openZDM

Open Platform for Realizing Zero Defects in Cyber Physical Manufacturing

The openZDM Platform

The openZDM project introduces a holistic approach to proactive quality control, facilitating the wide adoption of the zero-defect manufacturing philosophy. To achieve this, the openZDM system has been developed. This system utilizes advanced non-destructive inspection systems (NDIs), digital twins, high-performance data-driven quality assessment modules, and a decision support system for alternative process configurations. Moreover, an innovative open platform employing the asset administration shell (AAS) as its data model enables interoperability with versatile production systems and ensures scalability to accommodate future assets.

About openZDM Platform

The openZDM platform is designed and developed to support the five industrial use cases of the openZDM project. It targets different manufacturing systems and is implemented to be easily (re)deployable in diverse industrial scenarios with minimal customization at the platform level. The platform features increased modularity, scalability, and resilience, enhanced using Docker containers and Kubernetes for cluster management. Furthermore, the platforms APIs are documented using the OpenAPI Specification, which simplifies capability enhancement, while an AAS middleware facilitates seamless integration of new shop-floor assets.

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Architecture

Following the RAMI 4.0 model, the openZDM platform's architecture is structured into various interconnected layers and tiers, allowing for deployment in cloud, local, or hybrid environments. This facilitates easy integration with existing manufacturing systems. An overview of the architecture can be seen in Figure 1 and includes the following horizontal layers:

- **External data source and infrastructure layer:** This layer groups all assets of an industrial end-user of the openZDM platform, such as the legacy systems (databases, MES, etc), the various equipment and actuators in a production line and possible available NDIs.
- **Integration layer:** Facilitates communication between the external data sources and the rest of the platform. Its main component is a message bus that intercepts information coming from various assets. It includes services like MQTT for real-time data handling and supports AAS Type 3 services, including APIs and an Interaction Manager that enables proactive AAS communication.
- **Data layer:** Responsible for processing asset messages from the integration layer and the AAS message bus. The messages are either stored in the platform databases or forwarded to the various services of the platform. Lastly, the layer is also responsible for the main data storage of the platform.
- **Service layer:** Acts as the foundation for the business layer. Several components are part of the service layer, including, the user management components that provide user creation/deletion/update, the service orchestrator that defines the workflow users interact with, the discovery service that acts as a registry of active services that a user can access and the error and event handling components that manage errors and produce appropriate notifications.

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- **Business layer:** This layer groups the functionality that is offered to a user of the platform. It provides the platform administration component that facilitates the functionalities addressed to a platform administrator and the user dashboard that groups the functionalities provided to a standard user.

The platform also includes three vertical layers:

- **Authentication & Authorisation:** The layer groups together all functionalities necessary to identify users and services as well as the mechanisms for secure communication between the message bus and various assets.
- **Logging & monitoring:** The layer is responsible for logging all user activity in the platform and monitoring and recording system errors.
- **Data sharing:** The data sharing vertical layer enables the integration of the openZDM platform to data sharing ecosystems. It is responsible for the deployment of connectors that support secure data exchange such as the IDS for secure data communication with DataSpaces.

Figure 1: The openZDMs' platform Architecture

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The openZDM platform can support several types of data sources. Nevertheless, the openZDM NDIs have been designed in a manner that enables their seamless integration with the platform's integration layer. While each NDI may have a unique architecture, a generic architecture of the openZDM NDIs has been developed that includes:

- **openZDM NDI connector:** Links NDI data with the platform & integration layer.
- **NDI business logic:** Processes data to generate meaningful measurements.
- **NDI data storage:** Ensures data integrity and stores raw and processed data.

Implementation and deployment

The platform's main data flow comes from the external data source & infrastructure layer. The implementation approach followed consists of connecting the data sources with the AAS middleware of the platform. Real-time data is published to an MQTT broker, where the published information is intercepted by the AAS middleware and fed into the AAS models. Additionally, specific assets provide their real-time data directly to the AAS middleware using its standardised RESTful API.

Each asset connected to the openZDM platform has its dedicated AAS model. Currently, the main implementation of the openZDM AASs can be characterised as AAS Type-2 where AASs retrieve and communicate the data present in their submodels via a RESTful API. Nevertheless, a prototype implementation of the proactive AAS (AAS Type-3) has been developed utilising an interaction manager and the Industry4.0 language (as described in VDI/VDE 2193).

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All the platform's services and user interfaces have been secured using Keycloack and the OAuth2 standard. This implementation approach allows for different authentication workflows to be applicable based on the authentication scenario required. The platform's users are organized based on their distinct roles. Two roles have been implemented, which include the administrator and the operator, with each role having different access levels. Thus, depending on the user role a specific user interface is viewed by each user with specific functionality provided to each. In Figure 2 the user interfaces of the openZDM platform available to an administrator and operator can be seen.

To ensure the scalability and resilience of the openZDM platform's functionalities technologies such as docker containers and Kubernetes are being used. This modular approach allows for the deployment of redundant modules and together with error handling mechanisms increased robustness is achieved. The monitoring of the platform's components is being handled by dedicated implemented components that are powered by technologies such as Prometheus.

Targeting the high scalability of the openZDM platform each component of the platform can be deployed separately, while different deployment scenarios are supported. This is enabled by the loose coupling of the services. Currently, the platform has been deployed in cloud virtual machines. Nevertheless, through its components such as the MQTT broker, the integration of shopfloor assets, like NDIs, is seamless. Lastly, the integrated platform can be deployed following a cloud, hybrid or local approach facilitating different scenarios and expanding its adoption.

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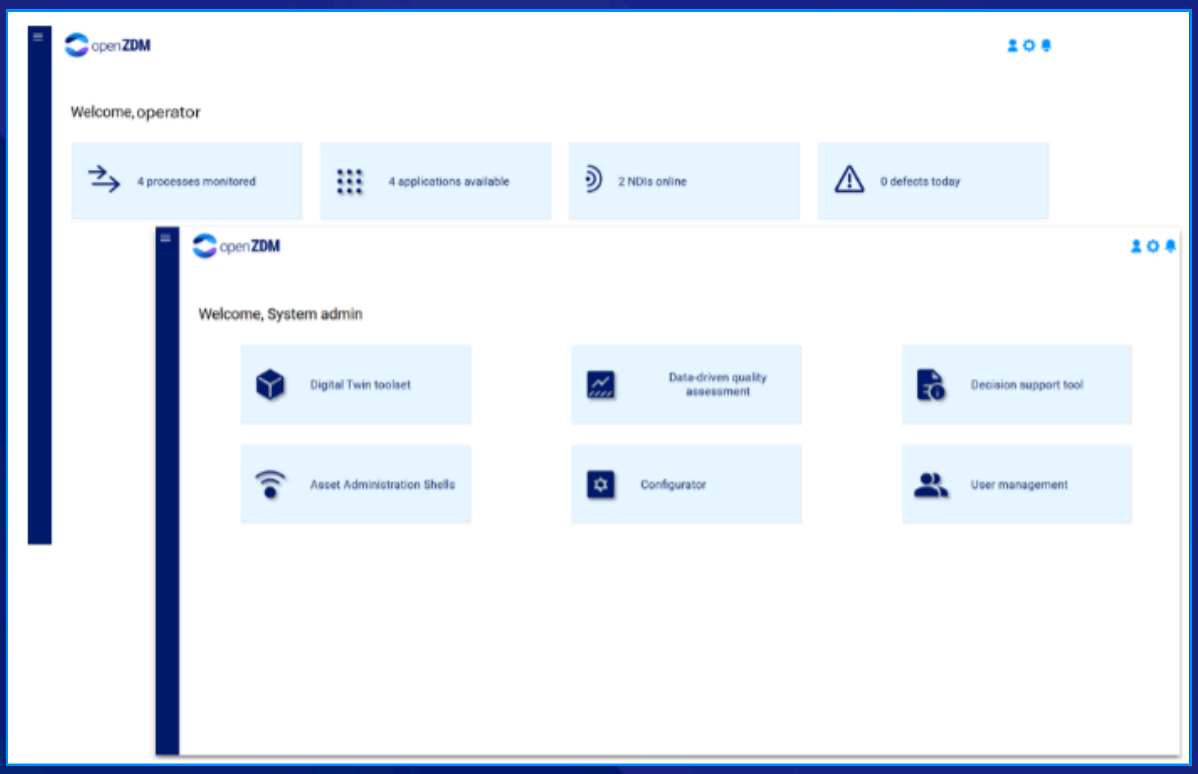

Figure 2: The user interface of the openZDM platform as seen by an operator and an administrator

Conclusions

The openZDM platform is strategically designed to support many data sources and services that holistically can enable zero-defect manufacturing. The layered approach of the platform's architectural design promotes its modularity, scalability, and flexibility, while the implementation approach follows a standardised approach promoting the platform's wide adoptability. Lastly, future work will focus on enhancing the capabilities of the openZDM platform such as the realization of the IDS connector to securely communicate data with external DataSpaces, and fully implementing and expanding the necessary components that support the AAS Type-3 implementation.

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