# Asset Administration Shell (AAS) based Plug-and-Produce (PnP) in Smart Manufacturing

## Our goal

We will actively cooperate with Germany leading the smart manufacturing sector to embrace standard technologies and provide our solutions to domestic experts.

## What is the Asset Administration Shell (AAS)?

It is a virtual representation of all the information and functionalities of an asset. It provides a standardized communication interface for information exchange.It is an access point of information and value-added functions in Industry 4.0.

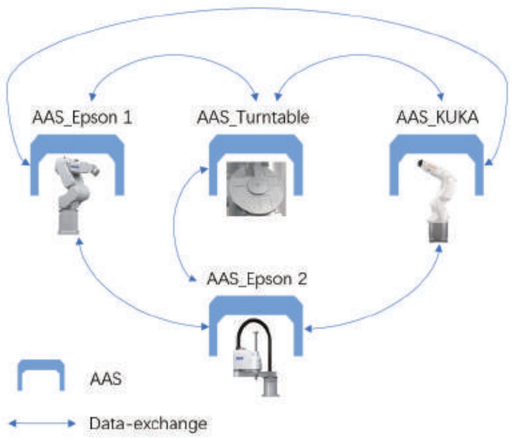


Fig1. Demonstration of AASs communication for PnP

## Why is the Asset Administration Shell needed?

The purpose of Asset Administration Shell is to facilitate the exchange of asset-related data along the production system life cycle. The Asset Administration Shell will make all the manufacturing components interoperable to realize the autonomy of Industry 4.0. 'Adaptable Factory' envisions a flexible factory where production lines can be re-configured during runtime.

Analogous to the "plug-and-play" concept for desktop computers, the vision of 'Plug-and-Produce' use case is to enable "plug-and-produce" capabilities for future production facilities. Compared to today's traditional production, 'Plug-and-Produce' makes a new production paradigm possible. If an error occurs in the working robot, After the field worker immediately replaces the robot, It connects to the work system that was being performed before. that is, new field devices or production modules shall be integrated into production lines with minimal overhead, thus greatly increasing the production flexibility. To support the automatic integration of 'Plug-and-Produce', manufacturing assets (including field devices, controllers, and machines) need to be equipped with device descriptions and capabilities. 'Asset Administration Shell' (AAS) can be adopted as a digital technology to meet this requirement for realizing 'Plug-and-Produce'.

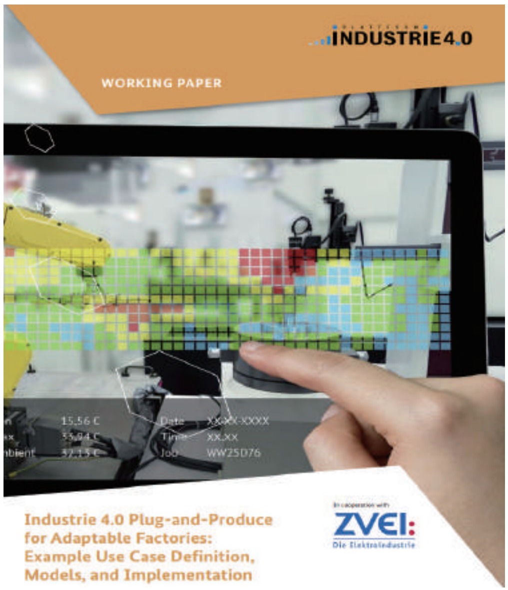


Fig2. A Working Paper: Industrie 4.0 Plug-and-Produce for Adaptable Factories: Example Use Case Definition, Models, and Implementation.

## How to implement the AAS?

First, we use AutomationML, standardized in IEC 62714, to model AAS information of the PnP system. AutomationML is an XML based data format that is suitable for describing information in AAS submodels. AutomationML contains an instance hierarchy module hierarchically modeling individual objects as internal elements.

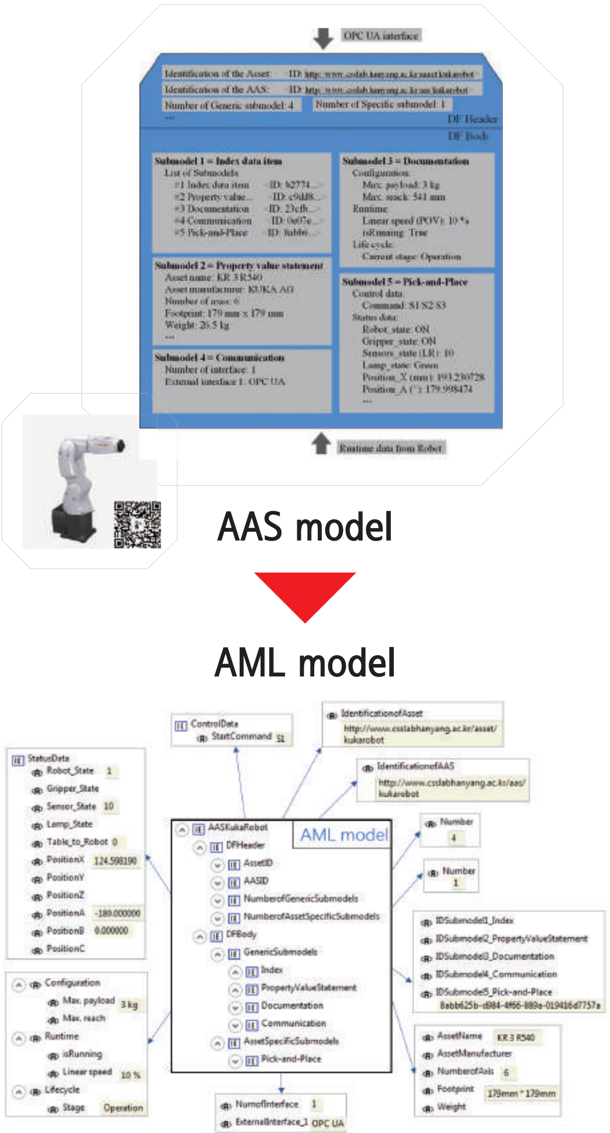


Fig3. AAS model mapped to an AML model.

Second, we use OPC UA, standardized in IEC 62541, as the communication interface to exchange data between AASs. OPC UA is a machine-to-machine communication method providing interfaces for data exchange between industrial assets. We adopt OPC UA client server mode to realize the communication capability of AAS. By utilizing AutomationML and OPC UA, AAS realizes the PnP capability in Industry 4.0.

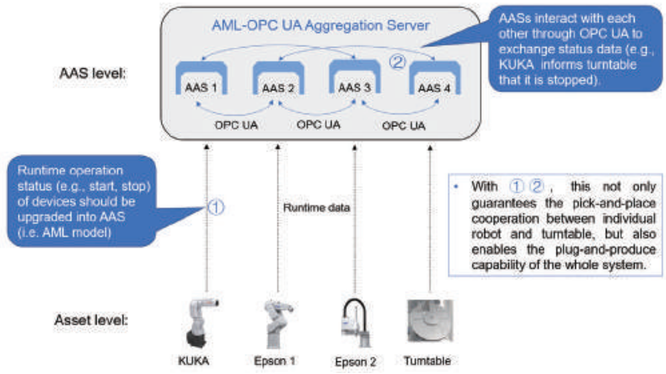


Fig4.: AASs communication through OPC UA

## Why and What is the Time-Sensitive Networking (TSN)?

Industrial communication requires highly reliable networks with hard temporal constraints. Thus, the IEEE 802.1 TSN Task Group proposed a promising technology, namely, time-sensitive networking (TSN), to complement the robust determinism and hard real-time capabilities of Ethernet via a set of enhanced IEEE standards. Generally, TSN provides benefits from four aspects i.e., time synchronization, bounded latency, ultra-reliability, and network resource management.

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## PnP System Architecture

### Cloud Layer:

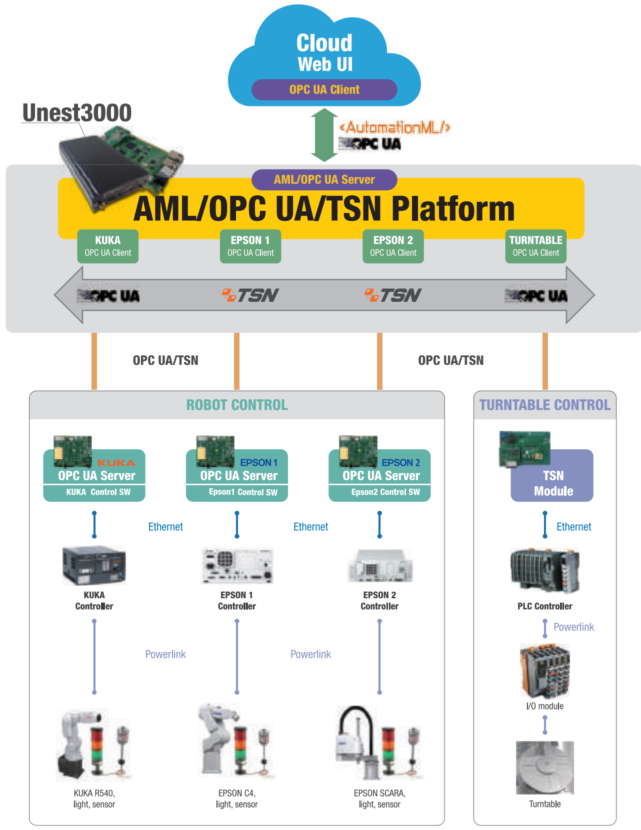
- A Web UI can control the operation of the PnP system, and demonstrate the AAS data of the system in real time.

### Platform Layer:

- AutomationML is applied as a common information model which represents the AAS data.
- OPC UA realizes the interoperability among the robots and the turntable and serves as the AAS communication interface.
- TSN guarantees real-time and deterministic data transmission for AAS communication.

### Field Layer:

- Vendor-independent Assets (i.e. robots and turntable) cooperate to realize the PnP operation.




PnP system architecture

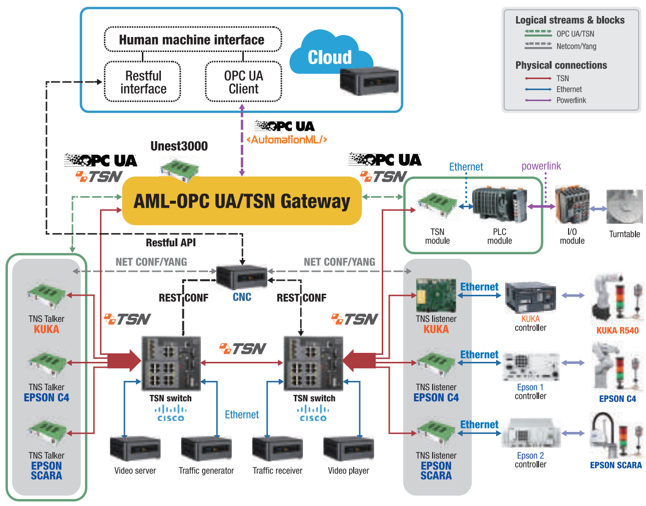
## TSN System Architecture

Towards the Industry 4.0-based smart manufacturing system, we developed a refined TSN-integrated architecture referencing the network model of IEEE Std Qcc.

- Cloud layer provides a web-based **human-machine interface** to demonstrate and operate the entire TSN-based Robot Control System.

- Communication layer adopts **OPC UA/TSN** to provide real-time service to exchange robot control commands and status feedback with TSN end-stations. Also, it employs Automation ML and OPC UA aggregation server to connect cloud- with field-layer.

- Field Layer contains various industrial facilities (e.g., TSN switches, TSN end-stations, Linux PC, industrial robots and turntable) for TSN-based robot control and turntable operation.




TSN integrated architecture
for a smart manufacturing system

한양대학교 HANYANG UNIVERSITY
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OPC UA
AAS Asset Administration Shell
TSN
IGI Korea

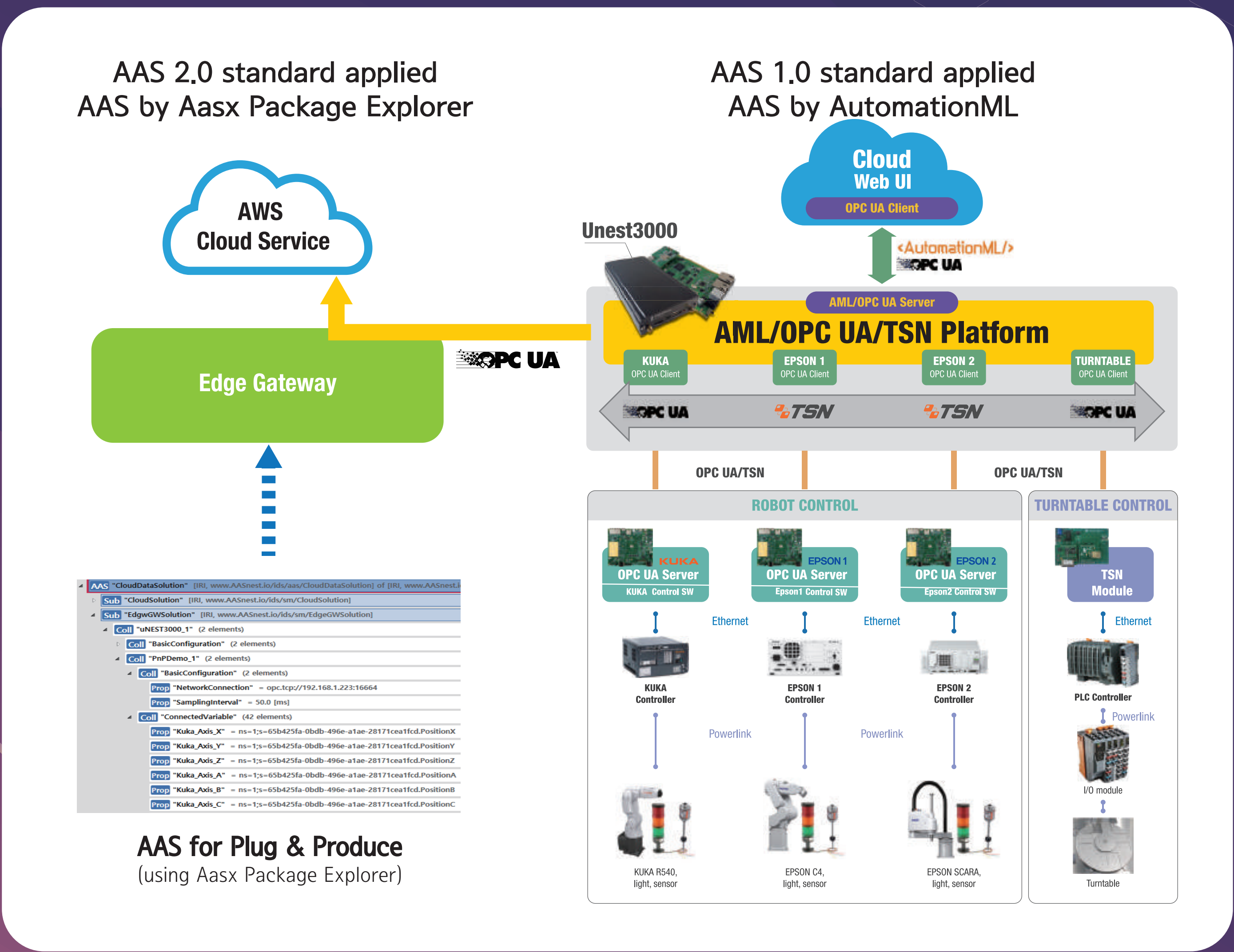
# What we are doing now

## Application of data collection/storage solution

- AAS modeling applying new standard
- Addition of newly developed data collection/storage solution to the existing demo system
- Additional data collection/save while maintaining existing Plug & Produce scenarios and functions

## Conclusion

- We try to provide a prototype implementation for the use case "Plug and Produce for Field Devices" derived from the Plattform Industrie 4.0 application scenario "Adaptable Factory".
- A true vendor-agnostic PnP for industrial devices fully based on Industry 4.0 standards is envisioned.
- The AAS is a core concept for implementing this strategy: it is a digital twin of the Asset.
- This could help plant and factory owners making production system much more flexible than today.
- End-customers could benefit from the possibilities of more individualized products because of faster commissioning time and decreased time to market.



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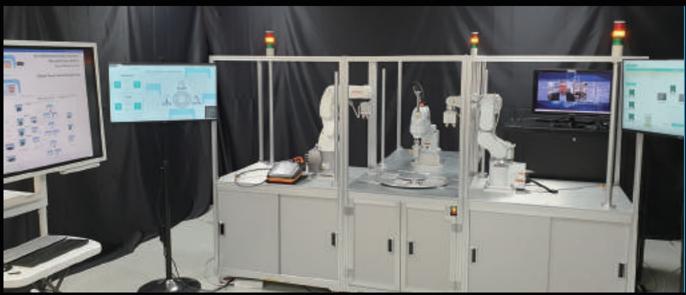
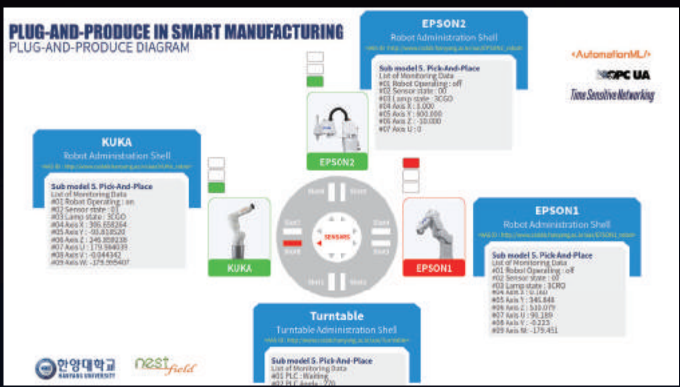
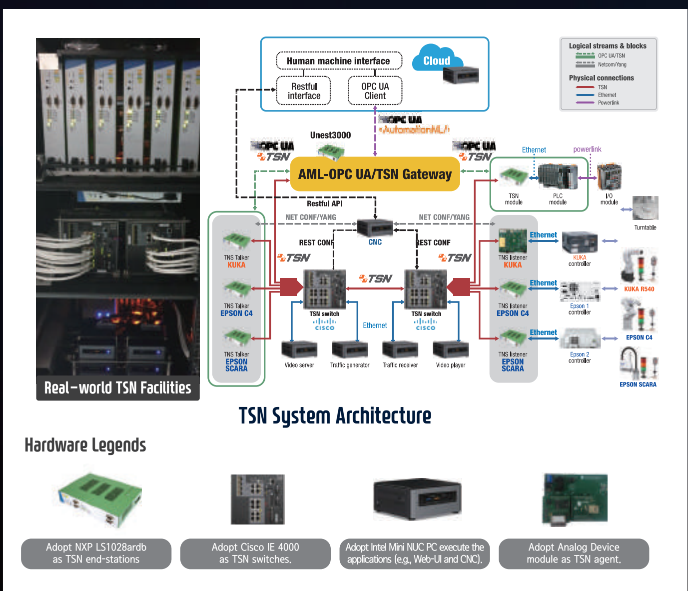
## • AAS based PnP demo system



## • Asset Administration Shell (AAS)




## • Time-Sensitive Networking (TSN)




### Key Characteristics

Each asset (e.g., robots and turntable) has a unique AAS.
Asset information are digitally represented in the AAS.
AASs communicate with each other to realize the PnP function.

### PnP Scenario

Plug-in and Plug-out of the asset (i.e., the robot) are managed by AASs to ensure the uninterrupted operation of the manufacturing system.

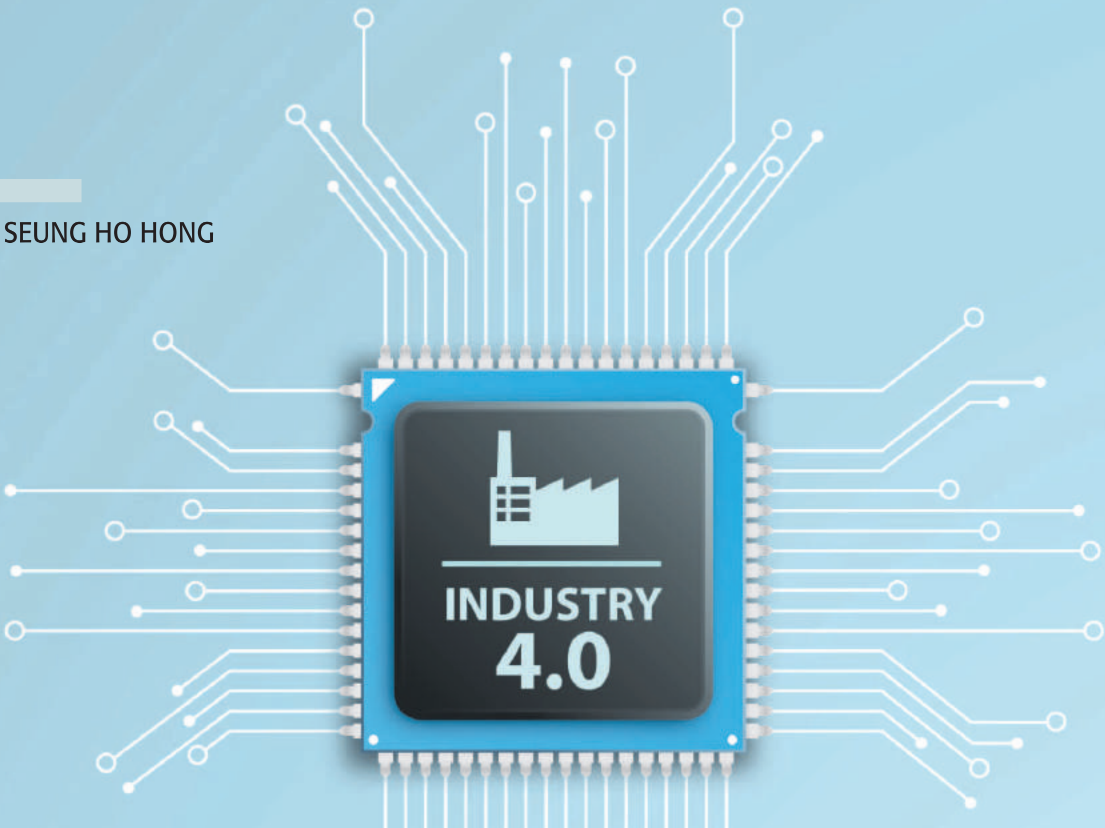
### AAS Implementation

AutomationML is applied as a common information model which represents the AAS information.
OPC UA realizes the interoperability among the robots and the turntable, and serves as the AAS communication interface.
TSN proves the real-time AAS communication.

### TSN System Implementation

Cloud layer provides a web-based human-machine interface to demonstrate and operate the entire TSN-based Robot Control System.
Communication layer employs OPC UA/TSN to provide real-time service to exchange robot control commands and status feedback with TSN end-stations.
Field Layer contains various industrial facilities (e.g., TSN switches, TSN end-stations, Linux PC, industrial robots and turntable) for TSN-based robot control and turntable operation.

XUN YE and SEUNG HO HONG

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# Toward Industry 4.0 Components

## *Insights Into and Implementation of Asset Administration Shells*

Diverse customer demands are increasing the need for improved flexibility, adaptability, and transparency of production processes; traditional manufacturing systems must change. To meet these requirements, cyber-physical system (CPS) technologies are being increasingly applied in industrial manufacturing, equipping production facilities with autonomous adaptation capabilities. This is achieved by incorporating physical objects and their virtual representations and enabling bidirectional information exchange between them.

The Industry 4.0 (I4.0) Component proposed by Germany's I4.0 initiative is an emerging CPS category. The concept of an administration shell or an asset administration shell (AAS) is a virtual digital representation of the I4.0 asset that plays a pivotal role in establishing communication among I4.0 Components. To date, the granularity of information modeled in an AAS remains undefined. Therefore, this article focuses on not only the general form but also the fine-grained details of the AAS. The goal is to present a high-level introduction to this topic, substantiated by an implementation example in a manufacturing system; to provide different I4.0 stakeholders (e.g., manufacturers, integrators, and operators) with best-practice guidelines for carrying out their own AAS-related activities; and to strengthen the interaction between academic research and industrial practice to accelerate the digitalization of industrial production through deploying AASs.

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### Digitalizing Manufacturing Assets

In recent years, industrial production has been subject to continuously increasing customer demands because of fast-changing market conditions. This is forcing production to shift from mass production

### *Best Practices for I4.0 Participants*

This article also summarizes best practices for partners in the I4.0 business. Most importantly, all partners must stick to the fundamental requirements set out in this article when managing their AAS-related setups.

- Device manufacturers should design AASs of their products so that integrators can integrate and configure them easily. The AASs should cover as much detail as possible to prevent ambiguities and misunderstandings. For example, version and compatibility information must be clearly identified.
- It is crucial for machine or system integrators to integrate virtual AASs before commissioning physical hardware as the AASs may have extra requirements, such as consistent transformation of planning data. This should be taken into account. Therefore, we recommend that integrators use the same engineering or commissioning tools as the device manufacturers. Furthermore, the information generated during the integration process should be loaded into the newly integrated AASs in a lossless manner.
- System or plant operators should explicitly express the device and machine requirements when calling for tenders. Operators should make service contracts with manufacturers and integrators in which they can request information on specific assets from particular AASs. Furthermore, operators can request that the functions of concerned assets be monitored or updated directly at the plant site. This is more effective than the traditional maintenance approach.
- Additionally, for I4.0 Component-related standard makers, standard interfaces must be specified to guarantee the exchange of the agreed AAS information between partners. Moreover, with regard to information storage, standard makers must specify the data format (e.g., zip file) in which the AASs should be stored. Another important factor to consider is security. The concept of role-based access control can be adopted to guarantee the integrity and authenticity of the information stored in AASs, e.g., operators cannot delete software from a robot because they do not have the required access rights.

### *Conclusions and Future Work*

When compared with the obscure introduction provided in the AAS specifications [33], [38], this study has provided readers with a more understandable description of the AAS. This may arouse more widespread interest in this topic. In this article, first a survey of the state of the art of AASs was conducted; existing gaps were analyzed. Second, the AAS template was formalized and a common information model was defined. Then, as an AAS use-case example, an experiment with a manufacturing line was set up. Finally, reflections on how to practically implement AASs were extracted. Applications and advantages of using AASs in a plant lifecycle and in a value chain were concluded. Best-practice recommendations for different participants in the I4.0 business were also presented.

Future work will focus on the Composite Component [52]. A complex of relationships between individual I4.0 Components will be modeled into appropriate AAS submodels to create new and higher functionalities. The plug-and-produce capability realized by AASs will be investigated in future studies, with the aim of enabling external I4.0 Components to be seamlessly integrated into existing I4.0 systems with no manual intervention. In addition, the demonstration system will be upgraded with more actuating devices to fulfill more complex production goals. It is also envisioned that operation in a real-world factory will aid further assessment.

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## Biographies

***Xun Ye*** (hanyangyexun@gmail.com) earned his B.S. degree in mechanical engineering and automation from the Wuhan University of Science and Technology, China, in 2016. He is currently working toward his Ph.D. degree in the Department of Electronic Systems Engineering, Hanyang University, Ansan, South Korea. He was a recipient of the Best Paper Presented by a Young Researcher Award from the IEEE International Workshop on Metrology for Industry 4.0 and IoT as well as the IES Students and Young Professionals Award from the IEEE International Conference on Emerging Technologies and Factory Automation, both in 2018. His research topics are information technology in industrial automation, cyberphysical production systems, and Industry 4.0. He is a member of the IEEE Industrial Electronics Society.

***Seung Ho Hong*** (shhong@hanyang.ac.kr) earned his B.S. degree from Yonsei University, Seoul, South Korea, in 1982; his M.S. degree from Texas Tech University, Lubbock, in 1985; and his Ph.D. degree from Pennsylvania State University, University Park, in 1989, all in mechanical engineering. He is a professor in the Department of Electronic Engineering and the director of the Connected Smart Systems Laboratory, Hanyang University, Ansan, Korea. He was a visiting scholar with the U.S. National Institute of Standards and Technology and with the Vienna University of Technology, Austria, and the Zhejiang University, China. Currently, he is a foreign expert with Tianjin University of Technology through the Tianjin Thousand Talents Program. His research interests include areas of smart manufacturing, smart grid, Industrial Internet of Things, cyberphysical systems, and artificial intelligence. He is a Senior Member of the IEEE, a member of the IEEE Industrial Electronics Society, and a member of the International Electrotechnical Commission System Committee Smart Manufacturing.

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