Demo Case Update

From Waternet – Wastewater Treatment Plant Amsterdam West

28 May 2021

Waternet has dedicated one of the seven treatment lanes of wastewater treatment plant (WWTP) Amsterdam West to investigate AI based process control strategies for energy optimization and N2O reduction and implementation of Fiware. In the past months Waternet, KWR and EUT have worked on data collection and quality of newly installed sensors at the research lane, research on reinforcement learning agents for a real-time control model of the research lane, the implementation of Fiware and on Fiware common information models for wastewater treatment.

Data collection

The research lane at wastewater treatment plant Amsterdam West consists of more than 25 newly added sensors and analyzers which measure more than 40 parameters. All sensors of the research lane have been installed. The majority of sensors are online and measure correctly. The data can be accessed and visualized remotely and dashboard mockups were made to enable data analysis (example, see figure 1 below).

Figure 1 Dashboard mockup for data analysis of new and existing sensors in the legacy system

Some sensors still require attention for solving teething problems in the coming period. To be able to measure the influent ammonium, phosphate and dissolved TOC concentration particles have to be removed from the wastewater. This will be done using a recently installed ultrafiltration unit. Once the ultrafiltration is continuously online, data collection will start. The coming months a student will determine the optimal settings to enable continuous operation for several days. A three month data set is required to train the model that describes the treatment plant behavior. It is expected that in the beginning of June sufficient correct measuring sensors and analyzers will be available to collect a proper dataset.

Reinforcement learning

For model based control of the research lane, reinforcement learning (RL) agents were realized. The improvement of performance and effectiveness of the RL agents is being studied with the aim of improving the weaknesses detected. Result improvements and time reduction are the main focus for the current work on the RL models.The implemented agents are deep q network (dqn) agents and a soft actor-critic (sac) agent. The dqn agents use a deep learning model (recurrent neural network because of time series data) as a function approximator for the action-value function and the sac agent uses a continuous version of the environment and learns both, an actor, and a critic function, with deep learning models. Further, the Tensorflow (tf) agents library is used with a number of developed customizations to better adapt the solution to the specific problem such as transfer learning from the environment model (an AI digital twin) of WWTP Amsterdam West to the deep learning models. The agents have been trained to analyze their learning capacity and detect the bottlenecks for further improvements on their training phase. For better analysis and understanding, the problem is being simplified and reduced to a more treatable case (by changing parameters and reducing the dimensionality of the problem). The variables of the environment, the relationships between them and historical data of the system are analysed to obtain a baseline for comparisons and evaluation of the trained RL agents. In addition, the analysis of the initial agents has led to new insights and improvement of the reward function.

Fiware implementation

Fiware is deployed in Docker containers. Each container has its own task and responsibility, the containers work together to provide the necessary functionalities. The Orion context broker, which routes data between components, and databases to store data, and IoT (Internet of Things) agents which can ingest data are deployed. The demo is ready on a Virtual Machine where all the containers are running consisting of the Orion Context Broker, Cosmos, Quantum Leap, MongoDB, CrateDB, MySQL, Grafana and Cygnus. Fiware relies on the data model that is provided. A number of data models for wastewater treatment are build and integrated with Fiware. Currently the connection to the legacy system is being built to retrieve the latest sensor data from the Waternet legacy system. Future work is to implement the connection to the legacy and connect the soft sensor models, such that we can derive and enrich information given sensor data.

Fiware common information models for wastewater treatment

To support the integration of Fiware within the legacy system NGSI-LD data models have been developed for data integration. These models have been developed to be used within the demo case and also in contributing to the interoperable and standardization principles of FIWARE and the digitalization of the water sector. The following NGSI-LD data models have been defined:

- **WasteWaterTank**: Description of a generic tank in a wastewater treatment plant. The models allows for the definition of all kinds of tanks present in the process (e.g. aerobic tanks, anaerobic tanks, secondary settlers) and contains properties that define various parameters that are typically measured.

- **WasteWaterJunction**: Description of junctions that could be in place in certain sections of the treatment plant. In wastewater treatment purposes, the junction is most useful for the local of a sensor that measures a specific variable, e.g., the point of effluent discharge into the water receiving bodies.
- **Blower**: This entity represents blowers that are used for aeration purposes in the wastewater treatment process. Important parameters are measured to regulate the amount of airflow provided to the aerobic tank in the bioreactor. Such a definition is important in the goal to reduce energy consumption by blowers through real-time control and optimization.
- **OffGasStack**: This definitions is relevant to this Demo Case. It is the description of off-gas stacks that are present in closed wastewater treatment plants. In the stack, the greenhouse gas emissions (such as N2O) generated from the wastewater treatment processes are emitted into the atmosphere. For the purpose of reduction of greenhouse gas emissions through real-time control and optimization of wastewater processes, this data model is essential.

To illustrate the different relationships between entities, the graphical representation of a WasteWaterTank data model and WasteWaterJunction data model are provided in the figures below. Additionally, the next steps would include the demonstration of using the developed NGSI-LD models with the Fiware implementation in order to send sensor data to update the context along with the simulation of developed soft sensor models. Based on our learnings from the demonstration, the data models will be updated to support the use case activities.

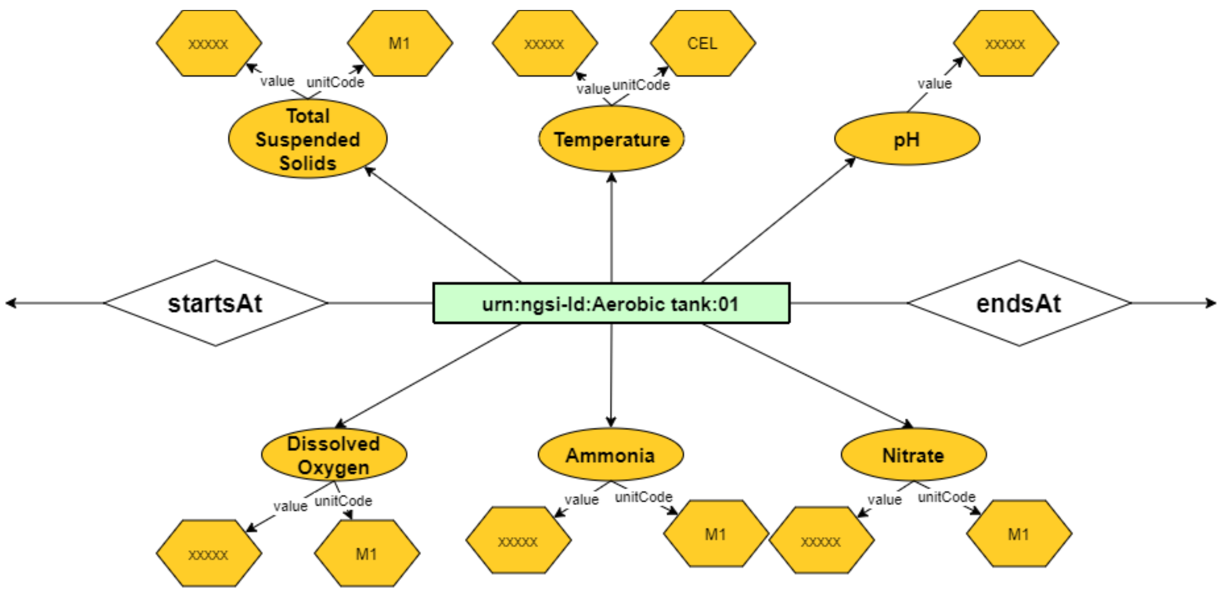

Figure 2 Graphical representation of an Aerobic Tank definition which is of type WasteWaterTank.

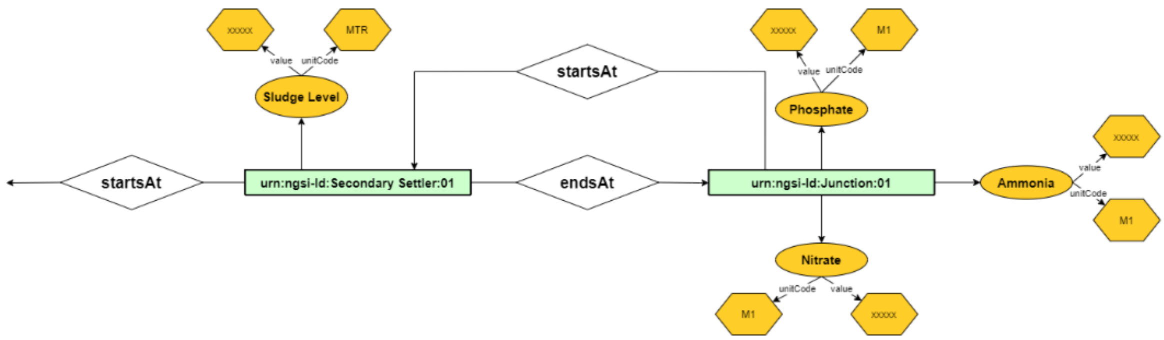

Figure 3 Graphical representation of a junction of type WasteWaterJunction that has a relation of 'StartsAt' with a Secondary Settler, which is of type WasteWaterTank

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Project Consortium

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