Deloitte.

Platinum
Business
Partner

2020

Blockchain and IoT

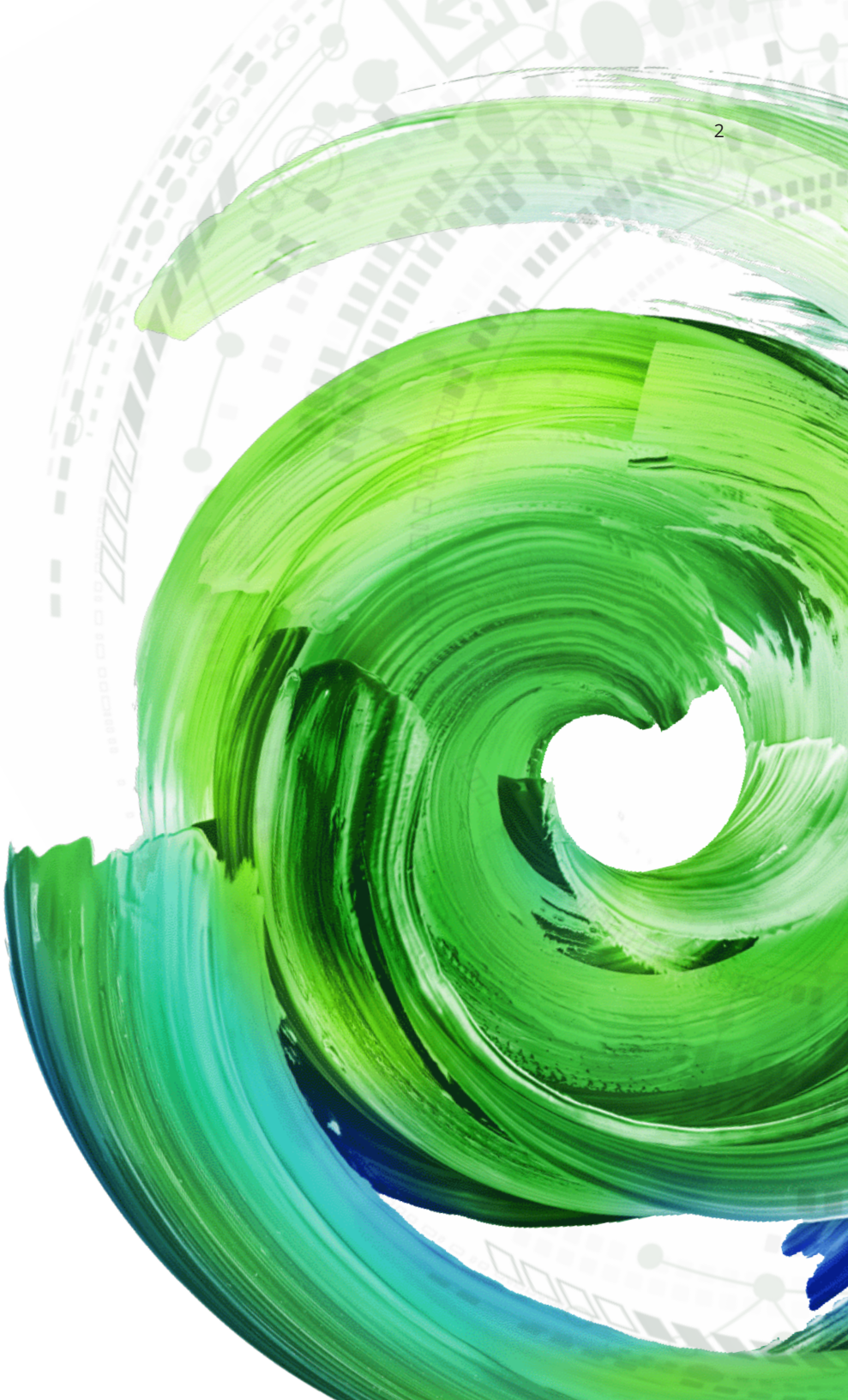
Using cutting edge technologies for wastewater management

Abstract

Over the past few years, both blockchain and Internet of Things (IoT) technology have become increasingly explored across industries worldwide. In a short period of time, both of these emerging technologies exploded into the joint business discourse—garnering attention, investment capital, and significant hype. However, the market adoption of these emerging technologies has faced challenges. A lack of technical maturity and an understanding of blockchain and IoT's unique capabilities have left the market unable to realize a vast potential for disruption.

Blockchain and IoT, as standalone solutions, can provide value in many circumstances. When used in tandem, the combined solution creates an opportunity for businesses to generate, gather, and process data in greenfield ways. The resulting united solution creates a vast network of data sources (IoT sensors) and participants (nodes on the blockchain network)—all interconnected within a distributed and secure platform that operates at scale.

This whitepaper examines the use of blockchain- and IoT-enabled solutions to address the current challenges in wastewater management.



Current scenario and challenges for wastewater 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.

Many companies across industrial sectors rely on old and outdated technologies and systems to support their waste management systems, which produce a greater number of pollutants compared to systems that leverage modern technologies. Additionally, pollution control policies vary both globally (especially in developing countries) and regionally, where policies might be less strictly enforced.

There is also mounting pressure from environmental groups to more closely monitor waste facilities. These groups are pushing governments to 'punish' these facilities and fine them for violations. As a result, water management companies are in greater need than ever before for better controls that allow them to be proactive rather than reactive.

A typical engineering problem across industries is that despite several technologies being used, there is no integrated system that can collect data from various sensors in a secure and trusted manner, analyze the data, and produce valuable insights that can be acted upon in near real time.

The problem becomes even more significant when the data aggregation efforts span across different organizations. Traditionally, this has led to the need for third party agencies who aggregate and monetize data before making it available to the industry.

A critical engineering challenge has been integrating the systems to behave in a holistic and trustful way. This is mainly due to the lack of interoperability of multiple platforms and their data. Data security is another major challenge that organizations face. To overcome this challenge, a robust security system should be built to collect, analyze, store, and report these data and analytics, which can be accessed only by the designated and permissioned systems or authorities.

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

Using IBM software and hardware technology has enabled Deloitte to build such a system. The solution is designed to meet industry and environmental needs. IBM's platform not only manages the industry issues but using IBM Watson AI allows the solution to offer remedies for issues as they are identified by the system. This reduces the need for delays caused by human interventions.

The solution can be implemented in two ways: a private company could configure, maintain, and own it to monitor its own wastewater 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.

Generate:

Producing real-time data at scale

IoT has been revolutionary in enhancing our capabilities to generate on-the-ground, high-quality data. For years, data gathering and collection at scale has no longer been wishful thinking but an industry standard. As a result, the question for organizations has shifted from *"how do I collect more data?"* to *"how do I create usable, real-time data while ensuring security?"* A secure and auditable blockchain solution integrated with IoT promises to help bridge this gap.

Gather:

Federating data collection

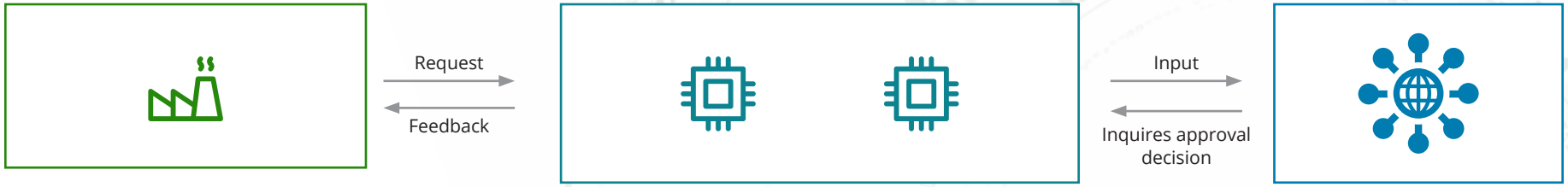
Blockchain technology removes the need to depend on a single endpoint as a data gatherer. Single endpoint architectures suffer from low reliability and high vulnerability to a denial of service. Whether this occurs from malicious actors or general system unavailability that brings down the entire system, blockchain technology's distributed architecture makes it far easier to safeguard the system so that it doesn't become unavailable in its entirety. Even if some devices go offline, using blockchains as data gatherers ensure that the rest of the system remains operational.

Process:

Synthesizing data streams into a single view

Enabling data standardization and quality is intrinsic to blockchain technology as a solution. While creating data consistency requires only a basic processing level, the potential to layer advanced analytics and machine learning capabilities onto the solution makes blockchain technology ever more promising. Blockchain and IoT technologies can transform traditional business models and push the world towards more decentralized ecosystems. This disruption not only creates new operating models but new technical architectures. While IoT takes on generating data 'on the field' from many devices and agents, blockchain makes the data more secure by enforcing the consensus mechanisms between many data generators. This creates a unified opportunity to enable standardization, shareability, and the real-time processing of data.

Wastewater design architecture using IBM® LinuxONE



Industry/third party company's waste treatment unit

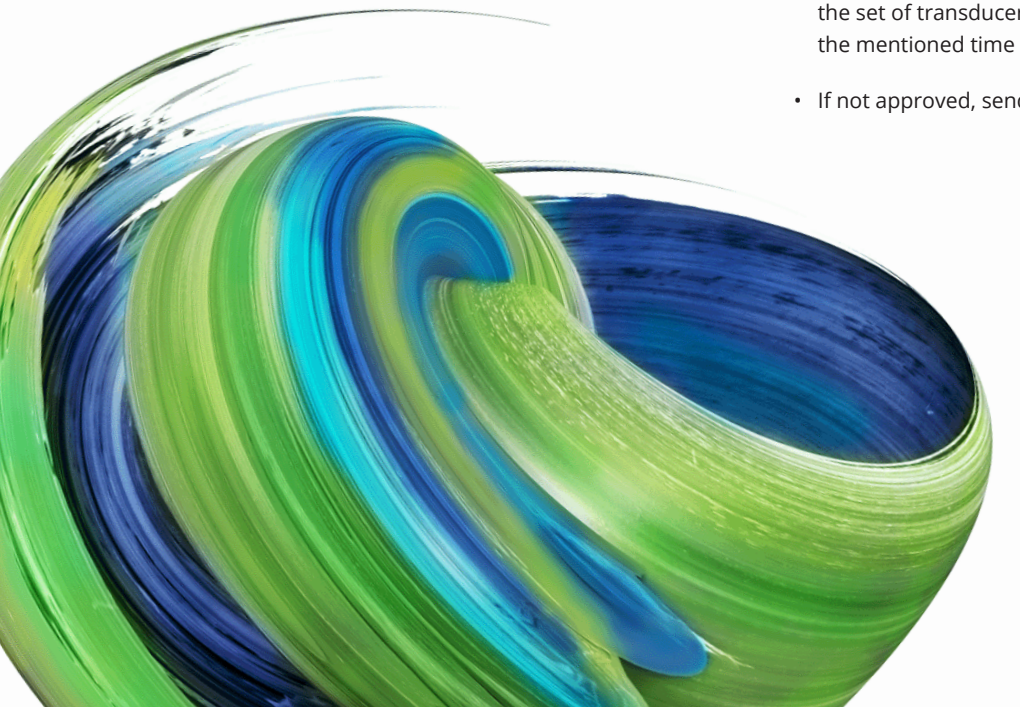
- Doing the neccessary treatment on the industrial water
- Once done, sends requests to the Monitor/Control platform to get approvals for the discharge of treated water

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 Fabric

- Taking the measurements as input, chaincode runs smart contracts to evaluate if adequate treatment is done
- Based on the transaction result, the network would update the ledger as approved/not approved with this transaction
- It is dependent upon the IoT system to communicate the approval/non-approval decision to the company that requested the discharge



IBM LinuxONE

IBM LinuxONE is the platform Deloitte chose to support the wastewater management solution. It offers these major advantages:

Security: LinuxONE features advanced encryption features—all built-in to the system and ready at install.

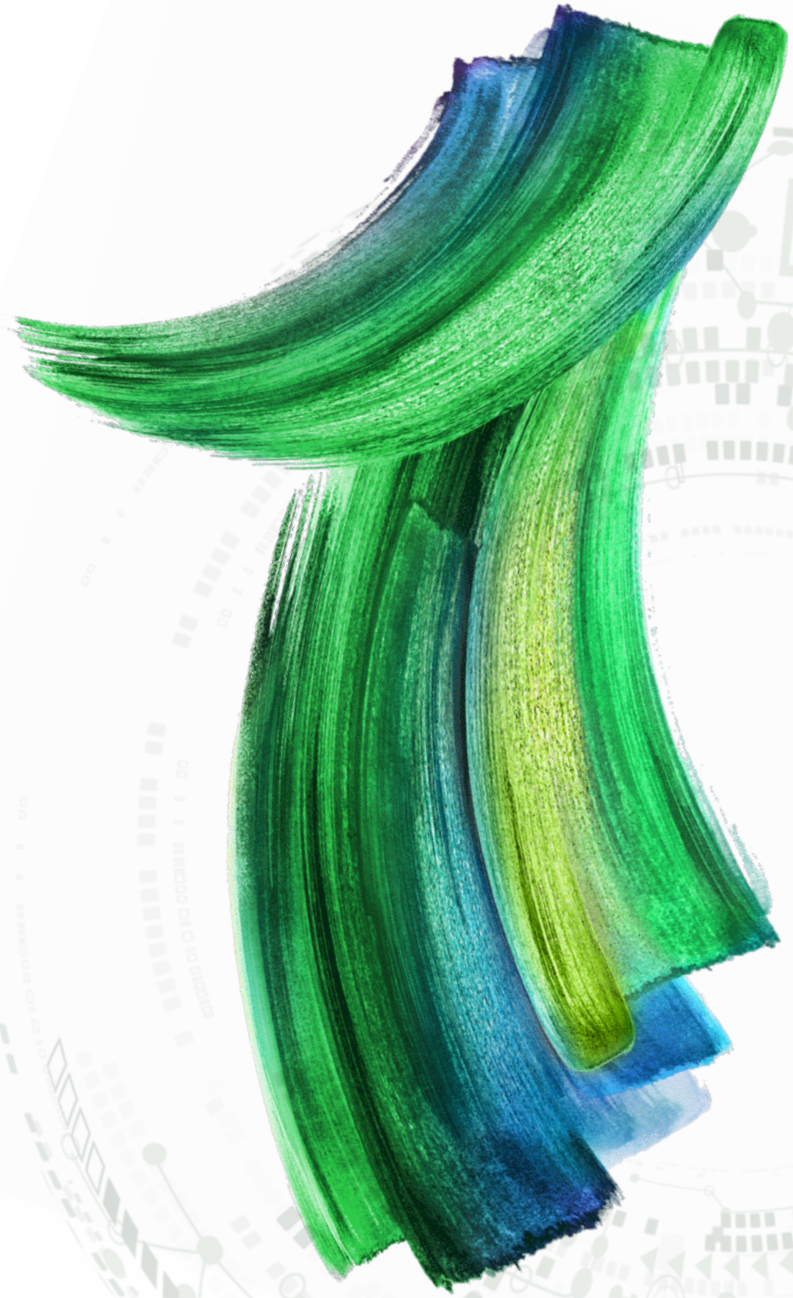
Compatibility: LinuxONE has the power to support almost all cutting edge technologies like artificial intelligence (AI), blockchain, and machine learning (ML). LinuxONE is compatible with almost all types of systems—and can connect them to different APIs.

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).

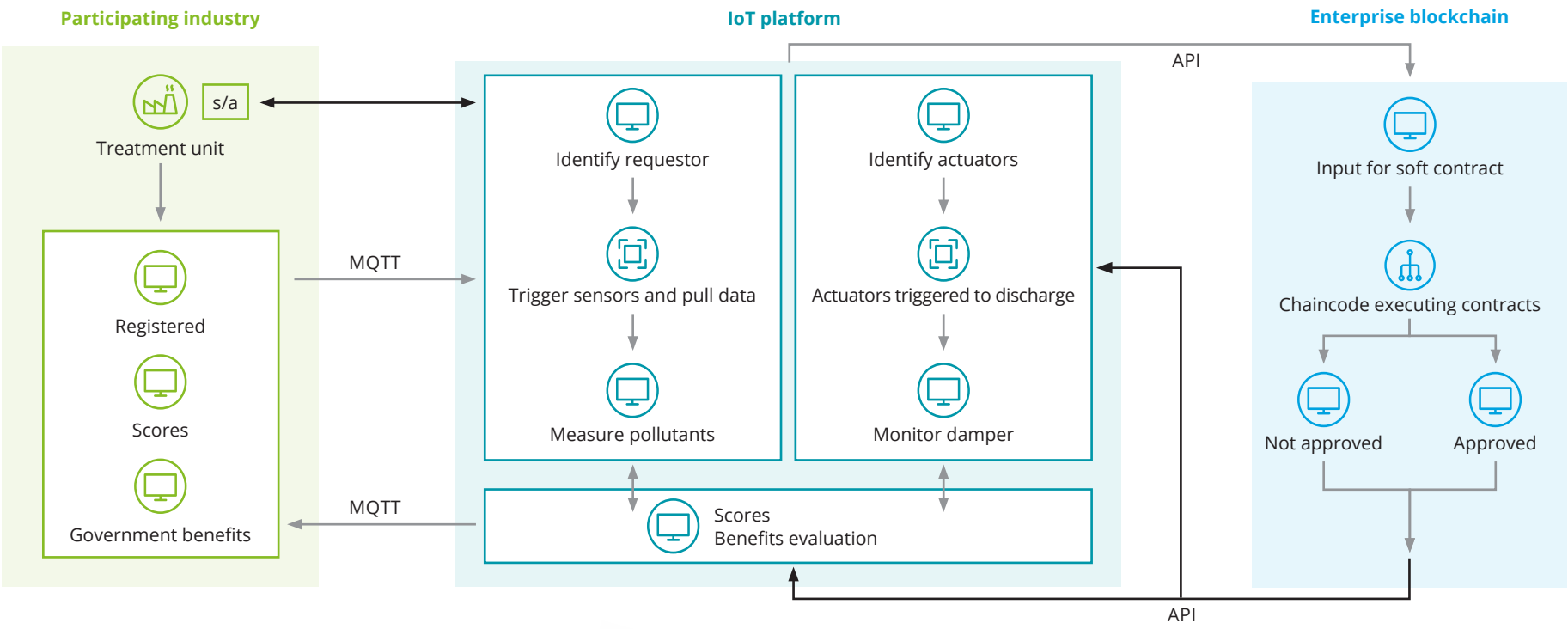
Performance: Built on the same technology platform as other mainframes, LinuxONE has power that other Linux servers do not possess, nor will they as their designs do not allow for that.

Flexibility: LinuxONE allows for three operating systems to be used on it: Red Hat, Ubuntu, and SUSE, which allows users to select the one that best fits their needs.

Total cost of ownership: LinuxONE has been proven to be cost effective not only at the software level, but based on a proof of concept performed by Deloitte, once you exceed 100 enterprise class Intel servers it is less costly to own a LinuxONE then Intel servers. A LinuxONE Rockhopper can have up to 800 lpars on it without increasing the costs appreciably. But for every Intel server added, you have to add direct costs as well as indirect service costs.



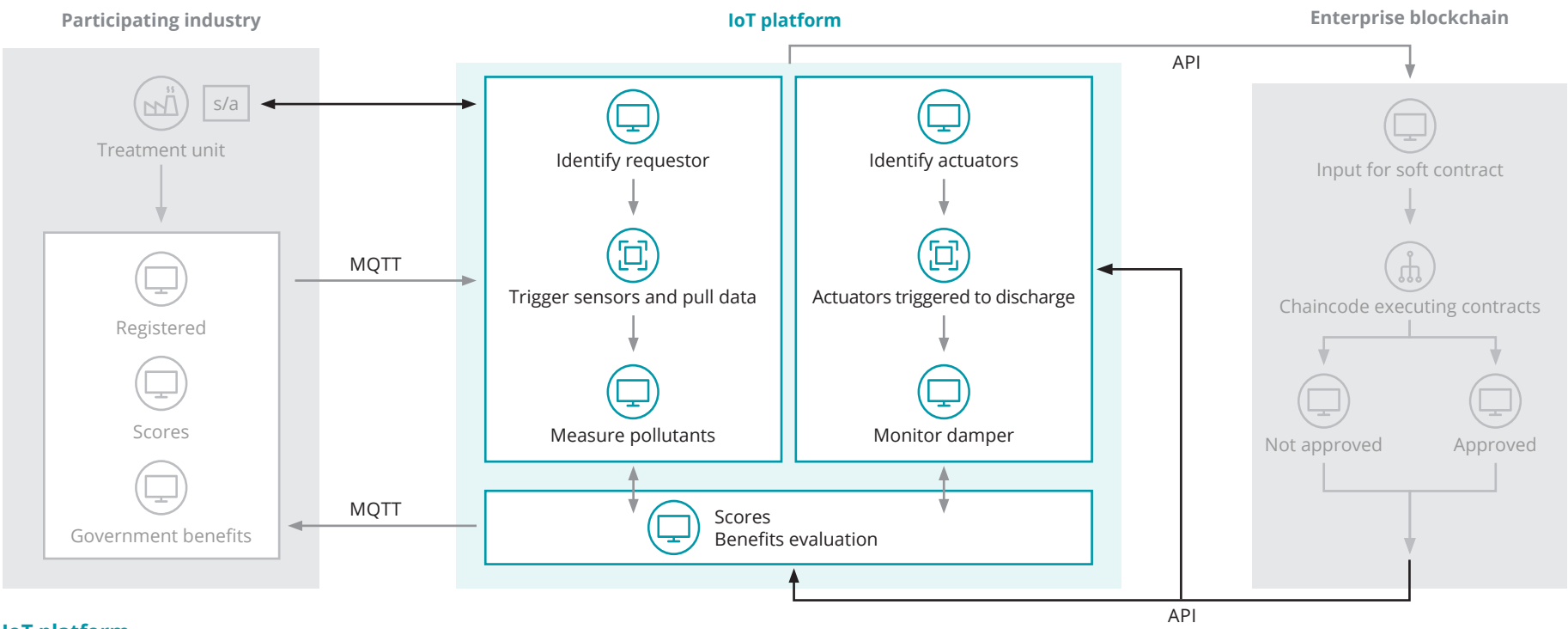
Solution reference architecture



Solution components

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

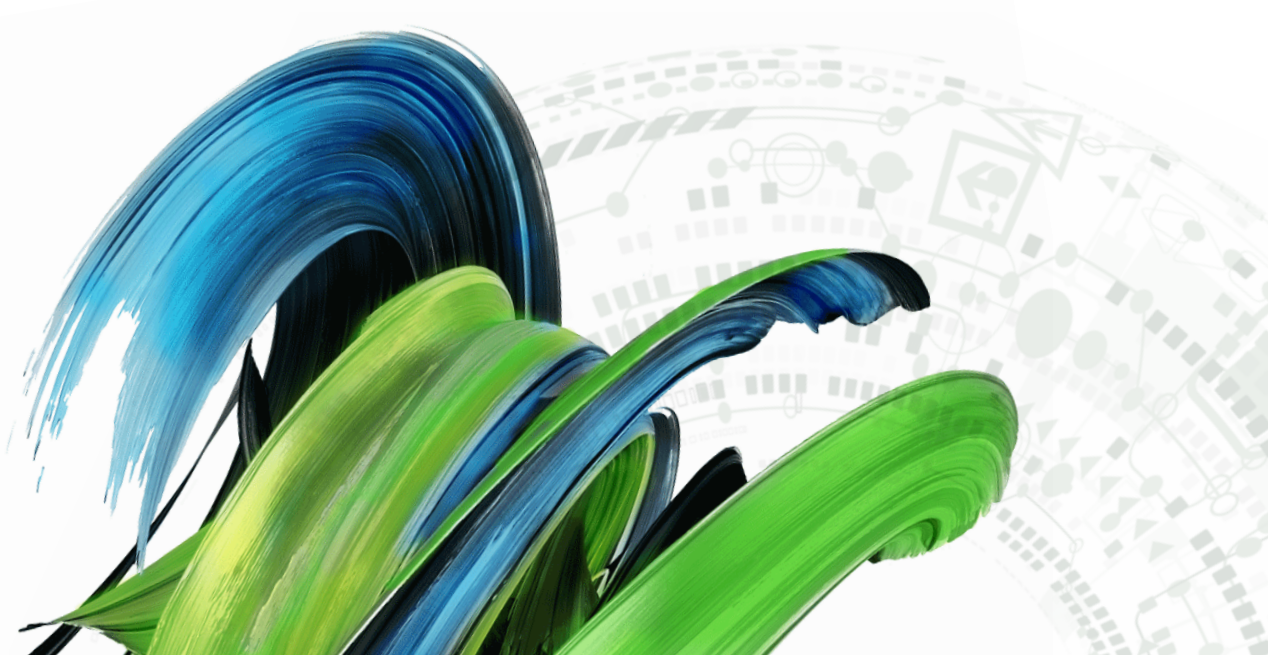
- Participating industry panels (individual company user interfaces)
- IoT agent (leveraging IBM Watson IoT platform on IBM Cloud)
  - **STAGE 1:** Pull data and validate
  - **STAGE 2:** Perform analytics
  - **STAGE 3:** Push instructions
- Blockchain: Hyperledger Fabric on IBM LinuxONE

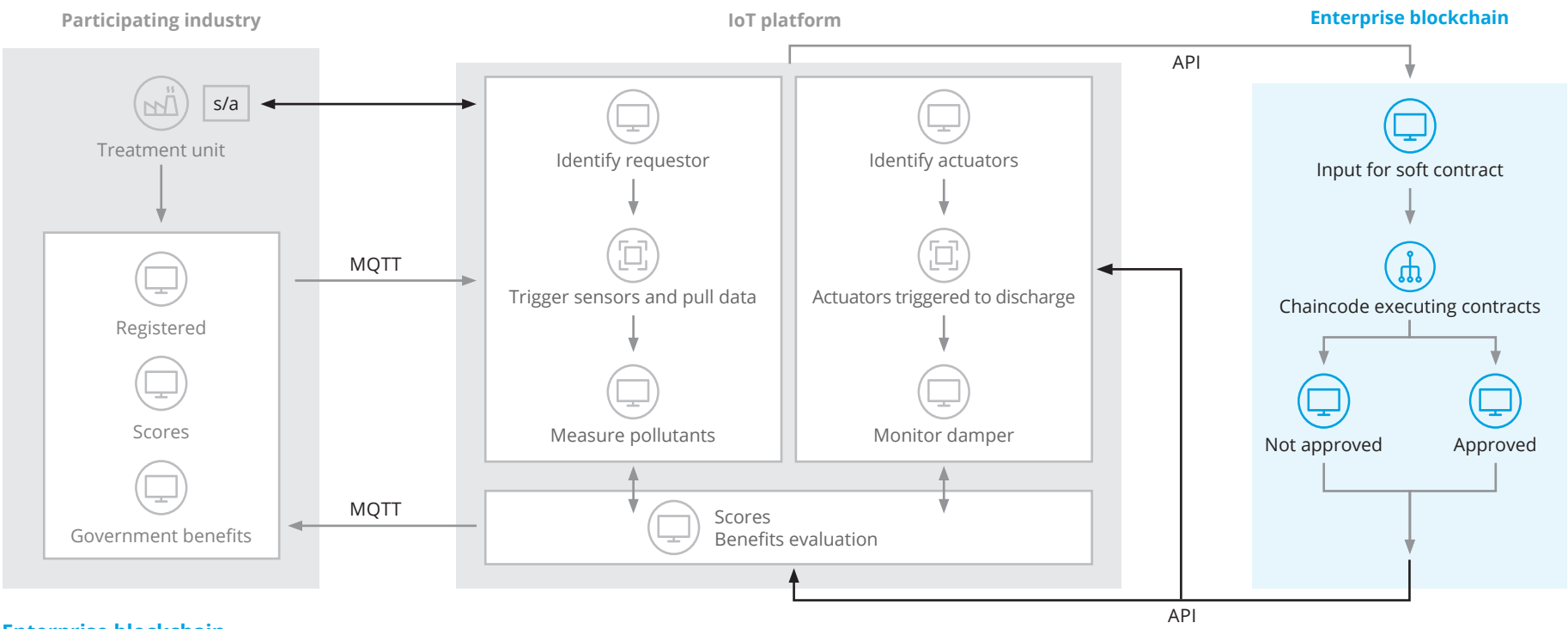


IoT platform

IoT, by definition, is a system of interconnected devices that can transfer data over a network. It is an umbrella term for several different technologies that, when used together, will help build a system of "smart" devices that can create a pool of data for presenting a more accurate and complete picture of a particular business concern (e.g., status of all parts of a home, state of different sections of a large farm or forest, geographical state of different parts of an area, etc.).

Although IoT is powerful for organizations to adopt, centralized IoT solutions suffer from security issues, operational and maintenance inefficiencies, and lack of clarity in data ownership. While decentralization alone cannot protect the unsecured devices themselves per se, distributed ledger technology (DLT) architecture provides the medium for connecting pools of devices. It removes the single point of failure semantics from the traditional solution building paradigms.





Enterprise blockchain

Blockchain is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets across a network. Almost all blockchains will allow access to a user only after secure identity verification of the user's access keys. There are now ample standards-based, IoT-friendly key security mechanisms available to aid with key storage and security, allowing for extremely reliable key storage on the IoT device itself.

Although there are many blockchain platforms on the market, Hyperledger Fabric has become the de-facto standard for enterprise blockchain platforms. Supported by IBM, Hyperledger Fabric is an open-source, modular blockchain framework that provides several advantages when building an enterprise blockchain solution, such as:

- A permissioned membership structure that controls which entities can access the blockchain network
- Performance, scalability, and reliability run-time quality attributes that make a system usable
- Data on a need-to-know basis via channels between two or more specific network members, to conduct private and confidential transactions
- The modular architecture of Hyperledger Fabric supporting plug-in components

Hyperledger Fabric is a decentralized, distributed, immutable digital ledger used to record transactions across many copies of a ledger secured by cryptography. Hyperledger Fabric is managed autonomously using a peer-to-peer network and a distributed timestamping server. Mass collaboration powered by collective self-interests authenticates blockchain transactions.

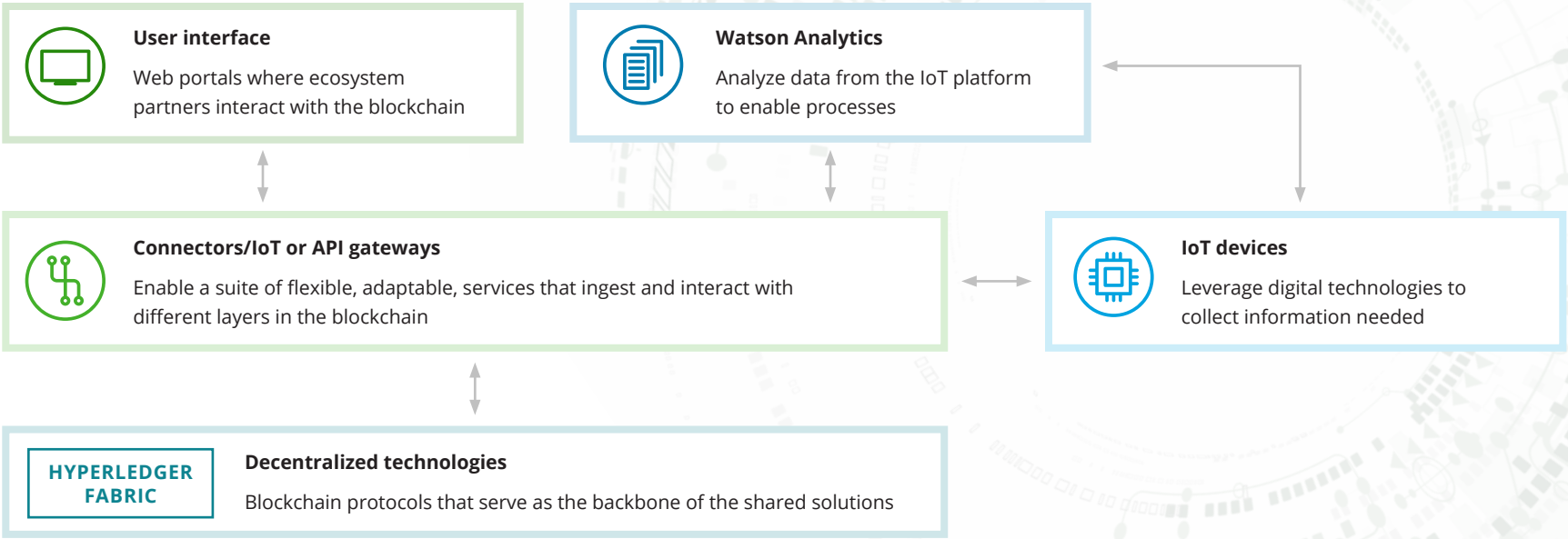
Information held on a ledger exists as a shared and continually reconciled database. The ledger isn't stored in any single location, meaning the records it keeps are federated within the network and easily auditable. No centralized version of this information exists for a hacker to corrupt.

Blockchain is already helping users build trust and visibility with regulators thanks to its immutable and transparent processes—bringing visibility and control into the value chain. Establishing a verifiable, single source of the truth from digitized sensors results in conditions and provenance to build trust. Integrating this information into the distributed ledger is achieved using modern infrastructure, equipment, and IoT data.

Wastewater using cutting-edge technologies

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

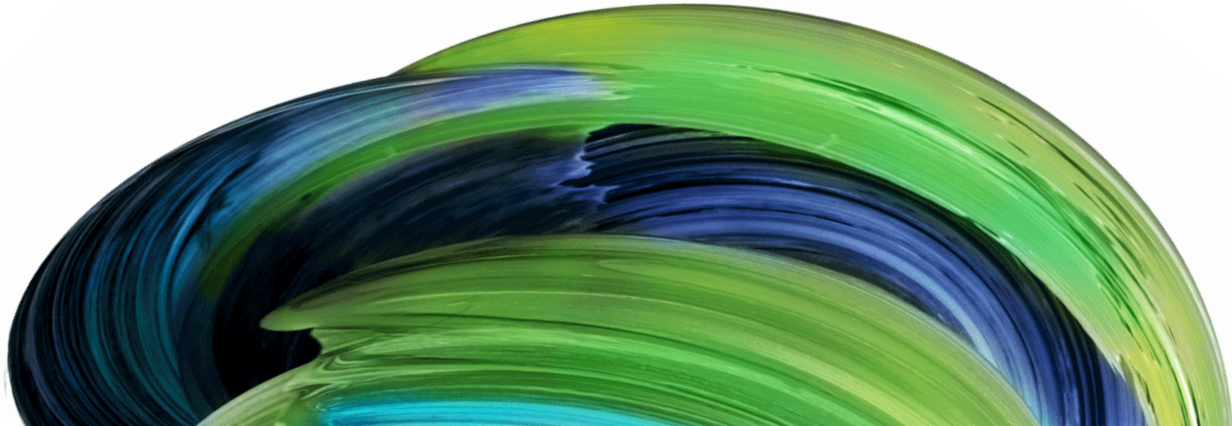
This section examines how a proposed system integrated with these cutting-edge technologies can bring a new, more robust ecosystem to fruition in wastewater management. Built with innovative IBM technologies—including the IBM Watson AI and IoT platform, Hyperledger Fabric, and LinuxONE mainframe, the entire system can run on a secured server and allow for future development.



IBM Watson IoT platform blockchain service 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 permissioned blockchain ledger shared by a business network. Companies can leverage this IoT and Hyperledger Fabric blockchain service to improve visibility, gain efficiencies, and increase regulatory compliance through automate sand streamlines business processes.

Additionally, the system allows for quick identification of chemicals in the grey water that can make it harmful for consumption. The software is configured with preset levels (based on regulations) that identify the variances and takes the necessary steps to send notifications to the appropriate resources. These participants (both human and device) can then take the appropriate steps to prevent the chemicals from entering the clean water system and eliminate the waste material in the water.

The proposed solution consists of three essential components: generate, gather, and process. When integrated, significant benefits and value can be realized throughout the wastewater management process.



Generate

For smart devices and sensors, each event can and will create data. This information will then be sent over the network back to the application via Watson IoT gateway.

Ecosystem participants

The first part of this ecosystem starts with the registration of the participating wastewater companies. When these companies register, a one-time set up will be carried out to register the organization's sensors. With the help of custom-built IoT gateways and an AI engine, these sensors are now connected to the ecosystem, and at the same time, the feed to the government agencies will be enabled.

IBM Watson IoT

IBM cloud-hosted service is designed to securely connect and manage IoT devices and make it simple to derive insight from IoT devices. It provides capabilities such as:

Device registration: Securely connect sensors devices and remotely monitor the status of the devices

Visualization: Dashboard shows a time-series view of device data that makes it easier to understand current conditions and trends with near real-time IoT data visualization

Notification rules and action: Criteria can be configured to detect situations where a device's state is outside the threshold range and automatically responds based on notification strategy.

Deloitte utilizes IBM Watson IoT capability with the scalability, monitoring, and governing mechanism in our solution. We recommend having custom-built gateways for every industry that will streamline connection services to IBM Watson IoT. Our solution uses IBM Watson IoT available sensors deployed in the wastewater ecosystem. The system pulls the continuous feeds from these sensors in real time. Once the data is obtained from the sensors, it is made available to the wastewater companies in parallel as raw data. The IoT system converts these data into the needed format to be stored and accessible for the AI system.

Gather

The external data used in this solution should be highly secured as it will store real-time data and invaluable insights into future solutions. Hence, there are several layers of security built for these databases.

Blockchain gateway for access

Any user or system which needs to access the database should first contact the Hyperledger Fabric blockchain administrator and request access. With the help of the membership service provider facility in Hyperledger Fabric, one blockchain network can be leveraged for multiple wastewater companies using various channels without compromising the data. After processing the request (achieved via running the chaincode), the request will be approved or rejected. Upon approval, the blockchain network will update the ledger with the request transaction, and the requestor will be given an access key. Using this access key, the requesting system will now be able to reach the IBM Data Privacy Passport, an encryption system.

NoSQL database for cost-effective and quick access

The external data will be stored in an IBM Cloudant database, which gives faster access on-prem or cloud access for the system. IBM Cloudant is a fully managed database service. It stores application data securely and allows quick and efficient retrieval. It is ISO27001, SOC 2 Type 2 compliant and, HIPAA ready. All data at rest and in-transit is encrypted, with optional user-defined encryption key management through IBM Key Protect. With all these multiple securities added, the data can be securely stored in the database with ultimate protection.

Node Red

It is a powerful, graphical programming tool built on Node.js and used to develop flow-based modeling to interact with hardware devices (IoT sensor), APIs, and online services. It provides a browser-based editor for wiring flows together. Node Red makes it simple to connect the devices registered on the IoT platform securely. It provides a browser-based editor that makes it easy to wire together flows using the wide range of nodes in the palette that can be deployed to its runtime in a single click.

Process

The vital part of the solution is the analytics system, which analyzes the real-time data and gives immediate insights by running various algorithms.

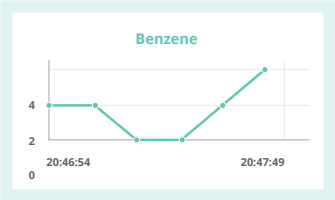
Dashboard

The dashboard provides valuable insights derived from the algorithms applied to the data collected from the IoT sensors. Auto mode is a key feature of the dashboard; in auto mode, decisions are pre-approved by the authorities. Once the decision is made by the chaincode, the communication will be sent to the sensors via the same process flow to ensure that the problem has been cleared or that the system needs to re-evaluate based on new data from the IoT sensor.

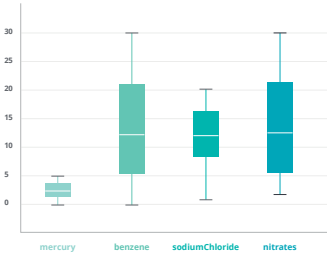
Data management and analytics

Based on the wastewater sensor data being collected, multiple different types of graphs can be plotted. This can enable the users to know the various thresholds, minimum, average, and maximum readings and understand the various data patterns acquired from the sensors. Below are a few examples of graphs which can be plotted using the received sensor data.

Spot threshold data provides a spot view of the sensor and its thresholds to understand if it is within limits or breaching the threshold.



We can have a time series graph to understand the data variation based on a specific time interval. This provides a trend in terms of the data moving in a particular direction based on process and resources. This will help the operators understand the time taken to complete a cycle for processing wastewater.



A box plot graph depicts a single view of the threshold, minimum, average, and maximum values of sensor readings. This will help us understand the kind of processing required to clean the contamination in the wastewater before it is being released.

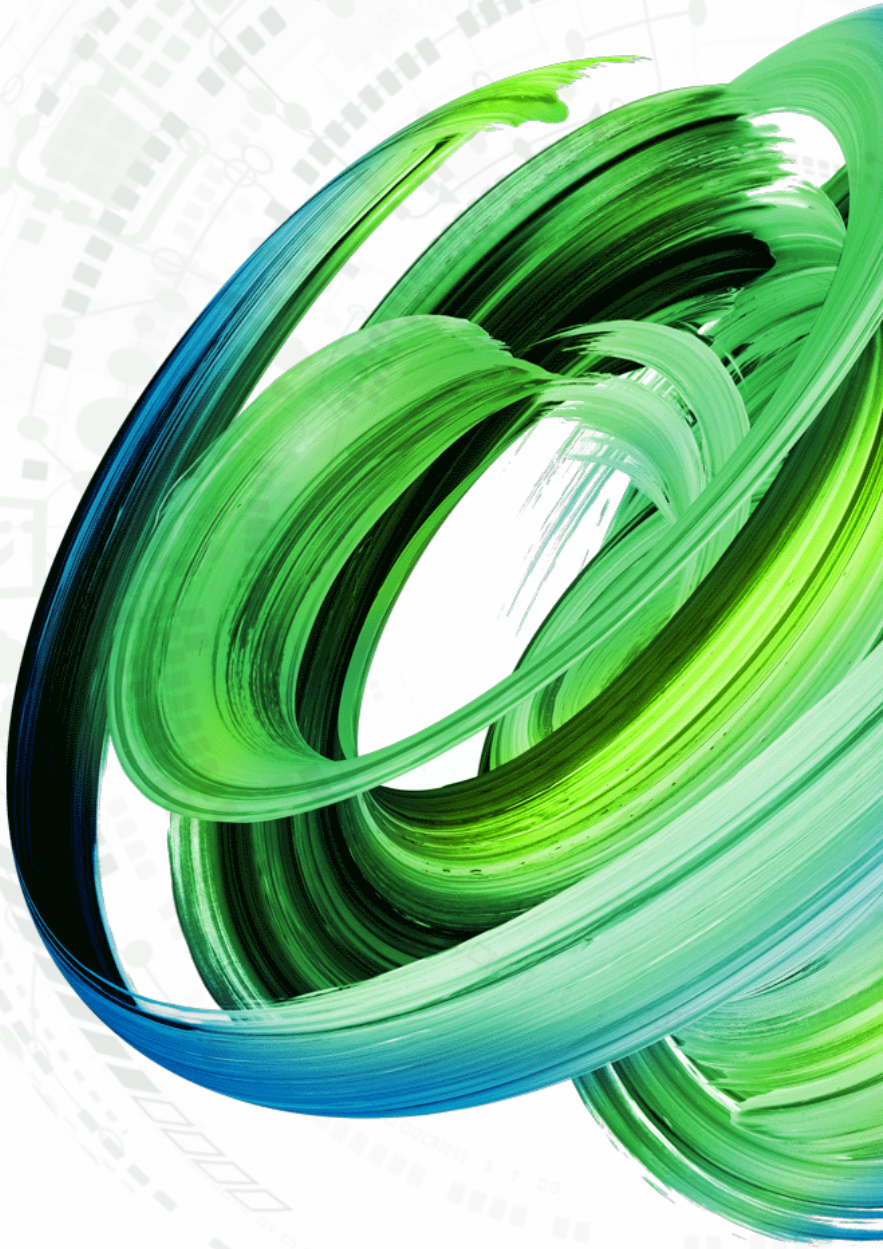
Conclusion

Deloitte sees the need for an intelligent platform in wastewater industries, which will monitor, automate, and give valuable insights derived from real-time data overcoming some of the challenges and shortfalls to get this done in real time today.

Adding AI to the decision-making process allows users to let the system provide insight, and suggest potential solutions based on previous historical data and results. Users can also make decisions faster and resolve issues more accurately. As a result, companies can reduce the risk of the release of contaminated water into purified water. AI can also provide a way to ensure compliance based on fixed government regulations and prevent deviations based on emotion or lack of understanding of the regulations by an operator.

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

As discussed above, Hyperledger Fabric is an anchor for trust with new technologies, including IoT technology. Leveraging blockchain as the backbone of an industry solution can present multiple benefits to drive long-term industry change.



Appendix

Future enhancements

There are numerous future enhancements and possibilities for wastewater management systems, including:

ITSM and email integration: Inform concerned authorities with a reason for rejection of records (subject to availability of ITSM and email services)

Leak detection: Send an immediate alert to a remote dashboard for mission-critical applications such as wastewater management in contaminated zones where human health and livelihood are on the line

Flag spread of dangerous bacteria in wastewater facility: An IoT wastewater sensor can also help detect and reduce the spreading of legionella throughout a facility. Legionella is spread through aerosolized mists, such as from centralized HVAC systems, and can be very dangerous for the facility's employees—not to mention the citizens downstream.

Artificial Intelligence/machine learning: Machine learning algorithms may also be useful for providing an estimation of the values to be considered for the sizing of the treatment units and forecasting of wastewater quality indicators.

- **PREDICTIVE MAINTENANCE:** Monitor and analyze the health of various sensors and predict when they might need servicing/maintenance
- **IDENTIFY PATTERNS:** Machine learning algorithms to identify trends of the data collected from such devices to enable better prediction rates for plant operations, water discharge, the duration for water processing requirements based on sensor readings, etc.
- **RESOURCE REQUIREMENTS:** Machine learning algorithms to predict the number of resources and time required to clean the wastewater based on the contamination level before discharge can occur

Service ticket management: Integration of ticketing system to inform the concerned authorities about the rejection incident and its criticality

Data security: Encrypt critical data such as threshold values and sensor device details using public key infrastructure

Identity: Features to create a self-sovereign identity of an entity and its assets (e.g., IoT devices using Hyperledger Indy)

Authentication: Integration of security products for the user authentication mechanism

Features to show IoT device calibration history

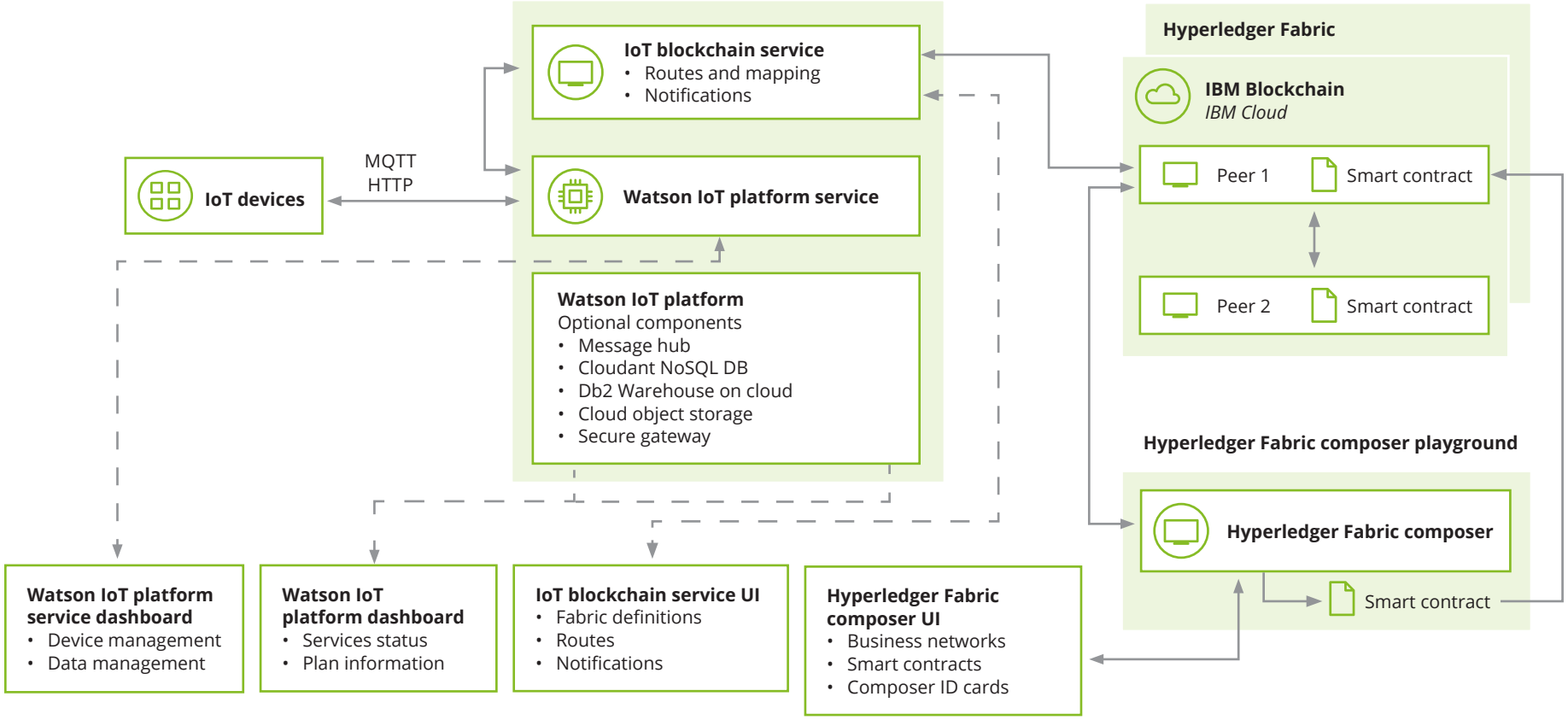
Gamification of running wastewater treatment plants across region and states

Blockchain and Watson IoT

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. Below 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.



Authors and contributors

Wendy Henry
Managing Director
Deloitte Consulting LLP
wehenry@deloitte.com

Bob Miller
IBM Alliance Solution Architect and Legacy Transformation Lead
Deloitte Consulting LLP
robmiller@deloitte.com

Sanjiv Maewall
Specialist Leader
Deloitte Consulting LLP
smaewall@deloitte.com

References

https://www.ibm.com/it-infrastructure/z/technologies/pervasive-encryption

https://whatis.techtarget.com/definition/LinuxONE

https://www.ibm.com/watson/

https://www.research.ibm.com/artificial-intelligence/