Full Implementation of BaSyx Asset Administration Shell Infrastructure: From Web UI to Real-Time Data Integration

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[*]Reporting Period: January 07, 2026 – January 13, 2026

February 26, 2026

Abstract

This comprehensive study details the deployment and configuration of an industrial Digital Twin platform utilizing the Eclipse BaSyx framework. The research covers the end-to-end implementation including the React-based Web UI, a Dockerized AAS environment, and a persistent storage mechanism using MongoDB Atlas. We investigate the integration of a BaSyx DataBridge to facilitate real-time telemetry from IoT devices using MQTT and JSONata transformations. Results demonstrate a functional three-column visualization system and a robust ETL workflow capable of managing complex asset lifecycles in Industry 4.0 environments.

1 Introduction

The development of a Digital Twin (DT) requires a standardized method to represent physical assets in a digital format [1]. This project implements the Asset Administration Shell (AAS) model following the IEC 63278 standard to ensure interoperability [2, 3]. The primary goal is to establish a secure, reliable information exchange layer using the BaSyx AAS Environment [4, 5].

A critical challenge in standard AAS architectures is the volatile nature of in-memory storage, which risks losing historical states during system restarts [6]. To address this, we integrate MongoDB as a persistent NoSQL layer [7]. Furthermore, the system incorporates middleware for Extract-Transform-Load (ETL) operations to bridge the gap between Operational Technology (OT) and Information Technology (IT) [8].

2 Materials and Methods

2.1 Web UI and Frontend Setup

The frontend utilizes the official Eclipse BaSyx web-ui repository [9]. Deployment involves:

- Cloning the repository and installing dependencies via `npm install` [10].
- Executing `npm run dev` to initialize the interface at `http://localhost:3000`.
- Configuring `basyx-infra.yml` to point to the backend service at port 8081.

2.2 Backend and Database Integration

The backend leverages a Docker Compose environment [11]. To enable persistence, the Java Server is configured with the `mongoDbStorage` profile [12].

```
services:
  aas-env:
    image: eclipsebasyx/aas-
        environment:2.0.0
    ports: ["8081:8081"]
    environment:
      - SPRING_PROFILES_ACTIVE=
          mongoDbStorage
      - SPRING_DATA_MONGODB_DATABASE
          =DT_DB
      - Basyx_Cors_Allowed-Origins=*
```

Listing 1: Docker Compose environment configuration

2.3 Real-Time Data Routing

The BaSyx DataBridge connects MQTT telemetry to the AAS server [8]. We configured a `routes.json` file to map CPU and RAM usage metrics from a Python simulation script to specific Submodel elements. The workflow uses JSONata queries to extract values and HTTP PATCH requests for updates [13].

3 Results

3.1 UI Features and Flow

The interface employs a three-column layout:

- **Left:** AAS list with search and upload (`.aasx`).
- **Middle:** Hierarchical Submodel tree visualization.
- **Right:** Detailed visualizations and JSON raw data views.

3.2 Persistent Storage Results

Data is automatically organized into MongoDB collections: `assetAdministrationShells`, `submodels`, and `conceptDescriptions` [14]. This ensures data persistence across container restarts [7].

3.3 API Architecture Reference

The system maps functions according to the ISO 23247-2 model. Key schema attributes are summarized in Table 1.

Table 1: Key Schema Attributes and Technical Roles

Schema	Attribute	Purpose
AAS	`submodels`	Links Shell to functional sets.
Submodel	`elements`	Stores states and specs.
Result	`messages`	Provides status feedback.
Reference	`keys`	Defines retrieval paths.

4 Discussion

Implementation encountered 404 and CORS errors due to infrastructure misalignments [16]. These were resolved by synchronizing the UI configuration and enabling global CORS origins.

The use of Value-Only representation (`/$value`) significantly reduced network overhead. While the current setup uses Docker for demonstration, production should transition to the full Java SDK for scalability [17].

Acknowledgments

Special thanks to the system integration team for their support in configuring the AAS environment [18].

Table 2: Comprehensive API Endpoint Reference for AAS Environment [15]

Functional Group	Method	Endpoint	Description
AAS Repository	GET	`/shells`	Lists all shells.
AAS Repository	POST	`/shells`	Registers a new shell.
Submodel Repo	GET	`/submodels/{id}`	Returns submodel data.
Submodel Repo	PATCH	`/submodels/{id}/$value`	Updates values only.
Operation	POST	`/.../invoke`	Triggers functions.
File/Attachment	PUT	`/.../attachment`	Uploads file content.

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