errors)
- Allows for quicker debugging and problem identification
Storage Life Monitoring
Predictive Maintenance

vtView

Analyze / predict storage life based on actual usage

Push notifications and firmware updates

Set thresholds and alerts
Conclusion
Failing to plan is planning to fail

- Reliance on datasheets and controller/FW is not enough
- Know how your application affects storage
- Model/Simulate app workloads to identify best storage solution at project outset
- Select storage and software/utilities that are flexible, scalable, and provide best TCO
Thank You!