2020

Next-gen industrial water pollution control
Blockchain and IoT for waste water management
When polluted water is discarded without adequate chemical treatments and safety checks for major pollutants, it becomes unfit for human and agricultural use. This is the case in many geographies; tainted water can cause significant risk to the surrounding human and environmental communities—and the companies that physically discharge the water.
Key causes for industrial water pollution

**Use of outdated technologies because of upgrade costs.** Many companies across industrial sectors rely on old and outdated technologies and systems to support their waste water management systems, which produce a greater amount of pollutants compared to systems that leverage modern technologies. Several companies recognize the high cost of modernizing systems as a barrier to entry for upgrading their tech.

**Lack of stringent regulatory pollution policies.** Pollution control policies vary globally, especially in developing countries. In other regions, policies might be less strictly enforced, making it easier for companies and agencies to bypass or only partially implement solutions that comply with pollution control policies.

Current challenges in waste water management

**Lack of transparency.** There are laws and environmental guidelines worldwide that indicate how companies and governments should monitor waste water for environmental impact, protect against contamination, and appropriate levels of treatment. However, there is a general lack of transparency about how companies and agencies are keeping track of these waste water records, which authorities are monitoring them, and how they are being checked over time. There is little to no transparency about which companies are maintaining safe waste water discharge practices versus those that are bypassing regulations and discharging pollutants.

**Lack of modern technologies.** Most current waste water monitoring technologies do not adequately track and measure pollutant levels according to set guidelines. These systems are also not able to automatically submit proof to regulatory bodies; therefore, records must be kept manually and are sourced directly from the bodies discharging the waste water themselves—which can be ineffective, time-consuming, and potentially risky.

**Lack of control.** Due to the lack of transparency and technology, many government agencies and environmental regulatory bodies have a lack of insight—and therefore control—over waste water discharge practices across private industries. Though these agencies and bodies can raise concern about suspect practices, they aren’t able to fully control waste water practices without the right tools in place. In turn, it’s common that freshwater is polluted by unsafe, polluted waste water.
A blockchain- and IoT-enabled solution for waste water management

To address the challenges in this area, government agencies, environmental regulation boards, and private companies in industrial water management sectors could leverage a blockchain- and IoT-enabled platform to manage waste water and industrial pollution. This could help ensure regulatory and environmental waste water policies are being followed and protect the surrounding environments, communities, and individuals.

Blockchain and IoT for waste water management solution components

**Industry/third party company’s waste treatment unit**
- Performs the necessary treatments on industrial water
- Once treatments are complete, company sends requests to monitor/control platform to get approval to discharge treated water.

**IoT system**
- Receives requests from industries
- Sends trigger signal to sensors for that industry to take the measurement on the water
- Sends measurements to the blockchain as soft contract input
- Inquires the blockchain and receives approval signals
- Upon receiving approval signal, IoT system actuates the set of transducers to allow the water to be discharged for the mentioned time and quantity
- If not approved, sends the feedback to the requestor

**IBM Hyperledger on LinuxONE**
- Taking the measurements as input, chaincode runs smart contracts to evaluate if adequate treatment is done
- Based on the transaction result, the network updates the ledger as approved/not approved
- It is dependent upon the IoT system to communicate the approval/non-approval decision to the company that requested the discharge
Hyperledger Fabric is supported by—and developed in collaboration with—IBM. The technology provides several advantages when building an enterprise blockchain solution, such as:

- Permissioned membership
- Performance, scalability, and levels of trust
- Data on a need-to-know basis
- Rich queries over an immutable distributed ledger
- Modular architecture supporting plug-in components
- Protection of digital keys and sensitive data

IBM LinuxONE is the platform we chose to support the waste water management solution. It offers three major advantages:

- **Security:** LinuxONE features advanced encryption features, all built into the system and ready at install.

- **Compatibility:** LinuxONE has the power to support almost all cutting edge technologies like artificial intelligence (AI), blockchain, and machine learning (ML). LinuxONE is compatible with almost all types of systems, and can connect them to different APIs.

- **Scalability:** LinuxONE can scale to meet the needs of nearly any enterprise or agency (i.e., number of users, I/O operations, connected devices, and overall performance).
Reference architecture and key components

Solution components
This solution only enables the discharge of industrial water that has been adequately treated. This process is made possible by three main technological components:

- Participating industry panel
- IoT system (leveraging IBM Watson IoT platform on IBM Cloud)
  - STAGE 1: Pull data and validate
  - STAGE 2: Perform analytics
  - STAGE 3: Push instructions
- Enterprise blockchain: Hyperledger on IBM LinuxONE
**Participating industry panel**

- An industry panel is an individualized company user interface system based on Node.js.
- Companies across industries can register to be a part of the network. Once registered, the company is given login credentials to its own individualized industry interface panel.
- The panel provides the option to trigger various capabilities:
  - **Request**: Request is the primary function used to request the approval for waste water discharge. It triggers the start of the transaction, requests the necessary approvals for the waste water discharge, and begins the transaction if requirements are met. The request will contain a unique ID, priority level, and requested quantity.
  - **Status**: Contains the status of the current waste water request.
  - **History**: Provides the record of the requests for the given time period.
  - **Benefit score**: Provides the benefit score associated with the waste water, assigned to the company/agencies based on a variety of industry factors.
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STAGE 1: Pull data and validate
- The IoT agent consists of multiple sensors that test the industrial waste water and send data to the blockchain platform for validation. These sensors can be placed depending on the use case and company leveraging them.
- The business unit that tests the water treatment (or the third party that performs this function) will send a request for waste water discharge approval to the system.
- Once the request is received, the system activates the corresponding sensors to read the level of treatment(s) necessary to comply with requirements.
- The sensors check the levels of pollutants such as asbestos, lead, mercury, nitrates, phosphates, sulfur, oil, petrochemicals, and more in the waste water.
- Upon completing the checks, the sensors send inputs to the blockchain-IoT platform to be validated.

STAGE 2: Perform analytics
- The IoT agent performs initial checks on the input from the sensors to ensure proper data has been collected and input.
- The system provides a basic validation on the data inputs and stores them in a database.
- The system formats the input data from the sensors to the corresponding format to meet the blockchain network requirement.
- The REST API connects to the Hyperledger Fabric loaded into LinuxONE, and triggers the transaction.
- Upon receiving a decision from the blockchain network, the IoT agent performs the analytics and calculates the benefit score for the company.
- The IoT agent sends feedback to the company.

STAGE 3: Push instructions
- This part of the system consists of multiple devices (sensors/actuators) controlled by the IoT agent. These devices are co-located with sensors in the larger system.
- Upon successful completion of the transaction in the blockchain, the blockchain approves the waste water discharge request.
- Watson IoT signals these devices to allow the waste water to discharge.
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Participating industry panel

- IBM Blockchain on LinuxONE is the key enabler of this solution. The blockchain consists of multiple soft contracts in the form of chaincodes, which are formed by government and environmental agencies.
- There are multiple nodes in this blockchain, most of which are restricted. Only authorized personnel can access relevant nodes.
- Watson IoT understands which participating companies are asking for approval to discharge waste water based on information secured on the blockchain. The sensor data can be combined with the Watson IoT inputs, formatted, and given to the blockchain for validation.

- Now, the system tells the blockchain platform what soft contracts should be run against the inputs to validate the level of water treatment. If all the nodes in the blockchain approve the transaction, the waste water treatment is deemed as adequate and meeting guidelines of the relevant governing and environmental bodies.
- If any of the nodes in the blockchain do not approve the transaction, it means the waste water has not been treated adequately. In that case, Watson IoT communicates the message back to the company or agency, along with the reason the discharge request was denied. Watson IoT can also recommend actions to meet the adequate level of treatment on the water.
Looking ahead: An advanced AI-enabled solution leveraging edge computing

Future evolution of this solution keeps a similar architecture and is still designed to meet industry and environmental needs, but also leverages AI. This would enable further customization for applications across use cases and industries like supply chain, food, airlines, and more. The AI and blockchain capabilities would reside in the same place—on a LinuxONE server. The IoT components would be built as edge computing devices, placed at the sites of work.

In conclusion

There are several environmental, societal, and technological challenges that make managing waste water, monitoring industrial pollution, and properly disseminating contaminated water difficult. This blockchain- and IoT-enabled waste water management solution can help major entities within the waste water management ecosystem—private companies, public agencies, and regulatory bodies and environmental constituents—monitor and control industrial waste water discharge into fresh water.

Built with innovative IBM technologies—including the IBM Watson IoT platform and Hyperledger—on a LinuxONE mainframe, the entire system can run on a secured server and allow for future development.

This solution could be implemented in two ways: a private company could configure, maintain, and own it to monitor its own waste water processes, or an environmental advisory board, government, or regulatory agency could maintain it and require companies to leverage the solution based on pertinent geographical and environmental regulations.
Appendix

Proposed technologies:

- **Blockchain**: CouchDB; Docker; Go; Hyperledger Fabric; Hyperledger Composer; Hyperledger on LinuxONE; Node.js; npm
- **Industry UI**: MongoDB; MQTT Clients: MQTTFX; MQTT Driver; Node.js
- **IoT Agent**: MongoDB; MQTT; Python; Watson IoT
- **Interface**: REST API

**Watson IoT™ and blockchain**

*With current product changes and updates, IBM no longer offers Watson IoT platform blockchain service and a new release date for the service is unknown.*

This solution was originally developed using this technology. Following are further details and a sample architecture based on that work.

IBM’s Watson IoT platform blockchain service is an add-on to IBM’s Watson IoT platform. It enables IoT devices and assets to integrate with business processes in a shared and immutable ledger—increasing trust and transparency across ecosystems.

The service allows IoT devices to send data and respond to business events through a private blockchain ledger shared by a business network. Companies can leverage this IoT and blockchain service to improve visibility, provide analysis, and engage users through devices to automate and streamline business processes and minimize delays, waste, and disputes in the supply chain.