Smart Storage Design for Edge Computing in Industrial IoT

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Outline

- Background: Digital World, IoT, Cloud/Distributed Computing, Data Processing, Edge Computing, …
- Key Factors in Flash Storage
- Intelligence (with ML or AI) in Flash Storage
- Security in Storage for Industrial IoT
- Application Example:
- Conclusions
Embedded Flash Storage:

- For the “Things”: Sensors, Actuators, IP Cams, I/O Controllers. (Low density)
- For the Gateway: Controller Hub, Network Gateway. (Mid Density)
- For the Server: the Cloud, Data Center. (Large/Super Density)
- Data Logger for All: (Low Density)
Facing the Data Explosion:

- Data Processing needs Computing and Storage.
- How to process and analysis data in more efficient way?
- Efficiency: Time saving, Energy saving, Material cost saving, ...
- Performance: Data traffic control, how fast to get the essential information? Content finding speed, ...
Extraction: Data => Information

Picture Data

Data Extraction

Information:
- Car Plate Number: AMG-1288
- Type: RV
- Brand: Mercedes Benz
- Model: GLK 220 CDI
- Color: Palladium Silver

Data Size ~ Million Bytes

Data Size ~ Hundred Bytes
Data Processing Scope

**Methods or tactics:**
- **Conversion**: converting data to another format.
- **Validation**: Ensuring that supplied data is clean, correct and useful.
- **Sorting**: arranging items in some sequence and/or in different sets.
- **Summarization**: reducing detail data to its main points.
- **Aggregation**: combining multiple pieces of data.
- **Analysis**: the collection, organization, categorizing, interpretation of data.

**Applications:**
- **Data Analysis**: providing the essential information for specific task.
- **Data mining**: extraction of useful and relevant data.
- **Commercial**: business, enterprise, banking, ...
- **Industrial**: manufacturing, factory automation,
- **Pattern recognition**: Human, Vehicles, specified objects, ...
Adapting the structure for operation optimization, or achieving better whole system performance.
Cloud Computing:
- A centric computer systems with computing power, data storages, memory devices, etc.
- Provides the services over the internet, such as hardware, software, ...
- Efficiency is platform independence; may provide the cost reduction for a typical organization.

Distributed Computing:
- Task-oriented: a project divided into several tasks.
- Tasks finished by the network with distributed multiple computers.
- Advantages such as scalability, redundancy, and resource sharing.
Edge in the IIoT:
- Real-time response / services for the IoT devices.
- Data buffering.
- M2M communications.
- Local / Basic Data Analysis.
- Data filtering and optimization.

Source: OAS
**Why Edge computing?**

- **Network / internet issue**: bandwidth bottleneck, instability, disturbances, uncertainties, ...
- **Information efficiency**: using the information at the place.
- **Decision Efficiency**: shorten the decision cycle; local issues, locally resolved.
- **Power saving**: shorten the data moving path; reducing the data traffic.

**What Edge computing can offer?**

- **Edge Data Processing**: near real-time response.
- **Machine Learning**: for typical situation / condition at the edge.
- **Information control**: control, filtering, and gating in the IoT.
- **Tasks executing**: processing and reporting to the Cloud Center.
Key Factors in Flash Storage

- **Response and Data Transfer Rate**: Random IOPS, Throughput.
- **Data Integrity**: ECC, Flash memory maintenance.
- **System Stability**: Keeping constant performance.
- **Product Life**: Host workload vs. Flash memory usage.
- **Health Status**: enhanced and informative S.M.A.R.T.
- **Robustness**: Rugged for environmental variations.
- **Customized functions**: for vendor application specific.
Concept of Intelligent Storage

Interface Controller
- SD, UFD
- uSD, eMMMC, UFS
- SATA, PCIe/NVMe

NAND Controller
- VLSI
- ECC
- DMA & Buffer
- Flash Sequencer
- Algorithms
- MCU & F/W

Host Data Processor
- Workload
- Hot ~ Cold Data
- Authentication
- Pattern Matching
- ...

Aux. Memory

Flash Memory Array

The Flash Storage System

Flash Data Processor
- Read Parameters
- Program / Erase behavior
- Signal Shaping
- Bit characteristics
- ECC, Soft decoding
- ...

System Data Processor
- Power control
- Temperature control
- Monitoring & Diagnosis
- Tasks Sharing
- ...

Passive Components
Peripheral Components / ICs

Interface Bus

Workload
- Hot ~ Cold Data
- Authentication
- Pattern Matching
- ...
Intelligence in Embedded Storage

**Objective:** to do the data processing near to the Storage.

- **AI on Host-side:** complying and fitting with Workload, "Hot ~ Cold data" analysis, Pattern recognition and pattern matching, Content finding, signature and authentication, ...

- **AI on Flash-side:** Read/Program/Erase behavior tracking and optimizing, ECC/RAID and flash memory maintenance, signal/data shaping, ...

- **AI on System:** Keeping the system stability in environmental variation. E.g., temperature control, power control, monitoring and diagnosis, ...

**Methodology:**

- **Multi Core architecture:** Data processors + Storage Controllers.

- **Algorithms:** Machine Learning, Artificial Intelligence, ...

- **Implementation:** Decision making by data-base; Neuro-fuzzy control systems, ...
Intelligent Data Storage for Edge

- **Intelligent Data Storage** is to minimize data movement and create intelligent edge computing.
- Multi Core architecture: Data processors + Storage Controllers.
- AI algorithm for Storage and application specific functions. Parallel processing by tasks sharing to the data processors in Data Storage devices.
- Provide the vendor application commands over NVMe interface.

**Specifications:**
- PCIe/NVMe Gen-3 x1/x2/x4 configurable SSD.
- Intelligent Flash memory maintenance;
- Informative S.M.A.R.T support.
- Vendor commands for application specific functions.
- Flash memory: 2D MLC, 3D NAND.
- Advanced ECC with RAID function.
- Wide temperature:
  - Industrial Grade: -40°C ~ 85°C
  - Standard Grade: 0°C ~ 70°C
- Power management.
Security Storage in Industrial IoT

**Digital Signature**
- Point identification and authentication by Private Key.
- Key management with Security Module.

**Data Crypto**
- Data Encryption and Decryption.
- Data hidden and Data encrypted.

**WORM**
- WORM: Write Once Read Many.
- Data printed and secure the Data chain.

Internet → Application Processor → Embedded Flash Storage

Controller
NAND Flash

Flash Memory Summit 2019
Santa Clara, CA
EmBestor i-TF & i-SD card can have an encrypted Key inside for Host system multiple functions within EmBestor SDK kit.

Customers can set up a Key String as the access.
The EmBestor i-TF & i-SD card provide Hidden Card mechanism. Customer Host device need to follow the Hidden Card specification rule.

This mechanism can enhance the data security level.
EmBestor i-TF, i-SD, UFD WORM support the Write Once, Read Many applications.

- Support WORM for Security Chain.
Host can get more of device’s SMART Information easily.

Support Customized Windows AP, the normal reader could get the SMART Info.

Support SDK for several Linux OS versions
EX: Smart Storage Design for Edge

- **Intelligent Data Storage:**
  - PCIe/NVMe M.2 2280.
  - With Intelligent Flash memory maintenance.
  - With Informative S.M.A.R.T function.
  - With Vendor commands for application specific functions.

- **Security SD Card:**
  - Security Key for Digital Signature.
  - Security Hidden for Privacy Data.
  - WORM for Secure Chain.
Smart Storage for Edge

- DRAM for System Memory
- Intelligent Data Storage PCIe/NVMe M.2 2280
- Internet
- EDGE Server
- Peripherals & Control
- Industrial uSD or SD card for Security Storage

Flash Memory Summit 2019
Santa Clara, CA
Conclusions

- Data processing near to the Storage gains the efficiency in Industrial IoT.
- Security features provides the safety and stability of Industrial IoT.
- Edge computing provides the near real-time responsive and efficient operations in Industrial IoT.
- A Smart Storage Design with Intelligent Data Storage and Security SD Card for Edge computing presented.
Thank You !!

Enjoy Best Service !!