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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
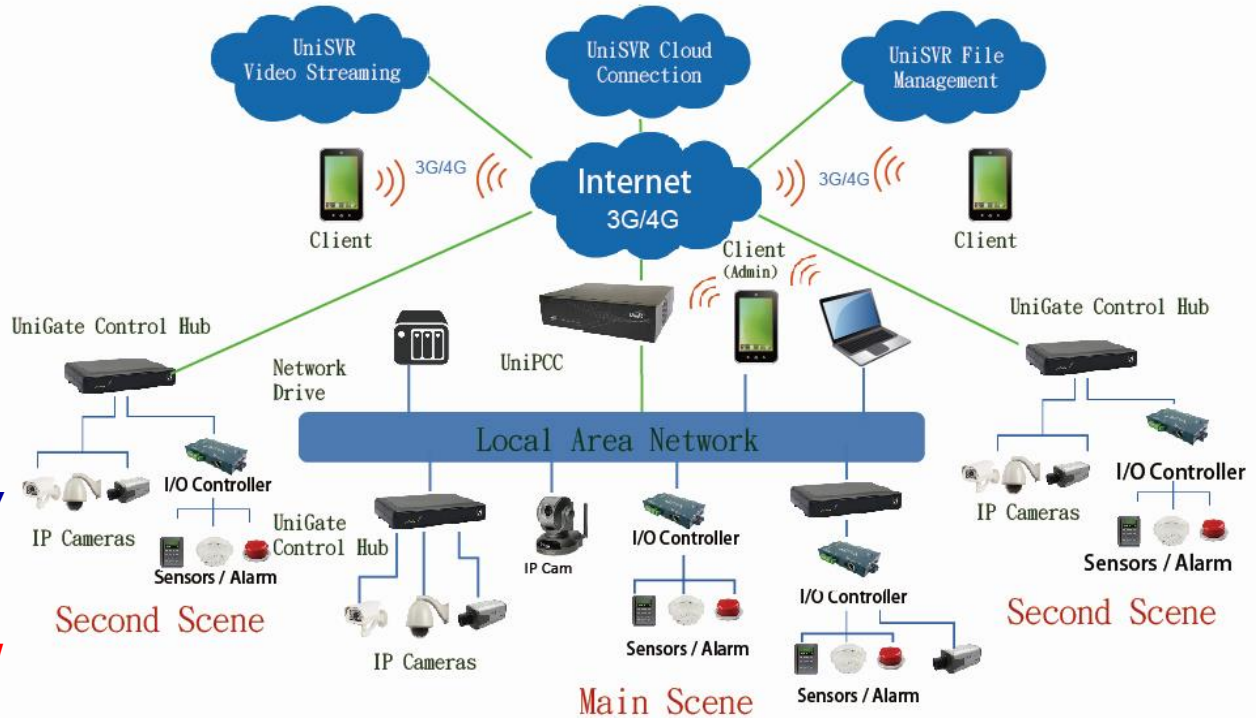
- Application Example:

- Conclusions

EFS in Industrial IoT Applications

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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**)
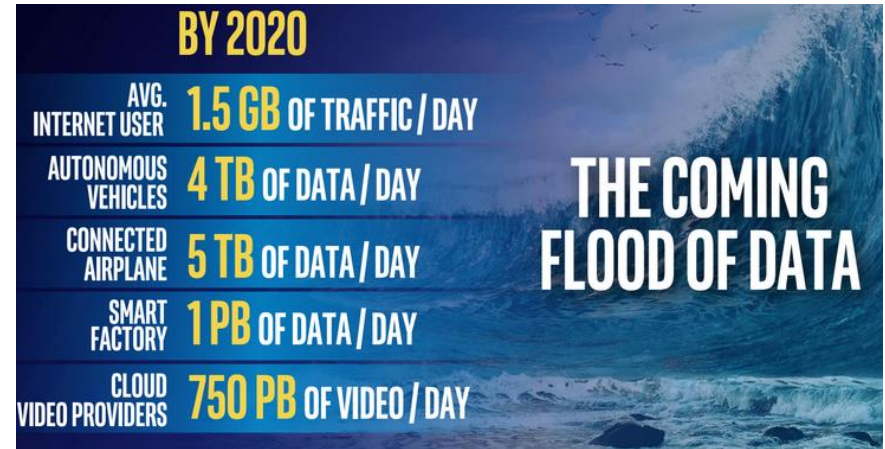

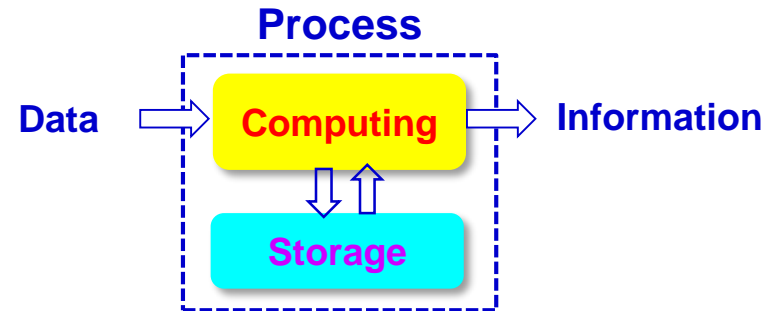Source: UNISVR

Data Generating and Processing

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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, …

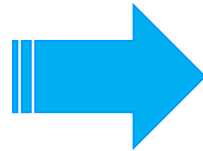- Performance: Data traffic control, how fast to get the essential information? Content finding speed, …

BY 2020		
AVG. INTERNET USER	1.5 GB	OF TRAFFIC / DAY
AUTONOMOUS VEHICLES	4 TB	OF DATA / DAY
CONNECTED AIRPLANE	5 TB	OF DATA / DAY
SMART FACTORY	1 PB	OF DATA / DAY
CLOUD VIDEO PROVIDERS	750 PB	OF VIDEO / DAY

THE COMING FLOOD OF DATA

Source: EE Times

Process

Data → **Computing** → Information

Computing ⇅ **Storage**

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 ~ Hundred Bytes

Data Size ~ Million Bytes

Data Processing Scope
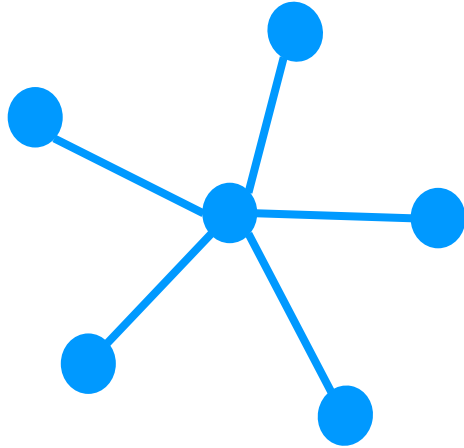
Methods or tactics:

- **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.

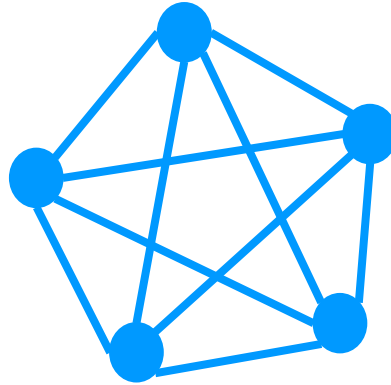- **Analysis:** the collection, organization, categorizing, interpretation of data.

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,

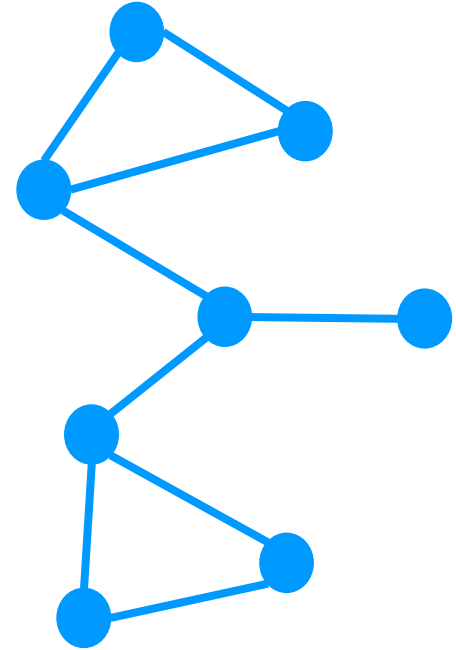- **Pattern recognition:** Human, Vehicles, specified objects, ...

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Flash Memory Summit

Centric, Distributed, and Hybrid.

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Centric

Distributed

Hybrid

Adapting the structure for operation optimization, or achieving better whole system performance.

Computing: Cloud vs. Distributed

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.
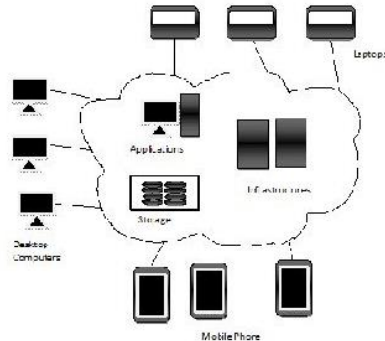
Distributed Computing:

- Task-oriented: a project divided into several tasks.

- Tasks finished by the network with distributed multiple computers.

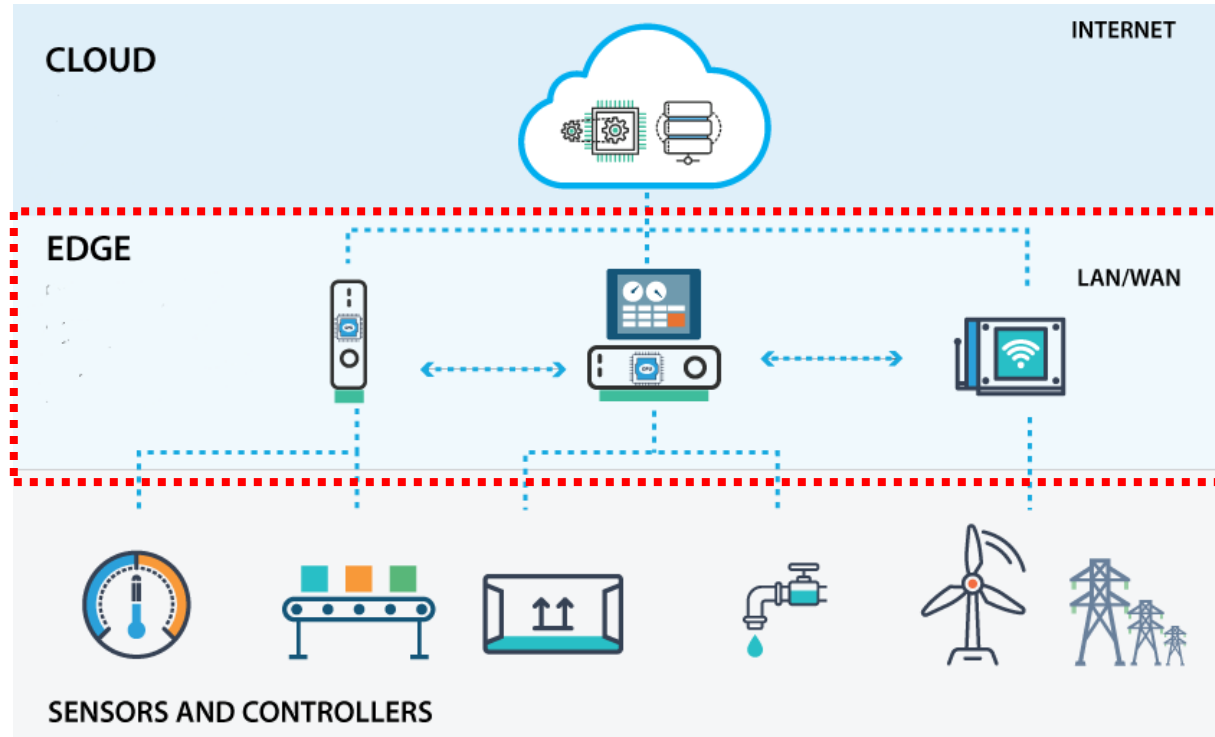- Advantages such as scalability, redundancy, and resource sharing.
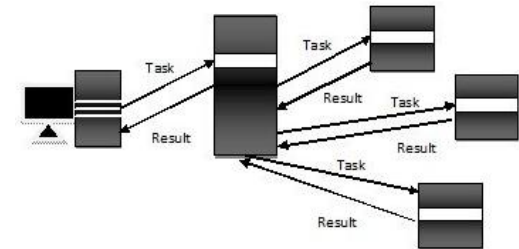
Edge in the Industrial IoT

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

Merits of Edge Computing

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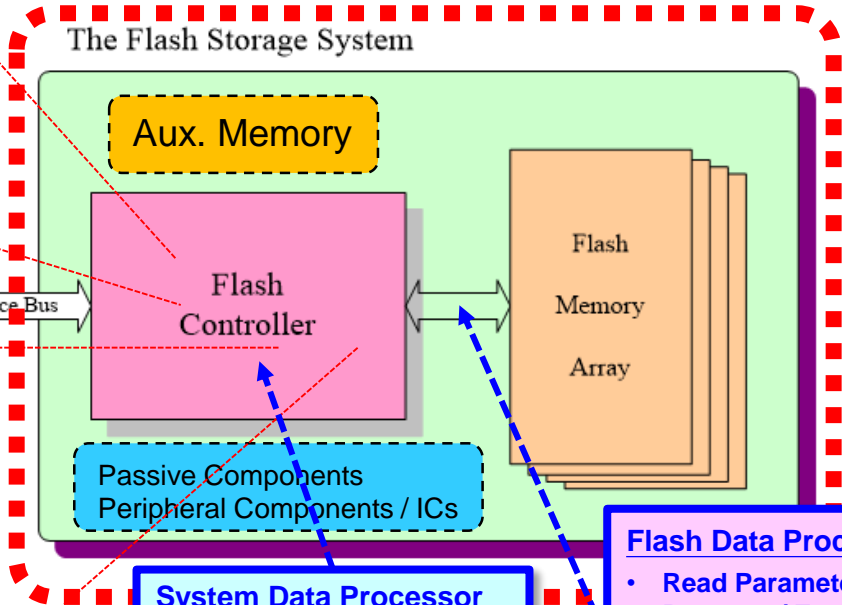
Interface Controller
- SD, UFD
- uSD, eMMC, UFS
- SATA, PCIe/NVMe

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

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

The Flash Storage System

Aux. Memory

Flash Controller

Interface Bus

Flash Memory Array

Passive Components
Peripheral Components / ICs

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

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

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Intelligence in Embedded Storage

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

- <u>AI on Host-side</u>: complying and fitting with Workload, "Hot ~ Cold data" analysis, Pattern recognition and pattern matching, Content finding, signature and authentication, …

- <u>AI on Flash-side</u>: Read/Program/Erase behavior tracking and optimizing, ECC/RAID and flash memory maintenance, signal/data shaping, …

- <u>AI on System</u>: Keeping the system stability in environmental variation. E.g., temperature control, power control, monitoring and diagnosis, …

Methodology:

- <u>Multi Core architecture</u>: Data processors + Storage Controllers.

- <u>Algorithms</u>: Machine Learning, Artificial Intelligence, …

- <u>Implementation</u>: Decision making by data-base; Neuro-fuzzy control systems, ...

Intelligent Data Storage for Edge

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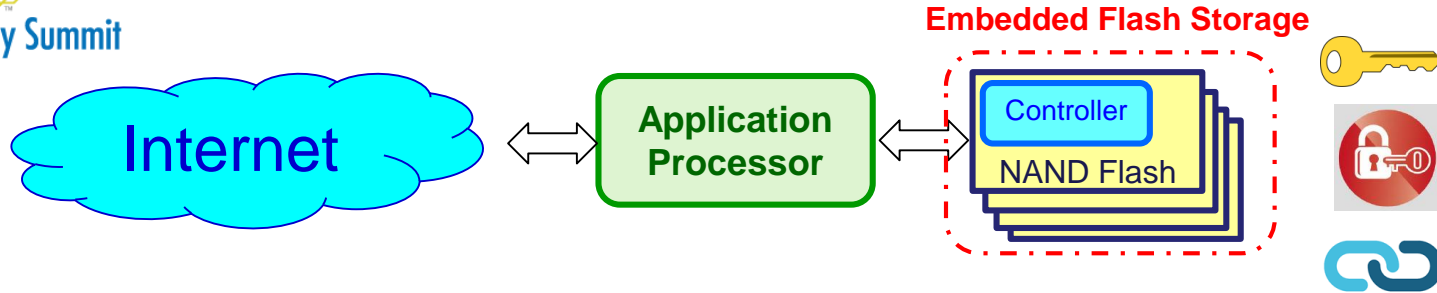*The Industrial Flash Storage Expert.*

- **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℃ ~ 85℃
  Standard Grade: 0℃ ~ 70℃
- Power management.

Security Storage in Industrial IoT

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Embedded Flash Storage

Internet ⟷ **Application Processor** ⟷ Controller / NAND Flash

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.

Security SD Key (Secured)

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- EmBestor i-TF & i-SD card can have a encrypted Key inside for Host system multiple functions within EmBestor SDK kit.

- Customers can set up a Key String as the access.

SD Card
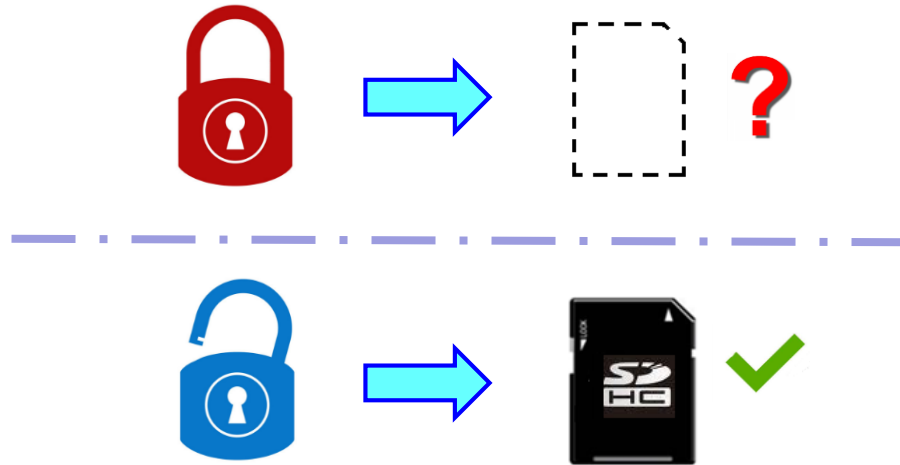
Host Systems

**Key Check**
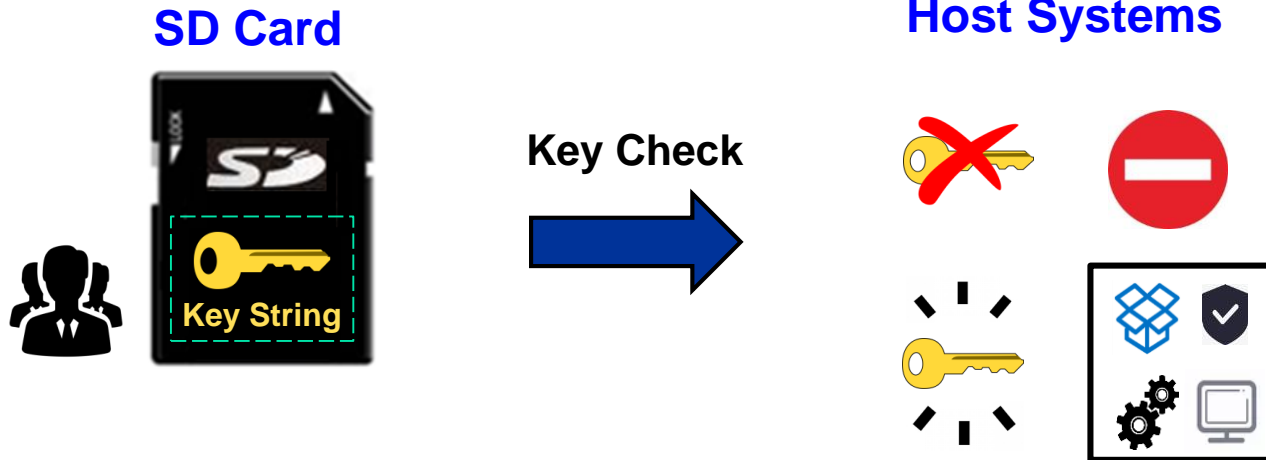
Security Hidden SD Card

- 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.

SD WORM (Write Once Read Many)

- EmBestor i-TF, i-SD, UFD WORM support the Write Once, Read Many applications.
- Applications: Fiscal/Tax Data, Legal Evidences, Important Data Backup.
- Support WORM for Security Chain.

SD Card

Host Systems

Write Once

Read Many

SD WORM

Real-time Remote S.M.A.R.T.
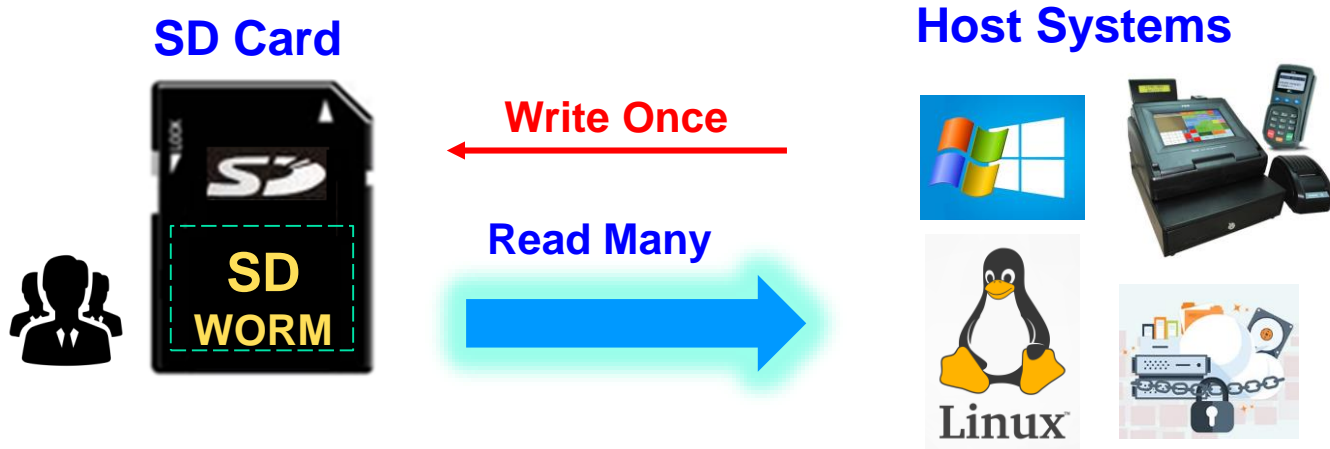
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- Host can get more of device's SMART Information easily.

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

- Support SDK for several Linux OS versions

SMART Info.

Host

Internet
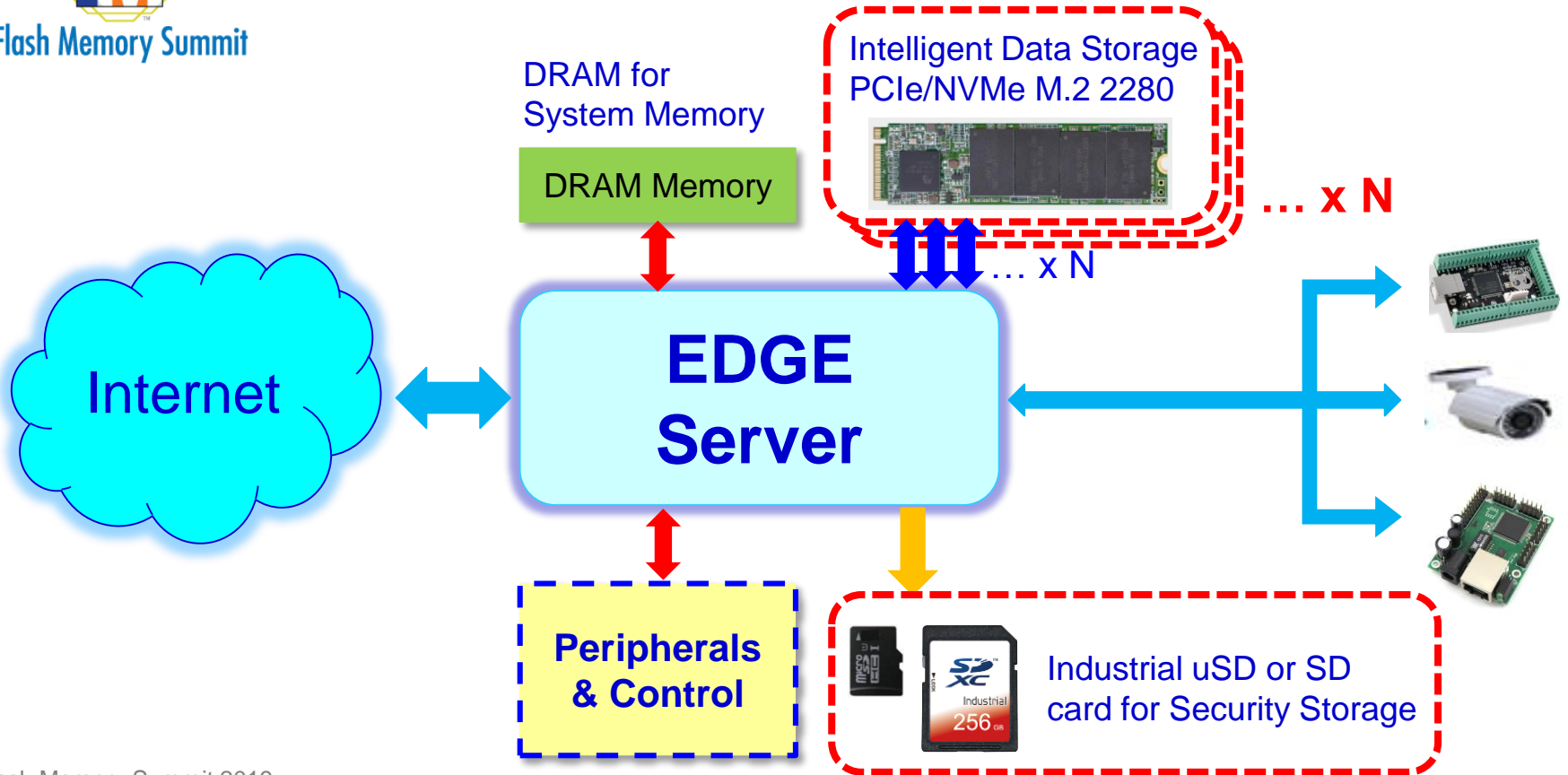
Device 1

Device 2

Device 3

Device 4
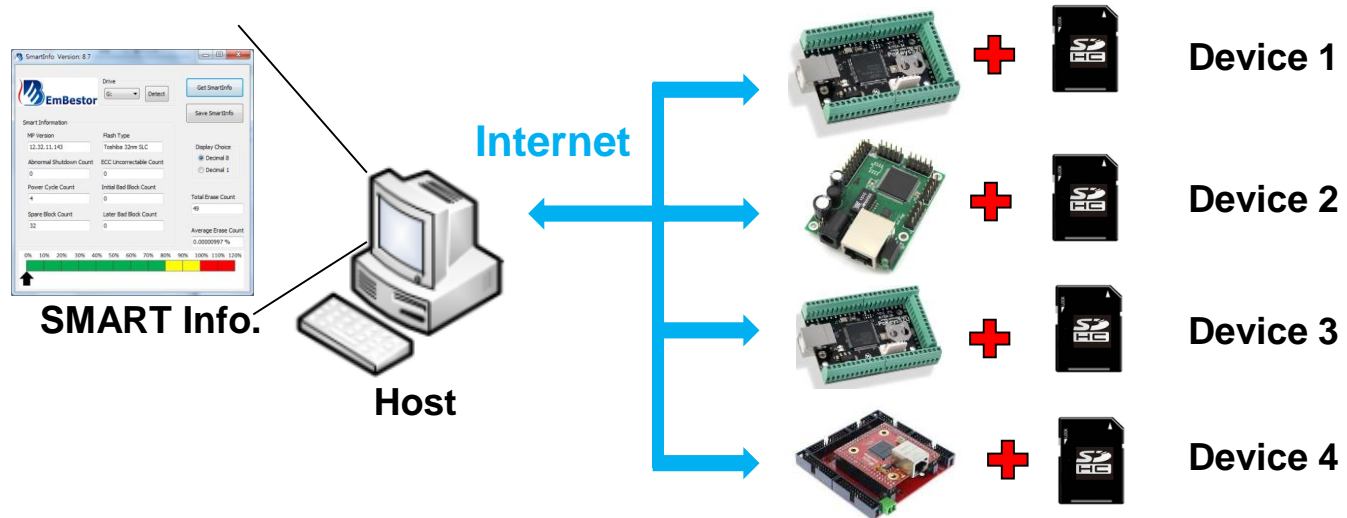
EX: Smart Storage Design for Edge

- **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.
  - ➢ With Remote Real-time S.M.A.R.T. feature.

Smart Storage for Edge

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DRAM for
System Memory

DRAM Memory

Intelligent Data Storage
PCIe/NVMe M.2 2280

… x N

… x N

Internet

EDGE
Server

Peripherals
& Control

Industrial uSD or SD
card for Security Storage

Conclusions

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- 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 !!