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In Depth Understanding of IoT and IIoT Ecosystems is Critical

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Introduction

The world will see a step forward towards the Internet of Things (IoT) and Industrial IoT (IIoT) ecosystems, when people will focus on in-depth understanding of how these ecosystems shall be structured without creating cyber security risks and how will they deliver operating and financial values. Important pointing out, that these end-point devices are not communicating each with other (peer-to-peer), but are collecting and sending data to their designated service providers, which upon analyzing the field conditions publish decision-oriented data. Once accepting these highlights, we may start talking about tens of billions IoT and IIoT devices expected in 2020 and 2030.

This paper is aimed to outlining the key considerations related to IoT and IIoT ecosystems, allowing you making business-wise decisions. You shall always verify that the proposed IOT or IIoT ecosystem concept is matching your expected goals and last but not least verify that the proposed ecosystem architecture complies with IoT /IIoT cyber security challenges.

IoT and IIoT Ecosystem Service Providers

Important to point out that IoT or IIoT devices are usually not communicating each with other, but each one shall communicate with its designated service provider. These supply chain computers (see illustrations below) perform a dedicated process related to each ecosystem they handle. Their operation is technology- oriented and business oriented and is aimed to generate the desired operating and cost benefits. The IIoT ecosystems may utilize the same sensing devices which are monitored by the ICS, or communicate with temporarily added IIoT devices, not linked to the ICS.

Table below is outlining few examples of specific "Service Provider" operations which are communicating with IoT and IIoT end point devices, analyzing the received data and are publishing (via the internet or via a secured channel) applicable business or maintenance related decisions.

IoT Ecosystems Service Providers	**IIoT Ecosystems Service Providers**
• Commercial and Retail ○ Temperature in the store refrigerators ○ Number of people present during the day ○ Level of stock on shelfs/in refrigerators	• Smart City Street lighting ○ Smart adjusting of the street light level ○ Compensating light intensity for faulty lamps
• Maintenance Prediction on Machinery ○ Data collection on Vibration Monitoring ○ Electric Motor temperature vs. speed ○ Pump efficiency monitoring & fault analysis	• Personal Health ○ Consistent analysis of smart watch data ○ Alerting on anomaly condition (hearth rate)
• Smart Cities ○ Monitoring # of people at each bus station ○ Tuning the buses' schedule accordingly	• Cars' and Trucks' Supervision ○ Based on constantly monitored parameters ○ Analysis of malfunction problems & alerts
	• Smart Home's Supervision ○ Air condition optimization in each room ○ Cost effective use of

laundry machines

- Agriculture Irrigation ○ Irrigation according to soil condition ○ Setting based on the weather forecast
- Just-In-Time Supply Logistics ○ Raw material sent to the production line ○ Periodic monitoring of production rates
- Manufacturing Process Control ○ Allows intelligent tuning of production rates ○ Preventing bottlenecks in processes

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IoT Ecosystem architecture

When dealing with commercial-type applications, such as are listed in the left side of the table above, we must pay attentio the system sections which comprise the IoT ecosystem:

a) The installed sensors are monitoring the relevant parameters applicable to the IoT ecosystem b) The network can be cell a 2 steps link using a gateway and a short-range link c) A cloud-based service provider/supply chain is handling the IoT ec publish the results of

the analysis to 3rd party users and/or the organization which handles each ecosystem.

Order **Processing**

Fig 1. IoT ecosystem through cellular

Figure 1 and Figure 2 above outline 2 typical configurations for connecting IoT field devices with their IoT service provide step wireless link and a 2 steps communication network using a gateway.

IIoT Ecosystem architecture

In industrial-type applications, such as are listed in the right side of the table above, some IIoT ecosystem architecture existing sensor devices (part of the installed ICS) and some other IIoT ecosystems may require adding new IIoT devices, cor (for cyber security purposes) from the ICS. In this case the following components and system sections comprise the IIoT e

1) Architecture similar to IoT Ecosystems

Figure 3 and 4 below are showing two IIoT ecosystem architectures which are similar to IoT Ecosystems. On the left side pumps monitored through a cellular network connecting the service provider to a single sensor. On the right side you see attached to a pump for monitoring multiple parameters through an on-site PLC which process the collected data. If re unidirectional gateway (diode) can be optionally added.

Figure 3. IIoT ecosystem utilizing a cellular network

Optional Secure Sensor Protocol

Human or DI/Al

Supervision

2) Reuse of existing sensors which are part of the ICS

a) The ICS sensors are monitoring relevant parameters, also applicable to the IIoT ecosystem b) These sensors are monitor gateway (Fig 5) and the data is sent to the IT network c) The IT system is publishing the relevant data by a webserver acce Internet d) A cloud-based service provider/expert center, is handling that specific IIoT ecosystem process, and it

will r esend the results of the analysis to users or the organization's IT network.

Human Supervision
Utilizing permanent or temporarily deployed sensors

D ,,, Order **Processing**

Figure 2: IoT ecosystem through IoT gateway
Figure 4. IIoT ecosystem using a PLC collection

3) Adding new sensors, which are isolated and independent from the ICS
a) The added field sensors are monitoring the relevant parameters applicable to the IIoT ecosystem b) The data is collected
gateway (Fig 5) which is linked to the organization's IT network c) The IT system is publishing the relevant data by a web
accessible via the Internet d) A cloud-based service provider/expert center, is handling that specific IIoT ecosystem proces
will r esend the results of the analysis to users or the organization's IT network.
Figure 5 below is outlining a combined IIoT ecosystem configuration as described in para 2 and para 3 above. As mentio
sensors will always communicate with the ICS control center through a PLC linked to the network. If for the IIoT ecosy
there is a need to add additional (permanent or temporary) sensors, these shall be linked through PLC directly to the IT netw
for enhanced cyber defense purposes, a secure unidirectional gateway (diode) can be added.

Gateway Corporate IT
SCADA-ICS in the ICS Zone
Human Supervision
Figure 5. IIoT Ecosystem utilizing existing ICS-related sensors and additional IIoT sensors.
4) Peer to Peer connection among IoT devices
Deployment of IoT end point devices is primarily done for periodic or on-demand monitoring of local conditions related to
commercial applications. There are just rare cases when these IoT end point devices are required to exchange data e
Furthermore, deployment of such process might significantly increase the system complexity and might lead to incorrect p
As majority of these devices are not capable exchanging and processing data received from other devices, peer to peer lings
to be popular. However, in the future, when new applications and next generation IoT end point devices will be availabl
with cyber secured communications capabilities, we may see configurable options which allow IoT devices in peer-to-peer
5) Peer to Peer connection among IIoT devices
Similarly, to explained for IoT ecosystems, in IIoT ecosystems serving industrial applications (see table above), majority
devices are also deployed for monitoring purposes. However, here we must differentiate among IIoT endpoint devices wh
or temporarily deployed (see figures 3 and 4 above) and those which are part of the ICS architecture (See figure 5 above).
In some specific ICS architectures, IIoT end-point devices may be responsible for assurance of operating safety and reliabilit
they need to perform active operation in coordination with the local ICS control center or the Automation Server (AS). For e
can be activated to fill the water tower even if the ICS control center failed issuing such command and the water tower is
peer to peer communication is requested for ICS type operations, in such case the operating range, may be limited to certa
limited to particular parameters.

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These functions must be highly reliable and therefore, if peer to peer link is required, they must utilize advanced-type IIoT devices wi
capabilities allow. Furthermore, if the peer to peer link is required to activate a Safety Instrumentation System (SIS), such function m
and tested to prevent its activation due to "false-positive" detection or other faulty condition.

IoT and IIoT related Cyber risks and defenses

Expanding existing infrastructures (commercial or industrial) with large number of IoT and IIoT end point devices significantly in surface". The meaning of this statement is, that attackers may easily find a huge number of "entry-gates" to your commercial or ind "attack vector" selected for the action describes the path and the available barriers which the attacker from the entry point until computer which shall be compromised in order to accomplish his attack. Obviously, the lager is the attack surface, more attack vect shall be protected. The following list describes some applicable IoT/IIoT defense methods (partial list).

- Physical security shall be in place to prevent unauthorized people from accessing IoT/IIoT devices. Prior installations, these dev with a private username and password.
- Both IoT and IIoT devices shall be authenticated prior connection to the network. To maintain their operation and detect any ma devices shall be properly supervised.
- In case the data is confidential or critical, consider adding end-to-end encryption such as IPsec. Use of cellular communication p cyber defense as these channels are encrypted.
- IoT/IIoT devices shall not allow manipulating their program and operating conditions. Locking of these capabilities will prevent devices to an attack tool (part of DDoS process).

Summary

In this paper I outlined multiple system architectures applicable for IoT and IIoT ecosystems. Furthermore, it is important pointin architectures such as outlined above must comprise an entity which handles the IoT/IIoT end point Device Management, respons and periodic software updates. Finally, important to emphasize again the following topics:

a) IoT and IIoT devices are not communicating each with other (some exceptions are possible) b) They communicate with a servic provides the operating and financial values c) IoT and IIoT Ecosystems may utilize similar sensors but the service provider perform Cyber security shall me an important component for most commercial IoT ecosystems but is highly critical

for IIoT Ecosystems serving operation of manufacturing and utility processes.

The achievable benefits delivered by these IoT and IIoT ecosystems always depend on the performance of the (cloud-based) service these topics will help your organization to deploy successful IoT and IIoT ecosystem. Defining IoT/IIoT architectures in collabo experts and the IT and OT cyber security experts will put you a step ahead of the attackers.

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