SmartCitiesWorld White paper

Why connected intelligent assets equal smarter cities

Cities increase uptime, reliability and gain maximum value from data collected

In association with

CLOUDERA

Silver Business Partner

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***SmartCitiesWorld* White paper reports examine an emerging or growing trend in smart cities, highlighting progress so far and future potential, as well as spotlighting case studies from around the world.**

In this report, we explore the benefits of connected intelligent assets and how to manage and extract maximum value from them.

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Making the future more predictable

When a streetlight stops working or a school bus breaks down, it means expense for the city and reduced quality of services for citizens. Finding ways to optimise equipment maintenance and reduce both costs and asset failure is high on every city's agenda. Connected intelligent assets have the potential to address these issues and point the way to a more efficient, automated and low-maintenance future for those who own and run them.

An asset is a physical object considered to have a value and, for a city, this could be anything from a municipal vehicle to a piece of machinery or an environmental sensor. Equipping these assets with sensing technology and connectivity enables them to monitor and relay information about themselves and their environment. They almost behave like a living thing, reporting on their own condition and performance. A streetlight could tell a municipality that it is getting close to failing or a waste truck could inform a fleet operations manager that it requires a spare part.

Connected intelligent assets enable cities and organisations to move from a corrective or preventative approach to maintenance to a predictive one. The benefits include increased uptime, reduced costs and more informed decision-making when it comes to allocating human and other resources. Cost-resource-savings can then be reinvested in areas that improve both quality of services and life for citizens and customers.

The data management challenge

Much is written and discussed around the sensor and connectivity technology built into a connected asset but far less around the data processing challenges that exist if they are to live up to their potential. A new model for connected assets, published by the IBM Institute for Business Value, says in the wake of the pandemic, organisations need to "aggressively pursue" operational agility and flexibility over the next two to three years. It contends, though, that new operating models need to be adopted to sift through "a mass repository of real-time data" to uncover the actionable insights to optimise performance.

This amounts to a huge data management challenge and one that is beyond the capabilities of classical and legacy data processing systems. What is a required is a robust platform, with advanced analytics capabilities that can continuously ingest and analyse high-volumes of data in real-time.

And there is another reason why this is crucial. The more connected a city or organisation is, the more complicated things can become. In its report, IBM is right to highlight that the technology connecting these assets also creates its own set of failure points to be managed, for example, what happens when a sensor in one of the assets itself fails? To ensure minimum downtime and uninterrupted operations, cities need to have a data management platform that can provide the always-on view of what is happening.

"What we're trying to do is help cities and the companies that work with them move from preventative to predictive maintenance of assets and there are so many opportunities to do this whether we are looking at infrastructure, public utility vehicles or smart grids," says Cindy Maike, vice president industry solutions and value management, Cloudera. "This helps cities to drive down costs as well as be more conscientious about how they spend their money. Every dollar saved is a dollar saved that can be reinvested in improving services."

Making the most of connected asset data is also about being able to combine it with other data sources. Again, this requires a platform that can ingest, store, process and analyse a wide variety of hybrid (structured, unstructured, semi-structured) data from different locations and apply the necessary governance and security requirements to that data. This relies on having a system capable of building huge data lakes and handling complex data lifecycles.

"The opportunities data is creating around how we maintain assets is really compelling and we can do so much more now that we can collect and access real-time data," says Maike, adding: "But we need to be able to generate actionable insights from the data and you can't do this without advanced processing and analytics. Without this, you just have an abundance of connected devices."

In this white paper, published by SmartCitiesWorld in association with Cloudera and IBM Storage, we discuss how connected intelligent assets, supported by advanced data processing and analytics, can help cities can move towards a predictive approach in terms of how they are managed and maintained which can, in turn, play a major part in making a city smarter.

Using data to maximise asset value

For any city, the management and maintenance of assets is a major cost centre. Recent years have seen cities move away from the corrective approach where maintenance is carried out only after a failure to a more preventative one where it is performed on a schedule. While this means downtime is managed and disruption reduced – and it brings cost-savings compared to the corrective approach – equipment is often replaced before it needs to be incurring unnecessary downtime and expense.

Predictive maintenance is the ability to determine when an asset should be maintained and what specific maintenance activities need to be performed, based on an asset's actual condition or state. The real-time monitoring that predictive maintenance permits through sensing devices and connectivity allows for optimisation of equipment, manpower and optimal downtime. Predictive maintenance can also factor in supply chain data so that replacement parts or equipment can be optimally staged prior to the equipment failing.

"It is all about predicting and preventing failures and performing maintenance on your time and your schedule to avoid costly downtime," says Hannah Smalltree, senior director, industry marketing, Cloudera.

According to a report by global consultancy McKinsey Global, using data analytics to predict and prevent breakdowns can reduce downtime by 50 per cent and adds up to 40 per cent reduction in maintenance costs. Predictive maintenance, therefore, starts to build a compelling business case for smart cities.

Edge platforms, Internet of Things devices that collect and feedback the data from a range of sources, and real-time dashboards that provide visibility are among the technologies that are helping to deliver predictive maintenance. It can also be enabled by digital twin technology, a virtual representation of a physical entity (or a process or system) that is updated using real-time data, leveraging machine learning data lifecycles that can simulate and project what is or could happen in the real world. For example, in the context of a connected asset, it can predict how it could perform and behave under certain environmental conditions.

> *"It is all about predicting and preventing failures and performing maintenance on your time and your schedule to avoid costly downtime"*

According to ABI Research's Smart Cities and Smart Spaces, the installed base of digital twin deployments is expected to increase from a scattering of pilots showcasing limited capabilities to more than 500 cities by 2025. Indeed, a number of cities around the world are already seeing the benefits of digital twin technology, including Helsinki, Copenhagen, London, Minnesota, Shanghai, Singapore as well as new cities being built from the ground-up such as Nava Raipur and Amaravati in India.

Their use and benefits go beyond monitoring the cities' connected assets but there is no doubt that the potential cost-savings and other benefits predictive maintenance brings will see this as one of digital twins' core use cases in the future. ABI says the growth in city digital twins will be driven by urban use cases across vertical markets and cites "optimised asset and demand-response resource management" as one of these.

Typical use cases

As well as sharing good practice and knowledge in this area, cities have much to learn from the private sector in how these technologies can deliver major efficiencies and positively impact the bottom line. Here are some typical real-life use cases which make use of Cloudera's technology for predictive maintenance that could equally be used in the context of many cities:

- A leading industrial automation company is utilising Cloudera in an IoT setting to ingest, store, and analyse petabytes of sensor data from thousands of diverse manufacturing systems, in real-time, to eliminate machine downtime.
- One of the biggest heavy equipment fleet manufacturers in North America is using Cloudera to parse large-volume and high-velocity data from sensors to continuously monitor performance of its fleet and implement predictive maintenance as well as advanced defect detection.
- One of the busiest airports in Europe is running Cloudera on Microsoft Azure to capture, secure, and correlate sensor data collected from equipment within the airport (for example, escalators, elevators, and baggage carousels) to prevent breakdowns and improve airport efficiency and passenger safety.
- A leading provider of cargo-handling solutions is utilising Cloudera to ingest and process IoT data that is streaming from sensors in port terminal machinery, including cranes and cargo-handling equipment, to improve operational efficiencies and increase uptime.

When it comes to the public sector, Maike highlights the specific example of Smart Dubai which uses Cloudera technology in its efforts to use data to help the Emirate fulfil its aims of becoming the "happiest city on earth". Having laid the foundations to support a scalable data warehousing infrastructure, Smart Dubai was able to unlock unprecedented insights and provide a huge variety of use cases in planning and development, social services and energy, for the benefit of the population.

"Smart Dubai is collecting so much data from the city to help it better manage its infrastructure and deploy assets," explains Maike. "They are using this data to optimse the energy grid, looking at how much electricity is being used. And on the predictive maintenance side, if there is a component of the grid that is performing at a subpar fashion based upon forecasted amounts of utilities being required, real-time visibility of that asset is invaluable."

In the bigger picture, predictive maintenance is about far more than taking a proactive approach to maintenance, it's also about improving the quality of services and therefore life of citizens. And as Maike makes the point, citizens are increasingly intolerant of any sort of downtime that interrupts services in the always on, 24/7 world.

"If a municipality isn't providing a service, the next time it wants to increase a tax levy, citizens will say "well you're already falling short in providing the systems you are supposed to," she says. "If we experience a major storm, and there is a power outage, those repair vehicles have got to get out there. If the proper maintenance hasn't been done on one of those trucks and it breaks down, a one-hour delay could turn into a five-hour one – or even longer – and that just doesn't fly in today's world."

> *"This helps cities to drive down costs as well as be more conscientious about how they spend their money."*

Global challenges
Maike's comments take on even more resonance as cities around the world tackle the impact of climate change and many have found themselves calling on all of their resources to battle flooding, wildfires and other extreme weather conditions that have had a devastating effect on communities and their infrastructure. Going forward, predictive maintenance technology will be instrumental in helping cities tackle a number of its critical challenges by helping it to build more resilience.

As well as the more day-to-day asset and infrastructure management, predictive maintenance and digital twin technologies can realise a range of use cases for cities, including emergency response planning by providing a real-time view on city assets and resources and scenario analysis through the simulation of the potential impact of natural disasters like flooding.

Indeed, the potential benefits of using such technologies to manage and maintain valuable assets across a city is only just starting to be realised. But before they reach this stage, cities must ensure they have the right advanced data management and processing systems in place to truly unlock the value from the data being generated.

> *"Every dollar saved is a dollar saved that can be reinvested in improving services"*

Rising to the data management challenge

The amount of data that cities are generating is growing exponentially and it is coming from all directions: from traffic management systems and connected vehicles to streetlighting and environmental monitoring to smart buildings and CCTV cameras. 5G and edge computing has extended the ability for real-time monitoring of data and will further increase volumes in the future. Globally, latest reports claim that 1.7Mb of data is being generated every second, per person. This isn't so surprising given the proliferation of connected IoT devices with the total forecast to reach 50 billion worldwide by 2030.

No matter how informed and forward-thinking cities are, they can't be expected to be expert in all of the technologies required to make a city truly smart. As already mentioned, there's no shortage of information or discussion around connectivity and devices but far less that drills down into the important data management challenges that exist in this area.

To extract maximum value from connected intelligent assets and predictive maintenance, it is important for cities to have a sufficiently robust and advanced data management and processing system in place. Moreover, this needs to be up to not just today's data demands but also those in the future. The limits of classical data management technologies such as plain file system storage and legacy databases aren't that well understood outside the field of data management and could stymie future smart city plans and ambitions.

Diverse data sources
Data collected from any individual source is valuable but when it is combined with information from other sources (including third-party data such as insight on next week's weather forecast or long-term roadworks in a specific area) it becomes truly powerful as correlations can be made and patterns identified. Historically, data collection has suffered from a fragmented approach in cities due to it being collected by different departments or units. "This creates data silos and no single view of assets, which is extremely limiting when it comes to using it for predictive maintenance," explains Hannah Smalltree.

As well as handling huge volumes of streaming data in real-time from a myriad of sources, systems need to be able to handle a diverse range of data structures, formats and schemas, including large amounts of unstructured or semi-structured data. If we take the example of a utility truck, among the information required to perform predictive maintenance will be: driver history; warranty information on that vehicle; repair manuals; data from product recalls and more. "Some of this information will be real time, some of its batch information, some of it is going to be in a PDF document because it's in a manual," explains Maike. "But we need to have a way of pulling in all of these different types of data."

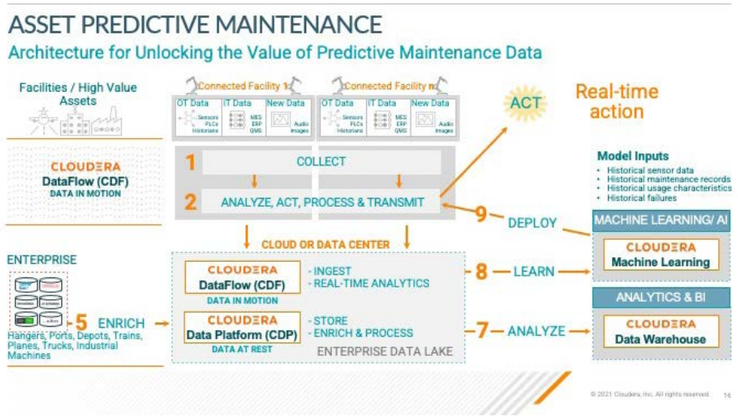
These are the typical predictive maintenance data elements required for assets:

- Failure history of the asset or and its component parts.
- Maintenance history, such as the repair history and previous maintenance activity, error codes and component replacements.
- Asset conditions and usage, including operating conditions fed back by sensors.
- Asset features such as make, model, specification and location.
- Operator features, such as certifications, past experience, known operating limits or fault patterns, including previous observations or defined by ISO standards.

Data collected needs to be identified, cleaned to ensure integrity and consistency and crucially, the correct levels of governance applied to meet the global demands in areas such as data privacy and compliance with legislation such as General Data Protection Regulation (GDPR). In addition, the necessary security and access controls need to be embedded.

This is just one part of the data lifecycle though. Having been collected and processed and transmitted to the cloud or a data centre, it must be ingested and analysed and stored in a data lake. Following this, it is analysed and then machine learning/artificial intelligence technology used to train scoring models and algorithms which are then deployed back out into the data lifecycle so the learning continues and enables predictive maintenance of an asset.

The below illustration shows the data lifecycle for predictive maintenance in full



“To really optimise costs requires us to look at data differently, and to use modern data management and advanced learning techniques around artificial intelligence and machine learning,” says Maike. “And this is where Cloudera technology can really help organisations because we can manage any and all types of data, apply these advanced techniques, look at areas such as cause and effect, and then actually move that data out to the edge to a sensor to change how that asset is performing in the field.”

Cloudera and IBM tackle industry challenges

Cloudera has been working with IBM since 2017 and in 2019 announced a strategic partnership to develop joint go-to-market programmes designed to bring advanced data and AI solutions across the Apache Hadoop open-source ecosystem. The aim was to help customers who want a hybrid and multi-cloud data management solution with common security and governance, as well as provide an ecosystem of integrated products and services, designed to help organisations achieve faster analytic results at scale.

Working together, Cloudera and IBM provide a hybrid multi-cloud solution made up of component parts that can stream and ingest real-time and other data from a range of diverse sources, store it at petabyte scale, enrich it, and build machine learning models that can be deployed for visualisation and analytics.

The Cloudera Data Platform (CDP) offers a central repository that takes care of issues such as security, governance and authorisation. It also catalogues and contains the metadata (basically the data that provides information about the data being held), which helps a city comply with legislation such GDPR. For instance, Personally Identifiable Information (PII) data that could be used to identify a person can be labelled and tagged and specific authorisation and access set.

As well as data collection and advanced analytics, the timeframes in which they can happen are also significant for predictive maintenance, explains Maike. “This helps to make it more actionable, and also really helps us drive down some of the costs compared to what has happened historically from a maintenance perspective,” she says. “This is one of things that makes predictive maintenance so compelling.”

“To really optimise costs requires us to look at data differently, and to use modern data management and advanced learning techniques”

Case study 1:

Navistar: reducing maintenance costs 30 per cent for connected vehicles

"Truck drivers get paid, freight haulers get paid if the truck's moving. So if that truck's not moving, nobody's making money and someone's not getting the package they expect," says Terry Kline, chief information officer, Navistar, a manufacturer of commercial trucks, buses, defence vehicles, and engines, and widely known for its International Truck and IC Bus brands.

He adds: "As a result, our focus is on uptime, and our goal is zero downtime related to unplanned maintenance."

Typically, vehicle manufacturers schedule vehicle maintenance based on miles travelled or time since last appointment. But these are very rudimentary and only two of thousands of data points that can signal the need for maintenance. Unscheduled maintenance and vehicle breakdowns account for a large share of total costs for vehicle owners.

To help fleet and vehicle owners move from a reactive approach to a more predictive model, Navistar needed to analyse a wider range of data in real-time, including vehicle sensor data. However, its traditional data warehouses couldn't support the growing volume of fast-moving, high-volume telematics data. "As we collected more data, the analytic process slowed to a near halt on our legacy systems," says Ashish Bayas, chief technology officer, Navistar.

Navistar built an IoT-enabled remote diagnostics platform, called OnCommand Connection, on Cloudera Enterprise with SDX. The platform brings in over 70 telematics and sensor data feeds from more than 375,000 connected vehicles, including engine performance, truck speed, acceleration, coolant temperature, and brake wear.

This data is then correlated with other Navistar and third-party data sources, including meteorological, geolocation, vehicle usage, traffic, historical warranty, and parts inventory information. The platform currently stores over 60 terabytes (Tb) of data and uses machine learning and advanced analytics to automatically detect engine problems early and predict maintenance requirements.

Fleet and vehicle owners can now monitor truck health and performance from smartphones or tablets, prioritise needed repairs, and quickly identify the nearest dealer service locations that have the relevant parts in stock, available technicians, and available service bays.

"With Cloudera, we can analyse data in ways and speeds that were not previously possible. We can evaluate billions of rows of data from connected vehicles in hours, not weeks, to enable predictive maintenance," says Kline. "And we expect to connect several hundred thousand more vehicles to the platform and don't have to worry about scaling.

> *"As a result, our focus is on uptime, and our goal is zero downtime related to unplanned maintenance"*

"By collecting and analysing our vehicle telematics, we have reduced maintenance costs and vehicle downtime by almost 40 per cent and have implemented remote monitoring coverage to more than 250,000 vehicles," he adds. "Cloudera's platform enabled us to ingest not only IoT and telematics data from sensors, but meteorological, engineering, traffic and vehicle usage, and access and analyse all these different data types in ways that weren't possible before."

"We continue to innovate using the Cloudera platform to gain valuable insights from growing sources of information and offer new applications against the data for different users," says Kline.

With Cloudera SDX, Navistar has unified controls for its data catalogue, security and governance across its many analytic workloads. As a result, IT staff can set policies once across all its analytic workloads, making it faster to deploy new applications, easier to maintain compliance with its data agreements, and more secure.

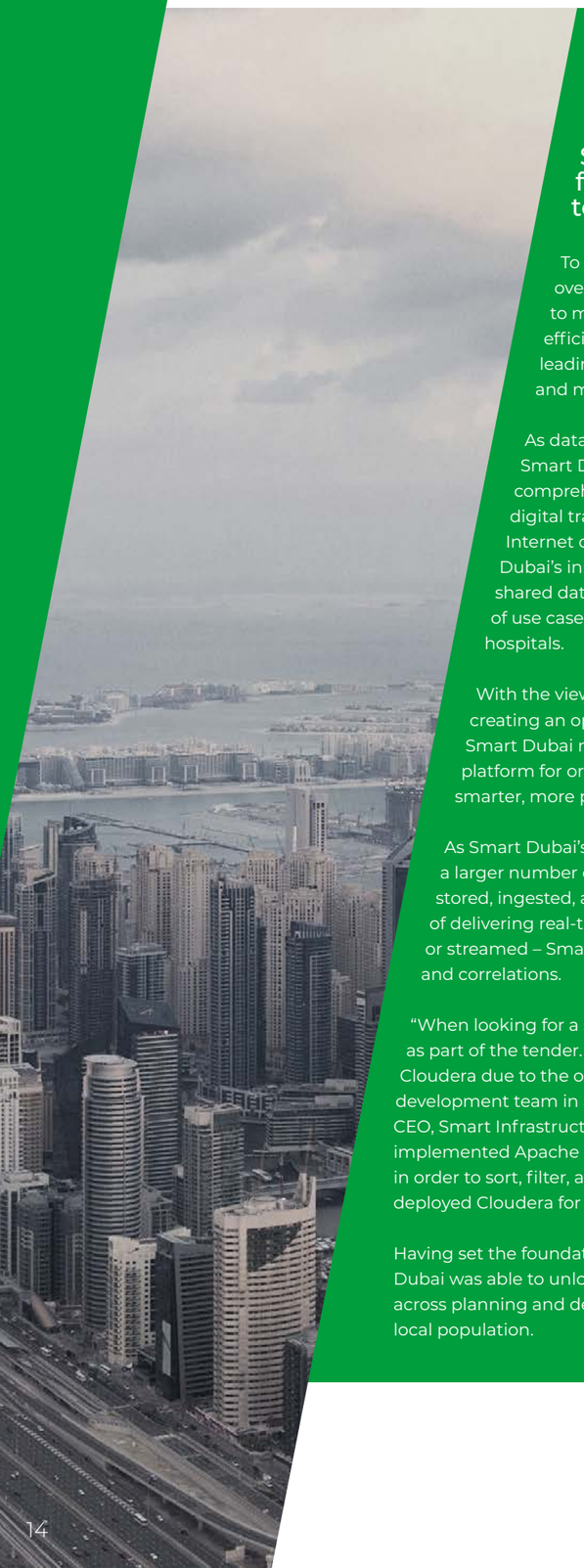
"We have a number of different applications running after our data every day, and Cloudera SDX is key to making that happen at Navistar," says Kline. "SDX is foundational in how we track, govern, and protect our data."

With OnCommand Connection, Navistar has helped fleet and vehicle owners reduce maintenance costs by more than 30 per cent. One Navistar customer reduced the maintenance cost-per-mile for its vehicles, which previously was 12 to 15 cents, to less than three cents.

Early detection also minimises downtime and towing costs. In addition, when downtime occurs, vehicle owners typically lose up to US$1,000 in revenue per vehicle daily. With over 375,000 vehicles across 2,300 customers, the total impact can be significant.

Navistar also uses the platform to help school buses run safely and on time. One school district with 110 buses that travel 1.5 million miles annually reduced the number of tows needed year over year, thanks to the predictive insights.

"The results are overwhelmingly positive," says Troy Clarke, CEO, Navistar. "Using real-time big data to frame business decisions and deploy proactive maintenance has opened new revenue streams and delivered additional customer value."



Case study 2:

Smart Dubai: establishing a governance framework and a platform for organisations to use and access data in real-time

To deliver the goal of 100 smart initiatives and 1000 smart services over the course of three years, Smart Dubai set out a data strategy to modernise the city's infrastructure and deliver innovation through efficient, seamless, safe, and personalised city experiences, ultimately leading to a stronger economy, better living, improved governance, and mobility.

As data-sharing became mandatory under the Dubai Data Law, Smart Dubai was created to lead the world's most ambitious and comprehensive data initiative in the world. As part of this unprecedented digital transformation journey spanning artificial intelligence (AI), the Internet of Things (IoT), big data and several other technologies, Smart Dubai's initial vision was to create a data repository to host open and shared data for both public and private sector entities, allowing for an array of use cases ranging from easing traffic congestion to limiting queuing in hospitals.

With the view to become an impartial market broker for citywide data by creating an open and well-regulated data market to spark new opportunities, Smart Dubai needed to establish a suitable governance framework and a platform for organisations to use and access data in real-time, in order to build a smarter, more prosperous city.

As Smart Dubai's data platform – Dubai Pulse – started to grow in size, hosting a larger number of datasets, the initiative was faced with a deluge of data to be stored, ingested, and computed to gain valuable insights for the city. With the view of delivering real-time dashboards based on available information – either ingested or streamed – Smart Dubai needed a scalable data platform to run deep analyses and correlations.

"When looking for a suitable partner, open-source technology was a crucial factor as part of the tender. After evaluating an array of options and providers, we chose Cloudera due to the openness of the platform and the opportunity offered to our development team in addition to dedicated support," said Matar Al Humairi, assistant CEO, Smart Infrastructure Sector, Smart Dubai. "As part of our technology stack, we implemented Apache NiFi as part of Cloudera DataFlow (CDF) for real-time ingestion in order to sort, filter, and parse data to help with the pace of real-time analysis. We also deployed Cloudera for ingestion and storage" he explained.

Having set the foundation to support a scalable data warehousing infrastructure, Smart Dubai was able to unlock unprecedented insights and deliver a variety of use cases across planning and development, social services, and energy that would benefit the local population.

"Our City Flow Dashboard has allowed us to turn raw utility provider data into a powerful visual tool"

As part of its data journey, the organisation built an electricity and water consumption dashboard in collaboration with Dubai Electricity and Water Authority (DEWA) that allows comparisons at building level, or across entire communities by analysing consumption data, GIS data and other district cooling operators' datasets. "Our big idea was to create a live dashboard that visualises how these resources are consumed, allowing for the comparison of use across buildings or entire communities, leading to a much better understanding of how water is used throughout the city and subsequently better planning" explained Al Humairi.

Additionally, by building a 360-degree profile of citizens based on DEWA's open data records, Smart Dubai has been able to illustrate flows of people moving across the city – whether to move to a new house, switch community, or simply travelling – by building a real-time dashboard. According to Al Humairi, "our City Flow Dashboard has become invaluable for city planners, government entities, real estate developers, and even new business start-ups. It has allowed us to turn raw utility provider data into a powerful visual tool that helps track community population trends and illustrates how Dubai's residents are moving over time and space."

Smart Dubai's data platform has identified more than 2,000 datasets from participating Dubai government and semi-government entities, of which over 550 have already been ingested; it also attracted more than two million hits from visitors and data seekers in 2019 alone, a figure that reflects the growing interest and importance of the city-data.

In an effort to go digital as part of the most recent Dubai Paperless Strategy, the organisation is looking to expand the remit of its DubaiNow: a consumer application aimed to host any mobile transaction for a better and safe customer experience that is already offering over 115 city services to citizens.

"In order to continue our mission to improve connectivity and capitalise on smart city data, we are always looking at ways to monetise and harness real-time data for the benefit of the community. We are working to increase the capability of the app and evaluate ways to improve the services our citizens rely on every day," said Al Humairi.

Conclusion

Ageing assets versus future opportunities

As cities around the world attempt to build back better in the wake of the Covid-19 pandemic, the area of connected intelligent assets and predictive maintenance represents one of many strands that can help them reduce costs, increase sustainability and build resilience.

Data isn't just growing in volume everyday but in complexity too. This is a double-edged sword for cities as the more multi-layered and faceted data becomes, the more power it has to inform decision-making as far as future investment is concerned. It also makes it harder manage unless the right systems are in place.

Maike believes the next challenge is ensuring we can take advantage of these capabilities and points to ageing assets and existing investments as one of the challenges. "If you've got an existing investment that's been capitalised by the city and it's on the books, what is the ability to write off this asset and say, 'I need additional money to look at a new investment?'," she says.

"People can see the opportunities for cost-savings in areas such as predictive maintenance but city managers need to look at asset acquisition and beyond the traditional CAPEX approach which may constrain the use of new technologies."

Cities around the world are facing major decisions when it comes to spending following the availability of government recovery packages. If investments are to ultimately convert to healthier, happier, safer and more sustainable cities to live and work in, they must break down silos and take a holistic view of how they operate, especially when it comes to data and how it is managed. As already stated the potential power of connected intelligent assets and predictive maintenance go beyond the management of equipment and can truly help cities channel their resources into areas that bring major quality of life benefits for citizens.

"The opportunities and capabilities are there and we have to stop and think about how to apply these technologies," says Maike. "We really need to use our imaginations and go beyond our traditional way of thinking."

About Cloudera & IBM Power Systems

Cloudera was founded in 2008 by some of the brightest minds at Silicon Valley's leading companies, including Google, Yahoo!, Oracle, and Facebook. And in 2011, 24 engineers from the original Hadoop team at Yahoo! spun out to form Hortonworks. Both companies, who joined forces in January 2019, were founded on the belief that open source, open standards, and open markets are best. This belief remains central to our values, evidenced by our significant investments in engineers and committers working with the open-source community. Today, Cloudera has offices around the globe and is headquartered in Silicon Valley, California.

IBM® Storage simplifies your data infrastructure using an underlying software foundation to strengthen and streamline the storage in your hybrid cloud environment, using a simplified approach to containerization, management and data protection. IBM offers a portfolio of hardware, software and services to help organizations cost-effectively address their IT infrastructure needs. These include robust data-storage solutions to enable always-on, trustworthy storage, and recovery from disaster. Because business needs shift, IBM solutions emphasize interoperability and the integration of new use cases or approaches, from analytics to multi-site backup to near- instant recovery. With IBM, organizations can create flexible, robust and resilient storage infrastructure to support critical operations for smooth operations and regulatory compliance.