SD cards in the Internet of Things

for Flash Memory Summit_SD Association

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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)

Industrial (Manuf.)

- Optimized Automation
- Manufacturing Process Control

Retail

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

Transportation

- Vehicles Communication
- Fleet / Traffic Control
- Logistics

Safety & Security

- Surveillance
- Disaster Management
- Emergency Service

Healthcare

- Remote Health Monitoring
- Geriatrics Care
- Tele Health

Utilities

- Smart Grid
- Water , Energy
- Waste

IoT Hardware and SD Card

The perfect fit for IoT hardware – SD card

- **Why?**

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

IoT Challenges – Environment Consideration

- **Operating under harsh conditions**

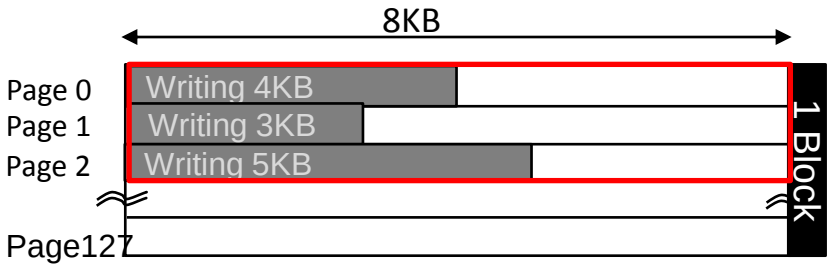
  Devices in the enterprise and industry/infrastructure IoT ecosystem will typically face more extreme challenges, specifically operational and environmental conditions:

  - 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

→ ↑ ‘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.

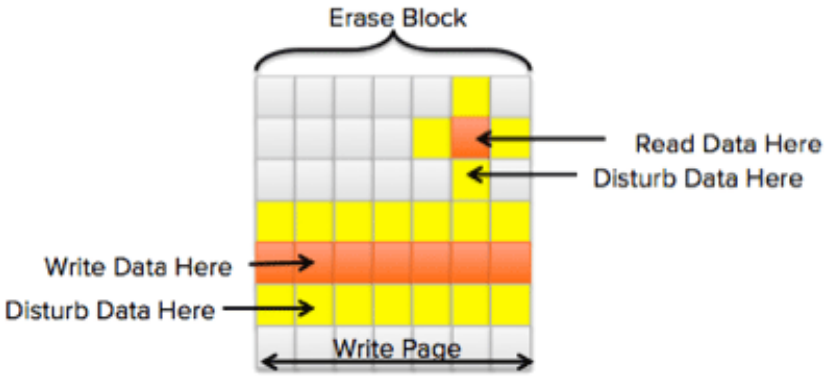
IoT Challenges – Data Consideration (Read)

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

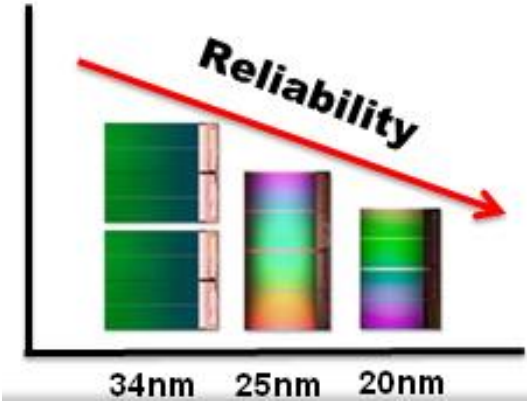
A variation in firmware may result in how the controller conducts NAND flash management or specific reliability features.

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



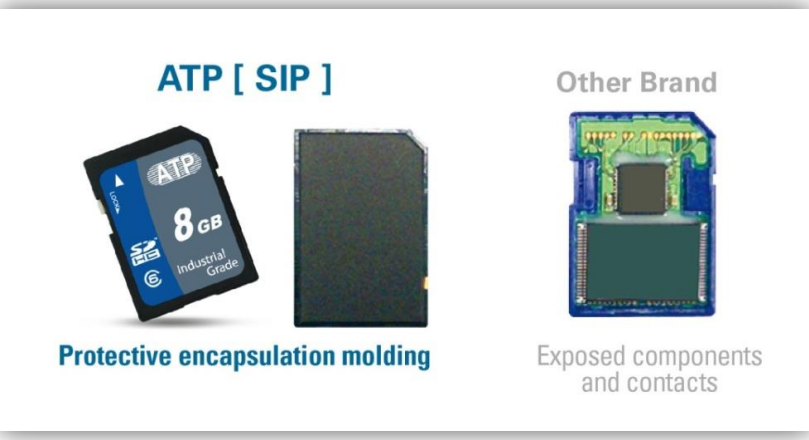
Solution – Small yet Robustness

- **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

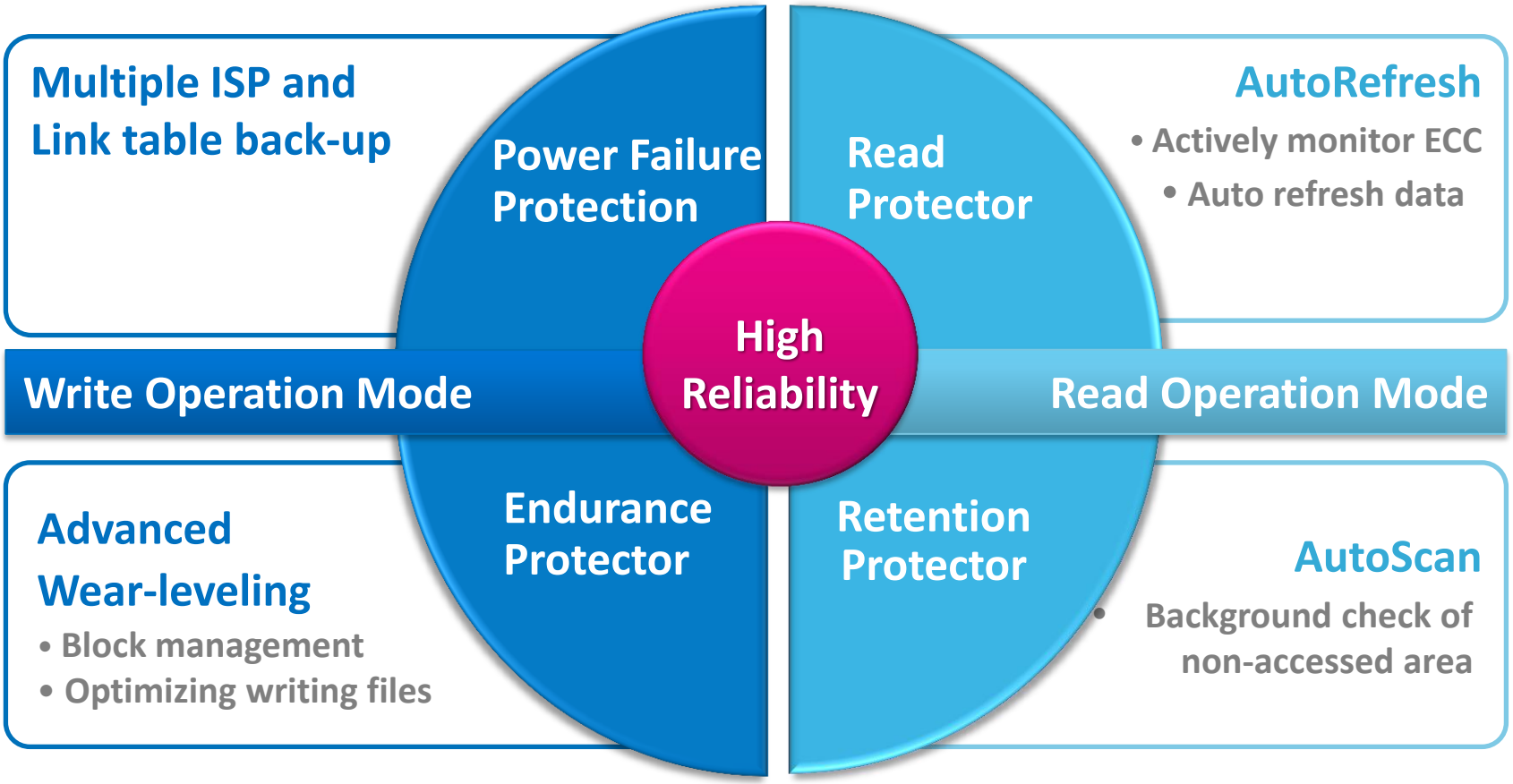
IP5x (microSD) IP6x (SD):

Dust proof test



Solutions –Advanced Technologies

Advanced Technologies



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

```
1)device AF UD appears on /dev/sg1
 [INFORMATION SUMMARY].
   Flash Brand:                          Micron
   Flash Type:                             SLC
   Later Bad Block Count:                    0
   Average Erase Count:                      2
   Total Erase Count:                     6059
   Spare Utilization Rate[%]:              >20
   NAND Flash Default Endurance:          60000
   Remaining Life[%]:                       100
```

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

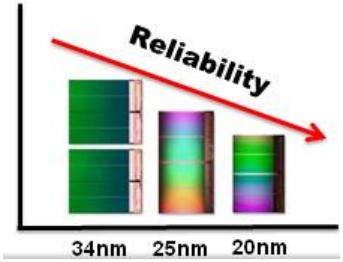
Solution – Rigorous Testing

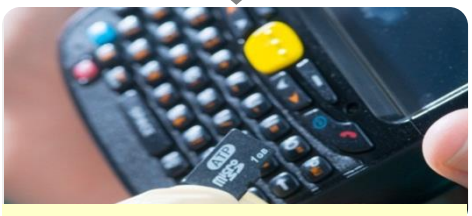
Optimize SD card for IoT applications :

NAND Flash IC Level

Ensuring the reliability of new NAND die

- Enhanced IC level validation (reliability and functionality)

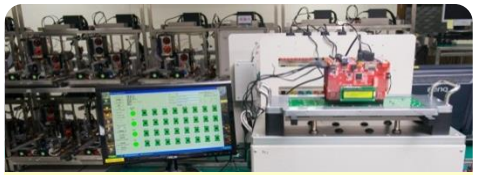




Joint Validation

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



Mass Production Level

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