SD cards in the Internet of Things

for Flash Memory Summit_SD Association
Table of content

- IoT Overview
  - Market trend
  - Industrial IoT applications

- Why SD card for IoT devices

- Challenges
  - Environment consideration
  - Data consideration (write/read)
  - Product longevity

- Mitigation planning
  - Solutions – Small yet Robustness
  - Solutions – Health Monitoring Software
  - Solutions – Advanced Technologies
  - Solutions – Rigorous Testing
  - Solutions - Supply chain Risk Aversion
The Internet of Things (IoT)

IoT, Connecting vast network of physical devices, systems, and services, intelligently capturing data, and seamlessly exchanging data to vital insight without human-human or human-computer interaction.

- **Market trend:**
  
  By 2020, market for **connect devices** will grow to **20 or 30 billion** units.
  
  By 2025, **IoT impact** on the global economy could reach **$6.2 trillion**.

(Source: McKinsey Global Institute)
IoT - Industry Applications (ATP focus mission-critical ones)

**Overview**

**Industrial (Manuf.)**
- Optimized Automation
- Manufacturing Process Control

**Transportation**
- Vehicles Communication
- Fleet / Traffic Control
- Logistics

**Healthcare**
- Remote Health Monitoring
- Geriatrics Care
- Tele Health

**Retail**
- Digital Signage & Advertising
- Retail/Hospitality Kiosk & POS

**Safety & Security**
- Surveillance
- Disaster Management
- Emergency Service

**Utilities**
- Smart Grid
- Water, Energy
- Waste
The perfect fit for IoT hardware – SD card

### Why?

<table>
<thead>
<tr>
<th>Demands [ IoT hardware ]</th>
<th>Characteristics [ SD memory cards ]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Space Limitation</strong></td>
<td>• Small and removable form factor</td>
</tr>
<tr>
<td></td>
<td>• Available in full size SD and microSD</td>
</tr>
<tr>
<td><strong>High Demanding</strong></td>
<td>• Compact build, dust /water and ESD resistance</td>
</tr>
<tr>
<td>Harsh environment</td>
<td>• Low power consumption</td>
</tr>
<tr>
<td>Real-time data transmission</td>
<td>• High throughput performance</td>
</tr>
<tr>
<td><strong>Reliable</strong></td>
<td>• Detect and error mitigation algorithms to distribute wear and enhance endurance and lifetime</td>
</tr>
<tr>
<td></td>
<td>• Wide operating and storage temperature range</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>• Digital content security and protection</td>
</tr>
</tbody>
</table>
Operating under harsh conditions

Devices in the enterprise and industry/infrastructure IoT ecosystem will typically face more extreme challenges, specifically operational and environmental conditions:

- Extreme temperature (e.g.: Heat/High temp cause data retention issue)
- Humidity
- Pressure
- Shock and vibration
- Ambient radiation
- Power supply instability
IoT Challenges – Data Consideration (Write)

- **Frequent Write Small-file Data**, typically in bytes ( < 1 page size ):

  - **Write Amplification Issue**
    - Frequently writing files < NAND page size
    - Used data area > Real data
    - High Write Amplification

  ![Diagram of NAND flash writing]

  - ‘Wear’ of NAND flash
  - Endurance & Usable life

  - 128 Writable Pages in 1 erasable Block

  Note: NAND flash is programmed at the page level and erased at the block level.
IoT Challenges – Data Consideration (Read)

- **Frequent Read Operation System**
  - **Read Disturb Risk**
    - Frequently reading without regular wear-leveled write operations
  - Data corruption

- **Seldom Read Application Program**
  - **Data Retention Concerns**
    - Loss charge its voltage level over time
    - High pre-condition of write/erase cycles
    - High ambient temperature
  - Data corruption
IoT Challenges – Product Longevity

- **Long Term Product Stability**
  - **BOM issue**
    A variation in firmware may result in how the controller conducts NAND flash management or specific reliability features.
  - **Dynamic NAND Industry**
    A roadmap presented during initial qualification is very likely to change due to market influences and process yield/maturity
  - **NAND die changes ➔ Changes in reliability**
    The changes may impact long term reliability of your usage model/IoT devices
Solution – Small yet Robustness

- System-In-Package Memory Card Manufacturing
  - Enhanced durability features
    - Water proof
    - Dust proof
    - Shock resistance
    - ESD resistance
  - Wafer/die level BOM control
    - Controlled die/stacking configuration
    - IC packaging level application specific design

IPx7: Water Proof Test
IP5x (microSD) IP6x (SD):
Dust proof test
Solutions – Advanced Technologies

- Multiple ISP and Link table back-up
- Advanced Wear-leveling
  - Block management
  - Optimizing writing files
- Power Failure Protection
- Endurance Protector
- Read Protector
- Retention Protector
- AutoRefresh
  - Actively monitor ECC
  - Auto refresh data
- AutoScan
  - Background check of non-accessed area
- High Reliability

Overview | Why SD Card | Challenges | Mitigation Planning
Solutions – Health monitoring software

- The availability of NAND flash wear and health status monitoring tools and development APIs across typical IoT platforms can be beneficial to the designer and operator alike
  
  - **SD Life Monitor**

Integrated ATP tool to **Linux** Embedded / Industrial system software (Open source Linux is more popular)
Solution – Rigorous Testing

- Optimize SD card for IoT applications:

  Ensuring the reliability of new NAND die
  - Enhanced IC level validation (reliability and functionality)

  Client-vendor joint platform/device validation
  - Improved SD card protocol and signal validation testing
  - Compatibility for new device/card level/host platform validation
  - Knowledge acquisition and transfer for dynamic process improvement

- 100% Burn-In Test
  - Screen out defects and assure complete reliability at scale
Solution - Supply Chain Risk Aversion

- **BOM Control**
  - Required firmware controller and firmware setting level BOM control

- **Long Term Partnership of Key suppliers**
  - Regularly roadmaps & BOM plan updates from NAND product supplier to avoid surprises
  - Work closely with NAND product supplier for smooth qualifications and transitions in supply chain
ATP, Place Highest Value to Serve Your IoT
Flash Memory Summit Conference
Session 302-E: Testing Issues
9:45~10:50, 13th, August
Embedded SSD Product Challenges and Mitigation

Visit ATP at Booth No. 729