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Article

Asset Administration Shell-Based Workshop Transportation System Design

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Abstract: In view of the lack of unified data architecture and model of workshop transportation system components,this paper proposes the concept of the workshop transportation system functional unit based on asset administration shell (AAS). The designed workshop transportation system can solve the problem of unified modelling for different types of equipment, and realize the rapid construction and adjustment of the system. Meanwhile, the system has been applied in the specific workshop transportation system and enables well application results. In the functional unit of workshop transportation system, automatic markup language (AML) is applied. This paper constructs the AAS model based on the industrial 4.0 reference architecture model (RAMI4.0), and introduces the workshop transportation system AAS model and its realistic mapping as an example . The workshop transportation system functional unit AAS model based on the RAMI4.0 provides an effective solution for the standardization and integration of workshop transportation system components, which is no requirement to develop specific data conversion tools for this purpose. All transportation equipment with AAS can achieve information exchange and interoperability. It is conducive for the rapid implementation of workshop transportation system engineering and provides a guide for the establishment of intelligent workshop. Thereby, the proposed methodology demonstrates the flexibility and interoperability of AAS in smart manufacturing.

Keywords: workshop transportation system; AAS; RAMI4.0; automated guided vehicle

1. Introduction

With the development of industrial automation, Automated Guided Vehicle (AGV) transportation system has been widely used in manufacturing industry. The rapid development of AGV transportation system is inseparable from its own advantages. It has the advantages of high work efficiency, simple structure, strong controllability and good safety. It can fully reflect its automation and flexibility and realize efficient, economic and flexible unmanned operation. AGV is an integrated intelligent logistics handling equipment integrating mechanical devices, electronic control equipment, safety and anticollision equipment, data information acquisition sensors, fieldbus and other technologies. Other functions can be expanded and added to the body, such as manipulator, roller, electronic scale platform and so on. AGV transportation system is widely used in workshop. Guney et al. introduced a centralized motion coordination controller that utilizes a dynamic priority logic to resolve motion conflicts between AGVs as they appear [1]. Yao et al. presented a decision support system capable of supporting workshop decision-making activities during the event of manufacturing disruptions by automatically adjusting both AGV and machine schedules [2]. Kłosowski et al. Offered a new model for in-plant transportation control with the AGV [3]. Yan et al. developed a scientific methodology for optimizing the layout design, operation and maintenance of a multi-AGV system [4]. Wang et al. took a Tablet PC manufacturing workshop as an example to study the AGV scheduling algorithm of smart workshops [5]. Rivas et al. solved the task assignment problem for a group of AGVs serving the internal transport of a

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warehouse or factory [6]. Wang et al. solved the needs of a pharmaceutical factory's logistics system for multiple AGV, a set of AGV scheduling system architecture was developed on the basis of the outdoor heavy-duty AGV that has been developed [7]. Mohamad et al. proposed a simulation-based vehicle requirement analysis of AGVs in warehouse area with low mixed product variation [8]. Theunissen et al. introduced a smart AGV for easing the collaboration between typical workers and robots [9].

In April 2015, Germany took the lead in proposing the RAMI4.0, which even preceded the industrial internet reference architecture (IIRA) proposed by the industrial internet consortium (IIC) [10]. The RAMI4.0 model is shown in Figure 1. The first dimension of RAMI4.0 represents the distribution of different functions and types in the factory, including products, field equipment, control equipment , production lines, workshops, enterprises, and connection boundaries [11]. The second dimension is the core function of CPS. It includes the asset layer, the integration layer, the communication layer, the information layer, the function layer and the business layer. The third dimension of RAMI4.0 is the product lifecycle and business value chain. It comprehensively manages the product from the process of demand, planning, development, and production and describes the correlation of different data in the whole value chain.

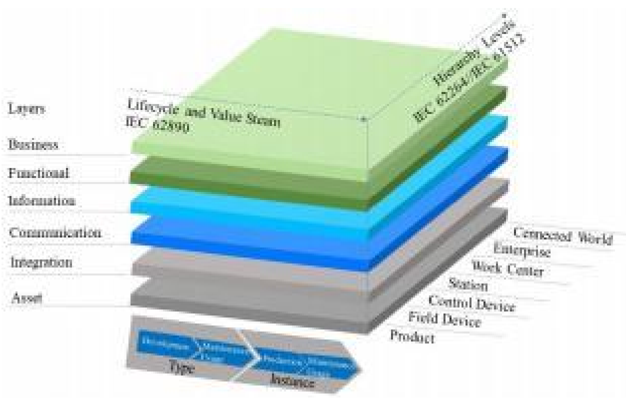

Figure 1. RAMI4.0 model.

The research on the workshop transportation system is mainly focused on the layout of production lines under specific scenarios. From the perspective of transport engineering, there are still some problems, such as the lack of consideration of the unified data structure and model, the lack of the rapid configuration of transport system, and the lack of the interconnection of heterogeneous systems. It is not conducive to the whole life cycle synergy and interconnection of all things [12]. In view of the above problems, this paper proposes the workshop transportation system based on AAS, and applies the AAS to establish a unified modeling of different functions and categories. It is to provide a reference for the interconnection of the heterogeneous equipment and system, as well as the rapid configuration and reconstruction of the system. In the research, the AAS model and its mapping of the workshop transportation system are established, which can realize various applications in the field of workshop transportation.

2.AAS

a. Definition of AAS

AAS is a kind of shell management software that digitally describes the asset characteristics and technical functions of the industrial 4.0 components in accordance with various relevant standards. With the self-describing digital "asset specification" that can be queried and read by the software platform, the assets become manageable and operable [13].

AAS establishes detailed portraits for each component, and also provides communication protocols to prepare for the interconnection and interoperability of all machines in the future.

b. A Survey of AAS

Park et al. introduced AAS to the vehicle component manufacturing system. Lang et al. used AAS to support humans during the maintenance process. Based on AAS for I 4.0, Al Assadi et al. developed AAS for the production workforce. Therefore, this paper proposes AAS-based workshop transportation system design.

c. The Used Mode of AAS

As shown in Figure 2, the basic composition of AAS is "Manifest + Component Manager". "Manifest " is used to represent the component content directory, such as the hierarchical range of business activities such as function, information and communication. "Component Manager" is to manage related assets within the scope of components. The AAS clearly defines the level, value stream and level of the component. It confirms the required data, function and security requirements [14].

Take the AGV transportation system in a "Digital Factory (DF)" as an example, as shown in Figure 3. If you expand the AAS structure of the AGV from left to right, you can see that the identification of total assets and AAS is in the "Manifest" of the whole DF, which is mapped to the "header" and " header" of DF through API. The feature list of the "header" ensures the identification and certification of DF's tangible assets. It also ensures the ability to reference some assets and views at the right time [15].

Below the "header" of the AAS is "body". The "Component Manager" is responsible for managing the submodels of the "main body". The submodel includes the level of asset characteristics and system level, and can refer to various data and functions for different assets. These quoted data mainly run in the information layer.

Through the determination of the AAS, all assets and corresponding models can be identified, interacted, implemented, verified, and maintained by the management platform during the entire life cycle. It achieves digital virtual product development and automatic testing, which can adapt to the high degree of uncertainty inside and outside the modern manufacturing system, optimize the allocation of manufacturing resources, and strive to truly achieve industrial upgrading.

This means that with the help of the AAS, we can finally use digital models and language to reflect the overall value of business, functions, information, communication, and assets. This makes the devices connected, which can truly realize the free flow of value streams on the entire timeline. It becomes a seamless connection between the physical world and the virtual world.

d.The structure and connection between physical item

The sensing devices include sensors and EPC readers. The workshop transportation system only uses the field data monitored by these devices. Therefore, variable attributes need to be included when building the information model of the sensing device type. Control equipment includes AGV, laser printer, stacker and robot. The workshop transportation system reads process data. At the same time, these control devices also realize specific operations in the production process. So the control device type of AAS model should include variable attributes and control methods. The physical structure of the system is shown in Figure 4, which defines the information model parameter. It binds the data source to the OPC UA server address space node, and uses OPC UA client to real time monitor and process the equipment data items.

Figure 2. AAS.

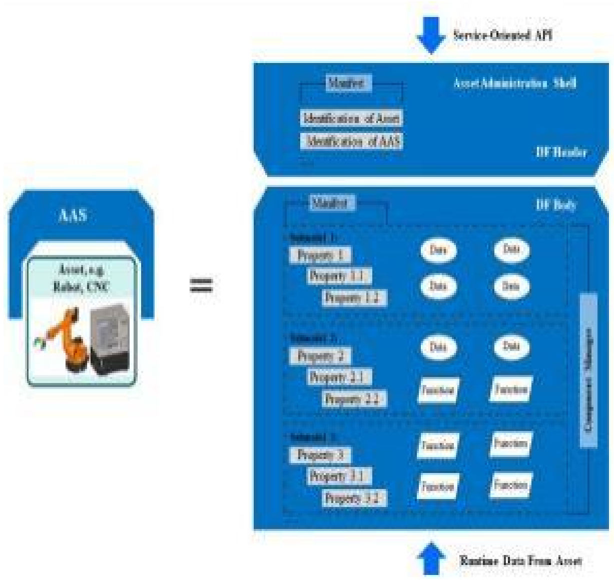

Figure 3. The structure of the AAS.

e. The Standards for AAS

All items in the AAS are tried to comply with standards as much as possible to lay a solid foundation for future system expansion and the internet of everything. Figure 5 outlines the standards and specifications that the characteristics of the AAS and submodules need to comply with.

3. Model Construction

According to the standards and modeling steps of AAS, we use AASX Package Explorer to model assets. AASX Package Explorer is a tool with graphical user interface meant for experimenting and demonstrating the potential of AAS. The contribution of this paper is to provide an example of AAS modeling. The AGV modelling results are shown in Figure 6. It is a typical automation equipment in production automation line. The detail of the equipment is as follows:

(1) Realtime PLC with execution of industry 4.0 containers for data preparation and artificial intelligence.

(2) Electrical drives and pneumatic sensors integratedtogether with IO-Link technology and versatile, customer- specific parameters.

(3) Pneumatic components with self-description of active Asset-ID.

The detail of asset administration shell is as follows:

(1) PLC with AASX server offers interface via discovery, browser, OPC UA, HTTP/ REST and MQTT.

(2) Individualized Digital Twins of components with data sheets, certificates, documentation, software versions, and parameter.

(3) Digital Twin of equipment and modules with machine documentation, schematics, bills of material, ICT interfaces to the external.

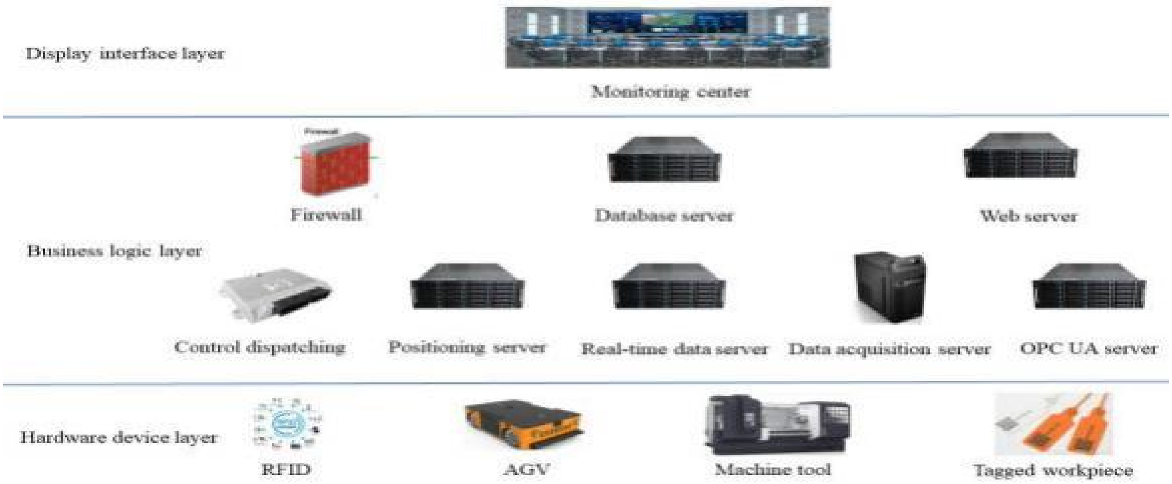

Figure 4. The physical structure of the system.

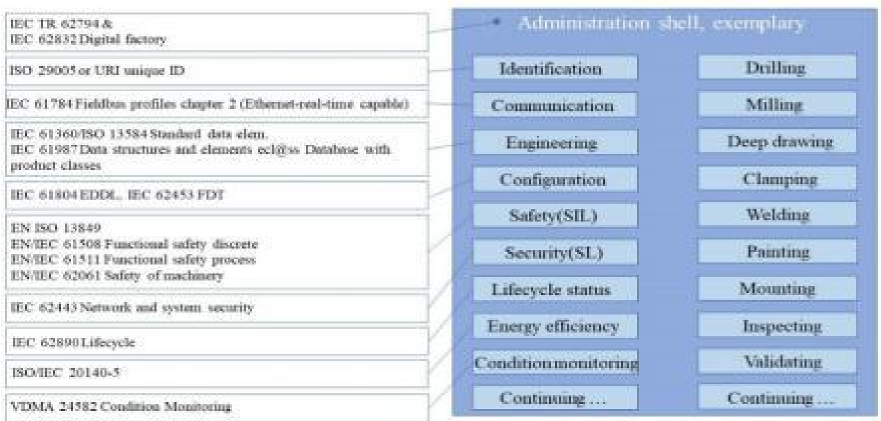

Figure 5. Standards for AAS.

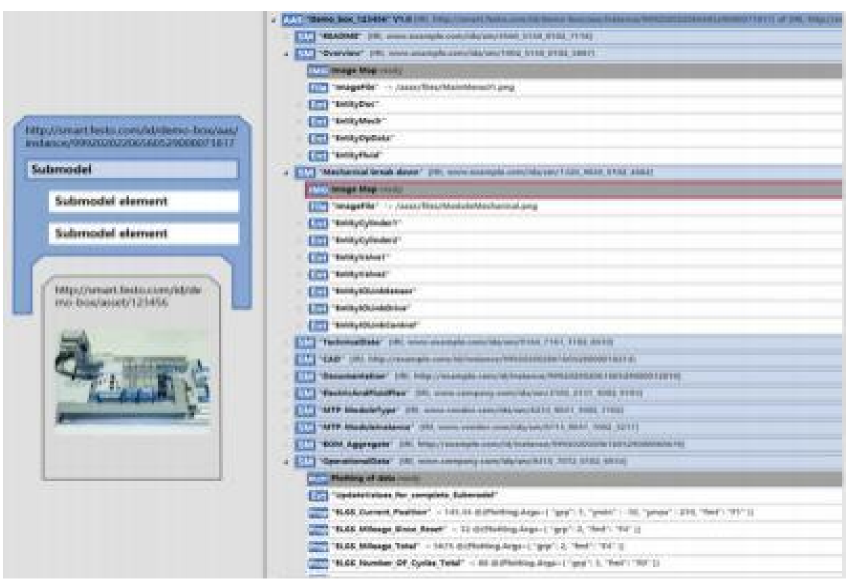

Figure 6. The model example of AAS.

Figure 7. The application scenarios of the proposed workshop transportation system.

4.Application Scenarios

The application scenario of AAS is shown in Figure 7. The control panel module includes AAS building mode and different application scenarios mode. When the modeling starts, we start the modeling button. The workshop transportation system starts the AGV modeling, and saves the built model in the library. When starting the scenario application, we first select the corresponding AGV of AGV transportation system in the library and deploy them to the corresponding places to form the required workshop transportation system. After the virtual debugging, the corresponding instructions are issued to the workshop transportation system. It can realize the interoperability between the transportation system equipment.

5. Conclusions

This paper constructs AAS-based Workshop Transportation System. Taking the AAS model of the workshop transportation system and its realistic mapping as an example, the AAS model of the workshop transportation system based on RAMI4.0 provides an effective standardized integration solution of workshop transportation system. It is helpful for the rapid implementation of work- shop transportation system.

The following work needs to be done in the future:

(1) The workshop transportation system is constructed and expanded in a highly modular way. All system extensions are overlapped in a building block like manner.

(2) Standard based protocols and interfaces can smoothly exchange data with other domestic and foreign partners without developing specific data conversion tools.

(3) All transportation equipment with AAS can realize information exchange and interoperability.

Conflict of Interest

There is no conflict of interest.

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