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8th International Workshop on the Application of Field Programmable Gate Arrays in Nuclear Power Plants

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Chipset Level Cybersecurity Issues

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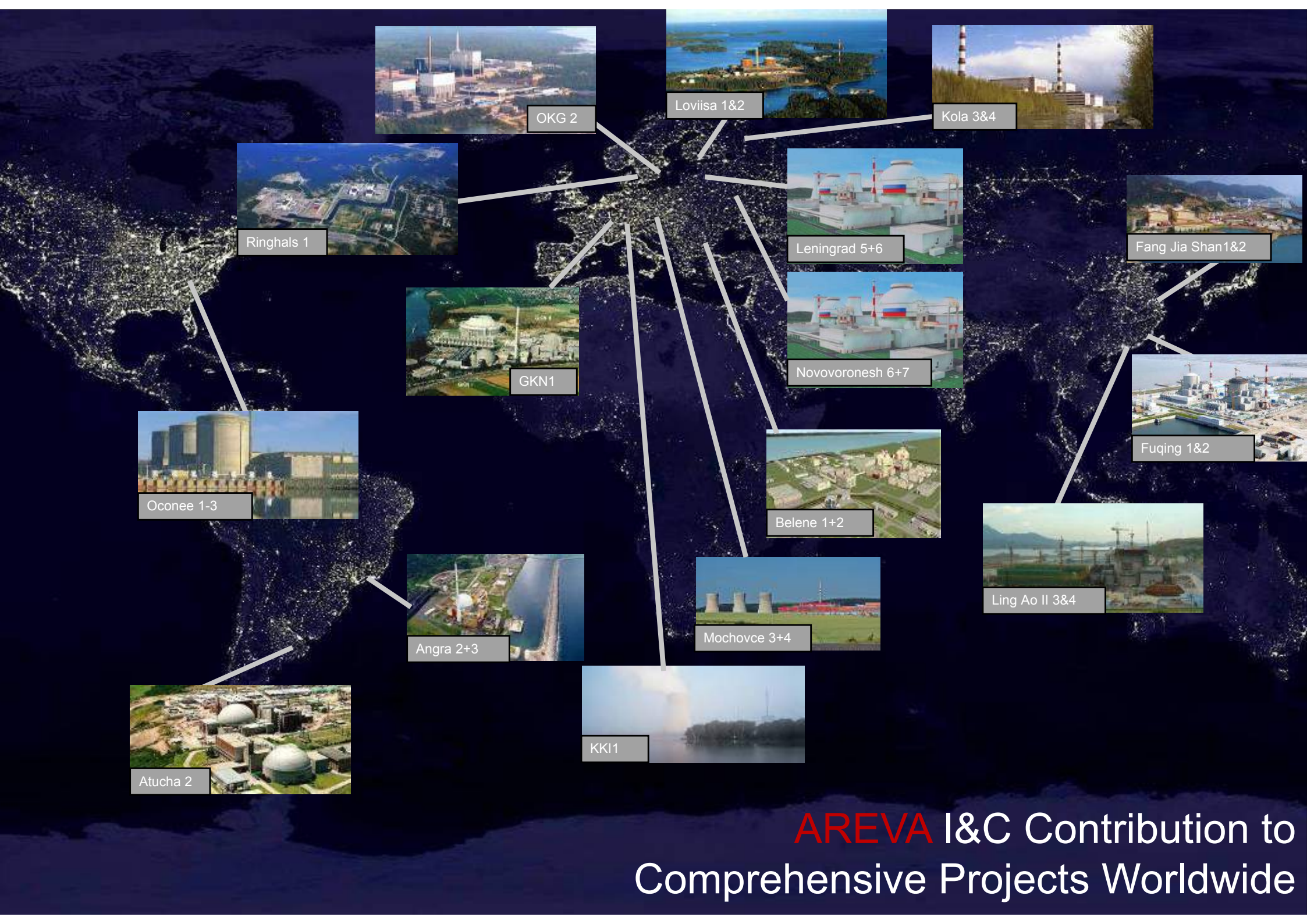
forward-looking energy

Chipset Level Cybersecurity Issues Topics

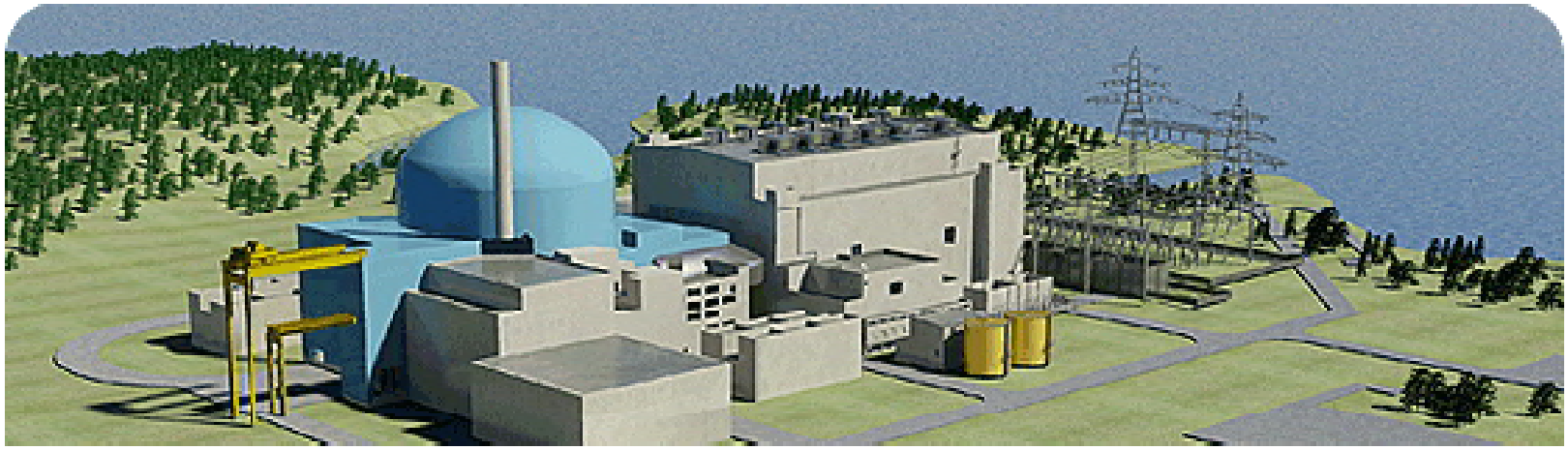
- COTS System HW Using Out-of-band Communication
- COTS HW Platform Management Interface
- The Unified Extensible Firmware Interface
- Preventive FPGA Based Security Controls
- Implications on Security Monitoring



AREVA I&C Contribution to Comprehensive Projects Worldwide

Domain Specific Cybersecurity for I&C New NPP Projects

AREVA EPR™



- Finland: Olkiluoto OL3
- France: Flamanville FA3
- China: Taishan TSN1, TSN2

TELEPERM XS Safety I&C

Chipset Level Cybersecurity Issues Topics

- COTS System HW Using Out-of-band Communication
  - Out-of-band communication
  - Example Scope of Applicability
  - DASH, SMASH, AMT
  - USB Redirection
- COTS HW Platform Management Interface
- The Unified Extensible Firmware Interface
- Preventive FPGA Based Security Controls
- Implications on Security Monitoring

Chipset Level Cybersecurity Issues
Commercial-off-the-Shelf System Hardware

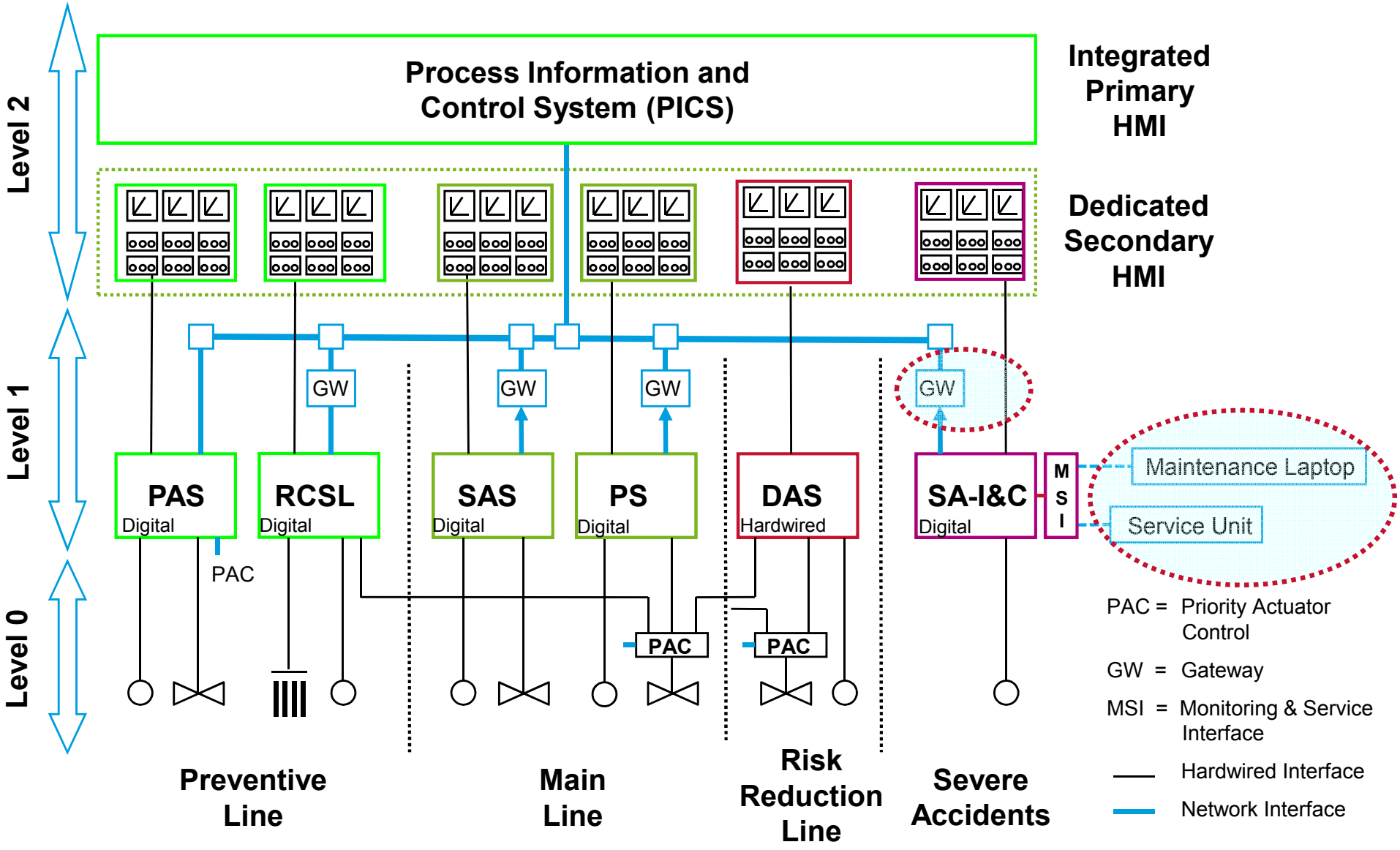
Era of mainboards with legacy single core processors

- **Functionality of chipsets and the Basic Input/Output Systems (BIOS)**
  - **rather limited**
  - **needing direct local access to the motherboard interfaces**
  - **often configurable via tiny Dual Inline Package Switches (DIP-Switches)**

Current Commercial-off-the-Shelf (COTS) office products

- **System Hardware level remote management technologies**
  - **Out-of-band communication at the mainboard level**
  - **System HW support for USB redirection via a Service Access Points (SAPs)**
  - **Optionally encrypted, remote power up/down/reset, like Wake-on-LAN** (remote wake-up, power on/up by LAN, resume by/on LAN, wake up on LAN)
  - **functionality resides in Flash memory** → [wrong settings / default passwords] **can be updated, e.g. via an infected USB key**

Chipset Level Cybersecurity Issues
Example Scope of Applicability



- **DASH (Desktop and mobile Architecture for System Hardware)**
  - **Uses out-of-band communication**
  - **Supports remote management of desktop and mobile systems**
  - **Support for the redirection of KVM (Keyboard, Video and Mouse)**
  - **Supports the management of**
    - software updates
    - BIOS (Basic I/O System)
    - Batteries
    - NIC (Network Interface Card)
    - MAC (Media Access Control)
    - IP (Internet Protocol) addresses
    - other configuration support

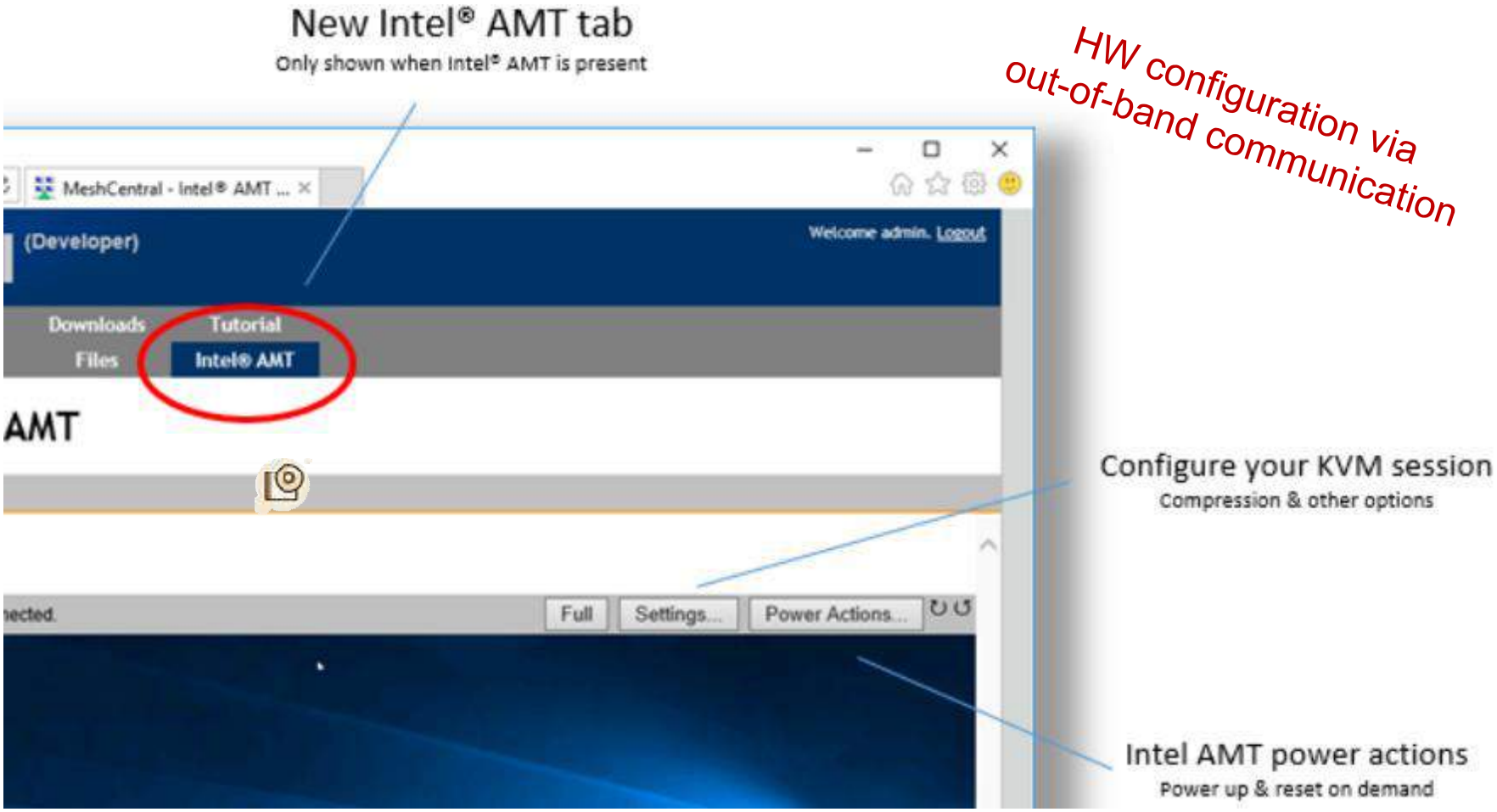
- **SMASH** (Systems Management Architecture for Server Hardware)
  - protocol specifications for increasing the productivity of the management of a data center
  - supports local and remote management of server hardware using out-of-band communication

- SMASH Command Line Protocol (SM CLP)
  - Provides an interface to heterogeneous servers
  - Independent of machine state or Operating System state
  - Independent of system topology or access method

Chipset Level Cybersecurity Issues
Active Management Technology (AMT)

- **AMT - Intel's Active Management Technology**
  - **currently a prevalent industrial mainboard level management solution**
  - **especially for remote desktop management**
  - Initially AMT was vendor proprietary. Since AMT 5.0 → DASH compliant
- **Other vendors, like AMD, also include DASH**
  - **as mainboard-level technology**
- Note:
  The frequently encountered Intel vPro logo advertises a set of mainboard level technologies that include AMT

Chipset Level Cybersecurity Issues
New: Web Based Hardware Configuration



- **Web based configuration (and possibly manipulation made easy)**
  - **MDTK Web Edition Commander 0.0.6**

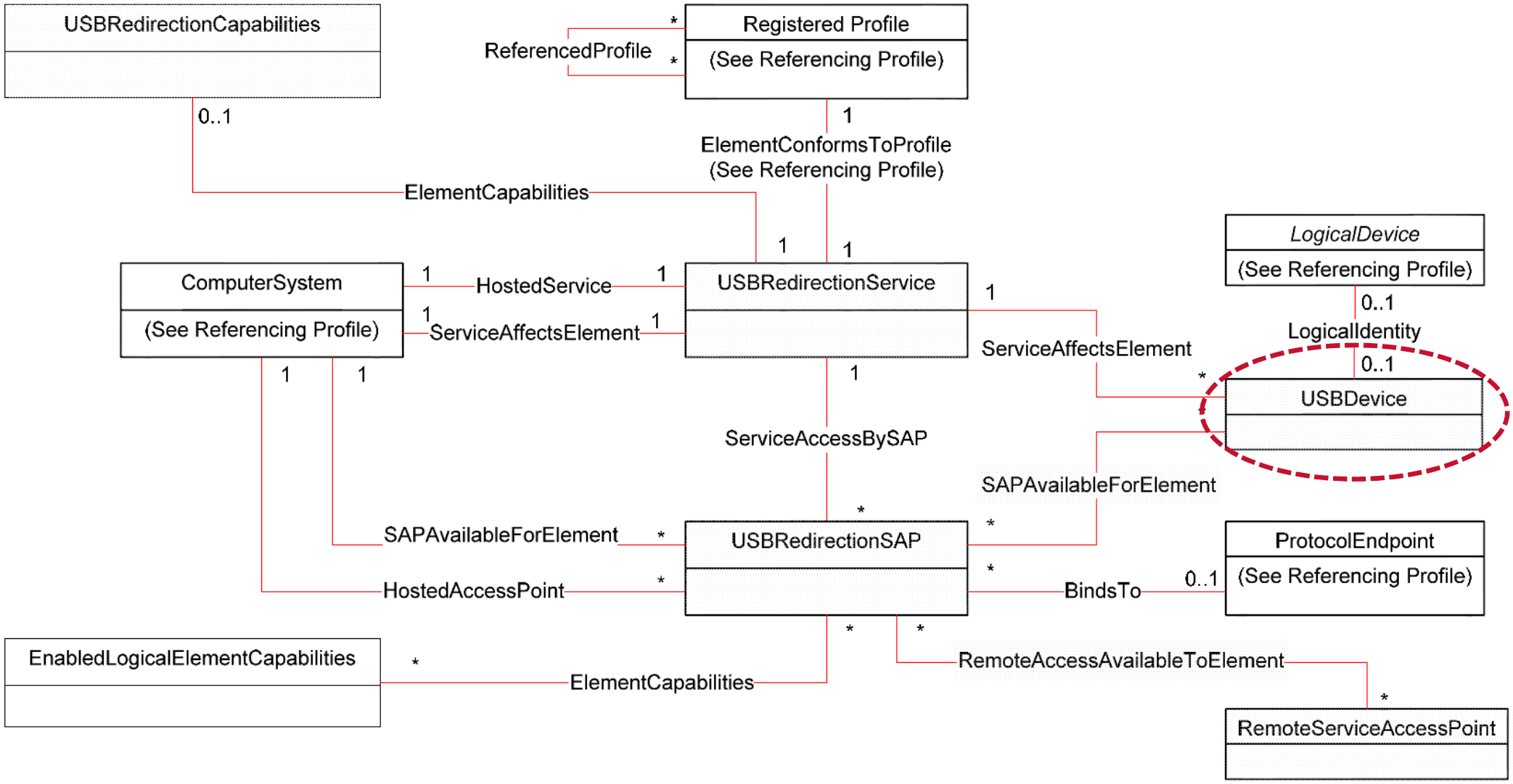
Chipset Level Cybersecurity Issues
Redirection Profiles

DASH Architecture for System Hardware specifies Implementation Requirements, including

- **Software Update Profile** (DMTF DSP1025 1.0)
- **Host LAN Network Port Profile** (DMTF DSP1035 1.0)
- **BIOS Management Profile** (DMTF DSP1061 1.0)
- **KVM Redirection** (DMTF DSP1076 1.0)
- **USB Redirection Profile** (DMTF DSP1077 1.0)
- **Media Redirection Profile** (DMTF DSP1086 1.0)
- **Role Based Authorization Profile** (DMTF DSP1039 1.0)
- **…**

DMTF = Distributed Management Task Force

Chipset Level Cybersecurity Issues
USB Redirection Profile



- **USBDevice → USBRedirectionSAP (Service Access Point)**

Chipset Level Cybersecurity Issues Topics

- COTS System HW Using Out-of-band Communication
- COTS HW Platform Management Interface
  - Intelligent Platform Management Interface (IPMI)
- The Unified Extensible Firmware Interface
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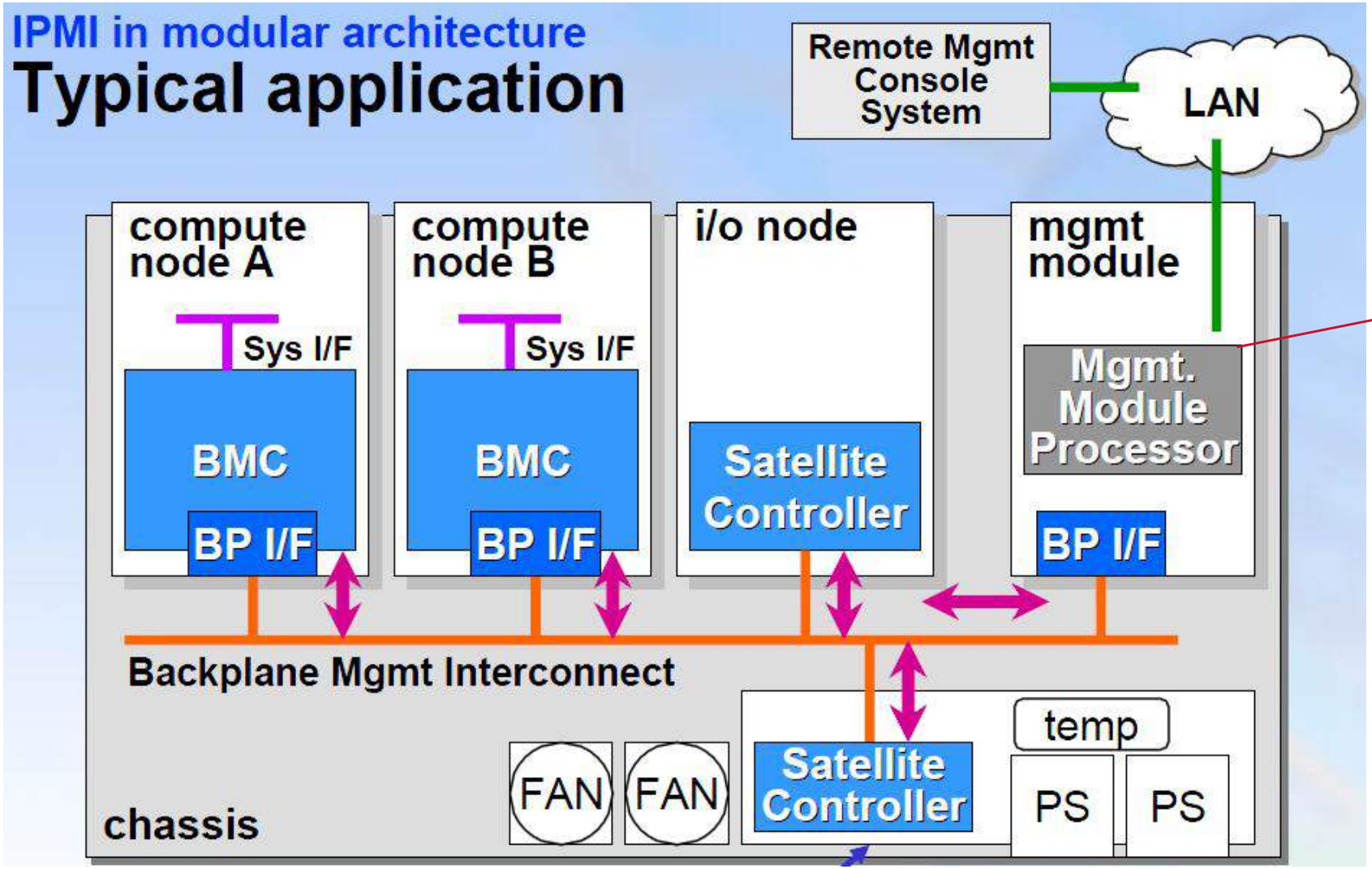
Chipset Level Cybersecurity Issues
Intelligent Platform Management Interface



Dedicated Processor

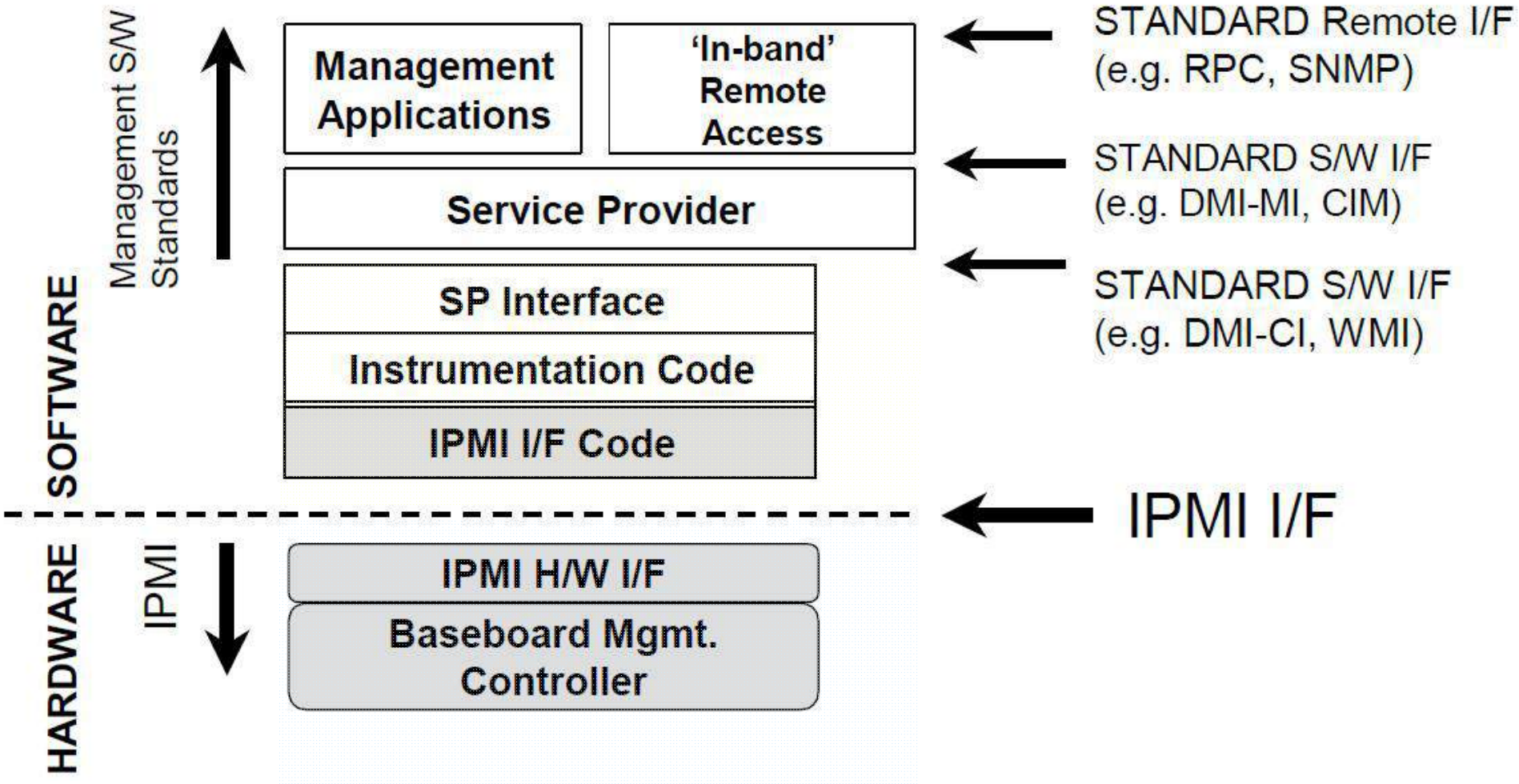
- **Initiation of actions without normal in-band mechanisms**

IPMI Platform Management Interface

IPMI (Intelligent Platform Management Interface)

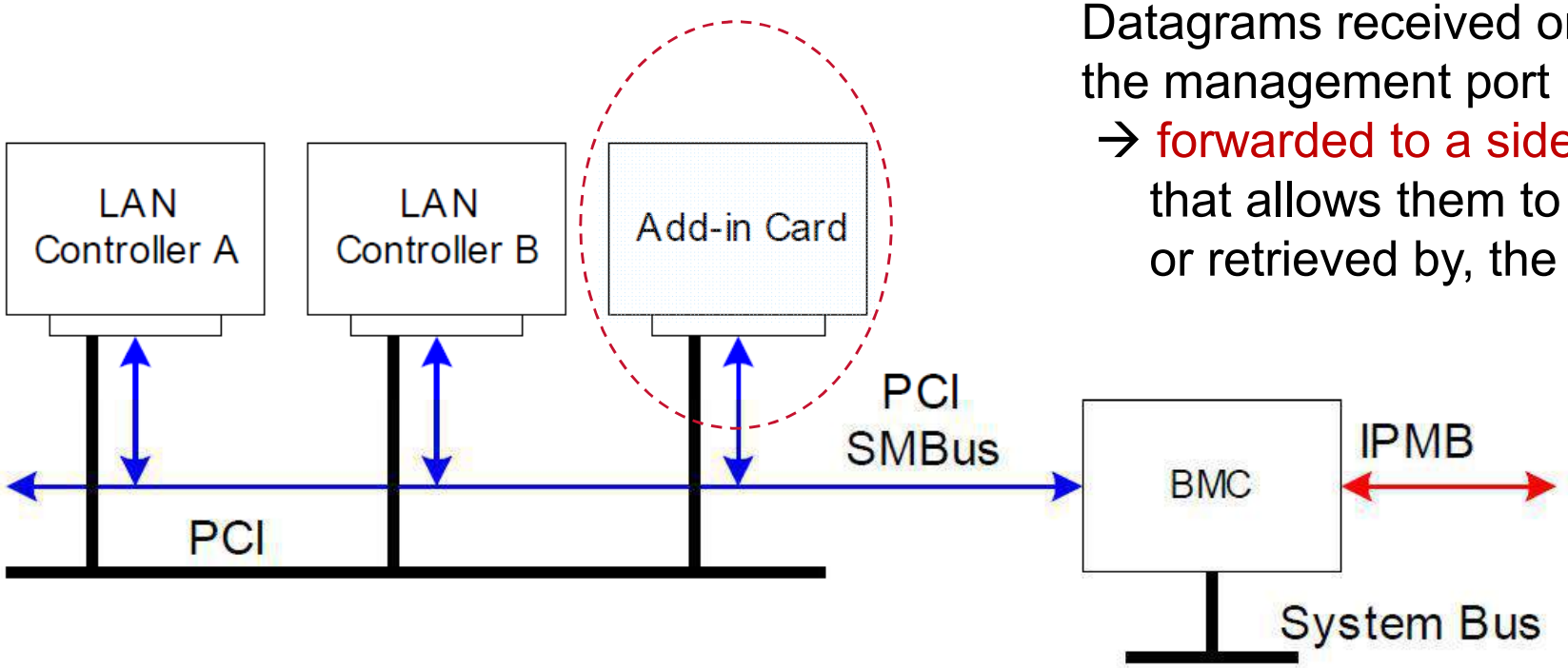
- Is a hardware level interface specification
- is management software neutral
- provides monitoring and control functions exposed through management software interfaces such as
  - DMI (Desktop Management Interface)
  - CIM (Common Information Model)
  - SNMP (Simple Network Management Protocol)
- The intelligence in the IPMI architecture is implemented by a Baseboard Management Controller (BMC)
  - a specialized microcontroller embedded on the motherboard of a computer

Chipset Level Cybersecurity Issues
HW and SW Part of IPMI



- Initiation of actions **without system management software**

Chipset Level Cybersecurity Issues
IPMI via LAN Controllers



Datagrams received on the management port
→ forwarded to a side-band interface that allows them to be delivered to, or retrieved by, the BMC

- **PCI** (Peripheral Component Interconnect)
- **BMC** (Baseboard Management Controller)
- **SMBus** (System Management Bus)
- **IPMB** (Intelligent Platform Management Bus)

Chipset Level Cybersecurity Issues Topics

- COTS System HW Using Out-of-band Communication
- COTS HW Platform Management Interface
- **The Unified Extensible Firmware Interface (UEFI)**
- **Preventive FPGA Based Security Controls**
- **Implications on Security Monitoring**

Unified Extensible Firmware Interface (UEFI)

UNIFIED EXTENSIBLE
FIRMWARE INTERFACE

- **UEFI gradually replaces the legacy Basic Input/Output System (BIOS) for COTS office IT hardware**
- **UEFI supports remote diagnostics and repair of computers**
  - **even with no operating system installed**
  - **includes remote attestation of a successful and secure boot**
  - **EFI UDPv4 Protocol can be used by network drivers, applications, or daemons**
    - to transmit or receive TCP/UDP (Transmission Control Protocol/User Datagram Protocol) packets
    - A protocol instance can either be bound to a specified port as a service or connected to some remote peer as an active client
  - **the EFI Debug Port Protocol provides services to communicate with a remote debug host**

Chipset Level Cybersecurity Issues Topics

- COTS System HW Using Out-of-band Communication
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Chipset Level Cybersecurity Issues
System Hardware Impact on Security (1)

- **With Active Management Technology AMT version 7.0**
  → use of a 3G cellular signal to send a remote kill command
  - **Such a command can improve the chance of deactivating a stolen computer before it gives up any sensitive information**
    - and similarly to reactivate the computer by an administrator, once it is recovered
  - **Such a command may be misused either due to a vulnerability or by an insider threat agent**
    - e.g. as a special Denial of Service (DoS) attack towards multiple targets

Chipset Level Cybersecurity Issues
System Hardware Impact on Security (2)

- **More common scenario** (due to older AMT versions) **for current power plants and industrial automation systems**
  - **manipulations via USB keys, based on USB redirection via a SAPs**
- **Infected USB with SW for accessing COTS system HW management functionality**
  - **may obtain access to the management functionality either**
    - due to a vulnerability (of the complex implementation) or e.g.
    - due to an unchanged default password
  - **this exchange of messages goes unnoticed by the operating system**

Chipset Level Cybersecurity Issues
System Hardware Impact on Security (3)

- Deployment of these hardware level technologies may extend from the COTS office IT networking scenarios
  - to the industrial automation domain and
  - to power plants
- Initial purpose of the COTS system hardware level management functions
  - facilitate the day-to-day work of administrators and
  - reduce reconfiguration and maintenance costs
- Deployment of these new technologies has to be carefully evaluated
  - segregation of duties of the respective administrators and maintenance staff
  - (non-manipulated) firmware, coming from the same source and being deployed on (or infecting) different independent systems

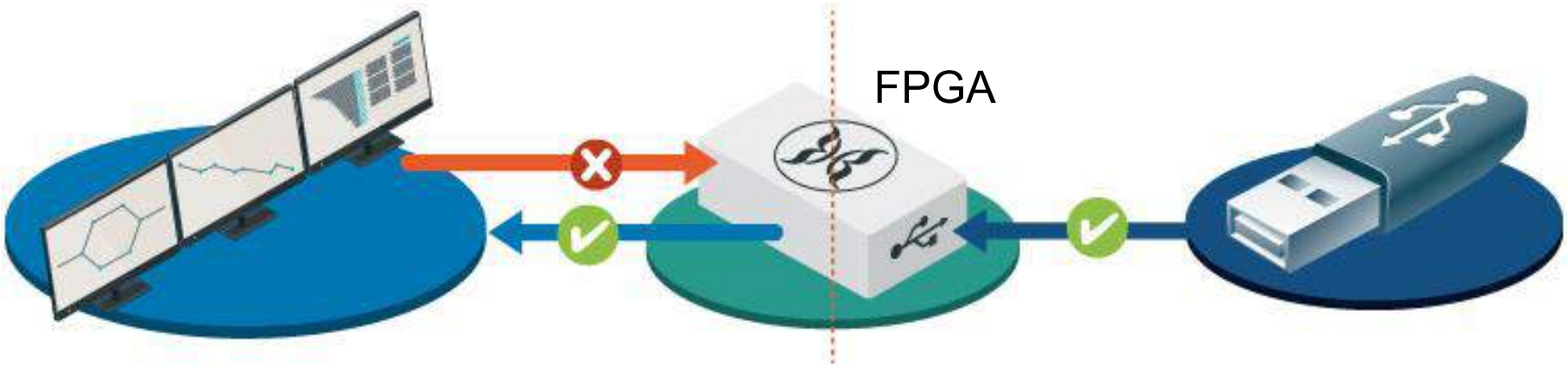
Chipset Level Cybersecurity Issues
System Hardware Impact on Security (4)

- **Cybersecurity threat due to unawareness**
  - **of new system level hardware functionality including**
  - **remote commands and remote debugging**
  - **USB redirection, out-of-band communication, …**

- **Staff technically knowledgeable and familiar with mainboard details deployed a decade ago**
  - **may not expect that switching to current COTS IT equipment will include**
    - new types of functionality that has not yet been addressed and thus
    - is not considered in locally maintained cybersecurity risk assessment procedures

- **Accordingly, I&C or industrial automation refurbishment projects**
  - **should be accompanied by appropriate security training and by**
  - **an update of the local security procedures**

Chipset Level Cybersecurity Issues
FPGA Based Security Controls



- **SECLAB SCOOP-MS**
  - **Selective COntrol Of Peripherals – Mass Storage**
  - **FPGA-based**
  - Note: Based on R&D results from SECLAB and EDF R&D
- **USB key (as Mass Storage example)**
  - **Read-write**
  - **Read-only → Reading logfiles without impact to the device**

Chipset Level Cybersecurity Issues
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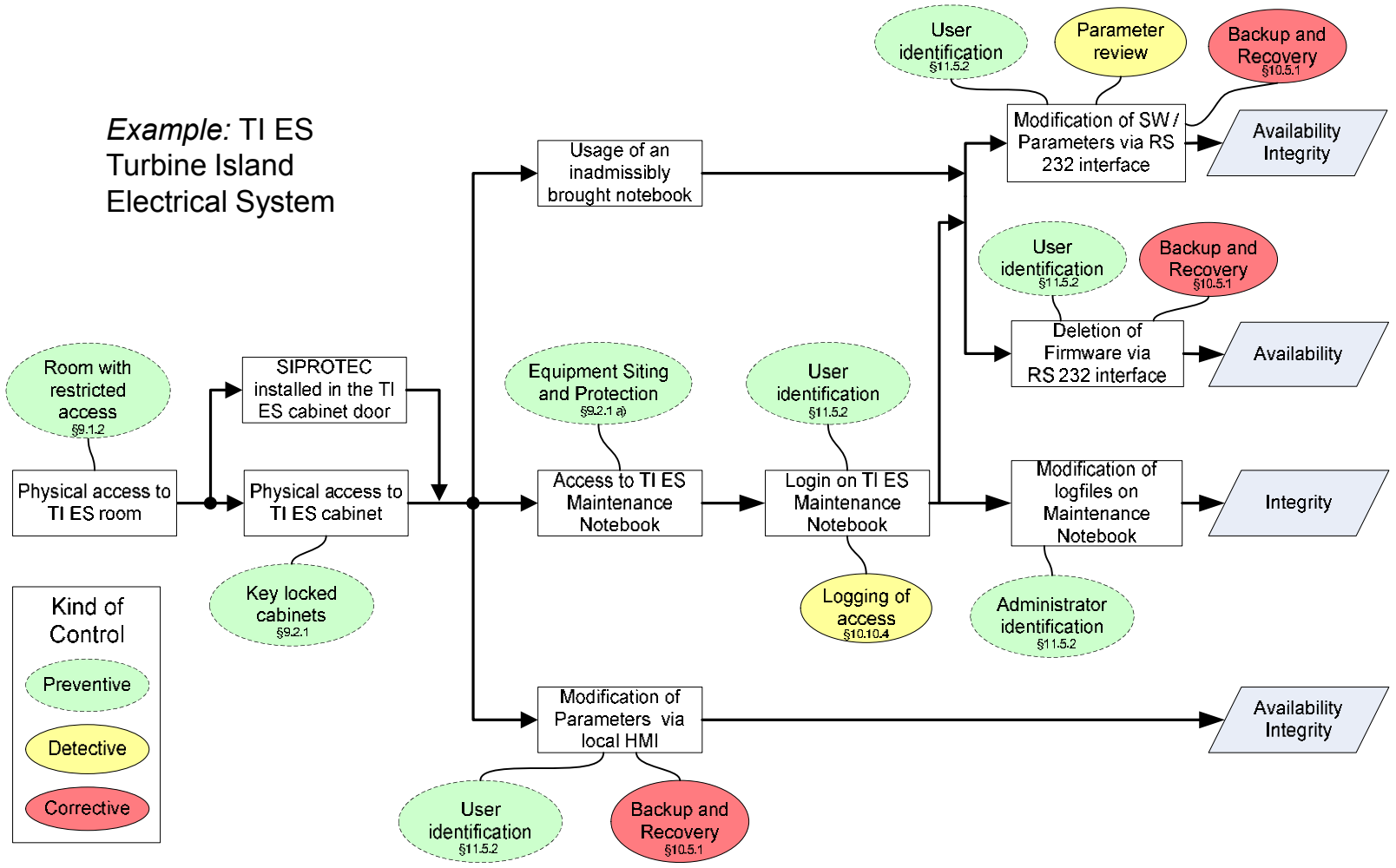
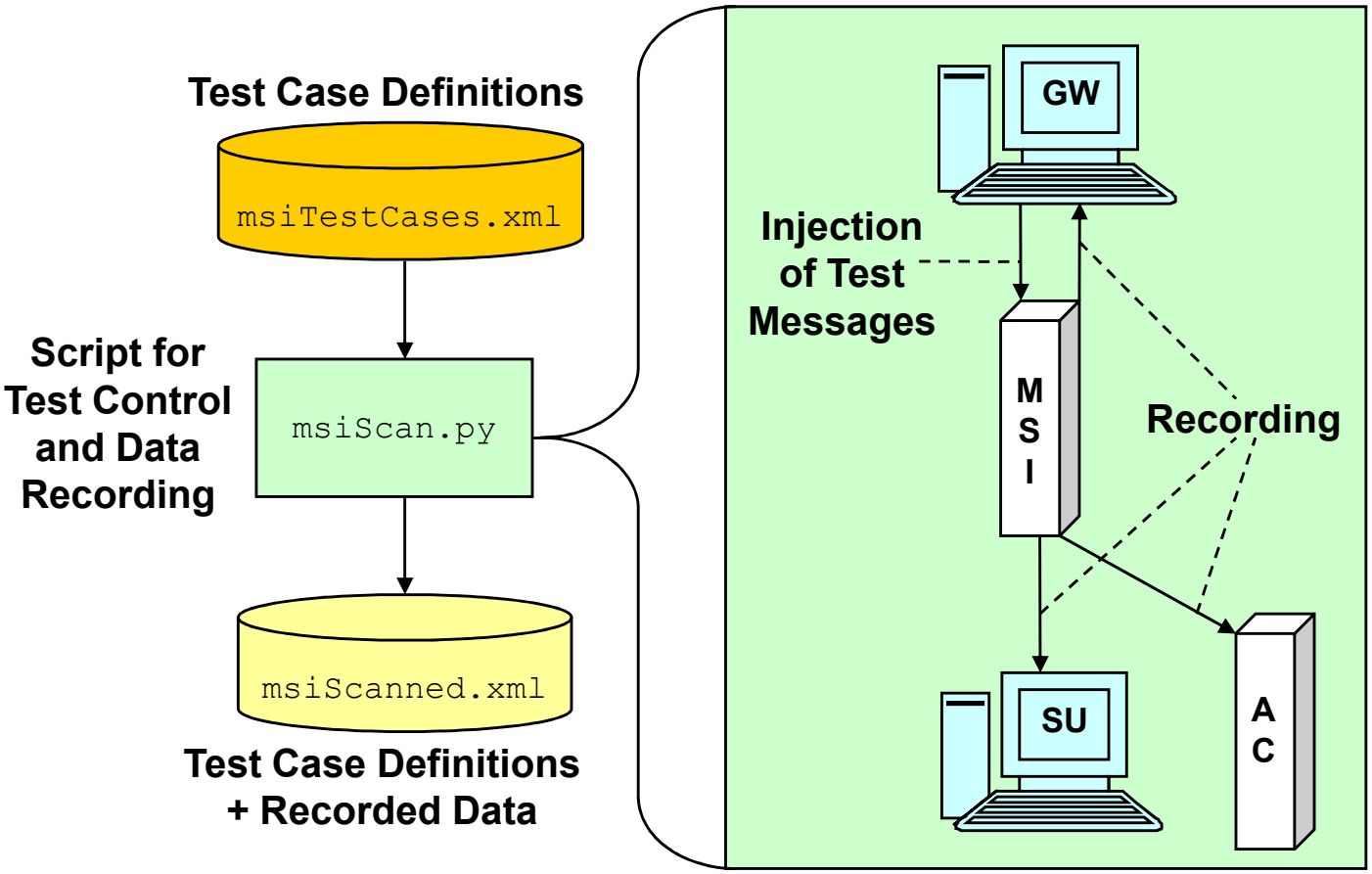
- **Implications on Security Monitoring**
- **Conclusion**

Preventive, Detective and Corrective Security Controls



- **SCOOP-MS can be deployed as a Preventive Security Control**
- **SIEM can be deployed as a Detective Security Control**

Chipset Level Cybersecurity Issues
Dedicated Network Security Tests



GW = Gateway
MSI = Monitoring and Service Interface
SU = Service Unit
AC = Automation Computer

- Dedicated network **security tests** can address the (absence of) **network traffic** initiated by system hardware management ports
  - Penetration and fuzz-testing suite with complete recording of network traffic

Chipset Level Cybersecurity Issues Conclusion

- DASH, SMASH, AMT, IPMI and UEFI show that
  - current COTS architectures of system hardware specifications support sophisticated functionality for remote administration
  - out-of-band communication at the mainboard level goes undetected by the deployed operating systems
- FPGA based Preventive Security Controls can be effectively deployed
- SIEM or network security tests can detect management messages on LANs
- Extended security awareness trainings needed
- Mandatory: update of local security risk management procedures

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Thanks to SNPAS for the org.!

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Thank you for your attention!

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