Invest in security to secure investments

ERPScan
Security Solutions for SAP

SAP Cybersecurity for Oil and Gas

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Mathieu Geli - Head of SAP Threat Intelligence, ERPScan

About ERPScan

- The only 360-degree SAP Security solution - ERPScan Security Monitoring Suite for SAP and Oracle
- **Leader** by the number of **acknowledgements from SAP** (150+) and Oracle (40+)
- **60+ presentations key security conferences** worldwide
- **30+ Awards and nominations**
- Research team – **20+ experts with experience in different areas of security from ERP to ICS and Mobile**
- Headquarters in Palo Alto (US) and Amsterdam (EU)

TECH TRAILBLAZERS
NETWORK PRODUCTS GUIDE HOT COMPANIES & TECHNOLOGIES 2013
Info Security Products Guide 2013 GLOBAL EXCELLENCE GOLD
NETWORK PRODUCTS GUIDE BEST 2013 BRONZE
THE GOLDEN BRIDGE AWARDS GOLD BEST 2013 BUSINESS WORLD
NETWORK PRODUCTS GUIDE BEST 2013 GOLD
CRN EMERGING VENDORS 2013
SC MAGAZINE AWARDS 2014 Europe

ERPScan

- ERPScan and SAP
  - Researching since 2007
  - 200+ vulnerabilities found
  - Applications covered: ERP, CRM, SRM, Business Objects, SAP GUI, HANA, Mobile, NetWeaver J2EE,Portal, SDM
- ERPScan and Oracle
  - Researching since 2008
  - 40+ vulnerabilities, 16 times acknowledged in Oracle CPU
  - Applications covered: Oracle DB, Oracle EBS, Oracle BI, Oracle PeopleSoft, Oracle JDE

Attention!!!

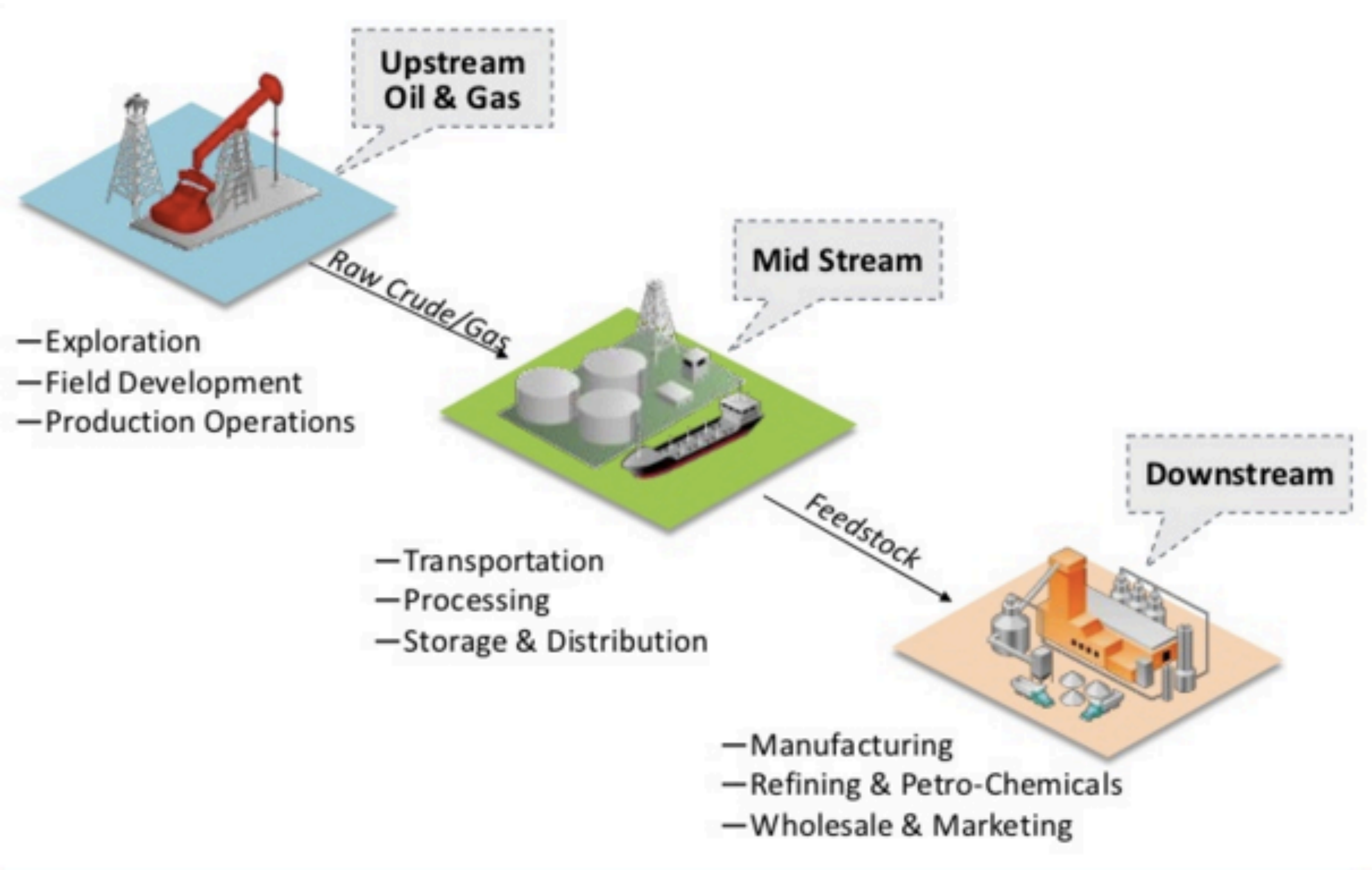
- This is NOT a traditional type of talk
- For me neither
- There are more questions than answers
- There is the first technical Oil and Gas Cybersecurity talk
- This is just a beginning

Oil and Gas 101

The oil and gas industry is usually divided into three major sectors

- **Upstream -** The upstream sector includes the searching for potential underground or underwater crude oil and natural gas fields, drilling of exploratory wells, and subsequently drilling and operating the wells that recover and bring the crude oil and/or raw natural gas to the surface. The upstream oil sector is also commonly known as the *exploration and production (E&P) sector*
- **Midstream-** The midstream sector involves the transportation (by pipeline, rail, barge, oil tanker or truck), storage, and wholesale marketing of crude or refined petroleum products. Pipelines and other transport systems can be used to move crude oil from production sites to refineries and deliver the various refined products to downstream distributors.
- **Downstream -**The downstream sector commonly refers to the refining of petroleum crude oil and the processing and purifying of raw natural gas, as well as the marketing and distribution of products derived from crude oil and natural gas. The downstream sector touches consumers through products such as gasoline or petrol, kerosene, jet fuel, diesel oil, heating oil, fuel oils, lubricants, waxes, asphalt, natural gas, and liquefied petroleum gas (LPG) as well as hundreds of petrochemicals.

Oil and Gas 101



Upstream Oil & Gas

- Exploration
- Field Development
- Production Operations

Mid Stream

- Transportation
- Processing
- Storage & Distribution

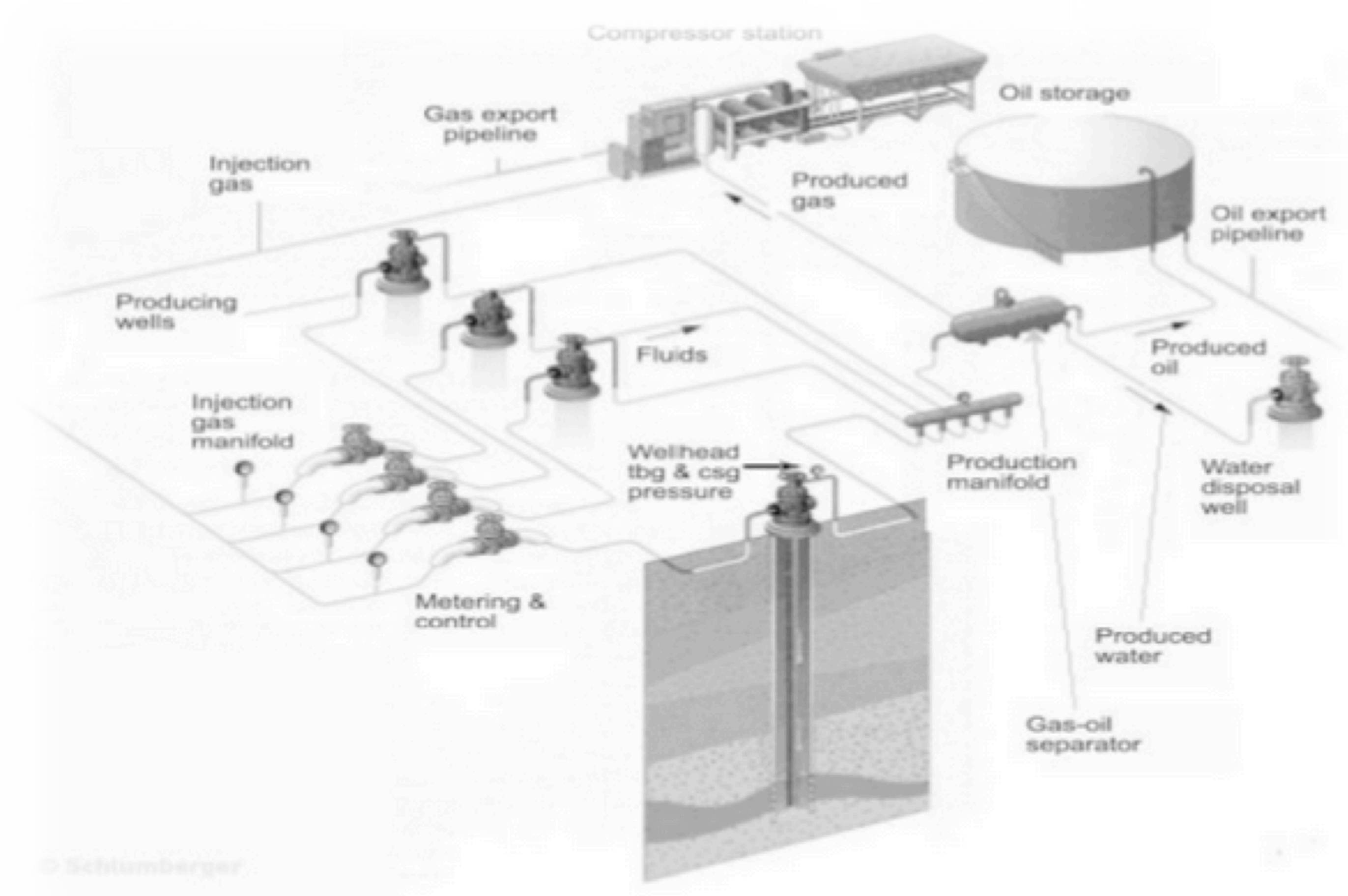
Downstream

- Manufacturing
- Refining & Petro-Chemicals
- Wholesale & Marketing

Upstream 101 (Onshore)

- Extraction (Drilling)
  - Pump controllers, blowout preventers, Flaring and Venting
- Gathering (From earth to separators)
  - Wellhead management, Manifolds management, Net oil measurement
- **Separation (Separate oil, gas and water)**
  - Multiple separators (2phase/3phase), Heaters, **Burners**, Coalescence, Desalting
- Gas compression (Prepare for storage and transport)
  - Multiple stages
- Temporary Oil Storage (Temporarily store before loading)
- Waste disposal
  - Water disposal
- **Metering (Calculate quantity before loading)**
  - **Fiscal Metering**, Liquid Flow Metering, Gas Flow Metering Systems, Wet Gas Metering Systems, Provers & Master Meters

Typical Upstream processes (Onshore)

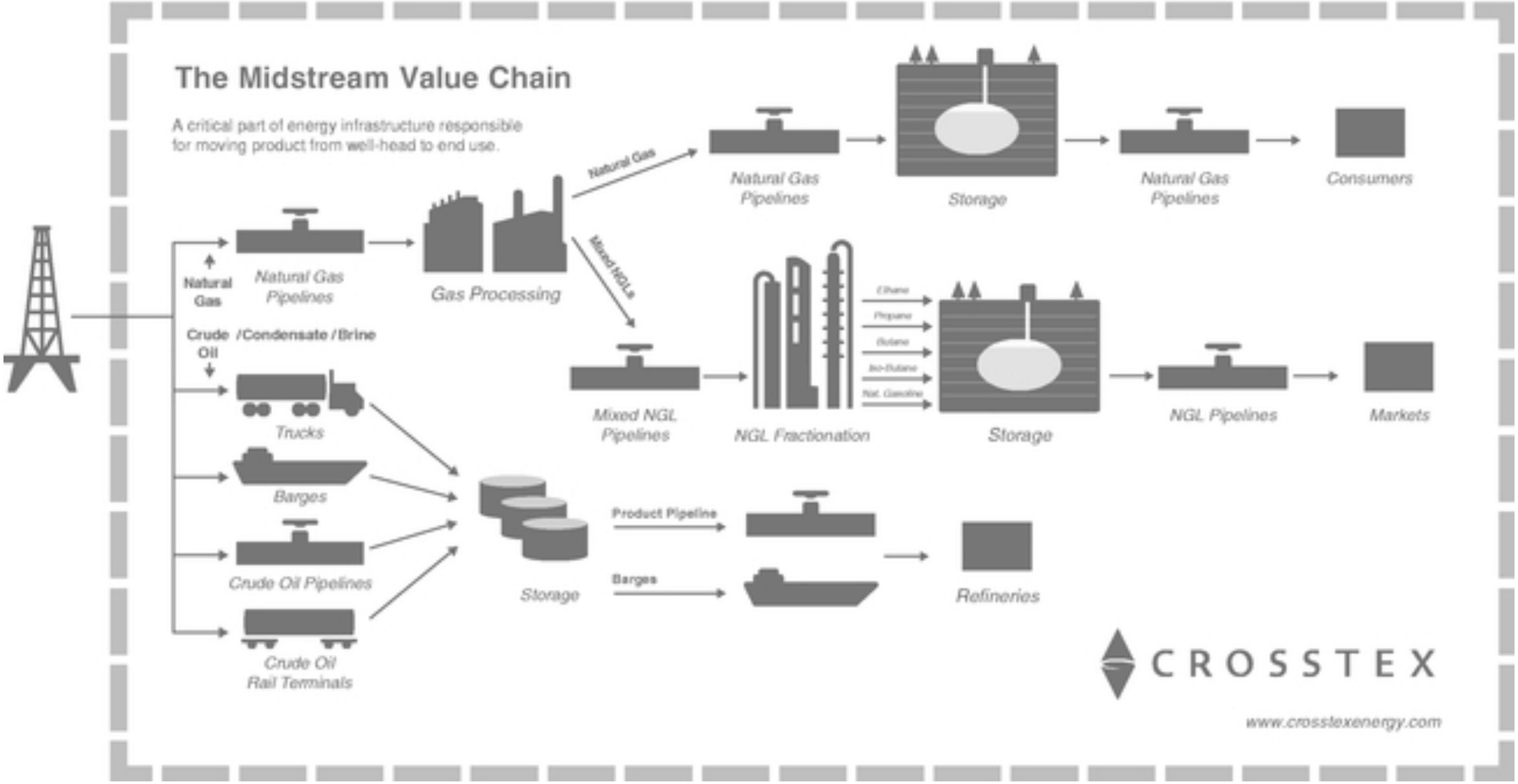


Simple Upstream oil and gas process

Midstream: Most critical processes

- Terminal management (Obtain oil from upstream)
  - Measurement, Automation, Order Movement Management
- Gas Processing (Separate natural gas and NGL)
- Gas Transportation (Transfer gas to storage)
  - Pipeline management
- Oil transportation (Transfer oil to storage)
  - Pipeline management
- Gas storage (Temporary and long-term)
  - Peak load Gas Storage, Gas storage, LNG Storage
- **Oil Storage (Long-term oil storage)**
  - **Tank inventory system,** Tank Temperature management, Tank Gauging System, Product Movement

Midstream 101



The Midstream Value Chain

A critical part of energy infrastructure responsible for moving product from well-head to end use.

Downstream: Most critical processes

- Refining (Processing of Crude Oil)
  - Blend Optimization, Movement Automation System, Emission Monitoring System
- Oil Petrochemicals (Fabrication of base chemicals and plastics)
  - Too many processes to be listed
- Gas Distribution (Deliver gas to utilities)
- Oil Wholesale (Deliver petrol to 3rd parties)
  - Loading
- **Oil Retail (Deliver petrol to end users)**
  - **Truck loading Automation, Gas Pump Monitoring Systems, POS**

What can happen?

Plant Sabotage/Shutdown

Equipment damage

Utilities Interruption

Production Disruption (Stop or pause production)

Product Quality (bad oil and gas quality)

Undetected Spills

Illegal pipeline taping

Compliance violation (Pollution)

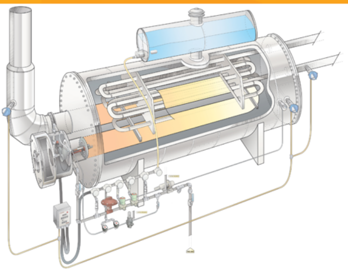
Safety violation (Death or injury)

Some critical processes in Oil and Gas: details

SEPARATION (GOSP)

- Gas Oil Separation Plant
- Risks:
  - Product Quality, Equipment damage, Plant Sabotage, Production Disruption, Compliance violation
- Management systems
  - ABB Totalflow XFC
  - Yokogawa CENTUM CS 3000
- Burner Management Systems (BMS)
- Compressor Control System (CCS)
- Vibration Monitoring System (VMS)

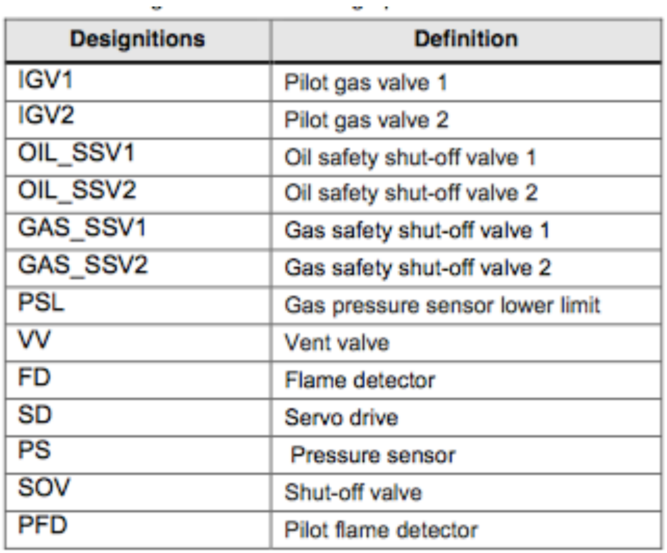
SEPARATION: Burner Management System (BMS)



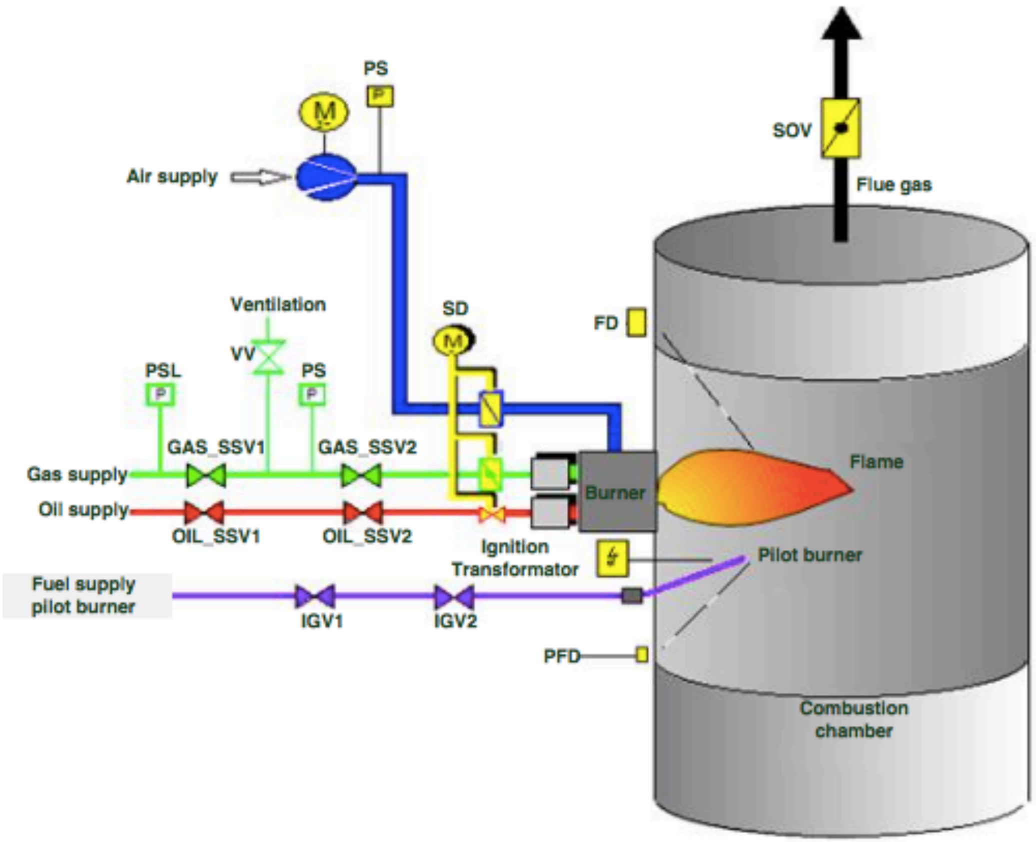
- Burner Management System
- Used in a variety of applications:
  - **Separators**, tanks, heaters, Incinerators, flare stacks, etc.
- Management systems: (easy to manipulate)
  - **Emerson's DeltaV SIS**, Invensys BMS, Honeywell's BMS, Combustex BMS-2000, Allen-Bradley, Siemens SIMATIC BMS400F
- PLC vendors:
  - GE, Modicon, Allen-Bradley, Koyo, Siemens
- Flame sensors:
  - Fireye, PPC, Honeywell, IRIS, Coen

SEPARATION: Burner Management System (BMS)

Simple Burner Management System



Designitions	Definition
IGV1	Pilot gas valve 1
IGV2	Pilot gas valve 2
OIL_SSV1	Oil safety shut-off valve 1
OIL_SSV2	Oil safety shut-off valve 2
GAS_SSV1	Gas safety shut-off valve 1
GAS_SSV2	Gas safety shut-off valve 2
PSL	Gas pressure sensor lower limit
VV	Vent valve
FD	Flame detector
SD	Servo drive
PS	Pressure sensor
SOV	Shut-off valve
PFD	Pilot flame detector



https://cache.industry.siemens.com/dl/files/036/109477036/att_856487/v2/109477036_Burner_Application_Example_TIAP_DOC_v102_en.pdf

SEPARATION: Burner Management System (BMS)

OK, what if we have access to BMS?

What can we do?

Some physical attacks?

SEPARATION: Burner Management System (BMS)

- There are **three components in the fire triangle**. If one of these components is missing, the reaction cannot be sustained.
- Control of the **air/fuel ration is one of the most important** functions of combustion/burner systems. It must ensure that sufficient excess air is maintained.
- If fuel is missing, then the system is safe, but **if air or heat for ignition is missing, the situation is potentially dangerous.**
- To minimize the explosion risk, we have to ensure that flammable mixtures do not accumulate anywhere within the plant
- There is a number of potential sources of flammable mixtures in furnace or process plant.
- **If an attacker wants to commit sabotage and stop operations by destructing burning process, he needs to control any of the sources of flammable mixtures**

SEPARATION: Burner Management System (BMS)

Flammable mixture sources:

- Oil or gas leaking into the combustion chamber through the burner as a result of **leaking fuel shut off valves**.
- Deposits of coal or oil from previous firing periods **not properly purged from the system.**
- Operation of the plant with **insufficient combustion air** resulting in CO and unburnt fuel in the downstream ducting and dust collector.
- Quenching of the flame **by cold dust entering the furnace**. Cold dust can reduce the temperature below the ignition temperature, Gas flames where the product is directly heated by the flame are particularly vulnerable to this problem. When dust bellow 500 c is entrained in the combustion air, its thermal mass reduces the flame temperature. If this occurs, unburnt gas is present in the combustion gases and there is a risk of an explosion.
- Fuel entering the furnace as a result of **repeated unsuccessful ignition attempts**. This is the significant risk with oil firing, particularly where the oil is not sufficiently hot to ignite easily. A typical cause is a cold oil remaining in pipes during a shutdown.

SEPARATION: Burner Management System (BMS)

- The burner management system performs a vital safety function, it prevents operator errors leading to danger and causes the safe shutdown of the burner in case of other equipment malfunction.
- The main function of the BMS is to allow and ensure the safe start-up, operation, and shutdown of the Fired Heater.
- Since BMS system manages all critical processes for burner safety, unauthorised access to BMS can lead to multiple risks including Explosion.
- The simplest attack on BMS System is to **turn off the purge**.
- As mentioned before, cold oil left in pipes during previous shutdowns can burn and damage the equipment.

METERING

- Risks:
  - Product Quality, Monetary loss
- Analyzes density, viscosity of content, temperature, and pressure
- Divided into several runs
- Each run employs one meter and several instruments for temperature and pressure correction
- Gas metering is less accurate (+-1%)
- LNG metered within mass flow meters

METERING: Fiscal Metering (Custody transfer)

How Custody Transfer Works:

- Custody transfer, sometimes called fiscal metering, occurs when fluids or gases are exchanged between parties.
- Payment is usually made as a function of the amount of fluid or gas transferred.
- A small error in measurement leading to financial exposure
- Typical pipeline is designed to pump 60,000 gallons of oil per minute.
- Over a year, the 0.1% error would amount to a difference of $50m.
- The error could either be on the high side, benefiting the seller; or on the low side, to the buyer's benefit.
- The engine of a custody transfer or fiscal metering installation is the flow computer.
- It is the device that takes the inputs from the measuring devices and calculates the amount of liquid or gas that has been transferred.

Error levels that would be tolerable in a process plant context can cost one side or the other tens of thousands of dollars in a matter of hours.

Fiscal Metering (examples)

- Production Accounting System
- Data Aggregation and management (easy to manipulate)
  - FlawCall – FlawCall Enterprise (! Internet access)
  - **KROHNE SynEnergy** (! Internet access + SAP access)
  - Honeywell's Experion® Process Knowledge System (PKS), MeterSuite™
  - **OPC Servers (Keepware, MatrikonOPC)** (SAP access)
  - Schneider Electric InFusion
  - Schneider Electric SCADAPack
- Flow computing: (hard to manipulate)
  - KROHNE Summit 8800
  - ABB TolatFlow
  - Emerson FloBoss S600 (previously known as Daniel DanPac S600)
  - Emerson ROC800
  - Schneider Electric Realflo
- Flow Meters
  - KROHNE, Vortex, etc.

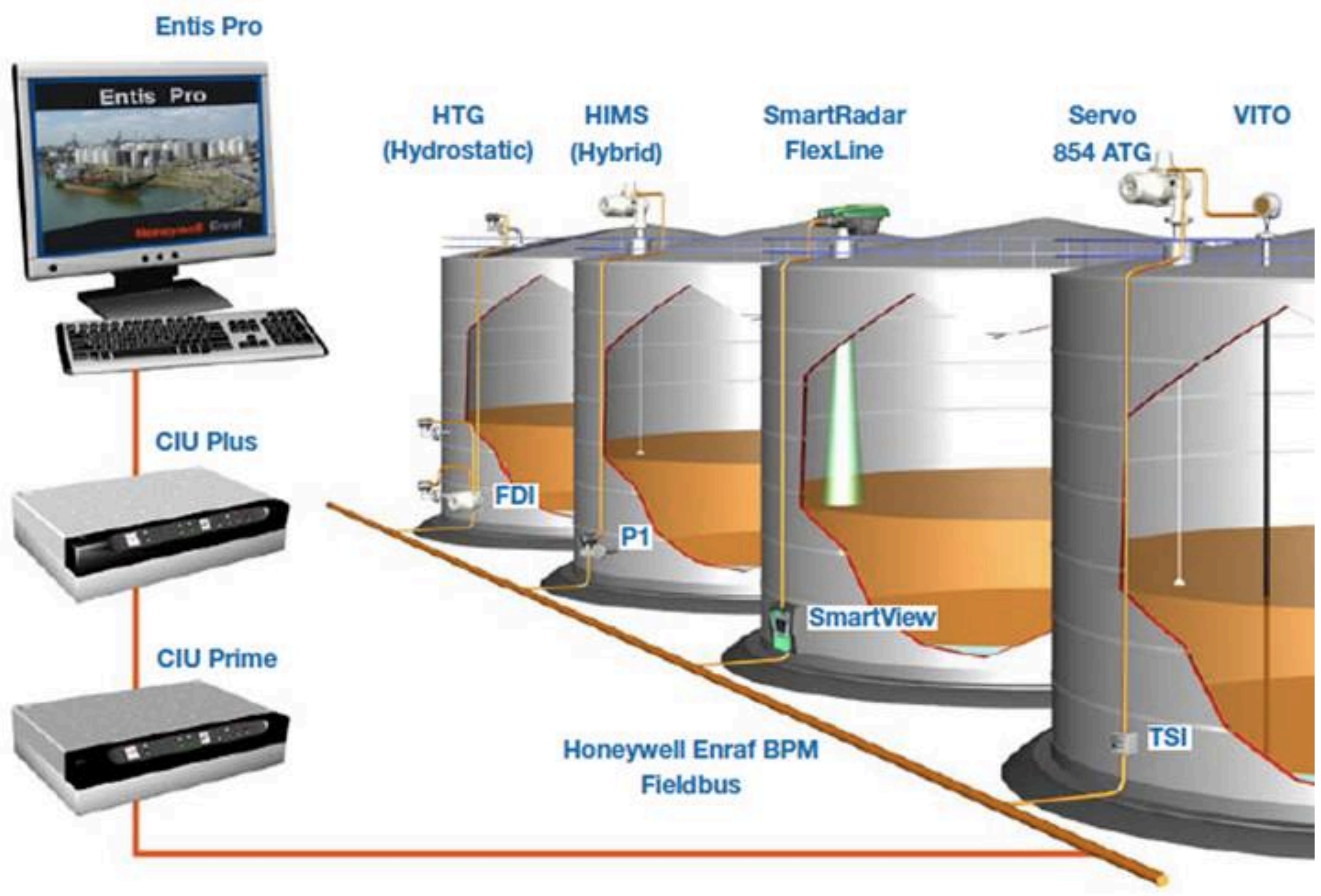
OIL STORAGE

- Risks
  - Plant Sabotage/Shutdown, Equipment damage, Production Disruption, Compliance violation, Safety violation
- Storage facilities usually consist of 10-100+ tanks with 1-50m barrels
- Managed by Tank Inventory Systems (TIA)
- TIS collects data from special **tank gauging systems** that are used to measure the level in storage tanks
- Accurate records of volumes and history are kept
- **Forecasting for stock control**
- Tank level deviations can result in hazardous events such as a tank overfilling, liquefied gas flashing, etc.

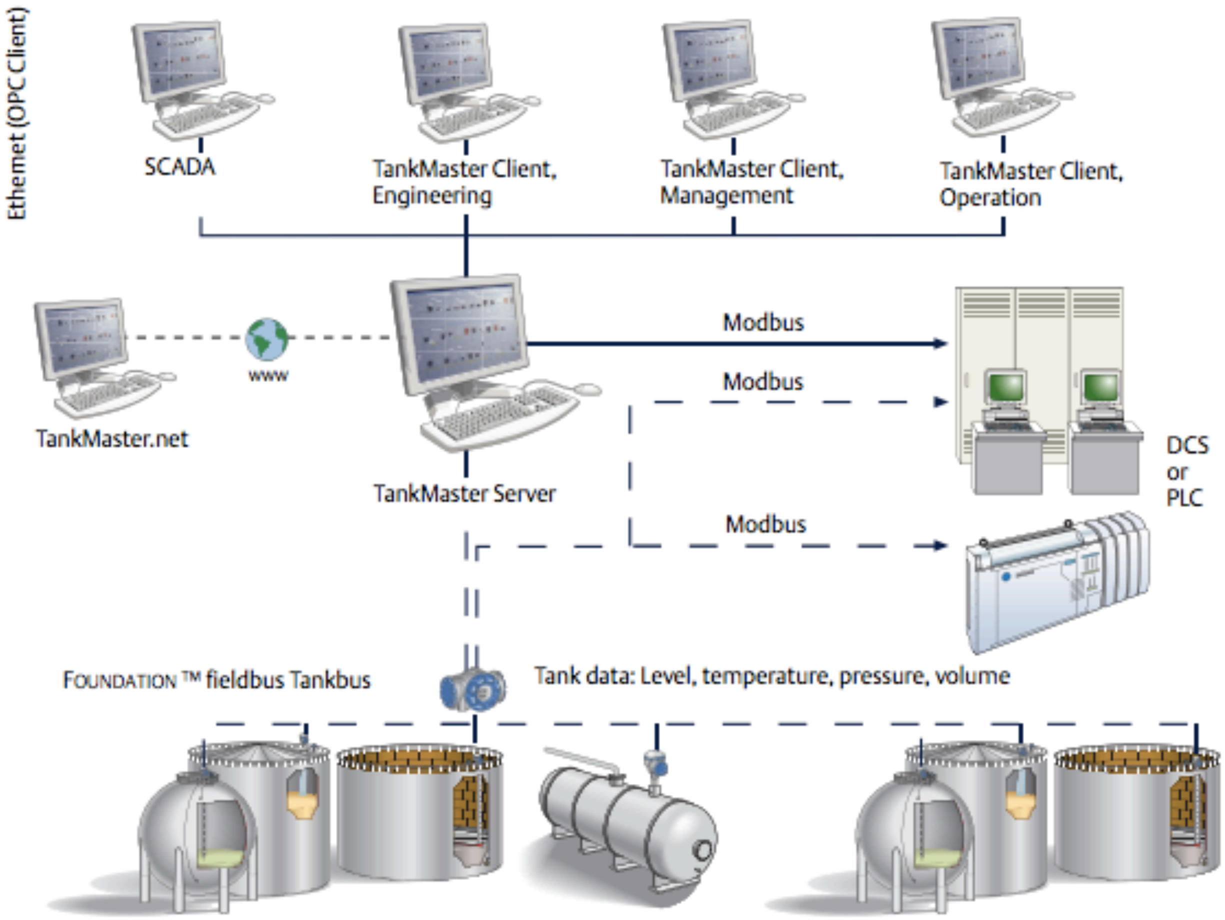
OIL STORAGE: Tank Inventory Systems (Details)

- Terminal Management
  - Honeywell Enfaf TM BOX **(connected with SAP)**
  - Emerson Syncade Terminal Logistics **(connected with SAP)**
- Tank Inventory Systems
  - Emerson Rosemount TankMaster WinOpi
  - Schneider-electric SimSci™
  - Honeywell Enraf Entis Pro
  - MHT's – VTW
- Tank Gauging Systems
  - Emerson TankMaster Server, Honeywell Enraf BPM, Saab, Varec, GSI, MTS
- Meter Management PLC's
  - ControlLogic, SmartView
- Meters/Gauges
  - SmartRadar FlexLine, ABB, Honeywell VIT, Enraf 854 ATG Servo Advanced Tank Level Gauge

Tank Inventory Systems (Honeywell Enraf)



Tank Inventory Systems (Emerson TankMaster)


Ethernet (OPC Client)
SCADA
TankMaster Client, Engineering
TankMaster Client, Management
TankMaster Client, Operation
TankMaster.net
www
TankMaster Server
Modbus
Modbus
Modbus
DCS or PLC
FOUNDATION ™ fieldbus Tankbus
Tank data: Level, temperature, pressure, volume

TankMaster distributes essential inventory tank gauging data.

Tank Inventory Systems (Emerson TankMaster)

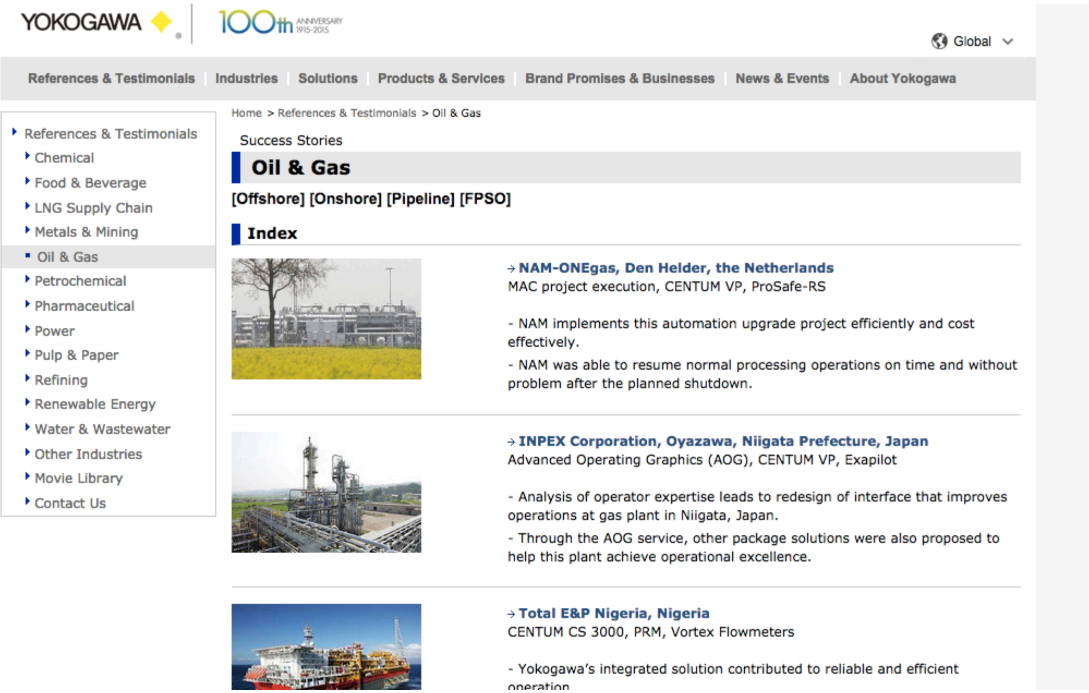
- Management console Emerson Rosemount TankMaster WinOpi
- View and **control**!
- Control commands
  - To change any alarm (Level, Temperature, Pressure)
  - To send management commands servo tanks (Freeze, Lock)

REFINERY

- Risks
  - Plant Sabotage/Shutdown, Equipment damage, Product Quality, Production Disruption, Compliance violation, Safety violation
- Oil refinery, or petroleum refinery, is an industrial process plant where crude oil is processed and refined into more useful products
- Gasoline, propane, jet fuel, heating oil, diesel fuel, kerosene, LPG, and petrochemicals are just some of the specially formulated products leaving the refinery.
- Oil refineries are typically large, sprawling industrial complexes with extensive piping running throughout, carrying streams of fluids between large chemical processing units.
- Oil refineries have much in common with chemical plants
- Technicians in a central control room can fine-tune refinery operations to produce the desired mix of products

How can an attacker get to know what victim uses?

- Press releases
- Vendor success stories
- LinkedIn
- StackOwerflow
- TechTarget
- etc.



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Success Stories

Oil & Gas

[Offshore] [Onshore] [Pipeline] [FPSO]

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→ **NAM-ONEgas, Den Helder, the Netherlands**
MAC project execution, CENTUM VP, ProSafe-RS

- NAM implements this automation upgrade project efficiently and cost effectively.
- NAM was able to resume normal processing operations on time and without problem after the planned shutdown.

→ **INPEX Corporation, Oyazawa, Niigata Prefecture, Japan**
Advanced Operating Graphics (AOG), CENTUM VP, Exapilot

- Analysis of operator expertise leads to redesign of interface that improves operations at gas plant in Niigata, Japan.
- Through the AOG service, other package solutions were also proposed to help this plant achieve operational excellence.

→ **Total E&P Nigeria, Nigeria**
CENTUM CS 3000, PRM, Vortex Flowmeters

- Yokogawa's integrated solution contributed to reliable and efficient operation

Enterprise Applications in Oil and Gas

Enterprise usage: Business Applications

SAP (ABAP, J2EE Mobile, HANA, BusinessObjects)

- More than 246000 customers worldwide
- 86% of Forbes 500
- 85% of Fortune 2000 Oil and Gas

Oracle (EBS, PeopleSoft, JDE, Siebel)

- 100% of Fortune 100

Enterprise usage: Business Applications

70 million barrels per day *of oil are produced by companies using SAP solutions*

(75% of total Oil production)

What can happen

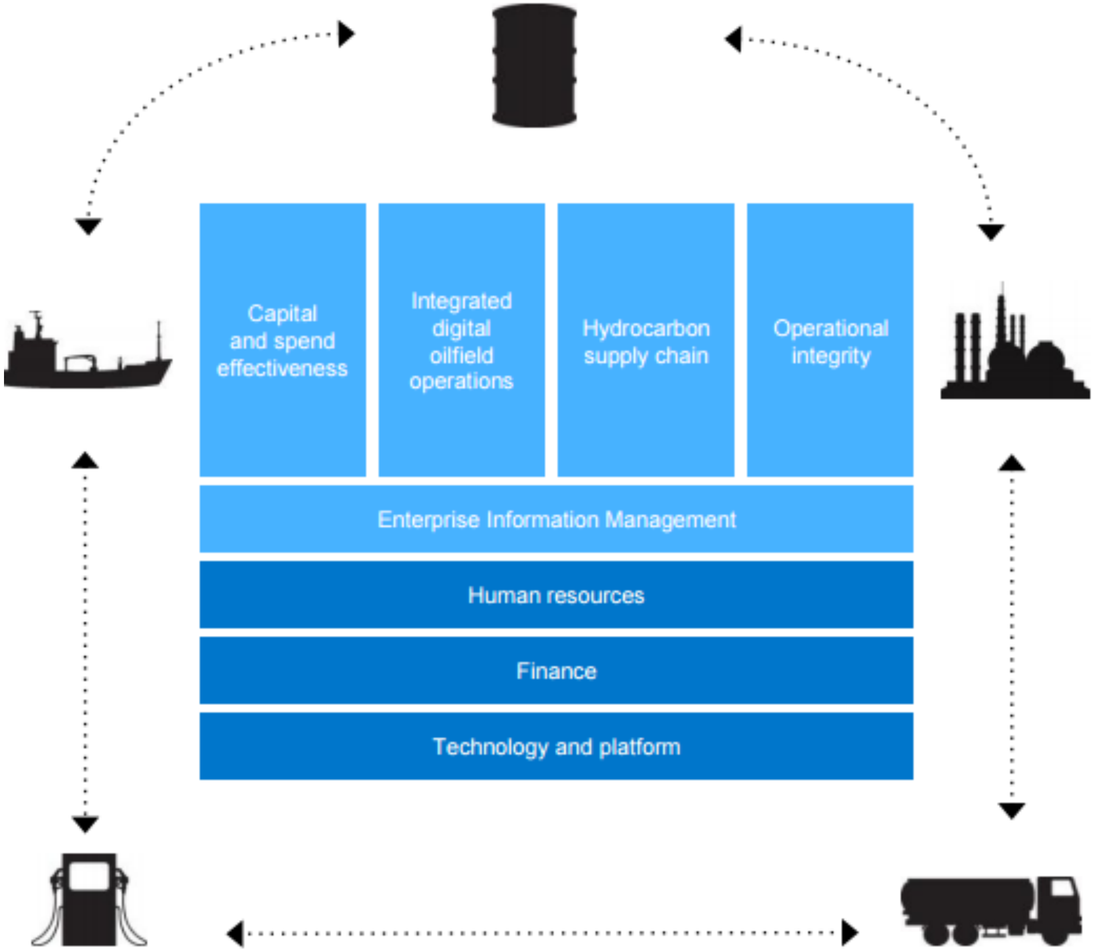
- **Espionage**
  - Theft of Financial Information
  - Trade Secret theft
  - Supplier and Customer lists theft
  - HR data theft
  - Other Corporate Data theft
- **Sabotage**
  - Denial of service
  - Modification of financial statements
  - **Access to Operations Technology network**
- **Fraud**
  - Modification of master data
  - Human Errors

SAP in Oil and Gas

According to SAP:

Today, upstream operations bring together many technical disciplines and ***business functions that are loosely connected****. The challenge is to support a closed-loop view, leveraging a common platform for operations and maintenance, to enable you to* ***gather, analyze, decide, and execute across the many elements that drive performance of assets*** *at different lifecycle stages.*

SAP in Oil and Gas



Capital and spend effectiveness

Integrated digital oilfield operations

Hydrocarbon supply chain

Operational integrity

Enterprise Information Management

Human resources

Finance

Technology and platform

SAP in Oil and Gas

Capital and Spend Effectiveness

- Capital Planning
- Portfolio and Project Management
- Strategic Sourcing and Supplier Management
- Procure To Pay and Business Network

Integrated Digital Oilfield Operations

- Hydrocarbon Production Management
- Hydrocarbon Revenue Management
- Field Logistics

Hydrocarbon Supply Chain

- Hydrocarbon Supply and Distribution
- Hydrocarbon Processing Visibility
- Commercial Sales and Marketing
- Secondary Distribution and Fuels Retailing
- Convenience Retailing

Operational Integrity

- Risk Analysis and Governance
- Workforce Competency
- Asset Integrity
- Environment, Health, and Safety

SAP In Oil and Gas: Capital and Spend Effectiveness

Advantages:

- Improving supplier relations
- Reducing the cost of processing supplier invoices
- Enhancing visibility and transparency

Risks:

- Availability – direct impact on cost effectiveness
- Fraud – price/quantity manipulation

Applications:

- SAP PPM

SAP In Oil and Gas: Hydrocarbon Supply Chain

Advantages:

- Hydrocarbon production management
- Hydrocarbon revenue management
- Field logistics

Risks:

- Supply chain Availability – direct impact on cost effectiveness
- Fraud in SAP – Manipulations with quantities*
- Sabotage - Physical damage

Applications:

- SAP ECC IS-OIL
- SAP xMII

**Hydrocarbon volumes, which are the basis for pricing, excise duty, and transportation fees, fluctuate depending on environmental temperature and pressure conditions; as we require masses and weights for product valuation, and weighing is not possible, we must derive them from volumes at ambient temperature and pressure conditions, requiring complex conversion calculations of the observed volumes at each custody transfer point. Different units of measurement are in use globally, further complicating the issue, as even modern terminal automation systems do not support all units of measure.* – Forrester Research

SAP In Oil and Gas: Integrated Digital Oilfield Operations

Advantages:

- Integrate production, maintenance, and engineering operations
- Streamline data collection, validation, surveillance, and notification
- Close the gap between decision-making and execution in the field

Risks:

- Sabotage - physical damage to production and engineering devices
- Operations Availability – direct impact on cost effectiveness
- Data manipulation in SAP – improper management decisions, lost profits

Applications:

- SAP ECC IS-OIL
- SAP PRA (production and revenue accounting)
- SAP RLM (Remote logistic management)
- SAP HANA

SAP IS-OIL Tank Master Data

- Tanks are maintained in the system as storage objects that reflect storage location stocks.
- One or more tanks can be defined at storage location level.
- A prerequisite for that is that the storage location is defined in Industry Solution Oil & Gas (Downstream) customizing as a tank storage location.
- You can make that setting by choosing HPM ® Silo/Tank Management ® Master Data ®
- Define storage location as storage location for silo/tank management.
- The characteristics of the tanks are defined as storage object characteristics.
- The following data is stored in the tank master data
  - Capacity of a tank (maximum capacity)
  - Allowable impurity quantity
  - Allowed mass
  - Throughput quantities

SAP In Oil and Gas: Operational Integrity

Advantages:

- Monitor key risk indicators and access control policy
- Maintain the structural and mechanical integrity of your physical assets
- Manage emissions, hazardous substances, and product and regulatory compliances

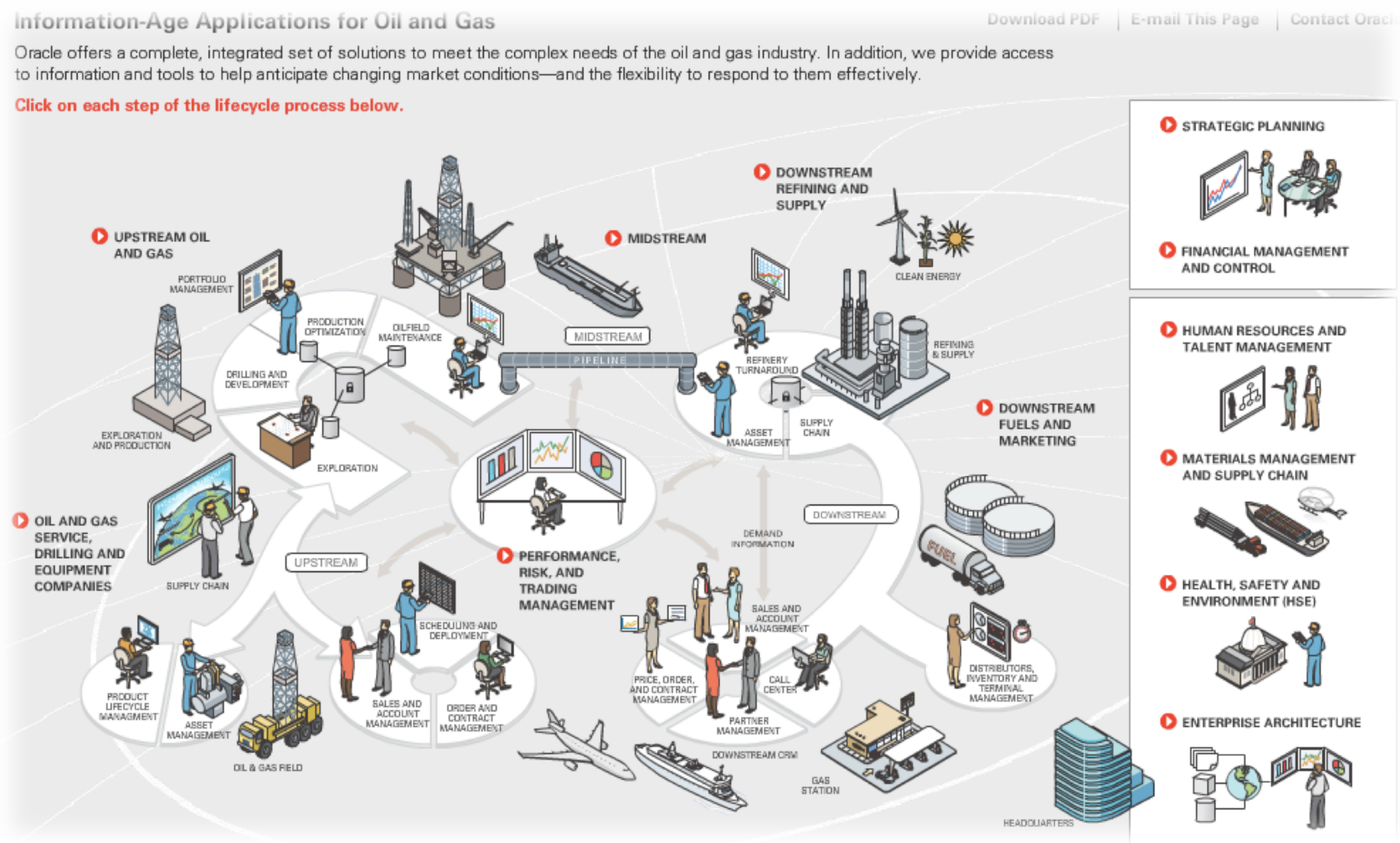
Risks:

- Access control for data manipulation
- Sabotage - Physical damage to production and engineering devices
- Compliance Violation – Data manipulation to give an illusion of meeting Compliance requirements

Applications:

- SAP EAS/PM (Asset Management)

Oracle in Oil and Gas



Information-Age Applications for Oil and Gas

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Oracle offers a complete, integrated set of solutions to meet the complex needs of the oil and gas industry. In addition, we provide access to information and tools to help anticipate changing market conditions—and the flexibility to respond to them effectively.

Click on each step of the lifecycle process below.

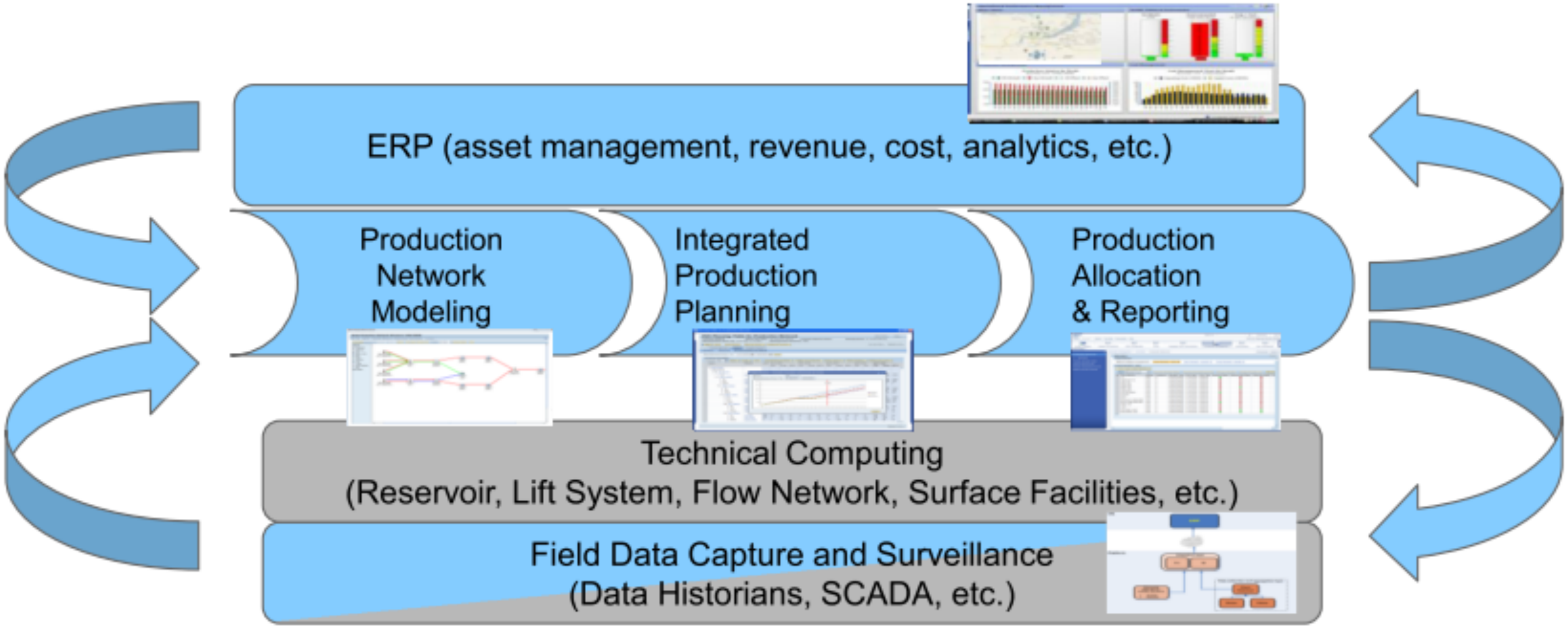
UPSTREAM OIL AND GAS
PORTFOLIO MANAGEMENT
PRODUCTION OPTIMIZATION
OILFIELD MAINTENANCE
DRILLING AND DEVELOPMENT
EXPLORATION AND PRODUCTION
EXPLORATION
MIDSTREAM
MIDSTREAM
PIPELINE
DOWNSTREAM REFINING AND SUPPLY
CLEAN ENERGY
REFINERY TURNAROUND
REFINING & SUPPLY
ASSET MANAGEMENT
SUPPLY CHAIN
DOWNSTREAM FUELS AND MARKETING
OIL AND GAS SERVICE, DRILLING AND EQUIPMENT COMPANIES
SUPPLY CHAIN
UPSTREAM
PERFORMANCE, RISK, AND TRADING MANAGEMENT
DEMAND INFORMATION
DOWNSTREAM
SCHEDULING AND DEPLOYMENT
SALES AND ACCOUNT MANAGEMENT
FUEL
PRODUCT LIFECYCLE MANAGMENT
ASSET MANAGEMENT
SALES AND ACCOUNT MANAGEMENT
ORDER AND CONTRACT MANAGEMENT
PRICE, ORDER, AND CONTRACT MANAGEMENT
CALL CENTER
PARTNER MANAGEMENT
DISTRIBUTORS, INVENTORY AND TERMINAL MANAGEMENT
OIL & GAS FIELD
DOWNSTREAM CRM
GAS STATION
HEADQUARTERS
STRATEGIC PLANNING
FINANCIAL MANAGEMENT AND CONTROL
HUMAN RESOURCES AND TALENT MANAGEMENT
MATERIALS MANAGEMENT AND SUPPLY CHAIN
HEALTH, SAFETY AND ENVIRONMENT (HSE)
ENTERPRISE ARCHITECTURE

http://www.oracle.com/ocom/groups/public/@ocom/documents/webcontent/oil-gas.html

Enterprise applications VS Oil And Gas processes

- Enterprise project portfolio management <- Exploration
  - SAP PPM, Oracle Primavera, MS Project, MS SharePoint
- Asset Lifecycle Management <- Refinery, Separation, etc.
  - SAP EAM (+AssetWise APM), Oracle EAM, Avantis, IBM Maximo
  - Connect with: OSIsoft® PI System, AspenTech® IP21, Honeywell® PHD
- LIMS <- Refinery, Separation
  - Custom app based on Oracle DBMS
  - Connect with OSIsoft PI
- Tank Master Data <- Tank Inventory
  - SAP IS-OIL-TAS, Aspentech
- Production Accounting System (PAS) <- Fiscal Metering
  - SAP IS-OIL-PRA

IT/OT connection looks like this



ERP (asset management, revenue, cost, analytics, etc.)

Production Network Modeling

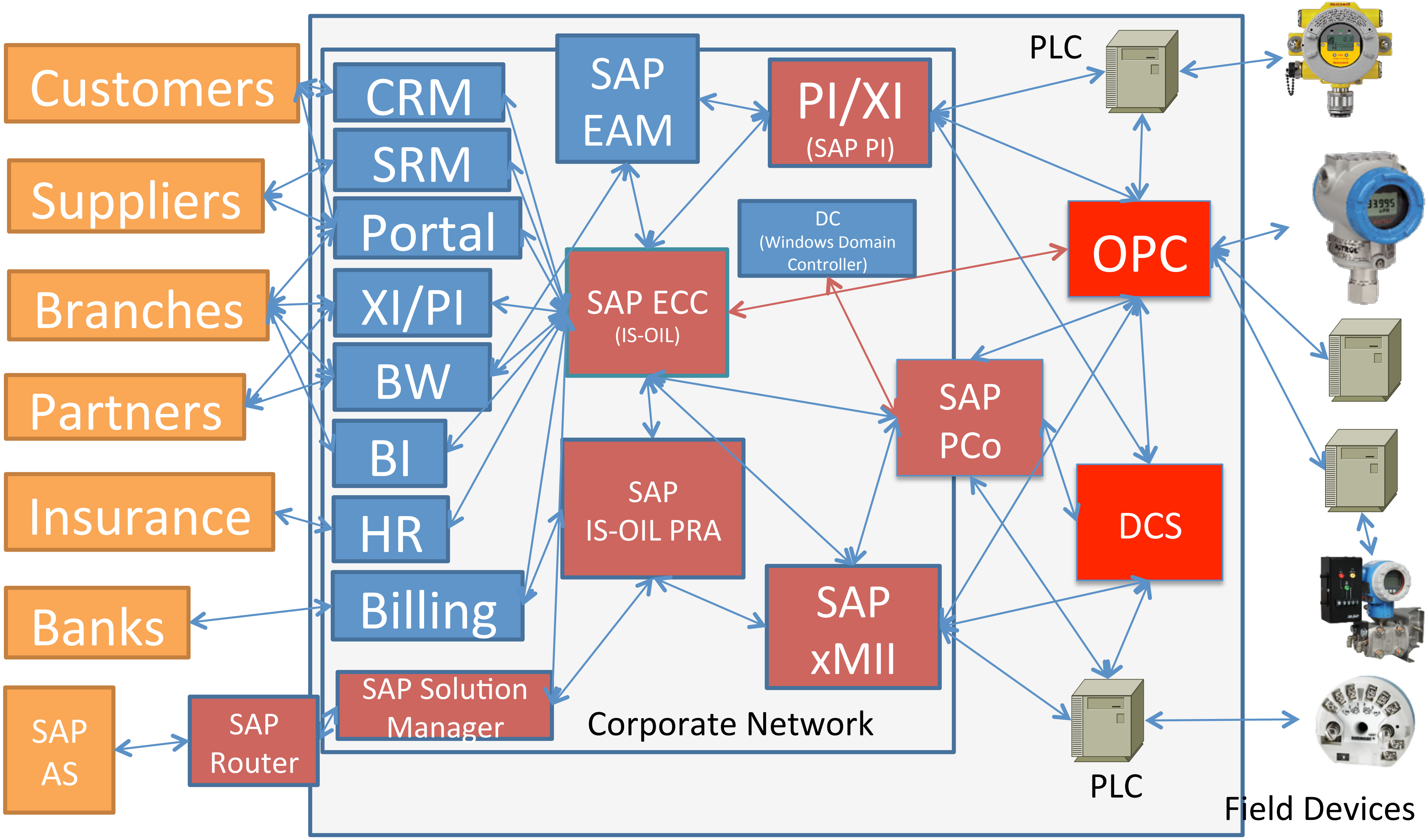
Integrated Production Planning

Production Allocation & Reporting

Technical Computing
(Reservoir, Lift System, Flow Network, Surface Facilities, etc.)

Field Data Capture and Surveillance
(Data Historians, SCADA, etc.)

Or like this


Customers
Suppliers
Branches
Partners
Insurance
Banks
SAP AS
SAP Router
CRM
SRM
Portal
XI/PI
BW
BI
HR
Billing
SAP Solution Manager
SAP EAM
PI/XI (SAP PI)
DC (Windows Domain Controller)
SAP ECC (IS-OIL)
SAP IS-OIL PRA
SAP PCo
SAP xMII
Corporate Network
PLC
OPC
DCS
PLC
Field Devices

Attacking Oil and Gas companies

From the Internet to CORP

Stage 1 (Internet to Corp.)

- Via Internet resources (SAP Portal/CRM/SRM)
  - http://erpscan.com/wp-content/uploads/2013/07/SAP-Portal-Hacking-and-Forensics-at-Confidence-2013.pdf
- Via Partners (SAP XI)
  - http://erpscan.com/wp-content/uploads/publications/SSRF-vs-Businness-critical-applications-final-edit.pdf
- Via SAP Router
  - http://erpscan.com/advisories/dsecrg-13-013-saprouter-heap-overflow/
- Via Workstations (Trojans)
  - http://erpscan.com/wp-content/uploads/publications/SAP-Security-Attacking-SAP-clients.pdf
- Via Unnecessary SAP Services in the Internet
  - http://erpscan.com/wp-content/uploads/publications/SAP-Security-Attacking-SAP-clients.pdf

From Corp to ERP

Stage 2 (From Internal Network to ERP)

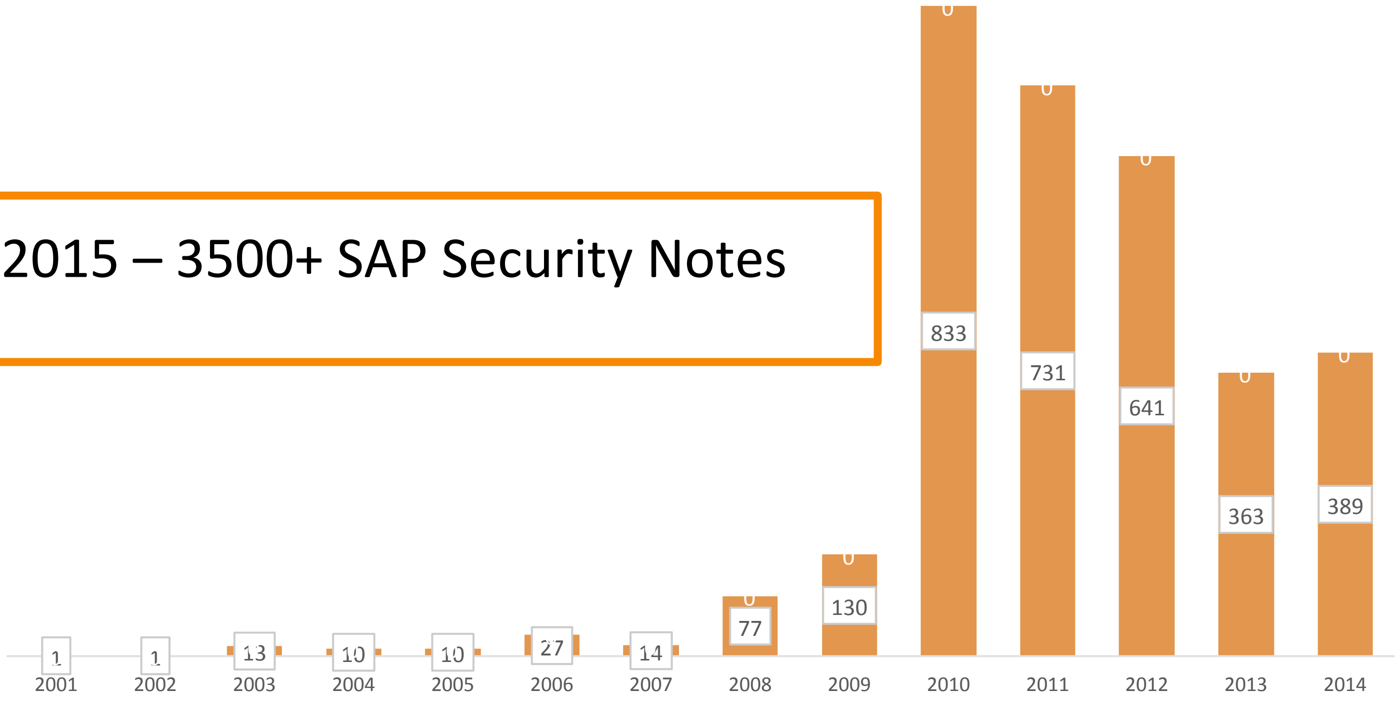
Numerous ways how an ERP system can be compromised:

- Vulnerabilities
- Misconfigurations
- Unnecessary privileges
- Custom code issues

ERPScan
Security Solutions for SAP

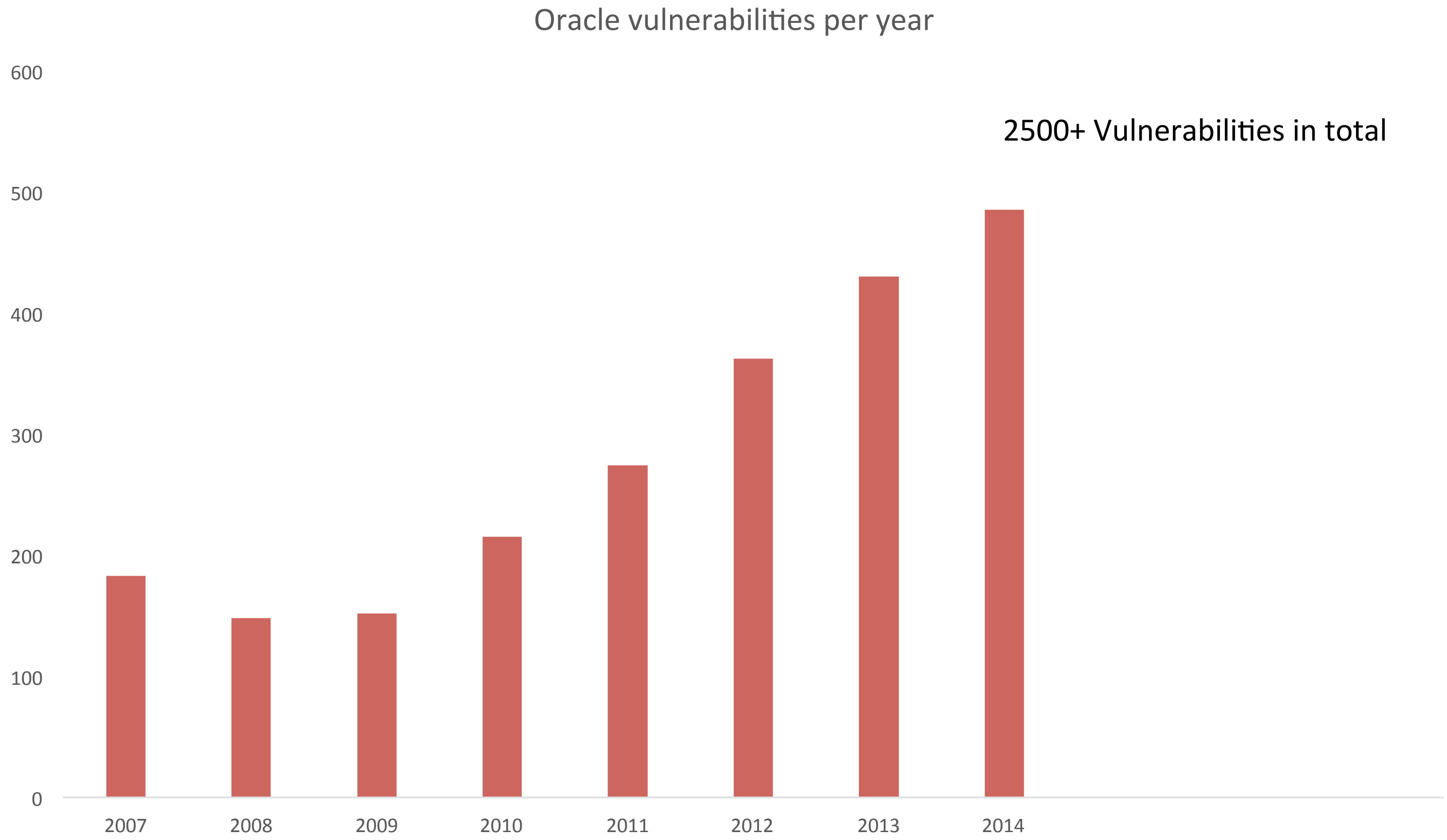
Stage 2 (Vulnerabilities in SAP Products)

By October 2015 – 3500+ SAP Security Notes



Only one vulnerability would suffice
to jeopardize ALL business-critical data

Stage 2 (Vulnerabilities in Oracle products)



2500+ Vulnerabilities in total

Stage 2 (Misconfigurations in SAP)

- ~1500 profile parameters
- ~1200 Web applications
- ~700 web services
- ~100 specific commands for MMC
- ~100 specific checks for each of the 50 modules (FI, HR, Portal, MM, CRM, SRM, PLM, Industry solutions…….)

All these configurations can be improperly implemented thus allowing cybercriminals to obtain access to mission-critical systems.

http://erpscan.com/wp-content/uploads/publications/EASSEC-PVAG-ABAP.pdf

Stage 2 (Custom code issues)

Domain specific languages in business applications (ABAP, PeopleCode, XSJS, X++) can have vulnerabilities as well as backdoors left by 3rd party organizations:

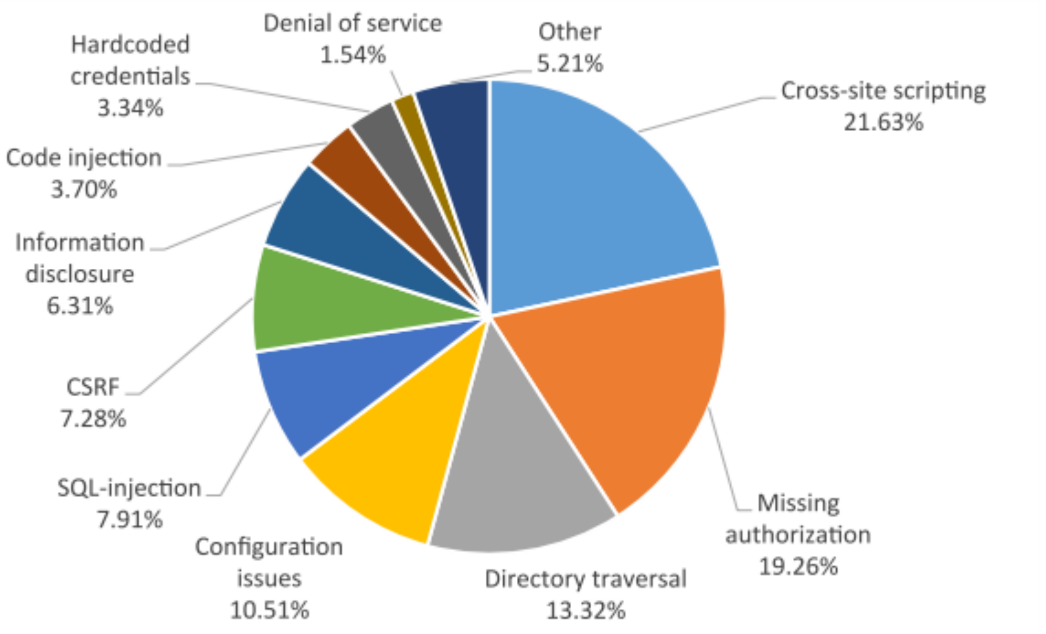


Figure 3.4-1 TOP-10 SAP Security Vulnerabilites, sorted by type

http://erpscan.com/wp-content/uploads/publications/3000-SAP-notes-Analysis-by-ERPScan.pdf

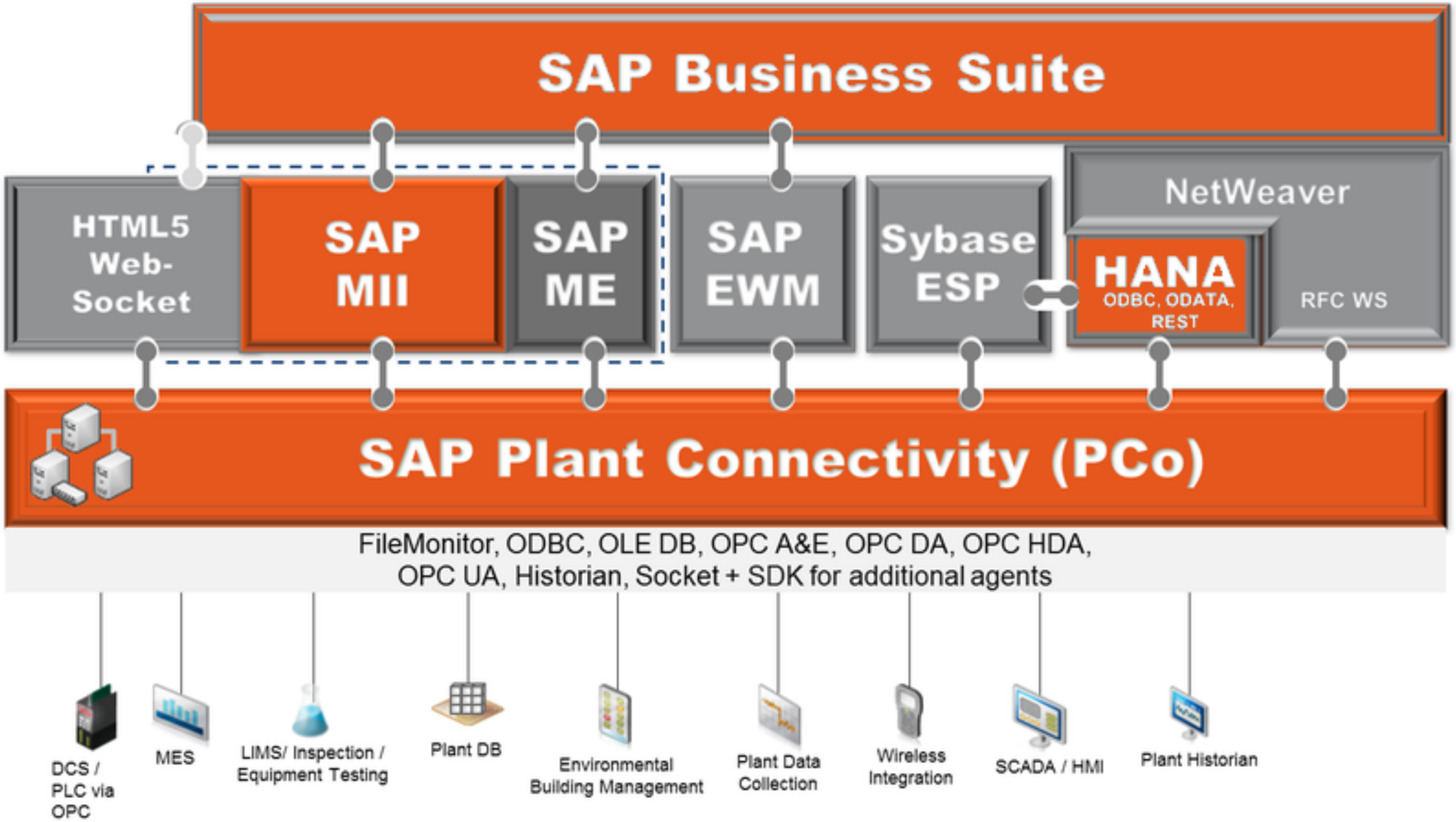
Stage 2 (Unnecessary privileges)

Critical privileges and SoD issues

- For example: Create vendor + Approve payment order
- 500k potential conflicts in typical company

From ERP to OT

Stage 3 (From SAP to Plant)


SAP Business Suite
HTML5 Web-Socket
SAP MII
SAP ME
SAP EWM
Sybase ESP
NetWeaver
HANA
ODBC, ODATA, REST
RFC WS
SAP Plant Connectivity (PCo)
FileMonitor, ODBC, OLE DB, OPC A&E, OPC DA, OPC HDA,
OPC UA, Historian, Socket + SDK for additional agents
DCS / PLC via OPC
MES
LIMS/ Inspection / Equipment Testing
Plant DB
Environmental Building Management
Plant Data Collection
Wireless Integration
SCADA / HMI
Plant Historian

Stage 3 (From SAP to Plant)

- **SAP ERP -> SAP XMII -> SAP PCo -> DCS/SCADA -> PLC -> Meter**
- SAP ERP -> SAP XMII -> SAP PCo -> PLC -> Meter
- SAP ERP -> SAP XMII -> DCS/SCADA(OPC) ->PLC-> Meter
- SAP ERP -> SAP PCo -> OPC Server -> PLC -> Meter
- SAP ERP -> SAP PCo -> PLC -> Meter
- SAP ERP(PP) -> SAP PI -> OPC-> PLC -> Meter
- SAP ERP(PP) -> SAP PI -> SAP xMII->OPC -> PLC -> Meter
- SAP PM (EAM) -> OsiSoft PI -> OPC
- **SAP HANA (Rolta OneView) -> OPC/DCS ->PLC->Meter**
- Oracle DB (LIMS) -> OsiSoft PI -> DCS -> PLC-> Meter
- **Oracle EAM -> OsiSoft PI -> DCS -> PLC-> Meter**
- Domain Controller -> SAP PCo -> PLC -> Meter
- Shared SSH keys
- Similar passwords
- Improper firewall configuration

Stage 3 (From SAP to Plant)

Finally, we need to find a way to hack

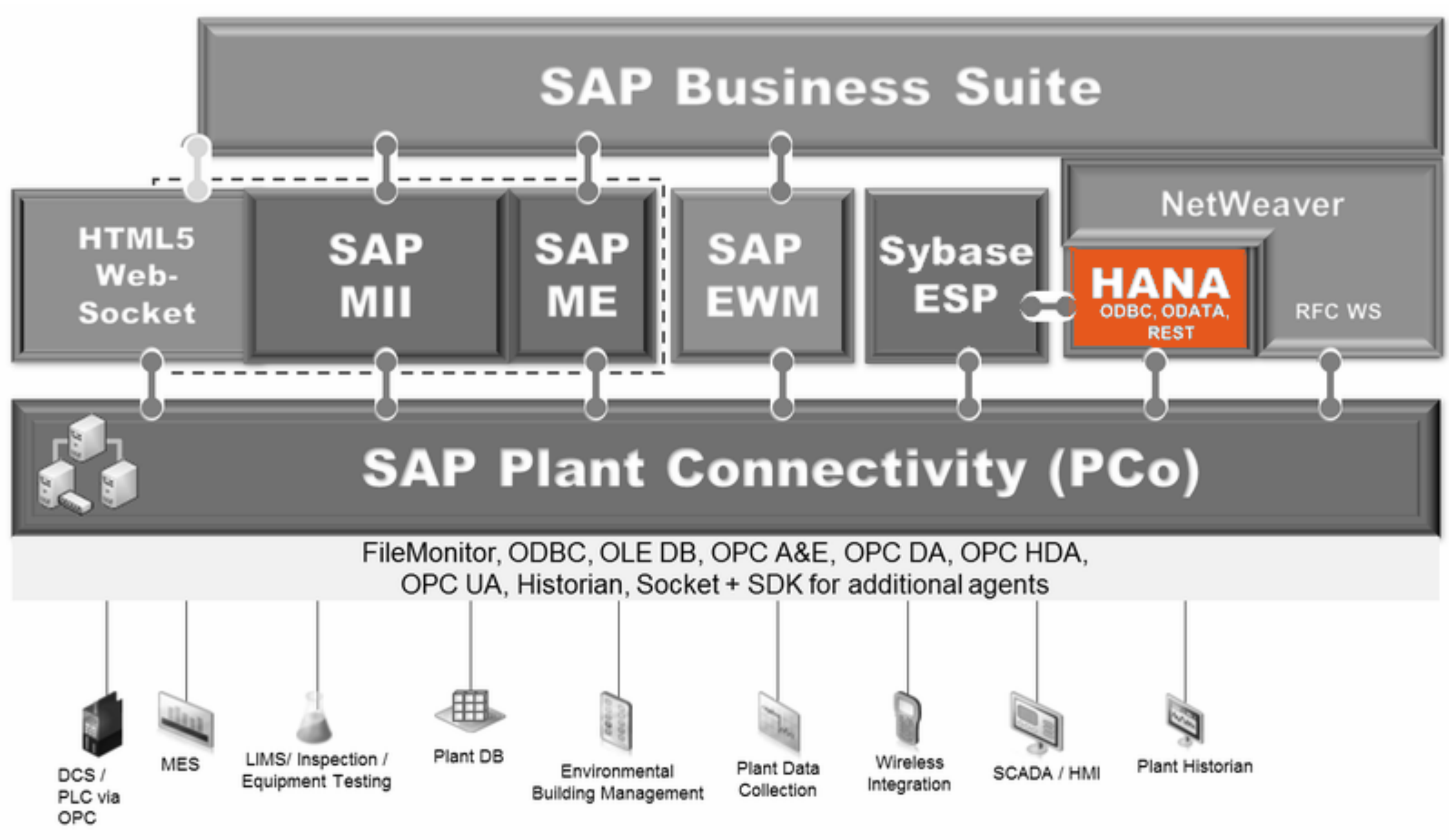
- **Oracle EAM**
- **SAP HANA**
- **SAP xMII**
- **SAP PCo**

Stage 3 (Hacking Oracle EAM)

- Oracle Enterprise Asset Management is an application based on Oracle E-Business Suite platform.
- Thus, every vulnerability that can be used to get unauthorized access to Oracle EBS can be used to break into Oracle EAM system.
- ERPScan's experts have recently disclosed details of 6 vulnerabilities in Oracle E-Business Suite.
  - XSS Vulnerability,
  - SQL Injection vulnerability,
  - XXE Injection Vulnerabilities, ([1], [2])
  - User Enumeration vulnerability.

http://erpscan.com/press-center/press-release/erpscan-took-a-closer-look-at-oracle-ebs-security-6-vulnerabilities-patched-in-recent-update/

Stage 3 (Hacking SAP HANA)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Stage 3 (Hacking SAP HANA)

- SAP HANA collects the most critical data from Plant for analytics
- It is a database used by many SAP and non-SAP applications
- Some of them (RoltaOneview) also store critical data to analyze

How to hack HANA?

- Connections with other systems (ERP, LIMS, Custom)
- SAP RFC connections
- **SAP HANA Vulnerabilities**

Stage 3 (Hacking SAP HANA)

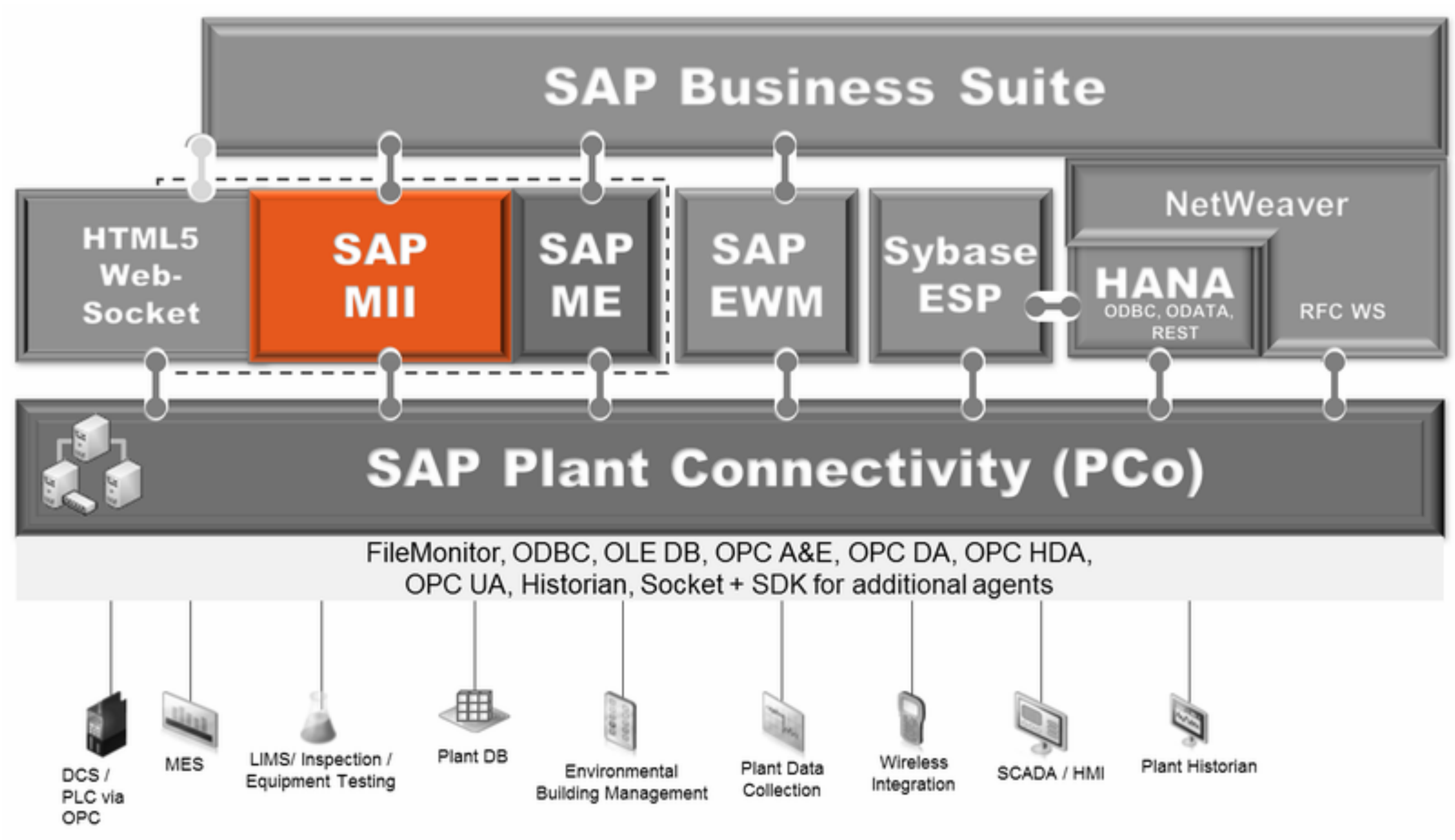
- **[ERPSCAN-15-024] SAP HANA hdbindexserver – Memory corruption**
- An anonymous attacker can use a special HTTP request to corrupt SAP HANA index server memory.
- An attacker can use vulnerability to execute commands remotely without authorization, under the privileges of the service that executes them.
- CVSS: 9.3
- http://erpscan.com/advisories/erpscan-15-024-sap-hana-hdbindexserver-memory-corruption/
- http://www.fierceitsecurity.com/story/security-holes-rise-sap-hana-big-data-platform-warns-erpscan/2015-10-15

Stage 3 (Hacking SAP HANA)

Correction

SAP Note 2197428

Stage 3 (Hacking SAP MII)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Stage 3 (Hacking SAP xMII)

Some systems should be connected at least on the network layer

Attack Surface:

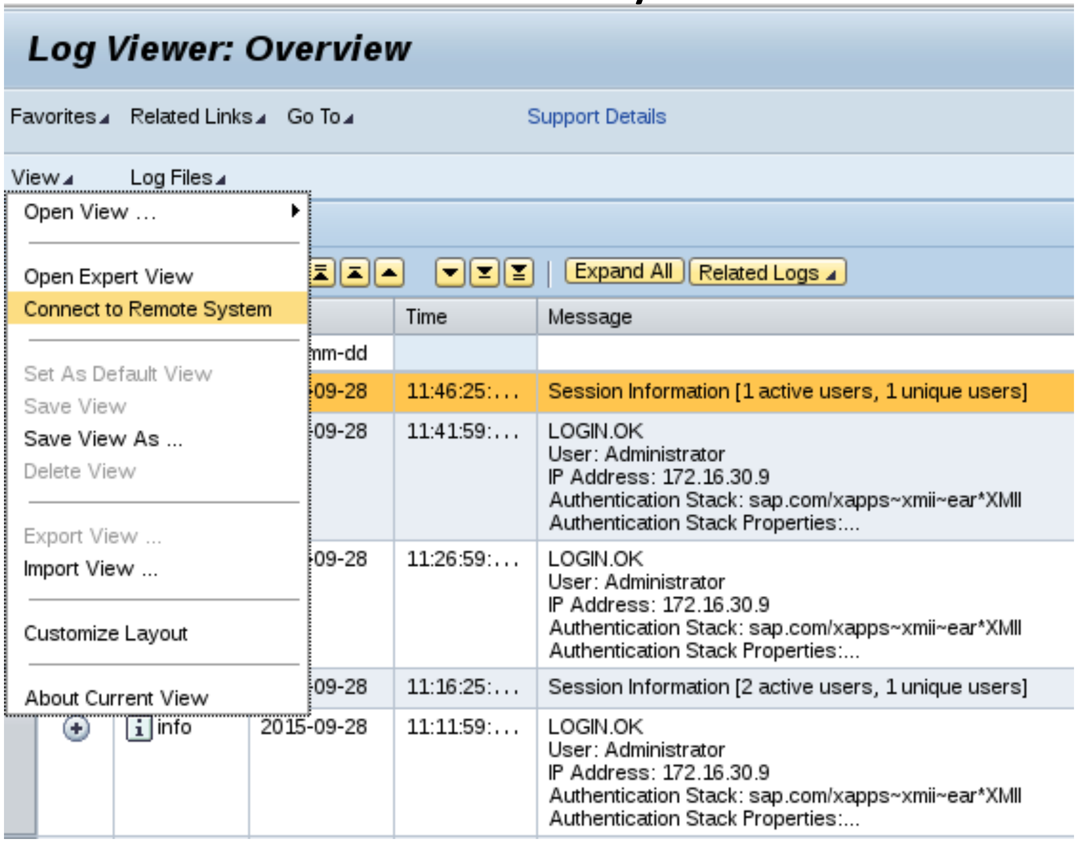
- SAP RFC links from ERP to xMII
- **NetWeaver J2EE Platform vulnerabilities (core of xMII)**
- Direct SAP xMII vulnerabilities (XXE)
- Database links to xMII
- Shared SSH keys
- Similar passwords
- Others

Stage 3 (SAP xMII overview)

- MII: Manufacturing Integration and Intelligence
- Connects manufacturing with enterprise business processes, provides information to improve production performance
- On top of SAP Netweaver J2EE (with its vulnerabilities)
- xAPPs technology exposes web services and data from multiple systems
- **Located on the corporate network**
- `xapps~mii~ears` is the main application with several endpoints accessible at http://server:50000/XMII
- Has some vulnerabilities (Blind SQLi/XXE) [can't disclose details]

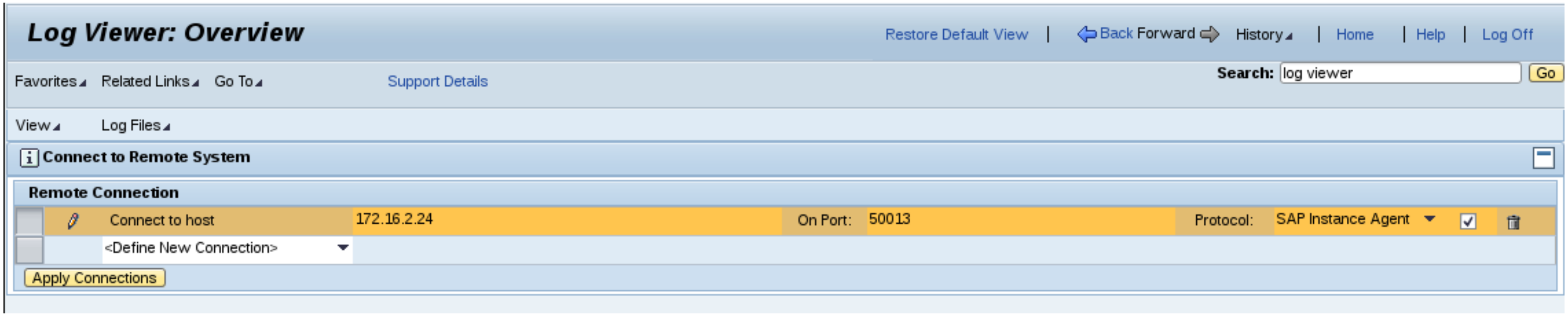
Stage 3 (Getting OS access to xMII)

- We have Admin access, but how to execute OS commands?
- In «Log viewer» we chose «Connect to Remote System»



```
09-28       11:46:25:...  Session Information [1 active users, 1 unique users]
09-28       11:41:59:...  LOGIN.OK
                          User: Administrator
                          IP Address: 172.16.30.9
                          Authentication Stack: sap.com/xapps~xmii~ear*XMII
                          Authentication Stack Properties:...
09-28       11:26:59:...  LOGIN.OK
                          User: Administrator
                          IP Address: 172.16.30.9
                          Authentication Stack: sap.com/xapps~xmii~ear*XMII
                          Authentication Stack Properties:...
09-28       11:16:25:...  Session Information [2 active users, 1 unique users]
info  2015-09-28  11:11:59:...  LOGIN.OK
                          User: Administrator
                          IP Address: 172.16.30.9
                          Authentication Stack: sap.com/xapps~xmii~ear*XMII
                          Authentication Stack Properties:...
```

Stage 3 (Getting OS access to xMII)



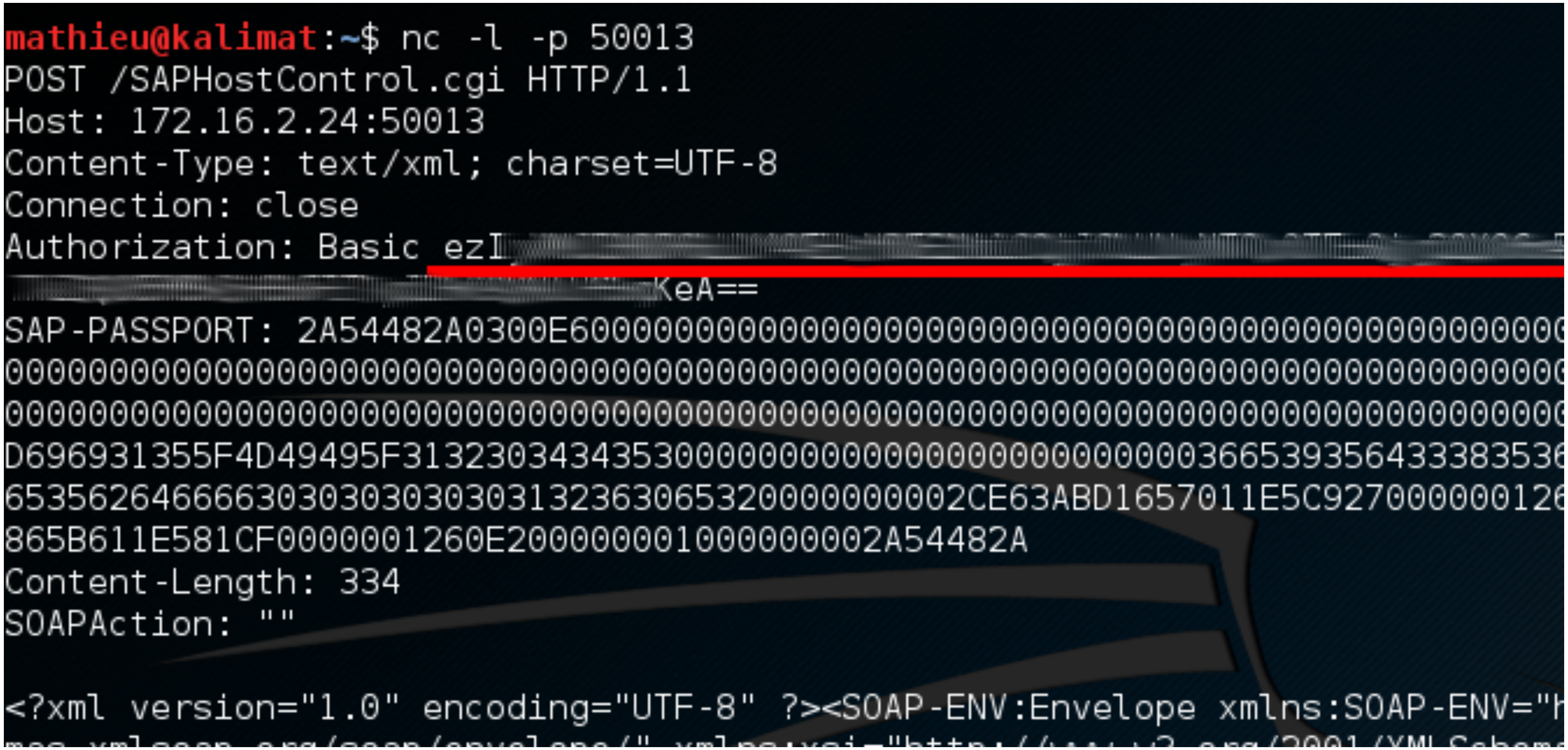
Search: log viewer

Connect to host	172.16.2.24	On Port:	50013	Protocol: SAP Instance Agent ☑
<Define New Connection>				

We enter the IP of a machine controlled by us

It will connect back to my laptop with something...

Stage 3 (Getting OS access to xMII)



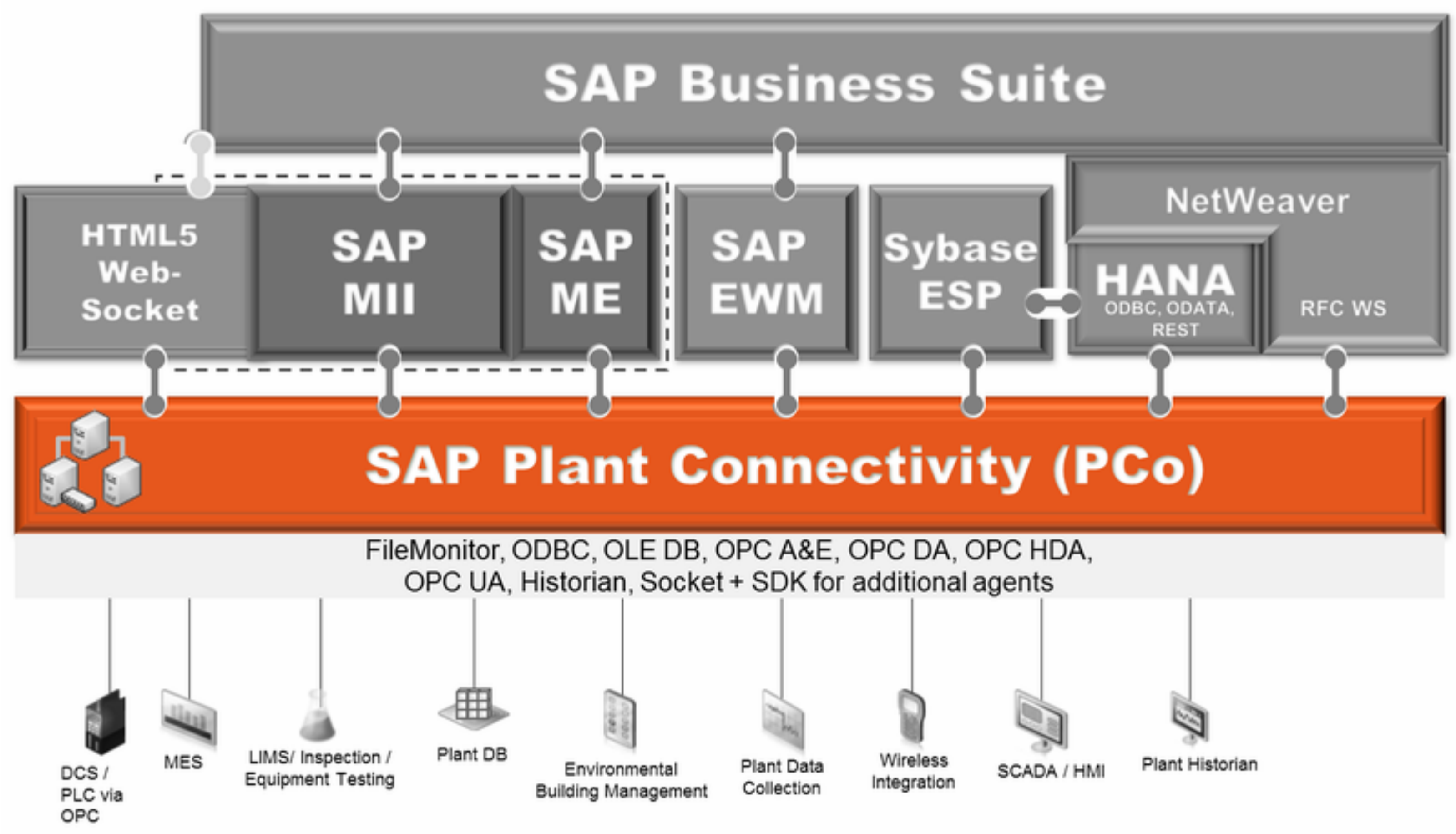
```
mathieu@kalimat:~$ nc -l -p 50013
POST /SAPHostControl.cgi HTTP/1.1
Host: 172.16.2.24:50013
Content-Type: text/xml; charset=UTF-8
Connection: close
Authorization: Basic ezI[redacted]
KeA==
SAP-PASSPORT: 2A54482A0300E60000000000000000000000000000000000000000000000
00000000000000000000000000000000000000000000000000000000000000000000
00000000000000000000000000000000000000000000000000000000000000000000
D696931355F4D49495F31323034343530000000000000000000000036653935643338353
6535626466663030303030303132363065320000000002CE63ABD1657011E5C92700000012
865B611E581CF0000001260E20000000100000002A54482A
Content-Length: 334
SOAPAction: ""

<?xml version="1.0" encoding="UTF-8" ?><SOAP-ENV:Envelope xmlns:SOAP-ENV="h
mas.xmlsoap.org/soap/envelope/" xmlns:xsi="http://www.w3.org/2001/XMLSchem
```

Request contains Basic Authentication header
We decode it as user « {221….} » and password x***********x
The password is random and lives max. the JVM lifetime

Stage 3 (Getting OS access to xMII)

- Welcome to built-in SAPControl accounts
- Usually, the SOAP endpoint on `tcp 50013/1128` is used with OS credentials, but there are exceptions ;-)
- SOAP function `OSExecute()` is granted with that special user
- `miiadm`" OS execution rights
  - Dump sensitive files like `SecStore.*` → get Sybase sa account
  - Dump backdoor, get remote shell
- Real pentest of PCo begins

Hacking SAP Plan Connectivity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HTML5 Web-Socket
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Hacking SAP Plan Connectivity

SAP Plant Connectivity (PCo) usually stays between SAP xMII and Critical device

Attack surface

- Connections with other systems (MES, LIMS, Custom)
- **SAP xMII connections (password decryption)**
- **SAP PCo vulnerabilities**
- SAP PCo extensions
- Domain credentials (if improperly secured)
- Database links
- Shared SSH keys
- Similar passwords

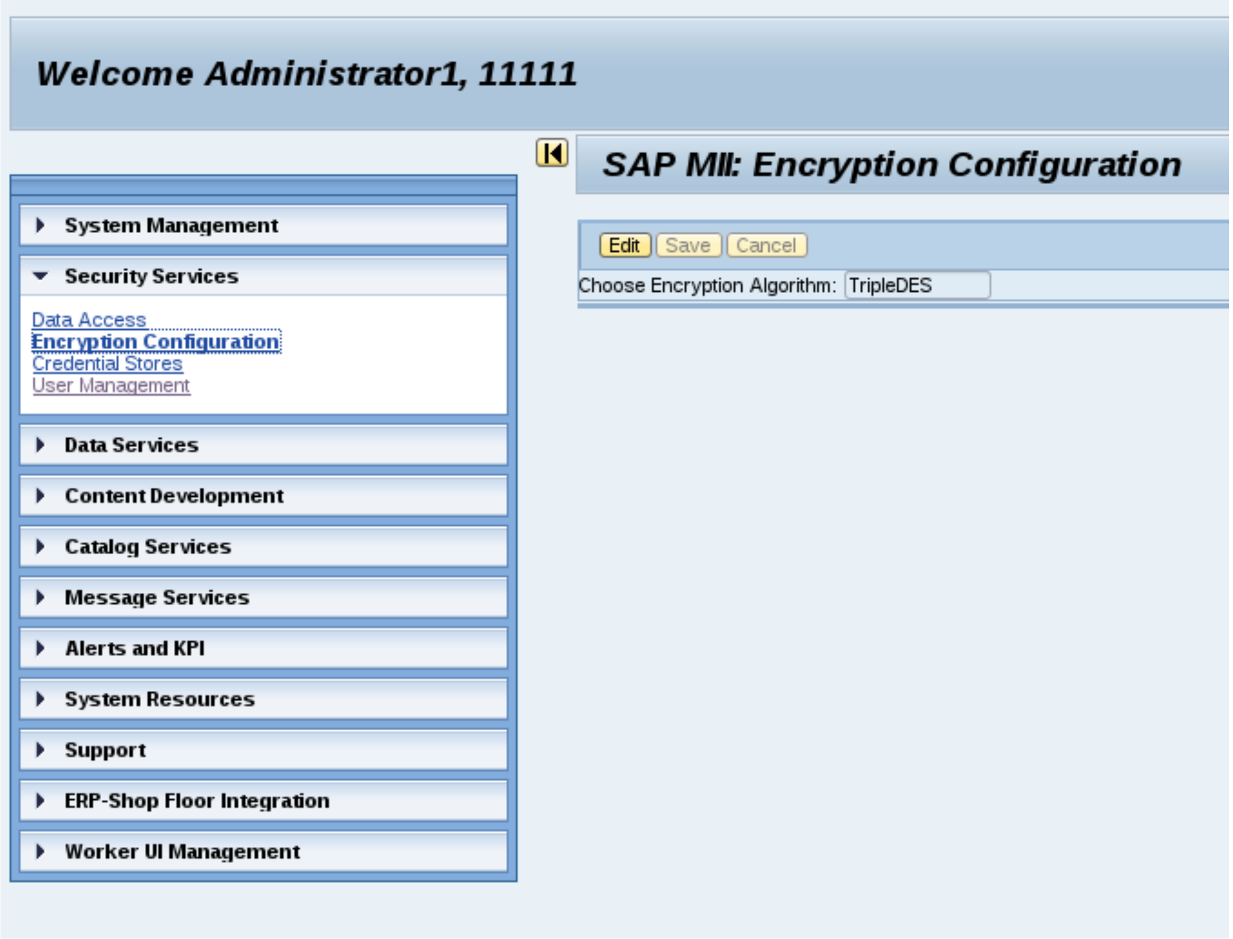
SAP PCo overview

- SAP Plant Connectivity
- Bridge between the industrial world and SAP Manufacturing modules
- Windows box, .NET application
- Usual pipeline Source→ Processing → Destination
- Source: OPC server (MatrikonOPC, Siemens Simatic, KEPServerEX) or DCS (???)
- Destination: SAP HANA, SAP XI, SAP xMII, LIMS, DB…
- Agent: Windows service that does the polling

Hacking SAP PCo

- We have Admin access to xMII
- Table `SAPSR3DB.XMII_SERVERPROP` contains the user/pass of PCo when in the «Query Process» mode
- Password is 3DES encrypted. Where is the key?
- Inside the SecureStorage
- But…

Hacking SAP PCo (lower encryption)

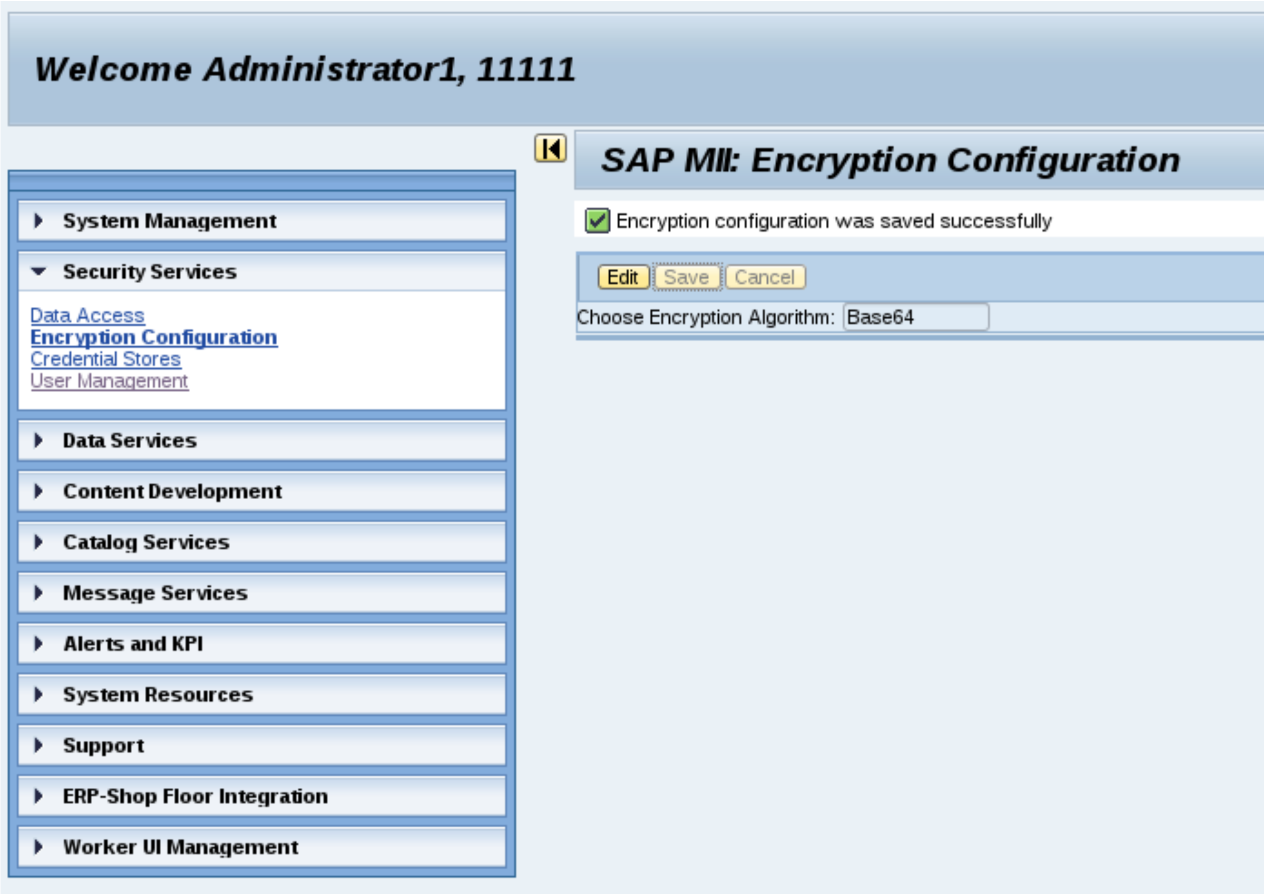


Welcome Administrator1, 11111

SAP MII: Encryption Configuration

Choose Encryption Algorithm: TripleDES

Hacking SAP PCo (now encryption is Base64)



Welcome Administrator1, 11111

SAP MII: Encryption Configuration

✓ Encryption configuration was saved successfully

Choose Encryption Algorithm: Base64

Hacking SAP PCo (now encryption is Base64)

Correction

SAP Note 2240274

Stage 3 (Hacking PCo)

- TCP/50050 : SOAP remote administration interface is offered by `pcohostsvc.exe` (Windows service manually started)
  - Start/Stop instance, dump configuration
- TCP/9000 : by default without authentication
  - «Active Queries» to the PCo instance via xMII protocol (XML)
- TCP/445: For Domain Access
  - Full access to PCo. Just use our login/pass from xMII

Stage 3 (SAP PCo – post-exploitation)

- Traffic modification: attacks based on the fact that the MII-PCo connection is not authenticated by default:
  - Fake PCo
    - Kill the actual PCo and show that everything is OK in MII
    - MITM + selective modification
    - Steal your oil, but tank level doesn't change
  - Protocol attack
    - MII = requests over XML
    - Protocol parsing on the PCo side
    - Fuzzing (Kill agent + mem leak)
  - Exploitation of the source via this channel?

Correction

SAP Note 2238619

Advisory

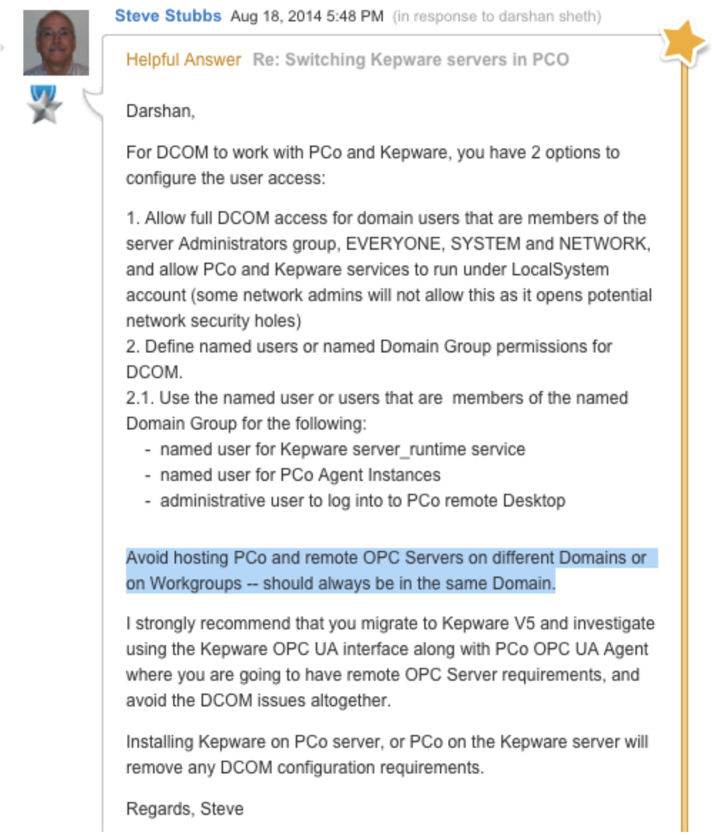
http://erpscan.com/press-center/blog/sap-security-notes-november-2015-review

Now we are inside your OT network and can do whatever we want, there is no Air Gap!

Stage 4 (Access to DCS/OPC/SCADA)

- SAP Plant Connectivity interacts with DCS/OPC
  - **On the same workstation**
    - **Required when configuring some DCS/SCADA systems**
  - **On the same network**
    - Example: OPC vulnerabilities
      - KEPServerEX Resource exhaustion https://ics-cert.us-cert.gov/advisories/ICSA-15-055-02
      - KEPServerEX Input Validation https://ics-cert.us-cert.gov/advisories/ICSA-13-226-01
      - MatrikonOPC Gateway DoS https://ics-cert.us-cert.gov/advisories/ICSA-13-106-01
      - MatricanOPC DoS (0-day) Planning to send it to vendor

- DCS/SCADA can control PLC
  - **Attack PLC using access to DCS/SCADA**
  - **Attack PLC via PLC vulnerabilities**
    - Example: ABB AC500
      - ICSA-12-320-01 : ABB AC500 PLC Webserver CoDeSys Vulnerability



Steve Stubbs Aug 18, 2014 5:48 PM (in response to darshan sheth)

Helpful Answer **Re: Switching Kepware servers in PCO**

Darshan,

For DCOM to work with PCo and Kepware, you have 2 options to configure the user access:

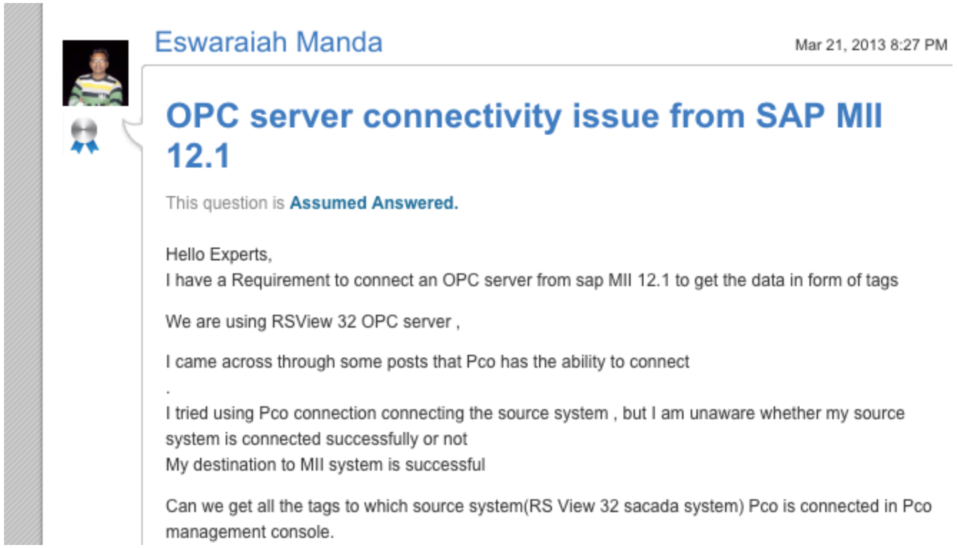
1. Allow full DCOM access for domain users that are members of the server Administrators group, EVERYONE, SYSTEM and NETWORK, and allow PCo and Kepware services to run under LocalSystem account (some network admins will not allow this as it opens potential network security holes)
2. Define named users or named Domain Group permissions for DCOM.
2.1. Use the named user or users that are members of the named Domain Group for the following:
  - named user for Kepware server_runtime service
  - named user for PCo Agent Instances
  - administrative user to log into to PCo remote Desktop

Avoid hosting PCo and remote OPC Servers on different Domains or on Workgroups -- should always be in the same Domain.

I strongly recommend that you migrate to Kepware V5 and investigate using the Kepware OPC UA interface along with PCo OPC UA Agent where you are going to have remote OPC Server requirements, and avoid the DCOM issues altogether.

Installing Kepware on PCo server, or PCo on the Kepware server will remove any DCOM configuration requirements.

Regards, Steve



Eswaraiah Manda Mar 21, 2013 8:27 PM

OPC server connectivity issue from SAP MII 12.1

This question is **Assumed Answered.**

Hello Experts,
I have a Requirement to connect an OPC server from sap MII 12.1 to get the data in form of tags

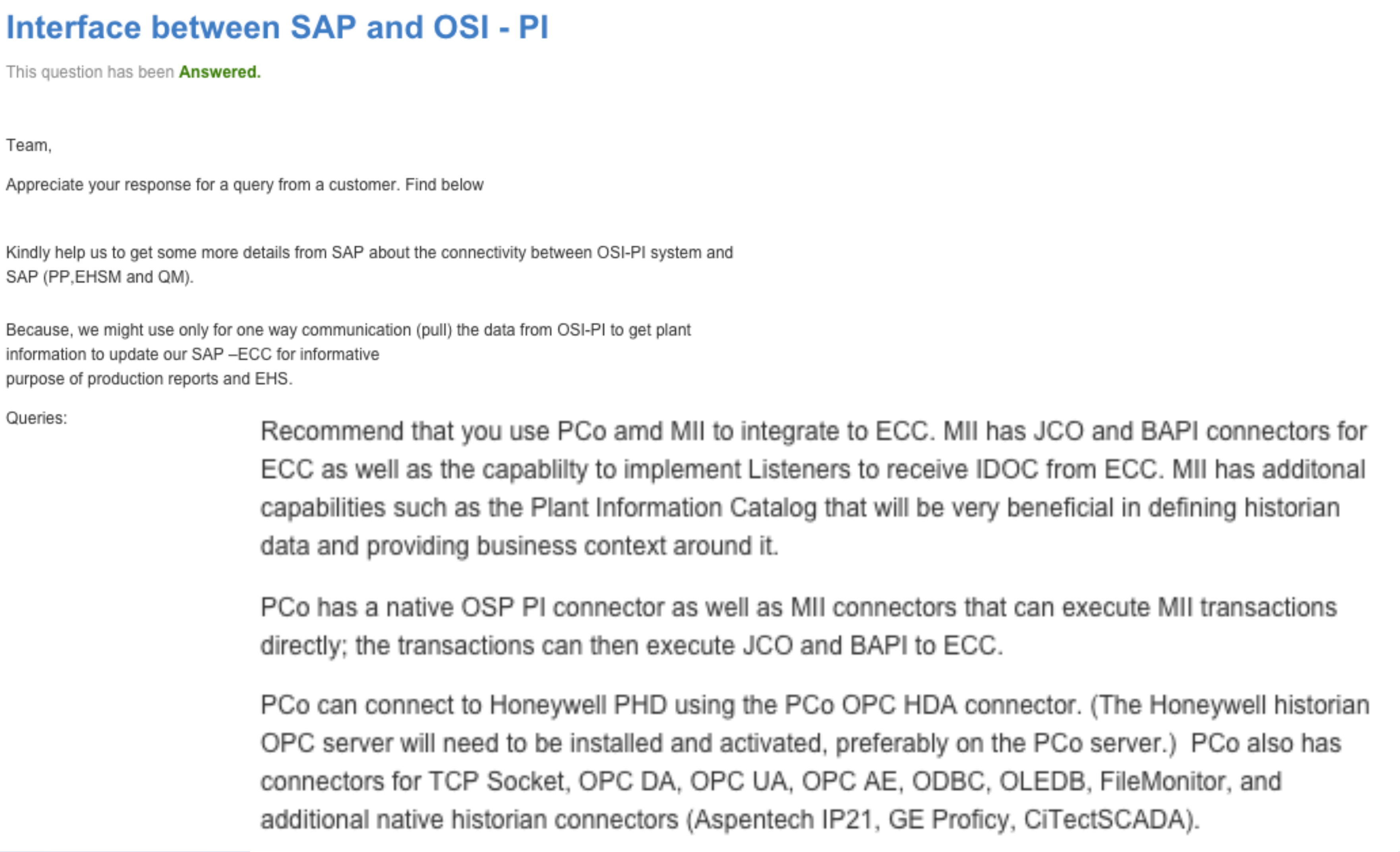
We are using RSView 32 OPC server ,

I came across through some posts that Pco has the ability to connect

.

I tried using Pco connection connecting the source system , but I am unaware whether my source system is connected successfully or not
My destination to MII system is successful

Can we get all the tags to which source system(RS View 32 sacada system) Pco is connected in Pco management console.



Interface between SAP and OSI - PI

This question has been **Answered.**

Team,

Appreciate your response for a query from a customer. Find below

Kindly help us to get some more details from SAP about the connectivity between OSI-PI system and SAP (PP,EHSM and QM).

Because, we might use only for one way communication (pull) the data from OSI-PI to get plant information to update our SAP –ECC for informative
purpose of production reports and EHS.

Queries:

Recommend that you use PCo amd MII to integrate to ECC. MII has JCO and BAPI connectors for ECC as well as the capablilty to implement Listeners to receive IDOC from ECC. MII has additonal capabilities such as the Plant Information Catalog that will be very beneficial in defining historian data and providing business context around it.

PCo has a native OSP PI connector as well as MII connectors that can execute MII transactions directly; the transactions can then execute JCO and BAPI to ECC.

PCo can connect to Honeywell PHD using the PCo OPC HDA connector. (The Honeywell historian OPC server will need to be installed and activated, preferably on the PCo server.) PCo also has connectors for TCP Socket, OPC DA, OPC UA, OPC AE, ODBC, OLEDB, FileMonitor, and additional native historian connectors (Aspentech IP21, GE Proficy, CiTectSCADA).

DEMO

Attack vectors

Oil market fraud

- Hackers can send fake information about oil quantity to managers who make their decisions based on this data.
- Assume that every day one sends information that there is much more oil in stock that we really have.
- One day the company will have sold out all the oil and won't be able to deliver it to its customers. The failure to perform the obligations could lead to a global scandal, changes in oil prices and huge losses up to the company's bankruptcy.
- Imagine what would happen if a cyber criminal uploads a malware that dynamically changes oil stock figures for all Oil and Gas companies where SAP is implemented.
- According to SAP’s statement, more that 70 million barrels per day of oil are produced by companies using SAP solutions. Oil Market Report says that oil production totals over 94 million barrels per day. In case of successful attack, cyber criminals can control about 75% of total Oil production.
- They can deliberately understate data about Oil in stocks of affected companies to increase Oil prices, or vice versa.
- Described attacks can be conducted by exploiting SAP xMII and SAP Plant Connectivity solutions that transfer data from Tank Management Systems to SAP Systems.

Attack vectors

Plant equipment sabotage

- Hackers can fake data about temperature, pressure, and other conditions.
- For example, they can spoof a report about a problem with equipment in a remote facility.
- Companies will spend a lot of time and money to investigate the incident if this facility is situated somewhere in the middle of the ocean.
- This can be done by exploiting vulnerabilities described in the talk. The easiest way to do so is to hack an SAP's or Oracle's Asset Management solution. Another system which can be under attack is Rolta OneView.

Attack vectors

Plant Destruction

- Burner Management Systems (BMS) and other critical systems are used in numerous processes including Separation and Refinery.
- Some of these systems not only send information, but also allow you to manage them through third-party systems, such as ERP, EAS, LIMS remotely via intermediate systems, SAP PCo and SAP xMII;
- With access to BMS systems, hackers can perform physical attacks.

How does one go about securing it?

ERP Security

- Protect your ERPs and other business applications
- Review all connections
- Secure connections where possible
- And please don’t include critical systems to domain

ERP Security

Business security (SoD)

Prevents attacks or mistakes made by insiders

Code security

Prevents attacks or mistakes made by developers

Application platform security

Prevents unauthorized access both within corporate network and from remote attackers

WTF it was?

- Researchers - now you know where to start from, Oil and Gas security is a small universe.
- Pentersters - now you know how to break into the most critical network and impress decision makers.
- CISOs - now you know that there is no Air Gap between IT and OT and what you need to check first.

About

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