Digital Twin in Water Treatment Plants

Ensuring cost optimization and value creation

WHITE PAPER

Abstract

By 2030, the world will face 40% water deficiency[1]. In fact, the UK is expected to face a whopping water shortage in the coming 25 years[2]. In order to deal with the crisis, it is mandatory for water companies to become more efficient. This means they have to reduce capex and opex which includes reducing leakage, energy consumption, becoming net zero, and increasing the lifecycle of key assets.

The COVID-19 crisis is exacerbating the challenges for all sectors, including water companies. Domestic water demand has increased, the price of raw materials and labor has risen, and the risk of more bad debt is higher due to the changed economic situation. Thus, water companies need to keep reducing costs and increasing the life of assets while maintaining the quality of service and complying with regulations.

Leveraging digital twin is key to enhancing operational efficiency while reducing manual effort and cost. This paper examines the digital twin architecture for water treatment plants, the challenges in their implementation, and how water companies can benefit from it.

[1] United Nations Environment Programme; Half the World to Face Severe Water Stress by 2030 unless Water Use is "Decoupled" from Economic Growth, Says International Resource Panel; March 21, 2016; https://www.unep.org/news-and-stories/press-release/half-world-face-severe-water-stress-2030-unless-water-use-decoupled

[2] Express & Star; Plan unveiled amid warning many areas of England 'face water shortages by 2050'; March 16, 2020; https://www.expressandstar.com/news/uk-news/2020/03/16/plan-unveiled-amid-warning-many-areas-of-england-face-water-shortages-by-2050/

Tackling Typical Operational Challenges in Water Treatment Plants

Water treatment plants (WTP) are fundamental to the main services a water company provides. Managing a WTP entails activities with large variances such as handling chemicals and managing various assets and instruments involved in the process, monitoring the raw and treated water quality and energy consumption, and producing the required volume of water every day.

However, external factors can have a big impact on the operations of a WTP, including extreme weather conditions, natural disasters, or drastic change in demand patterns. Besides these factors, the new ways of remote working also affect how a WTP is run. Proactive maintenance and faster response to operational issues are critical while improving asset utilization and cost optimization, increasing the overall efficiency of the plant.

Water treatment in a typical WTP comprises the following stages: screening, aeration, coagulation, flocculation, sedimentation, filtration, chlorination, and storage. As each stage of the treatment involves the use of one or more equipment, each device requires a daily set of planned maintenance activities as well as reactive work in the event of sub-optimal performance and instances of equipment failure. This requires the involvement of primarily three teams:

- Field operatives who rely on individual knowledge and experience to detect issues
- Team leads who allocate and manage the work done by the field operatives
- The control center team that monitors real-time assets and operations data

Digitalization, Intelligence & Simulation: The Future of Water Treatment Plants

The first step to addressing the challenges faced by water utilities is to create a digital twin—or virtual replica—of a WTP, which is the starting point of the municipal water supply. Digital twins of WTPs model the physical systems of blowers, pipes, aerators, pumps, valves, and tanks and are also designed to include historical data sets such as failure records, maintenance activities, and real-time interactions, which allow them to be used for

analyzing multiple scenarios. This enables plant operatives and plant managers to virtually walk through plants, gain insights into current and predicted performance, and run simulations (see Figure 1).

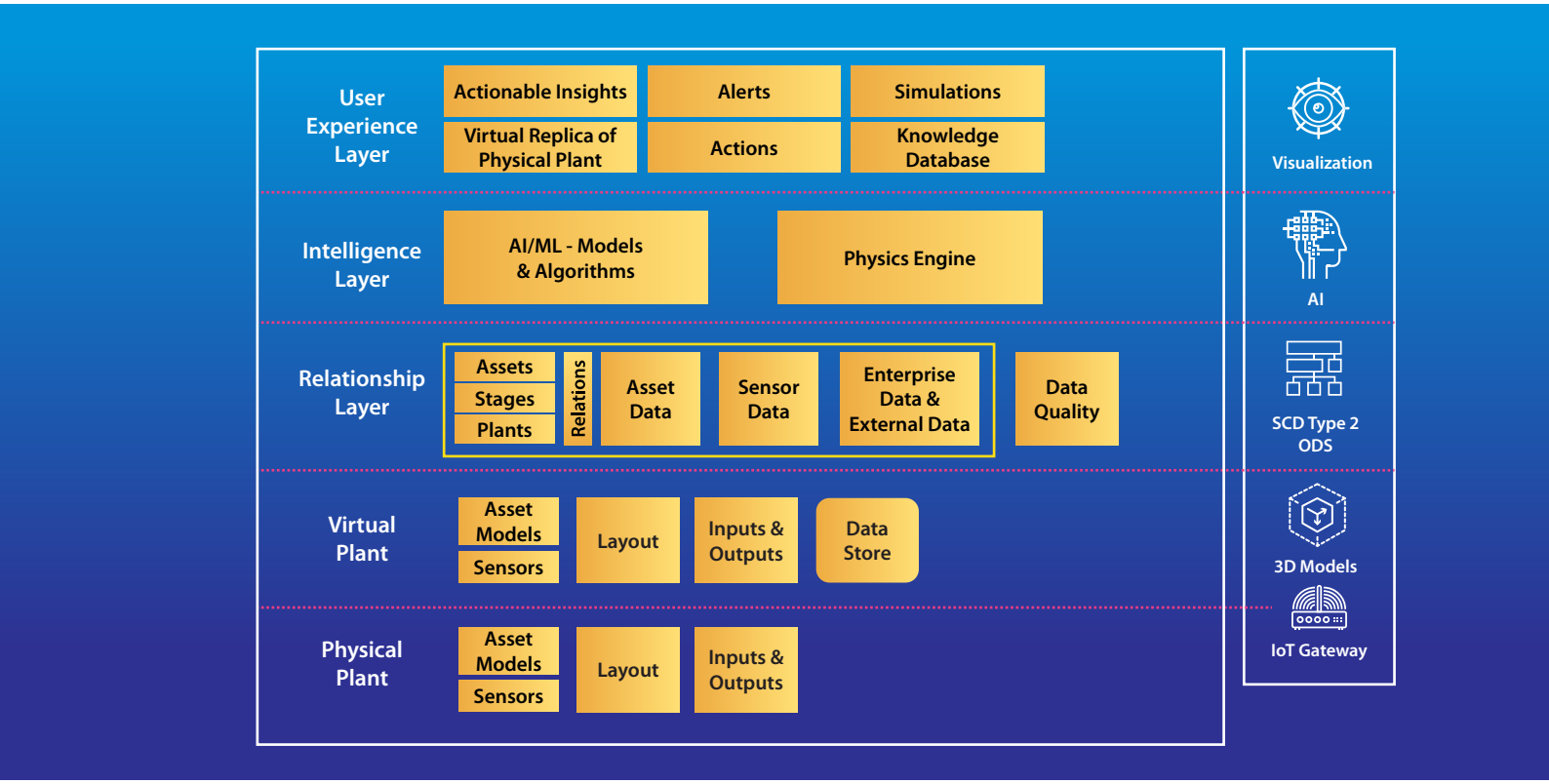

Figure 1: *Techno-functional architecture of a digital twin in a water treatment plant*

Benefits of Digital Twin in Water Treatment Plants

Digital twins have numerous benefits for the management and optimization of water treatment plants, as listed below:

- Monitor water quality and volume for each plant based on regulatory compliance/customer side demand
- Obtain an improved understanding of new and existing operational processes
- Optimize new process designs, while identifying and eliminating errors
- Enhance operational efficiency and reduce the cost of maintenance
- Plan for extreme weather conditions and other scenarios

- Proactively maintain and improve the lifecycle of assets within the plants
- Ensure consistent operational and ongoing standards
- Communicate and educate stakeholders and customers on process dynamics
- Reduce dependency on the knowledge of individuals, making it easy to train
- Test the impact of key business scenarios before implementing them
- Improve inventory management at plant sites

Some use cases of a digital twin in a water treatment plant have been illustrated below to demonstrate the benefits of the technology:

Predicting optimal dosage with digital twin: Coagulants are dosed in a solution at a rate determined by the raw water quality. The efficiency of the coagulation process depends on the raw water properties, the chemical used as coagulant, and operational factors including mixing conditions, temperature, dose rate, pH, and turbidity value. However, using coagulants to treat small supplies requires accurate dosing and thorough mixing and frequent monitoring. This creates additional need for accurate dosing equipment and qualified personnel who can monitor the dosage of chemicals and ensure maintenance.

In case of a drastic change in the raw water quality such as turbidity, the dosage rate has to be adjusted for coagulation of the impurities. Alternatively, the time to settle impurities in a tank has to be increased. In a typical scenario, the decision to increase coagulant dosage or to increase the settling time is taken by experienced operatives. A digital twin can create alerts to change the input water quality and prescribe the optimum dosage or increase the settling time. It can determine these factors based on historical action data and its ability to replicate the behavior of the plant at any given time. Alternatively, it can simulate and predict the optimal dosage for a given set of values of the raw water parameters. Thus, digital twin in this case will not only reduce maintenance effort but will also assist experienced personnel in better decision making.

Improving decision making in instruments and equipment in the treatment process: Equipment such as pumps, turbines, and motors used in a water treatment process seldom function at their default settings, which can be changed based on the requirements of the treatment process. Similarly, operating parameters can be changed based on the raw water quality or the chemical used in the interim processes. As there are no formal records of the operating parameters of the equipment, power cuts can hamper an equipment's operational effectiveness, putting the operator under relentless pressure to restart it. But it is very difficult for the operator to know the exact operating parameters for the pumps or turbines.

A digital twin can store the operating parameters in real time and prescribe the ideal ones to the operator based on historical data. This will improve decision-making while eliminating the need for extensive on-site operations and extended operating hours

Challenges of Building a Successful Digital Twin

Building a digital twin for WTPs is challenging as it involves two components: an engineering design and specifications, and process control systems embedded with technologies like internet of things, augmented and virtual reality, artificial intelligence, and machine learning. Thus, water companies need to put in substantial effort to capture data in the WTP. This means commissioning additional sensors and loggers and connecting the same to the top end telemetry, which in turn requires additional costs, both capex and opex. Securing funds, using effective sensor technology, and the return on investment period are the main limiting factors of using a digital twin. To effectively implement it, the volume and methods of data capture should be aligned to the final outcome and the goals of stakeholders.

Currently, digital twin implementation is hindered by a lack of digital records of plants, historical records, and operational data, which are not connected to the top end telemetry.

We firmly believe that water utilities must change their approach and mindset to embrace digital capabilities like digital twin. They will need a contextual strategy specific to them to leverage digital twin to its fullest potential.

Winning with Successful Digital Twin Implementation

With digital twin, water companies can meet regulatory compliance requirements of water quality and volume while reducing the need for physical presence. This improves operational efficiency and decreases maintenance costs, enabling proactive maintenance and increasing the asset lifecycle. It also reduces dependency on individuals, personal interpretation of incidents and changes, and the physical presence needed in plants, which is even more important given COVID-19.

About The Author

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Avishek Chaudhuri leads the water and wastewater practice for utilities at TCS. He has over 22 years of experience in the global water sector, having worked with multiple water utilities in France, Australia, Canada, the Philippines, India, and the UK. He has helped water companies manage global challenges like climate change and water scarcity using new-age digital technologies. He is a member of the International Water Association (IWA) where he is a part of the steering committee for digital water initiatives. He is also an advisory board member at Aquatech, an innovation forum.

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