Briefing Paper

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How Technology Helps Cities Become Sustainable and Inclusive

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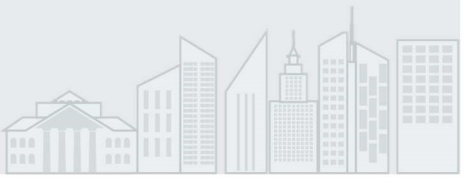


Introduction

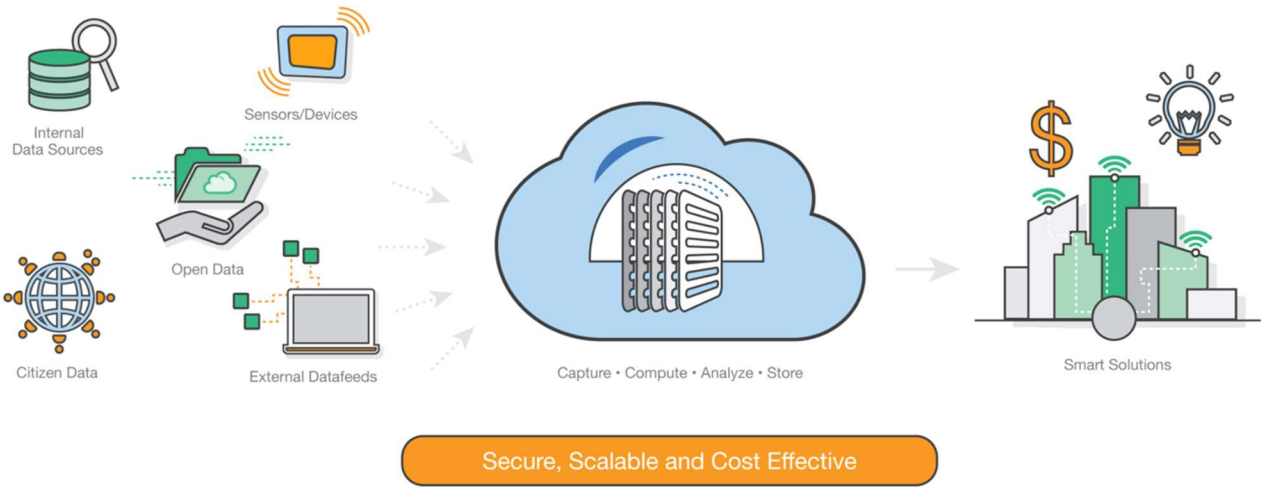
Cities are expected to be home to two thirds of the world's population by 2050, according to the United Nations. As the population expands, so too does the imperative to ensure that urban infrastructure and services can accommodate growth. Cities are adopting innovative technology to meet rising demands on public services and infrastructure, as well as to address urban challenges related to the environment, national security, and public health, among others.

Information and communications technology advances of the 1990s gave rise to the "smart city," or a city that continuously enhances quality of life for its residents, providing efficient and effective services, using technology and data. Today's technology – including cloud services and Internet of Things (IoT) – promises to unleash a new wave of innovation and transform cities into economic hubs that serve as safe and healthy homes to their residents. It offers solutions not just to economic and logistical challenges, but also to social and environmental issues plaguing cities around the world, including public health crises and natural disasters.

Data, and the technology used to collect it and turn it into insights, are a means to an end: to better serve residents. Cloud technology allows city leaders to focus on serving residents by offering a reliable and secure infrastructure to administer services. The cloud ensures data privacy and allows leaders to focus their time and resources on innovating for their residents. And while cloud technology helps optimize resource allocation and improve decision making, the process of transforming cities requires the leadership and active participation of citizens.

This paper examines how cities are using cloud technology to address public challenges, using the framework of the global coalition, Smart Cities Council. This framework promotes three core values for smart cities: **livability**, providing clean, healthy living conditions without pollution and congestion; **workability**, providing an enabling infrastructure (energy, transportation, internet connectivity) and high-quality jobs; and **sustainability**, doing so at no cost to future generations, as the Council puts it. This paper proposes a fourth core value, **inclusivity:** provisioning services to all city residents regardless of their background.

Data Alone is, Simply That



A smart city platform is made up of inputs, processes, and outputs. This approach highlights the centrality and importance of data, which can help you build the right solutions for the long and short term.

Cities generate overwhelming amounts of data. This provides opportunities as well as challenges, including how disparate types of data are integrated and used. Existing systems data, historical trend data, and other relevant data from third-party sources offer valuable insights. Decision makers can tap into this data to visualize, explore, and build sophisticated analytics using machine learning (ML) and artificial intelligence (AI). These real-time insights can help government and business leaders make smarter choices, respond more effectively to the needs of city residents, and offer better solutions to unforeseen incidents – from weather to security threats.

Cloud technology facilitates the collection, secure storage, analysis and dissemination of data to aid this process. It does this in an affordable and secure way that helps leaders meet their goals and ensure compliance with the appropriate regulations.

Livability

Smart cities use data produced by internet-connected devices to derive insights and improve residents' quality of life – measured by health, work-life balance, education, social connections, personal security, civic engagement and governance, environment and subjective well-being, according to the Organization for Economic Cooperation and Development (OECD)[1].

SAME DATA, MORE INTELLIGENT INSIGHTS

Technology offers city leaders new ways to derive value from data. Newport, Wales, used data analytics and IoT to address air pollution. Newport's typical process for gathering air quality data involved collecting air samples in glass vials at 85 different locations and using traditional server infrastructure for storage and analysis – a process that used to take a year. Newport had only a monthly average available, which meant limited insight into how pollution levels change over time and in response to various conditions.

The city deployed sensors to gain an in-depth, real-time understanding of pollution levels so it could address them more effectively, and it was able to gain and act on insights in just one month – a dramatic improvement for the city.

The same technology allows Newport to improve its flood defenses. Because it is situated on an estuary, drainage is critical to keeping the city safe and livable. Previously, the city would have to manually check drainage at each point and often only became aware of blockages after flooding occurred. By deploying sensors in drains, the city can monitor water levels to identify and clear blockages before flooding happens.

Additionally, Newport wanted to provide better, more cost-effective waste management services. IoT-connected receptacles can now report their capacities, enabling the city to avoid servicing them too often or, worse, not often enough. The collection, storage, transfer, and analysis of data happens entirely in the cloud. After adopting this system, leaders can focus on translating those insights into action plans.

IMPROVING CITY AND HEALTHCARE SERVICES

Chicago, Illinois, uses the cloud to run OpenGrid, an open source geographical information program providing instantaneous, vital information to city residents, such as emergency services, transit and mobile asset locations. This app collects data from multiple sources, including social media platforms to help officials better understand urban problems and determine the optimal use of resources.

In 2015, Chicago expanded the program, which became known as WindyGrid, to share real-time data on new business licenses, environmental inspections, healthcare alerts, and immediate weather concerns, among other things. It put the open source application on the cloud, which allowed it to rapidly scale without jeopardizing performance or security. This move enhanced government transparency and fueled

[1] OECD Better Life Index http://www.oecdbetterlifeindex.org/

innovation[2]: Developers can now add new features and data sets and share information tailored to the needs of the city's various communities.

The city of Recife in Brazil is also using the cloud to provide improved services to its 1.62 million residents, including waste management. Recognizing inefficiency in city cleaning operations, leaders partnered with RasSystem to introduce sensors in cleaning trucks that take real-time photos of the streets as they are being cleaned. Data is sent to the cloud in real-time and analyzed.

City officials can access the data and better monitor operations and progress by looking at images taken before and after cleaning. The technological solution, called RasCol, also enables officials to track cleaning vehicles and estimate daily demand for street cleaning and waste removal, as well as provide insights on any irregular or unauthorized waste collection.

Sometimes it's not just governments but also nonprofits who are innovating on behalf of the public.

Nextleaf Analytics is helping deliver vaccines in more than ten countries across Africa and Asia. The organization developed a wireless sensor that monitors the temperature of vaccine storage units, to help keep immunizations safe and effective. This is helping prevent vaccine spoilage and provide vaccines to more children in those countries.

[2] New OpenGrid App Illuminates City Data for Residents, The Computation Institute https://www.ci.uchicago.edu/press-releases/new-opengrid-app-illuminates-city-data-residents

Workability

Cities must ensure that residents have opportunities to learn relevant skills, find jobs, and gain access to educational resources. Data is critical to understanding and addressing challenges in education and workforce development; identifying industry needs, creating career pathways that begin in K-12 and extend to the workforce; developing apprenticeship and training programs; and designing partnerships with educators, employers, and non-governmental initiatives. Increasingly, cities are looking to bridge the chasm between skills of today's graduates and the skills required by the job market – or, the *skills gap*. The skills gap is currently preventing many cities from reaping the benefits of technology and embracing the process and impact of digital transformation. Governments, private enterprises, and educational and nonprofit organizations all have a role to play in bridging this gap.

THE SKILLS GAP

A February 2018 LinkedIn workforce report[3] listed Los Angeles (LA), California, as one of the cities with the most significant scarcity of skills, prompting LA education and city leaders to take steps to rectify this issue. Seeing an increase in demand for cloud computing skills – with approximately 2,500 job openings annually in the state – 19 LA community colleges and their local high school partners announced a collaboration with Amazon Web Services' (AWS) program, AWS Educate, to address the local skills gap by offering a cloud computing certificate program. This collaboration offers students the option for dual enrollment in a certificate program on cloud computing, as well as professional development opportunities like training workshops. The initiative is part of LA's Strong Workforce Program and the LA Center for a Competitive Workforce, aimed at aligning local talent development systems, K-12 institutions, workforce boards, community colleges, and four-year universities with the future labor demands.

The state of Virginia is also innovating in education and workforce development. Northern Virginian Community College (NOVA) launched in June 2018 the Cloud Associate Degree program, in collaboration with AWS Educate. The degree teaches students cloud computing skills required by AWS and promises to build the state's pipeline of talent in cloud computing. AWS is providing content for IT curricula, training, as well as access to top talent in the field of cloud computing, to support educators and students.

This comes at an opportune time as the state also transitions its own infrastructure. In September 2018, Virginia's governor, Ralph Northam, announced that the state would embrace cloud technology to provide Virginians with fast and convenient services. "Cloud services will provide several benefits, including reducing response time, reducing power and space requirements,

[3] LinkedIn Workforce Report, United States February 2018 https://economicgraph.linkedin.com/resources/linkedin-workforce-report-february-2018

and providing for better continuity of service in the event of a disaster or service outage," Northam said in an announcement.

FOSTERING ENTREPRENEURSHIP

Cities are also becoming hubs for entrepreneurs and innovative ideas, offering internet connectivity, programs, and resources to nurture entrepreneurship and innovation.

Porto, the second largest city in Portugal, is known for its stately bridges, port wine production, and more recently, for being a pioneer in digital modernization.

Porto wanted to minimize the digital divide by providing expanded internet access for its residents. It focused on mobile public assets: buses, garbage-collection trucks, and municipal vehicles. It created a mobile connectivity network by deploying a real-time, vehicle-to-everything communication solution. Each vehicle included in the solution contributes to improving the network as a whole, and all vehicle devices are connected through a cloud-based platform. These connections complement the existing fiber and Wi-Fi networks, thereby increasing the range and quality of free internet connectivity.

Reliable internet connectivity and transportation systems contribute to Porto's reputation as an entrepreneurial, innovative, and smart city, and also a living technology lab, where companies can test solutions on a city scale.

Transformation efforts not only attract talent and spur innovation, but also revitalize economies. Kansas City adopted an analytics and intelligence platform that collects data on crime, economic indicators, tax collections, employment rates, maintenance records, and weather, among other things. By partnering with a software provider powered by the cloud, Xaqt, the city does not have to take on the daunting task of managing traditional infrastructure and accounting for the costs associated with it. Assured by the reliability and security of its cloud service, city officials can shift their attention to understanding the city's problems, including crime, substandard learning outcomes for Kansas students, and other pressing issues.

The city's efforts have helped it attract talent. "Ten years ago, we had fewer than 5,000 people living downtown," says Bob Bennett, Chief Information Officer of Kansas City, Missouri. "We have seen a 520 percent growth in the number of residents downtown and a 400 percent growth in development investment. I believe our Smart City project has played a prominent role in getting people excited about living here." The International Data Corp. (IDC) recognized Kansas City in its 2018 Smart City North America Awards (SCNAA) for its work developing a unified smart city platform and its successful civic engagement.[4]

[4] IDC Smart Cities North America Awards https://www.idc.com/prodserv/insights?utm_source=PR&utm_medium=PR&utm_campaign=smartcitiesnaawards18#government-smart_cities_awards

Sustainability

City leaders must consider the social, economic, and environmental impact at the core of their planning. Cities must create resilient environments for growing populations, and make it easy for future generations to uphold these sustainable behaviors. Cloud technology plays a key role in sustainability: its inherently environmentally friendly services help organizations reduce their carbon footprints. It also supports emergency preparedness and disaster response.

IT'S GREENER IN THE CLOUD

Cloud technology helps organizations in the public and private sectors cut their environmental footprint by making more efficient use of technology capacity. Customers use only the services that they need, which prevents them from wasting capacity and power. In fact, AWS Chief Evangelist Jeff Barr estimates that using AWS represents an 88 percent reduction in carbon emissions for customers when compared to on-premise data centers.[5]

In addition to helping organizations globally meet their sustainability goals, AWS has committed to achieving 100 percent renewable energy usage for its global infrastructure, and it is already halfway there.

EMERGENCY PREPAREDNESS

When disasters strike, information can mean the difference between life and death. In Jakarta, one of the most densely populated cities in the world, citizens are using social media to report and obtain information on extreme weather conditions. The University of Wollongong's Global Challenges Program and Twitter launched PetaJakarta in 2013, a tool for citizens to share information on flooding conditions. The tool proved so useful that the project, now known as PetaBencana, has expanded to four cities in Indonesia, reaching more than 50 million residents. The tool integrates crowdsourced data

[5] Barr, Jeff. Cloud Computing, Server Utilization, & the Environment, AWS News Blog, https://aws.amazon.com/blogs/aws/cloud-computing-server-utilization-the-environment/ June 5, 2015.

with data from other origins, including government agencies and water-level sensing devices, enhancing data accuracy. The cloud enables immediate collection and analysis of data from various sources, as well as the transfer for mapping and decision-making. In 2017, the US Federal Communication Commission recommended the project as a best practice for disaster information crowdsourcing.

With funding from the National Institute of Standards and Technology (NIST), the College of William & Mary's Virginia Institute of Marine Science created Stormsense, a low-cost tool that predicts flooding from storm surge, rain, and tides in Virginia Beach. The tool combines hydrodynamic flood modeling and forecasting abilities with IoT-enabled water level sensors to provide insights on water levels. Collaboration with the VIMS Tidewatch network allows this to be scaled throughout the Chesapeake Bay. The project won AWS's 2017 City on a Cloud Innovation Challenge and, in 2018, was recognized by IDC for its innovation within the "Smart Water" category[6].

Systems to predict extreme weather and improve flood resilience are also valuable in developing countries with limited resources and connectivity. In 2013, Cambodia was hit by floods that affected nearly 1.7 million people, killing 50 and displacing hundreds of thousands. More than a third of those affected had no idea that a flood was coming. In the aftermath of the flood, People in Need, a nonprofit organization, developed a flood-detection system to predict future floods and automatically send mobile message alerts to people in affected areas. This open-source, early warning system is hosted on the AWS cloud and allows for speedy analysis and delivery of messages to thousands of residents.

DISASTER RESPONSE

The cloud is a reliable source of data even when natural disasters hit and other systems typically go down. NASA's Jet Propulsion Lab uses the AWS cloud to process radar data from satellites after earthquakes, hurricanes, and other natural disasters. It provides imagery no matter the time of day, visibility conditions, or location of the damaged areas. This data allows scientists to locate worst-damaged areas and quickly deploy relief efforts, potentially saving lives.

Cloud-based mapping proved useful when Hurricane Harvey hit Texas in August 2017. Houston officials partnered with Mapbox, an open-source mapping platform powered by AWS, to map all potential hazards resulting from flooding of the city's chemical plants, refineries, and other toxic sites. Mapbox also worked with Catholic Charities USA and data scientists to create a social vulnerability map using Census Bureau data from the American Community Survey. The map showed where unemployed, low-income, youth, seniors, and non-native English speakers were located, which helped inform agencies where to set up distribution centers and assign volunteers. Mapbox's platform pulls data from OpenStreetMap, an open-source world map.

[6] Winners Named in IDC Smart Cities North America Awards
https://www.idc.com/getdoc.jsp?containerId=prUS43731718

Inclusivity

As city leaders look to transform digitally, they must first ensure that new technologies respond to the needs of their constituents. Specifically, the voice of residents should be front and center in new technology adoption. Leaders must also design their cities in ways that ensure inclusion of underserved communities and marginalized groups, such as the homeless, and those struggling with opioid addiction. Cloud technology is facilitating the process of learning about these groups, while ensuring their data is safe, and offers a diverse array of services to respond more aptly to their needs.

UNDERSERVED COMMUNITIES

Cloud technology is helping schools and colleges all over the United States better understand how to enhance learning outcomes for underserved students. Ivy Tech Community College of Indiana, the largest community college in the United States, wanted to better understand student engagement after enrollment. With close to two million student records at 23 campuses, Ivy Tech needed to scale its systems, and find new ways to store and analyze data on student performance. When it adopted a new cloud-based data warehouse service to perform predictive analytics, Ivy Tech was able to quickly gain insights on students who were struggling, which enabled them to intervene sooner to provide support. Ivy Tech started detecting issues like financial aid fraud more easily with this technology.

Seattle Public Schools are using cloud technology to close the opportunity gap for historically underserved students. With the help of predictive analytics, the Seattle Public School District is designing a system to reach marginalized students. The system will not only provide better insights, but it will do so in a quicker and more cost-effective way, enabling educators to focus on improving student outcomes. The schools were awarded an "honorable mention" in the AWS 2017 City on a Cloud Innovation Challenge.

HOMELESSNESS

Homelessness is a challenge facing cities around the world, and yet it is hard to quantify. The most recent report, conducted by the United Nations in 2005, estimated that there were 100 million homeless people worldwide – excluding those residing in slums, temporary settlements, living with families or moving frequently.[7] The lack of multi-agency collaboration complicates the process of obtaining accurate data about homelessness trends.

California-based VerticalChange offers a cloud-based application to manage and analyze data in the social service and public health sectors, including family support, early childhood education, and homelessness. Through this app, multiple organizations can securely share data and use it to understand the needs of people experiencing homelessness nationally. VerticalChange enables secure data-sharing, in accordance with U.S. healthcare portability and privacy regulations, and its data interoperability fosters collaboration among the various agencies working on this issue.

THE OPIOID CRISIS

Technology offers solutions to another challenge that is resulting in the death of more than 115 people every day – opioid addiction.[8] The Centers for Disease Control and Prevention estimates that the total "economic burden" of this crisis is $75.5 billion a year, as it includes the cost of healthcare, lost productivity, addiction treatment, and criminal justice involvement. The lack of data-sharing and collaboration across jurisdictional boundaries further complicates the delivery of public health services.

Since the opioid epidemic became a national emergency in 2017, technology companies have been using the cloud to enhance the accessibility and analysis of opioid data. Healthcare organizations hc1 and Appris Health teamed up to address opioid use disorder and improve patient outcomes. They developed the hc1 Opioid Dashboard to analyze anonymous diagnostic test results from millions of healthcare providers in the United States and map substance use disorders across states. Appriss Health built a prescription drug monitoring program to deliver information about this epidemic to 42 states and empower them to take appropriate action. Both platforms are cloud-based and facilitate the immediate collection, analysis and dissemination of information. Health advocates hope that with the proper cross-jurisdictional sharing agreements, this tool will offer doctors or pharmacists an

[7] Global Homeless Statistics https://homelessworldcup.org/homelessness-statistics/

[8] CDC/NCHS, National Vital Statistics System, Mortality. CDC Wonder, Atlanta, GA: US Department of Health and Human Services, CDC; 2017. https://wonder.cdc.gov.

immediate, comprehensive look at a patient's consumption history.

EMPOWERING UNDERREPRESENTED GROUPS

Cloud technology has fueled entrepreneurship by reducing barriers to entry for entrepreneurs. It allows them to build secure, smart, and scalable businesses while staying lean – a key success factor in any startup's early stages of development. From building secure, reliable websites to using ML-powered customer service chatbots, the cloud provides a wide array of solutions. It helps startups eliminate unnecessary spending by first, providing services that startups no longer have to build from scratch, and, second, by charging only for the services used.

In doing so, the cloud democratizes access to opportunity for entrepreneurs with limited capital or technical backgrounds. It allows anyone with an idea to start building. This makes a huge difference to entrepreneurs who may not have access to capital or networks.

In addition to these services, programs like AWS's We Power Tech ensures individuals from underrepresented groups have opportunities to learn skills and pursue careers in the technology sector. It provides training and mentoring opportunities and collaborates with nonprofits who share its mission of empowering diverse groups to achieve their professional goals.

Leading Change

The challenges facing city leaders today are complex. Fortunately, many of the answers lie within the data, and cloud technology is empowering leaders to take action. While technology alone cannot solve these problems, it is part of a solution that empowers leaders to make timely and effective decisions to improve people's lives. To truly succeed, leaders must engage with residents and ensure they are partners in bringing about change. The city of Chicago learned this lesson in 2016 as it embarked on a new environmental project.

"It was critical that we solicit input from Chicago's residents to ensure that we were addressing community needs and concerns through the platform. The AoT community engagement process informed the new norm for how Chicago deploys new technologies in our city."

Danielle DuMerer, Chief Information Officer and Commissioner of the City of Chicago.

CIVIC ENGAGEMENT

Chicago implemented a project known as Array of Things (AoT), in which it mounted 500 sensors on the city's light posts to collect real-time data on the environment, air quality, noise pollution, among other metrics. AoT is expected to provide information to residents to track their exposure to weather or health conditions, as well as to help the city cut costs by regulating traffic and predicting severe weather incidents. This project would not have been successful without the involvement of Smart Chicago Collaborative (now City Tech), a civic organization that hosted a series of neighborhood events to address residents' questions and collect their feedback. AoT's project leaders published draft privacy and governance policies online and released the final version of the policies in August 2016 that underscores the public's role in influencing its guidelines.

Collaboration was at the heart of another successful project in Denmark led by Wonderful Copenhagen, a public-private initiative. City leaders wanted to capitalize on an annual increase in the number of incoming tourists – and for that, they needed to know what was attracting them to the city in the first place. They collected data from multiple resources including tourists' social media posts – and used cloud-based machine learning to extract insights on visitor preferences, behavior, and new business potential. They focused on local residents, making sure that the city was as pleasant for those living in it as it is for visitors. This ensured harmony between residents and visitors, and helped the organization achieve its goals.

Wonderful Copenhagen is now a network that comprises more than 300 organizations and enterprises – all with the shared goal of enhancing their city's tourism and boosting its economy.

CONCLUSION

City leaders around the world can consider the examples cited in this paper as they plan for the future. From predicting the weather and improving public transportation routes – to mitigating complex public health crises, leaders have a plethora of technology resources available to them. There's no shortage of data to help inform their strategies and ultimately make cities more resilient. What leaders do with this data, and how effectively they involve their constituents in the solution, will determine their success.

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The AWS Institute convenes and engages global leaders who share an interest in solving some of the world's most pressing challenges using technology. The Institute brings together experts and decision makers from across government, business, academia, and nonprofit organizations for small, private, high-level, collaborative roundtable discussions to explore innovative ideas and activities to advance and transform the public sector. The Institute provides a dedicated platform for public-private dialogue and resources to turn ideas into actions.

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