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Enabling the Age of Smart Cities with Event-Driven Architecture

What makes a smart city smart? Smart cities put data and digital technology to work to make better decisions and improve the quality of life. More comprehensive, real-time data gives agencies the ability to watch events as they unfold, understand how demand patterns are changing, and respond with faster and lower-cost solutions."

McKinsey Global Institute,
Smart cities: Digital solutions for a more livable future

Time to wake up. Time to take the trash out. Time to catch the metro. Time to sign for a parcel. Time to visit the bank. Time is inextricably interwoven into the fabric of how many us move through the modern world.

And when you consider that business survival in this modern world increasingly depends on real-time decision-making, it's easy to see why the value of data diminishes the longer it remains stagnant.

"Smart Cities" have long been touted as both an answer to our increasingly urbanized population, and myriad secondary challenges such as clean transportation, public safety, and citizen health. Smart cities harness the power of IoT, sensors, and embedded devices to create a connected data ecosystem that promises operational efficiencies and improved quality of life.

Yet smart cities often fail to thoroughly consider a vital variable in their data strategies: the time value of data.

Cities are like living, breathing organisms in that they are constantly adjusting, adapting and evolving. To create responsive smart cities and gain meaningful data insights from such complex systems, a static approach to data won't suffice. Whether it's monitoring inner-city traffic or tracking the number of patients admitted to a hospital, the value of the data will perish the longer it takes to feed it into a system where it can be leveraged.

Yet city infrastructures tend to rely on legacy systems and static data models that are woefully behind the technology curve, thereby limiting the potential of any smart city initiative.

Modern businesses across the board are striving to harness the power of big data and remain agile in the face of increasing VUCA (volatility, uncertainly, complexity, ambiguity) and countless unexpected challenges. Smart city leaders need to adopt the same approach in order to cope with increasing urbanization and the increasing number of megacities forming around the world.

Real-time access to information is a critical element of any future-proof data strategy. As such, in addition to the modernization of legacy systems and the integration of those systems with new technologies, smart city leaders need to embrace the shift to event-driven thinking.

All of the things that happen within and to your city can be thought of as "events" – transit requests, inventory updates, sensor readings, the works. The value of knowing about a given event, and being able to react to it, degrades over time. The more quickly you can get information about events where they need to be, the more effectively the organism of your city can create seamless, connected experiences for those living within it.

The software design pattern that enables this shift is referred to as event-driven architecture (EDA). EDA enables decoupled applications to asynchronously publish and subscribe to events via an event broker (modern messaging-oriented-middleware). Event-driven architecture is a way of building IT systems that lets information flow between applications, microservices and connected devices in a real-time manner as events occur throughout your city, instead of periodically polling for updates.

For smart cities, and indeed for most modern enterprises, pushing information as events happen is a better approach than waiting for systems to periodically poll for updates, as is the case with the API-led approach most companies take today.

Event-driven architecture, smart city leaders can track and analyze data events in real-time, essentially creating an active data model that more truly replicates the many "events" taking place in the living, breathing cities we inhabit.

In this paper, we will explore several smart city projects under development, the reason why real-time data is essential for the future of urban development, and how an event mesh can help.

Why Smart Cities are the Future

According to a report from the United Nations, the global population in 2018 was 7.6 billion and the urban population was 4.2 billion.

By 2030 it is predicted there will be 43 megacities of over 10 million inhabitants each. By 2050, the global population is expected to soar to 9.7 billion, with 68% of the population living in urban areas.

In China, urbanization is so extreme that the urban development policy includes the notion of city clusters which will aim to house a staggering hundred million people.

Without proper planning, which includes leveraging real-time data to cope with increased populations and the subsequent pressure this will place on public infrastructures such as roads or schools, the rapid expansion of cities will delay global efforts to reduce carbon emissions by 2030.

A study conducted by the University of Hong Kong has found that this is already a critical issue, with cities in lower-middle-income countries experiencing rapid expansion of built-up urban areas without adequate infrastructure developments or greening projects in place. In turn, this has created problems with overcrowding, slums, and poor air quality that seriously impact people's quality of life and global sustainability targets.

If better planning and development isn't achieved, cities and megacities across the world all face the same ticking time bomb. Smart cities aim to address at least some of these challenges by harnessing the latest technological developments and applying these to vital public services and infrastructure projects.

It's important to keep in mind that building smarter cities is not just about creating smoother experiences. In many ways, it's about creating the necessary circumstances for human survival.

Some of the most common use cases include traffic and parking, environmental issues, assisted vehicles, citizen connection, waste management, public safety, utilities, and transportation.

At a time of physical distancing and lockdown, digital technologies are playing a major role in relaying real-time life-saving information, ensure the continuity of key public services and bridge social isolation."

OECD,
Smart Cities and Inclusive Growth

Smart cities offer better use of space, less traffic, cleaner air, and more efficient civic services through the use of IoT technologies, data tracking, and automation. As more public services go through this digital transformation, data can be connected to create an intelligent, city-wide grid that promises to boost efficiencies and cost-savings even further.

Let's take a look at a few examples.

Street lighting is something we often take for granted. We're accustomed to the familiar nightly glow that illuminates the streets of our cities, but streetlights also help to reduce crime, improve public safety, and support nocturnal economic activity.

As cities turn into megacities, something as simple as streetlights could start to seriously dent public budgets. By digitizing the system, governments can spot outages, efficiently manage lighting schedules, and manage their energy footprint to save costs –all while improving public safety.

Smart streetlights are already being put into action in Pune, India. For a city with an annual population growth of 40%, the ability to achieve a 30% to 50% reduction in costs will help to support sustainable development.

Civic services are another example of an area that's ripe for digital transformation.

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In the face of ballooning populations, public offices will quickly become overwhelmed and unable to cope with demand. Rather than endlessly opening up more locations or leaving citizens to cope with countless delays, remote public services can help.

According to a report from the German National Regulatory Control Council, by digitally modernizing public services, smart city governments could slash operational costs by up to 50% and reduce case-handling time by 60%, all while offering the public 24/7 access to these services.

Streets and highways are an integral part of any transport infrastructure that will need to undergo a major transformation as cities expand.

In Singapore, which has long been considered the world's smart city leader, the Land Transport Authority is investing in a Next-Generation Electronic Road Pricing System. The new system will equip all vehicles with onboard devices to offer drivers real-time updates on traffic routes to avoid heavy congestion and keep cars moving.

And let's not forget sidewalks, micro-mobility (e.g. bikes, scooters, etc.) and other alternative modes of transportation. A report from the INRIX National Traffic Scorecard highlighted hat Americans lose an average of 99 hours each year due to traffic congestion. Smart city leaders must factor productivity into their planning, which means leveraging both historical data (such as the knowledge of this productivity drain) with real-time data (what is the best work commute route for your connected electric scooter?).

These examples highlight some of the tangible benefits happening with smart cities, but these represent only standalone projects. To fully adapt to the changes ahead, governments must aim for city-wide digital transformation to connect all the dots.

In addition, legacy systems and static data processing strategies need to be fully integrated with new technologies and, in some cases, decommissioned and left in the past altogether.

For smart cities to offer their inhabitants a full range of benefits, data needs to flow as freely as the millions of activities taking place in the city itself.

Covid-19 put this need into sharp perspective. Although efforts were made to develop symptom-tracking apps in many countries, these could only go so far without the support of automated, nationwide monitoring that reported risk-cases in real-time.

Now we have the tools to build systems that respond to things – events – as they happen.”

Tom Fairbairn,
distinguished engineer

Supply chains also faced major disruption as flights were grounded and docks were shut down to due outbreaks of the disease, and the vast majority of companies were unable to easily recalculate routes or the associated costs. Meanwhile, buyers were left waiting in the dark and consumers ran out of vital products.

And that was *before* the Ever Given blocked the Suez Canal. About that incident alone, *Interesting Engineering* reported: “...the Suez blockage event was also very costly, which could spark a new conversation around the need for ocean-based shipping to find novel ways of managing the rapidly globalizing marketplace, and leveraging real-time updates to plan ahead for the emergent complications that follow.”

The piece went on to quote engineer Tom Fairbairn, who said that “in the past, companies approached IT and logistical issues on a case-by-case basis, ‘but now we have the tools to build systems that respond to things — events — as they happen.’”

As we’ve seen from various use cases from all around the world, the ability to access and leverage data in real-time is critical for nearly every smart initiative. The smart city leaders who build their city on an digital architecture capable of accessing and managing these events will reap the rewards for years – potentially decades – come to come.

Why Time-Value is Vital for Clean Data

Data silos are bad news for any digital transformation project, and smart cities are no different. In fact, there is even more opportunity for silos to occur given the scale of data and number of inputs for such ambitious infrastructure projects.

The problem with data silos is their ability to hamper data flow. And data flow, as all smart cities leaders can understand, is critical for real-time decision-making.

Data scientists have proposed that the power of an artificial intelligence solution depends on its ability to access data in a timely manner. The longer it takes for data to reach its processing center, the more the value of that data will perish. In short: the older the data, the less relevant the insights.

A holistic data strategy needs to incorporate access to historical data and context, but smart cities in particular rely on the kind of perishable insights that need to be actioned immediately.

Examples of this could include a major accident on a highway, a portion of the energy grid malfunctioning, or an extreme weather condition.

> **Smart Cities have the potential to generate $20 trillion in economic benefits by 2026."**
>
> **Barclays,**
> The future of Smart Cities

To unlock the value of data, it needs to be put in motion.

To move from a reactive environment to a predictive one, smart cities must begin to consider data as a real-time stream of events. As we stated earlier, EDA is a software design pattern in which decoupled applications can asynchronously publish and subscribe to events via an event broker. That event broker accepts events from senders and routes them to all the systems that want to receive them.

In a big data and microservices world, the velocity of events trends towards millions per second. A fully connected smart city could expect to easily surpass 100 billion events per day. When this volume of real-time events are coupled with historic data and other contextual information, meaningful insights can arise – from the minute that lead to immediate decisions to the macro that can inform future plans.

As such, urban planners will need to build their digital infrastructure just as robustly as their physical city. And they will need visibility into this interconnected ecosystem of events. Solace, a company that provides event-driven architecture tooling and helps smart city leaders around the world, enables this with its novel event mesh solutions.

In order to improve remote management of critical infrastructure and services, 30% of cities will turn to IoT, AI, and digital twins to create a hybrid physical/digital solution by 2025."

Strategic Finance,
Tech Trends for Smart Cities in 2021

Enter the Event Mesh

How does the management and movement of big data impact information technology infrastructure?

Take shipping as an example. The basic principle of shipping is simple: moving people and/or goods from point A to point B. In practice, it can be much more complex when an enterprise has to consider different geographies, the various modes of transportation and their interconnections, and varied payment methods or currencies encountered.

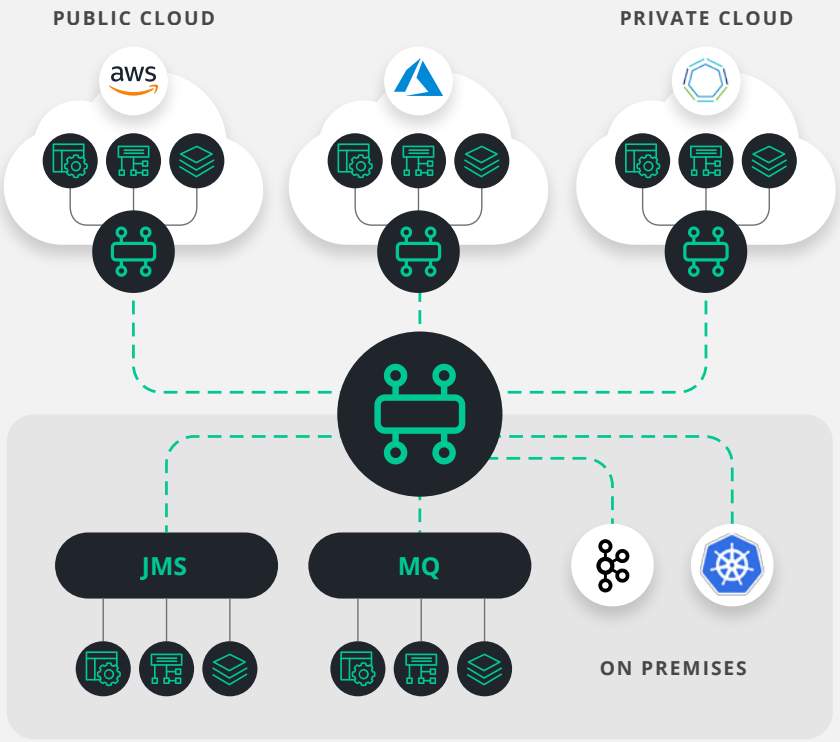
To handle the influx of data from various sources (IoT devices, legacy systems, manual inputs, GPS, weather, etc.) and to manage it accordingly so that the information is useful and shared with necessary downstream people and applications, the underlying IT infrastructure is key.

An event mesh is an architecture layer that allows events from one application to be dynamically routed and received by any other application no matter where these applications are deployed (no cloud, private cloud, public cloud). This layer is composed by a network of Event Brokers. Event brokers are a modern form of messaging middleware, which are designed to move events across the distributed enterprise.

Here are some of the benefits of implementing an event mesh:

- Provides data as a service: Event mesh makes all data that touches the mesh available on demand in a secure, reliable manner
- Brings IT and OT data together: IT is legacy integration. OT is the sensing of devices. Event mesh is the glue that ties old technology with the new.
- Enables superior customer/citizen experience: Real-time data delivery means no waiting. Spikes in demand are handled easily so end users/systems don't crash.

Solace helps organizations build an event mesh with a powerful event streaming and event management platform called PubSub+ Platform. You create an event mesh with Solace by deploying PubSub+ in any/all your environments (public/private clouds, on premises), and then connecting them, at which point all applications, microservices, cloud services, SaaS, iPaaS and legacy systems



connected to an event broker in the mesh will be instantly and continuously connected with one another.

What makes PubSub+ Platform the best way to build an event mesh?

An event mesh built with PubSub+ Platform is self-routing, self-learning and self-healing, enabling the automated and efficient trans-mission of events between producer and consumer applications, wherever they run. Dynamic Message Routing creates an "internet of events" that automatically routes events between applications and devices connected to separate event brokers, which can live in different cloud and on-premises environments. It saves operators the considerable time and effort it would take to identify and manually configure connections between producer and consumer applications running in different environments.

An event mesh built with PubSub+ Platform provides native support for multiple open protocols and APIs, providing unparalleled flexibility to develop modern, cloud native applications. Simple. PubSub+ provides native support for popular open standard protocols and APIs, including REST/HTTP, AMQP 1.0, MQTT, Websocket and JMS, so developers don't have to worry about how their app or microservice will communicate with other apps using different protocols/APIs.

NCS and the Singapore Land Transportation System

NCS has been leading various innovative Singapore Land Transportation system projects, including connecting thousands of public transport trains and buses and 1.5 million connected cars.

These types of projects deal with immense volumes of real-time data.

One aspect of managing public transport projects is that the integrity and confidentiality of the data are of utmost importance. The Singapore government governs all technology architecture with a prescriptive deployment model: AIAS (Application Infrastructure Architecture Standard). The AIAS specifies how data and application systems are secured so that events are being secured for the right level of access.

Security is especially important as this report from IDC highlights makes clear: malware and ransomware could impact 20% of the digital devices deployed by urban governments.

The deployment approach mandates clear segregated IT security zones with strong needs forplacement of integration broker components to gate the ingress and egress traffic. The use of Solace's event mesh technology to support high transaction volumes, low latency, high availability, and highly secured anti-tampering data protection were all key criteria to support such a complex, high-security infrastructure.

Conclusion

Densely-populated cities and rapid urbanization require agile new tech solutions to ensure these megacities of the future are sustainable.

A smart factory, port, or retail outlet will always be limited if the external environment it interacts with is not digitally active and if the events generated are not leveraged.

Grassroots initiatives and startups will keep finding new solutions, like the mailman mapping Brazil's largest favela, but these innovations need to plug into a stable, real-time, city-wide event mesh to truly succeed.

With the correct digital infrastructure in place, smart city leaders can continuously adopt new innovations as they are developed so the environment and its inhabitants can thrive – even as the pace of change intensifies.