Hype Cycle for Smart City and Sustainability in China, 2020

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Smart city initiatives form an important part of the Chinese government's aim for sustainable economic and social development. This research helps local government and technology providers assess emerging technologies and solutions to achieve a sustainable societal outcome.

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What You Need to Know

The "New-Type Smart City" remains the key initiative being pushed forward aggressively by the Chinese government. In 2020, while hundreds of smart city projects are being implemented and optimized, there are four major themes that influence future smart city rollout in China:

- **COVID-19:** Changing/enforcing smart city priorities on resilience, community-level and citizen services, data exchange across smart city ecosystem, among others.
- **New infrastructure:** Seven areas including 5G, big data centers, artificial intelligence (AI), industrial internet, electric vehicle (EV) charging infrastructure, subway/express train, and ultra-high-voltage electricity transmission are listed as new infrastructure with increased investment. Most of these are critical city infrastructure enabling smart city and ecosystem services.
- **Standardization:** In addition to the existing standards guiding smart cities in China, Xiong'an released an intelligent city standard framework, providing a reference for cities in China on planning, design and construction of physical and digital cities simultaneously. This will be a valuable supplement to the current standards under new-type smart city framework.
- **Smart city operators:** As smart cities transition from large-scale construction into operation and optimization, and increasing participation from private sector, the role of smart city operators becomes prominent, with Shenzhen leading the trend by setting up a State-owned Assets Supervision and Administration Commission of the State Council (SASAC) wholly owned enterprise responsible for Shenzhen smart city funding, planning, implementation, operation, cooperation and so on. This transitioning to increase focus on operation will drive data-related initiatives to the next level.

To reflect these trends, we continue to track government cloud, government open data, computer vision and Internet of Things (IoT) in smart cities, digital twins of government, 5G in China, electric vehicle and charging infrastructure, and advanced metering infrastructure. We also introduced new Hype Cycle entries such as **Citizen Twin** and **Blockchain in Government**, along with the existing Hype Cycle entries.

The Hype Cycle

The Gartner Hype Cycle for Smart City and Sustainability in China (see Figure 1) is designed to help CIOs in government and the urban ecosystem evaluate emerging trends and technologies that are relevant to smart city and sustainability initiatives. CIOs and IT leaders should use it to determine the maturity level and associated risks of emerging technologies, as well as to decide the implementation plan. Government officials should use this as a reference to set policy and guidance for better adoption of technologies in smart city initiatives. Meanwhile, business leaders of technology providers can use this to develop products and solutions to monetize from China's opportunity.

This Hype Cycle contains a subset of the technologies analyzed in "Hype Cycle for Smart City Technologies and Solutions, 2020," but in the context of the Chinese market. These technologies include:

- **Energy-Water Nexus**
- **Water Management**
- **Sustainability and COP 21**

- **Data for Good**
- **Digital Twins of Government**
- **Citizen Twin**

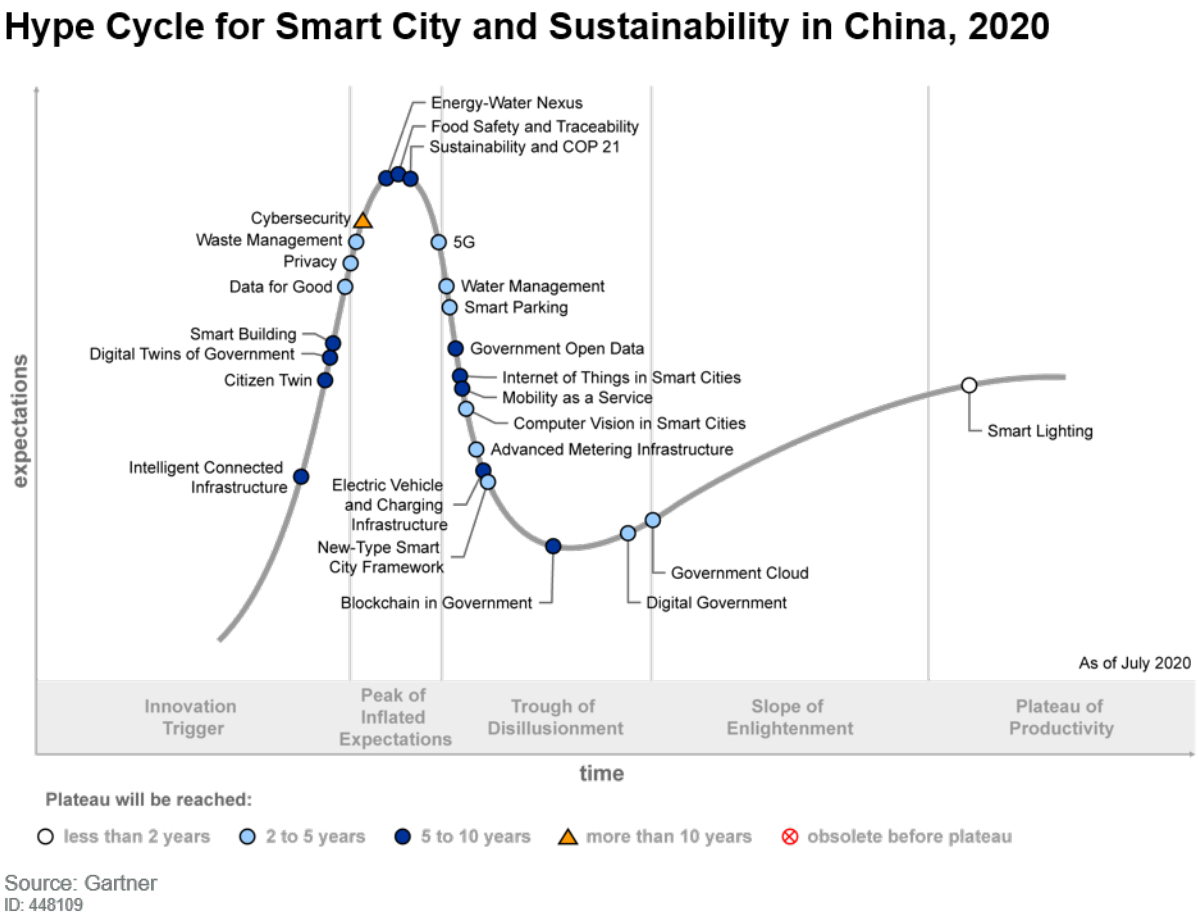
In addition, we included a few smart-city-relevant technologies that appear only in this Hype Cycle, because these technologies are particularly relevant and important in China and are becoming hot topics:

- **Government Open Data**
- **Government Cloud**
- **New-Type Smart City Framework**
- **Food Safety and Traceability**
- **Waste Management**
- **Blockchain in Government**

Meanwhile, we renamed/replaced some Hype Cycle entries to reflect the market dynamics; see the Off the Hype Cycle section for more details.

With this combination, Gartner believes it better addresses the audience's interests and provides a more comprehensive view of the technologies specific to the Chinese market.

Figure 1. Hype Cycle for Smart City and Sustainability in China, 2020



Source: Gartner
ID: 448109

The Priority Matrix

The Priority Matrix provides further details about when the Hype Cycle entries will enable cities and governments to achieve a degree of benefit. Smart city and sustainability are underpinned by a broad array of technologies and use cases, most of which are between two and 10 years from mainstream adoption. The following Hype Cycle entries are responsible for introducing transformational benefits to cities:

- **Internet of Things in Smart Cities** and **Smart Building,** along with **Sustainability and COP 21,** are transformational, expected to mature in a five-to-10-year time frame. These offer high risk-reward benefit, and require careful planning and prioritization while exploiting the potential benefits these technologies can bring.
- The impact of the **New-Type Smart City Framework** initiative will be profound and transformational. Being a focal point of the Chinese government's 13th Five-Year Plan, it will

likely be duplicated in the 14th Five-Year Plan beginning in 2021, **New-Type Smart City Framework** is expected to mature within five years.

- **Computer Vision in Smart Cities** brings transformational benefit within five years, driven by surveillance with facial recognition and behavior analysis for public safety and number plate recognition for parking and traffic monitoring. The role it has played in the support of combatting COVID-19 has been widely recognized in disease diagnosis, prognosis, prevention, control, treatment and management.

A large proportion of Hype Cycle entries will see high benefit:

- **Cybersecurity** and **Intelligent Connected Infrastructure** have high benefit but will not see mainstream adoption for more than 10 years, since it takes time to improve uneven security and risk management practices in China. The absence of standards and immature technologies for intelligent connected infrastructure takes time to improve.
- **Smart Lighting** will reach mainstream within two years bringing high benefits to adopters, given the basic features for energy-saving purposes are advancing rapidly to become well-established technology.
- The Hype Cycle entries that will witness mainstream adoption in two to 10 years include:
  - **5G** (in China)
  - **Advanced Metering Infrastructure**
  - **Digital Government**
  - **Government Cloud**
  - **Smart Parking**
  - **Waste Management**
  - **Water Management**
- Some technologies are composites and are composed of multiple elements or technologies, which require a big collaborative effort across different government departments and industry sectors, as well as integration of multiple technologies. The complexity brings uncertainty to technology adoption speed. The following Hype Cycle entries that will take more than five to 10 years to reach mainstream adoption include:
  - **Blockchain in Government**
  - **Citizen Twin**
  - **Digital Twins of Government**
  - **Electric Vehicle and Charging Infrastructure**
  - **Food Safety and Traceability**
  - **Government Open Data**

- **Mobility as a Service**

This year, we revised the timeline for **Privacy** in China and **Data for Good.** We reduced the time we expect them to reach mainstream adoption from five to 10 years to two to five years. The main reason is that the Chinese government is accelerating laws and regulation enactment, providing great urgencies on businesses operating in China to adopt privacy protection practices. COVID-19 has pushed the demand for data analytics from public sector, nongovernmental organizations (NGOs), and data and analytics providers to grow exponentially. It also proved how data transcends organizational boundaries bringing societal benefit.

Figure 2. Priority Matrix for Smart City and Sustainability in China, 2020

Priority Matrix for Smart City and Sustainability in China, 2020

benefit	years to mainstream adoption			
	less than two years	two to five years	five to 10 years	more than 10 years
transformational		Computer Vision in Smart Cities New-Type Smart City Framework	Internet of Things in Smart Cities Smart Building Sustainability and COP 21	
high	Smart Lighting	5G Advanced Metering Infrastructure Digital Government Government Cloud Privacy Smart Parking Waste Management Water Management	Blockchain in Government Citizen Twin Digital Twins of Government Electric Vehicle and Charging Infrastructure Food Safety and Traceability Government Open Data Intelligent Connected Infrastructure Mobility as a Service	Cybersecurity
moderate		Data for Good	Energy-Water Nexus	
low				

As of July 2020

Source: Gartner
ID: 448109

Off the Hype Cycle

No Hype Cycle entries have been removed from this year's Hype Cycle. However, the following Hype Cycle entries have been renamed or recast:

- **Intelligent Traffic Management Systems** has become **Intelligent Connected Infrastructure** to reflect the emergence of the transport infrastructure enabled by an integrated mesh of AI, IoT, cloud, analytics, telecommunications and autonomous technologies.
- The **5G** entry is specific to 5G in China in order to emphasize the country-specific progress and deployment; since China is leading the world for 5G in infrastructure rollouts, device shipments and identification of use cases.

On the Rise

Intelligent Connected Infrastructure

Analysis By: Ivar Berntz; Venecia Liu; Thierry Kuperman Le Bihan

Definition: Intelligent connected infrastructure (ICI) is an integrated "mesh" that enables transport infrastructure to exchange data with surrounding entities. The mesh is made up of elements such as artificial intelligence (AI), Internet of Things (IoT), cloud, analytics, telecommunications and autonomous technologies. The transport infrastructure can include ports, bridges, roads, airports and airways, and highways. And surrounding entities may include vehicles, technicians, equipment and other assets to transport authorities.

Position and Adoption Speed Justification: ICI kept gaining traction in 2020 among transport authorities that have a vision for pulling all technologies together to communicate, provide insight and enable decision making to take action. Enclosed campus environments, such as port authorities or airport authorities, have taken steps to implement intelligent connected infrastructures using 5G and Long Term Evolution (LTE) infrastructures.

Some of the enablers of ICI, such as IoT and vehicle to vehicle (V2V) communications, are at the Trough of Disillusionment. Others are already mature, (for example, electronic tolls, in-vehicle telematics or sensor-based charging stations), whereas some may have different standards or not exist yet. ICI combines these diverse data sources to create an intelligent infrastructure that can provide insight and initiate appropriate action(s). Example ICI use cases include:

- Notifying drivers about different road conditions (such ice or obstacles)
- Monitoring vehicles going into, or currently inside, tunnels, parking lots, facilities and restricted access areas/roads to organize assistance or evacuation in case of fire or accidents
- Orchestrating cargo prioritization at the port yard for rail and trucks
- Pulling in diverse data points from ground operations to air traffic control and airlines to decrease airplane gate turnaround time

ICI is still an emerging area since it requires a digital mesh infrastructure across various technology touchpoints and entities in the ecosystem for an orchestration and collaboration to realize this vision.

User Advice: CIOs seeking to advise COOs and operations managers on how to optimize the operations of leading should consider the following:

- Governmental and private transport agencies or concessionaires should examine ICI to obtain multiple sources of data for a holistic view of infrastructure maintenance, planning, forecasting, safety and traffic flow.
- Port authorities and operators need to look into ICI as a means to improve the orchestration of multiple stakeholders, (such as truck drivers waiting for unloaded cargo, pilots, tugboats, crane operators, rail cargo, shipyard equipment, shipper and emergency services).
- Airports, passenger and cargo airlines, catering and ground handling ought to consider ICI to meet higher asset utilization and reduced greenhouse gas emission targets through the sharing of infrastructure.

Business Impact: ICI combines diverse, transport-related data sources, coalesces the data and provides an amalgamated view to produce actionable, intelligent insights back into the transportation ecosystem to deliver a seamless and optimized network. ICI can improve traffic flows, safety, infrastructure maintenance and road condition notifications such as hazardous conditions, accidents and collisions, roadblocks and vehicle usage. It can supplement vehicle sensor capabilities with information from other vehicles on the road and from the surrounding infrastructure. ICI could also enable a charging mechanism built into the infrastructure.

ICI can play a crucial role in the viability of autonomous vehicles. It can also provide economic savings and environmental benefits by improving transportation efficiency, which could offset the required investments. For example, with ICI, an autonomous ship could monitor itself and navigate the water conditions using sensors and algorithms that reduce required staff, as envisioned by Rolls-Royce.

The connected intelligent infrastructure will be able to communicate the status of the asset condition and if any maintenance is required. Smart motorways will be able to share which toll booths are open, which route is optimal, avoid hazards, inform users of road conditions and usage levels/patterns, and suggest speeds and fuel stops. A partial example is some tunnels that already control the heat of truck engines before allowing entrance, as this could be automated and eventually avoid huge queues and delays in case of fires. Smart ports would benefit from ICI in optimizing operations and improving terminal management by communicating with cranes, rails, port authorities and trucks on the loading and off-loading of cargo, cargo weight, size, location, hazardous materials and customs documentation and processes. The use of 5G as a ubiquitous network for IoT connectivity could provide the tissue for further extension of such capabilities. Smart airports would benefit from an increased capacity enabled through the better orchestration and coordination of members in the airport ecosystem including assets and ground service equipment. ICI in the sky partially exist today with direct plane-to-plane communication and air traffic control managing exceptions.

The risk level is high. New technologies offer new possibilities, but also come with unknown risks. For example, absence of standards and immature technologies can lead to unintended consequences and facilitate hacking. These will need to be considered in the design, development, implementation and operation of resilient ICI components.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Embryonic

Sample Vendors: Alibaba Cloud; Bosch Group; Cisco; Ford Motor Company; IBM; Mercedes-Benz; Qualcomm; Rolls-Royce; Siemens

Recommended Reading: "Market Guide for Vehicle Routing and Scheduling"

"Market Insight: Roadmap for V2X Technologies for Autonomous Driving — When to Invest"

"Hype Cycle for the Internet of Things, 2020"

"Hype Cycle for the Future of CSP Wireless Networks Infrastructure, 2019"

"Hype Cycle for Connected Vehicles and Smart Mobility, 2020"

"Market Guide for Transportation Mobility Technology"

"Market Trends: Monetizing Connected and Autonomous Vehicle Data"

Citizen Twin

Analysis By: Alfonso Velosa; Marty Resnick

Definition: A digital twin of a citizen is a virtual representation of an individual. Governments use citizen twins to support new or enhanced citizen services or government missions such as pandemic or safety management. The citizen twin has model, data, a unique one-to-one association, and monitorability. It integrates data into the twin from siloed public and commercial sources such as health records, social media, phone location logs, and physical infrastructure such as cameras and wearables.

Position and Adoption Speed Justification: Governments are increasingly developing digital twin models of citizens to monitor and help address health, safety, travel, membership, and social media impacts on society. The citizen twin can be used to build profiles, personas, and scores helping stakeholders make decisions, such as aligning medical treatment, managing transportation resources, or taking sensor data to try to understand the health of passengers arriving on an airplane. Aggregated versions of the anonymized citizen twin will be used to understand broader societal patterns, drive government resource allocation and utilization, and impact societal behavior.

Precursors already exist. In western countries, financial organizations provide citizens with credit rating scores. Retailers model shoppers. China has a citizen social credit system. A variety of airport and retail vendors are developing passenger and shopper tracking solutions.

User Advice: CIOs need to help their governments or enterprises take advantage of this emerging trend to serve citizens and customers better. At the same time, CIOs must protect their citizens, governments, and enterprises from misuse of citizen data. Key steps include:

- Transparently develop robust privacy and digital ethics policies

- Establish clear benefits to citizens such as certifying children in a classroom are all healthy or simplifying medical triage to get a citizen to medical care.
- Develop sensor and IoT monitoring capability.
- Invest in integration skills to connect into a diverse set of data sources.
- Use AI to build and test the usefulness of a variety of citizen-twin-based scores.

Business Impact: Governments' safety initiatives will increasingly aggregate citizen data across the world, as they seek to serve citizens, to protect them from pandemics or other crises. This will have a range of key impacts, including:

- Increased debates over privacy and the merits of government access to citizen data, although this has been difficult due to politization in a variety of western countries.
- Expect scope creep as government bureaucracies increase the types and quantity of data collection.
- Government curation of aggregated citizen data a security risk for government data and possibly a safety risk for the individual citizen.
- There will be increased regulation to balance the government use of the data with the citizens' respective rights to privacy.
- As governments work to collect more data on citizens, this may drive a dialogue to get more services and other financial benefits in return to citizens, but it will expose a lack of integration skills across data sources — and political infighting over data siloes.

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: Alibaba Cloud; Apple; Google; Tencent; VANTIQ

Recommended Reading: "Getting Started With a Digital Twin of Government"

"Top 10 Plausible Directions Resulting from COVID-19"

Digital Twins of Government

Analysis By: Bill Finnerty; Milly Xiang

Definition: A digital twin of government is a virtual representation of government and partner assets, people and operations to provide real-time analysis, operations automation and scenario-based planning. Key features will include a single point of visualization and access to supporting data, APIs for issuing commands to things and processes, and the ability to use AI for scenario

planning and urban modeling. As a digital twin of government matures, it becomes a system of systems requiring strong integration capabilities.

Position and Adoption Speed Justification: Digital twins of government are starting to appear in jurisdictions around the globe. This emerging solution provides a single interface to the operations of a jurisdiction. Many start as GIS models or business operating systems; a fully realized future state will:

- Include command-and-control capabilities.
- Leverage AI for scenario planning at scale.

A number of challenges to digital twins of government may impede their implementation and growth. Foundationally, they are integrated systems that will span the silos of government, silos being an ongoing challenge for governments. This requires both coordination on data standards and integration capabilities. Expectations are high. However, sustaining interest, budget and business unit participation in developing a digital twin of government will require focus over multiple administrations.

Advances in offerings from vendors, progress on governmental standards in the U.K., Australia and other countries and the growing number of digital twins of government (such as Virtual Singapore, New South Wales [NSW] governments Spatial Digital Twin, the Dutch government's digital twin of The Hague and others) have advanced digital twin of government's position on the Hype Cycle.

CIOs planning for digital twins of government will need to address fundamental questions of any emerging technology — privacy, ethics and business value.

User Advice: Government CIOs must create a long-term vision for a digital twin of government by establishing clear expectations, setting an implementation timeline and communicating regularly with executives and business leaders to ensure they do not become fatigued and lose interest. CIOs leading the development of a digital twin of government must:

- Define the vision in business terms to maximize understanding and buy-in.
- Use future planning exercises, such as scenario planning, to develop potential use cases that can be used to prioritize investments and communicate the "art of the possible."
- Establish the protection of citizen data as a guiding principle through the implementation of privacy controls and end encryption capabilities.
- Be mindful that the digital twins of government need not be a complete clone of the jurisdiction. They can be, particularly in the early stages, a digital manifestation of a single aspect. For instance, Transportation-related digital twins have been created for rail stations in China and the U.K., and in Colombia for city mobility.
- Have a vision that extends beyond currently available capabilities. For example, repurposing a 4D GIS map as a digital twin of government can lead to confusion. It is important to clarify the difference and the ways in which these solutions complement each other.

- Access relevant vendors or solutions that could support your vision based on their ability to integrate with existing systems, use of nonproprietary data standards, ability to scale using cloud services and vendor technology roadmaps.
- Focus early efforts on scenarios that can deliver high business value but present low urgency and risk.

Business Impact: Digital twins of government will provide single interfaces for awareness and operational control for jurisdictions in the future. Business impact will extend across government tiers and jurisdictions and the ecosystem. In the short term, governments will need to identify a focused use case for a proof of concept of a digital twin of government. In the midterm, governments will leverage digital twins for command-and-control operations, many of them automated, requiring fewer staff to respond to incidents. Over time, digital twins will be used to test scenarios related to policy and legislation, providing opportunities to model proposals based on historical and projected data.

Use-case examples include:

- Using a digital twin of road and transportation systems to automate traffic management for incidents, weather and emergency response
- Creating a digital twin of a school campus to model student movement for maximizing space utilization and minimizing utility costs

In the wake of the COVID-19 pandemic, digital twins of government are being used to model community health, including the individual's.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Cityzenith; Esri; Estudios GIS; Eutech Cybernetic; IBM; Idrica; OSIsoft; View; Worldsensing

Recommended Reading: "What to Expect When You're Expecting Digital Twins"

"Governments Are Developing a Unique Kind of Digital Twin"

"Getting Started With a Digital Twin of Government"

"Use 4 Building Blocks for Successful Digital Twin Design"

Smart Building

Analysis By: Gavin Tay

Definition: A smart building is a facility where multiple functions cooperate to achieve sustainable outcomes through the analysis of contextual and real-time information, shared among Internet of Things (IoT), information and communication technology (ICT), and operational technology (OT) systems.

Position and Adoption Speed Justification: Much of what has made a building "smart" (mostly operational efficiency) has been heavily reliant on building management systems (BMSs), even up to the present day. Due to the legacy nature of how BMSs are implemented, adoption rates are fairly slow. New hardware for HVAC and lighting that is implemented with new construction has a lifetime of 10 to 20 years. Retrofits take place only when a system fails and needs updating.

IoT and AI has the potential to speed up the implementation of more IT into the BMS space by extending and augmenting existing equipment. Depending on the age of the equipment, BMS software companies can often tap into the data stream or APIs. If the system is older, it is possible for sensors to be economically placed on boilers, chillers, air conditioning units and other hardware to enable real-time monitoring of legacy equipment. Wireless connectivity can reduce the installation overhead of this retrofit. Cost savings that can be achieved by integrating the sensors with BMS software could help to accelerate the adoption of integrated BMS in older buildings. In some cases, it might be more economical to upgrade rather than adapt an older system.

By 2028, Gartner estimates that there will be over four billion intelligently connected IoT devices in commercial smart buildings. CIOs will struggle with provisioning them, managing them, connecting to them and analyzing their data. Adding to existing complexity, there will be no dominant IoT platform in any smart building, so CIOs will need to compose end-to-end IoT solutions from multiple providers.

User Advice: According to ENERGY STAR, the average building wastes 30% of its energy through inefficiencies in lighting, heating and cooling areas that are not occupied. Much of the energy from these inefficiencies can be recovered by using real-time data from the IoT and IT infrastructure to enable communication between the different BMS in a building. CIOs, real-estate and facilities professionals can leverage the significance of IoT to build holistic, engaging employee experiences while increasing building competitiveness. CIOs should opt for flexible payment methods instead of treating such investments as a capital liability. Channel savings obtained — from building efficiencies to the repayment of these solutions or services — make it an operating expense instead.

Gartner predicts that, by 2022, the IoT will save consumers and businesses $1 trillion a year in maintenance, services and consumables. CIOs must assemble an IoT business solution to alleviate the potential business and technical challenges of creating a smart building. An end-to-end IoT business solution is a heterogeneous mix of IT and OT assets, including IoT endpoints (often many), one or more IoT gateways (optional) and one or more IoT platforms. All assets including building management systems are integrated with existing enterprise systems and big data, and may include newer forms of unstructured data such as surveillance footage. Performance monitoring backed up by predictive maintenance, using AI, will not only improve the efficiency and effectiveness but reduce operational expenses.

In assembling a smart building, IoT business solutions require a clear vision from CIOs of its foundational architectural building blocks, beginning with the IoT platform and an understanding of the privacy and data security implications. Delivering digital experience, given limited exposure to governing all moving parts and the flow of activities in smart buildings can be diverse and complex. CIOs will need to become accustomed managing the complexity of a multivendor IoT landscape and technology architecture.

Business Impact: Post COVID-19, much of what real-estate and facilities managers have to deal with when managing a building will involve the CIO or their ICT counterparts. Today, the operating elements of a smart building typically include space, environment and maintenance management, along with wellness, energy management and sustainability. Such rapid evolution of smart buildings means that facilities and real-estate professionals will want to leverage the ICT expertise that is part of the CIO portfolio. Integration will be a key component and remains difficult for data residing in various custom-made BMS repositories to interact with one another. As the demands and expectations of workers shift from merely going to an office that has good air, temperature and now hygiene to a place where they have work-life ambience, a smart building experience requires the exploitation of an ever-growing number of IoT business solutions.

Being able to learn human preferences that are constantly adjusted based on human activities, emotional states and reactions in real time can be used to optimize a building's performance and improve predictive maintenance. Smart buildings are able to constantly respond to change, which results in healthy, delighted and productive tenants. Such insights can only come from multiple sources of information, further calibrated by understanding the behavior of workers and how they interact with every aspect of their surroundings. Formulating such holistic solutions will stretch the way business, IT and real estate align to address work-life ambience.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Eutech Cybernetic; GE; Honeywell; Intel; Johnson Controls; Schneider Electric; Siemens; Signify; Spacewell; Terminus

Recommended Reading: "Evolve Your Smart Building Solutions in the IoT Era"

"Technology CEOs Should Differentiate Smart Building Solutions Based on Buildings' Purpose"

"Exploit Indoor Location Services to Differentiate IoT Solution Value"

"3 Areas to Drive IoT Differentiation Beyond Functions and Features"

"Crafting Workspaces That Enhance the Employee Experience"

"Top 10 Strategic Technology Trends for 2019: Smart Spaces"

Data for Good

Analysis By: Julian Sun

Definition: "Data for good" is a movement in which people and organizations transcend organizational boundaries to use data and data-driven insights to improve society. This data usage may be within an analytics and BI context, or in more sophisticated data science and machine learning use cases, but the purpose is focused on social impact.

Position and Adoption Speed Justification: China is implementing a national big data strategy that is centered on building the country's strength by nurturing a digital China and smart society. The demand for data and analytics from public sector and NGO grew exponentially amid COVID-19.

However, public sector and NGOs in China are struggling to be data-driven due to the lack of analytics skills and technology. Many commercial organizations have both the technologies and the people required to make things better for the good of society, and these two elements are starting to make joint efforts to build better cities based on data. Chinese government has collaborated with these commercial organizations to develop multiple analytics applications such as "health code" to prevent and combat epidemics. It reinforces people's understanding of the power of data for good.

There are a number of organizations in China that have data for good initiatives.

For example:

- Alibaba Tianchi is a data science competition platform to allow users to apply data science powered by Alibaba Cloud to solve urban problems.
- Telecommunication providers in China provide geospatial analysis for epidemic prevention and control using its own unique signal base station data.
- Chinese nonprofit organizations collaborate with data and analytics service providers to build data visualization sites that allow the public to better navigate and share the information in a visual way.
- SODA (Shanghai Open Data Apps) hosts data analysis competitions with open government or social-related data to solve societal problems such as management of bike sharing service, green transportation and food safety in Shanghai.
- Local governments (in Shanghai, Zhejiang and Jiangsu) have started opening their data as a service in a dedicated portal. Crowdsourcing data and analytics experts, or system integrators can freely develop products based on traffic, public services and education data that is provided for free.

Data for good is specifically advantageous for organizations that are both contributing the data and using it. To date, such contributions are often considered altruistic and justifications for participating can be difficult to develop. Post-COVID-19 could see data for good initiatives extend and grow.

User Advice: CIOs and data and analytics leaders should:

- Use data for good initiatives instituted in response to COVID-19 as a launching point for continued, extended data for good initiatives.
- Collaborate with international companies and vendors to prototype data for good strategies as a way to improve employee's data literacy.
- Use analytics based on open data such as COVID-19-related data to solve social problems through internal training programs.
- Encourage employees to participate in more community events hosted by organizations that have data for good projects.
- Pilot data visualization technologies about smart cities to bring more visibility about how data can improve city life.
- Make useful internal data public to solve the urban problems while adhering to privacy regulations.

Business Impact: Data and analytics solutions are China's CIOs' top investment priority according to Gartner's most recent CIO survey. But the culture, and lack of analytics skills, continues to be hard to change, especially for nonprofit organizations and the public sector. Data for good provides an option to have technology and expertise at lower cost, but with a higher social impact. The benefits of this type of crowdsourcing come to prominence because of China's unique population dividend.

Data for good initiatives are a good rebranding of social responsibility. Local BI vendors are a bit behind international vendors on these approaches. Local data and analytics service providers are having more engagement with nonprofits and the public sector, and more deals from smart city projects. As the Chinese government builds a more centralized and digital system, product vendors that take a data for good approach will get more social impact investment.

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Alibaba Group; China Unicom Big Data; Kaggle; SAS; Tableau Software

Recommended Reading: "How to Use Data for Good to Impact Society"

"Coronavirus (COVID-19) Outbreak: Short- and Long-Term Actions for CIOs"

Privacy

Analysis By: Jie Zhang

Definition: Privacy in China is preserved by a national standard for privacy, a cybersecurity law, and is enforced by other relevant regulations. Personal information for Chinese citizens is defined to

include two categories: general and sensitive. The Privacy Standard, the Chinese Cybersecurity Law and the multiple-level protection scheme (MLPS) outlined special data protection practices on both types of personal information. For example, locally storing private data collected in China or data localization is a mandate.

Position and Adoption Speed Justification: The position is adjusted from 2019 as the drivers for hype continue to exist. The rapid adoption of digital business in China (especially mobile payment, large and complex third-party data sharing and processing especially in financial services, online shopping, and news and information content platform) continues to add risks for personal data to be breached or mishandled. The overall trailing privacy practice in society, fraud activities, excessive data collecting and trading (among others), have driven Chinese lawmakers and regulators to establish guardrails for protecting its citizens' privacy. The government effectuated MLPS 2.0 which includes further guidelines on private data protection at the heel of its first Privacy Standard in May 2018 and the first Cybersecurity Law in June 2017 and subsequently drafted a regulation on cross-border data transfers. In early 2019, China also finalized its "Guideline for Internet Personal Information Security Protection" offering additional detailed privacy requirements. These guardrails have a direct impact on how both global and local businesses operate in China. Reactions to Chinese privacy-related topics peaked immediately after the enactment of the law (demonstrated by media and business interest, and Gartner client interactions). Cases (see "China Cracks Down on 100 Apps for Illegal Collection of Personal Data" and "China Redoubling Crackdown on Apps Over Privacy Violations") of severe penalties have been continually reported on mishandling or insufficient protection of personal information in 2019. These cases demonstrate the will and wish from the central Chinese government of controlling and regulating personal data protection practices. The pandemic of COVID-19 has also pushed the hacking of personal information to another level (see "Chinese 'Frontline' COVID-19 Research Firm Reported Hacked: Data Now On Dark Web"). The clarity provided by the Privacy Standard plus MLPS 2.0 continues to provide urgencies on business to pay attention to privacy protection practices. However, it will take time for the overall privacy culture or lack thereof and the associated legal enforcement to mature.

User Advice: Security and risk management leaders should:

- Discover, classify and map data between operations in China and other corporate locations, as it is the necessary first step to prepare for collecting explicit consent and preparing for data localization.
- Incorporate a privacy assessment for the Chinese privacy standard in enterprise information governance by treating it as a parallel, but complementary, effort to General Data Protection Regulation (GDPR), California Consumer Privacy Act (CCPA) and other privacy compliance requirements.
- Continuously monitor the development of future guidelines relevant to privacy by working with legal experts that specialize in the Chinese market with strong privacy practices.
- Treat the Chinese Privacy Standard and MLPS 2.0 within the context of the Chinese Cybersecurity Law as privacy requirement is not only an integral part of the law but also guided and enforced by the law in reality.

- Separate data protection and retention for China operations from global information governance as local privacy rules could often be enforced differently from other regions.

Business Impact: Defining and addressing privacy compliance needs support business goals and market access especially for businesses in highly regulated sectors such as financial services or multinational operations expanding in China. Therefore, global business leaders need to rethink their market growth strategy. Additional investment is necessary, or a path of "China for China" strategy is needed as potentially the privacy risks outweigh business benefits; because costs for new IT infrastructure, application architecture, data management and skills will rise. Although the central government and industry-specific agencies continue working on defining details around privacy requirements, compliance risks and potential penalties for violations in China are real and can be significant. For businesses serving the China market, privacy leaders need to consider introducing new roles, new controls and policies to manage Chinese privacy requirements. Near-term privacy management changes from various Chinese authorities (specifically, industry-specific agencies) are also expected. Therefore, privacy in China has an ongoing impact on monitoring and security audit/assessment as well.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Recommended Reading: "China's Data Privacy Standard Unfolds Measures for Its Cybersecurity Law"

"Security Assessment Becomes Prerequisite for Transmitting Data Out of China"

"Address Chinese Cybersecurity Law With This Playbook"

"Balancing the Risk of China's Social Credit System for Business Benefits"

At the Peak

Waste Management

Analysis By: Milly Xiang

Definition: Waste management refers to collection, transportation, disposal and recycle of industry and residential garbage, sewage, and other waste products. Waste management encompasses management of all processes and resources for proper handling of waste materials, from maintenance of waste transport trucks and dumping facilities to compliance with health codes and environmental regulations, as well as behavioral changes.

Position and Adoption Speed Justification: Urban waste management requires support by three key measures: Law and regulation system, government-funding guarantee, and participation from private sectors, as well as new technologies and business models.

In China, urban waste management is being carried out step by step. The government regulations on the “Implementation Scheme of the Classification System of Household Garbage” specifies 46 cities to implement mandatory classification of household waste. Large cities such as Shanghai and Beijing also released local “Urban Living Waste Management regulation” to guide disposal, collection, classification, transportation and recycling of waste. IoT-enabled waste management solutions are coming to market quickly, focusing primarily on waste collection and classification. Local municipalities are engaging with waste management vendors to modernize their waste management processes.

Urban waste management is still challenged by imbalanced execution in different geographies, lack of a well-accepted classification standards for various wastes such as food wastes, waste to energy, recyclable wastes, among others and dedicated funding, low penetration of technologies, low level of private sector participation, lack of supervision systems and so on.

User Advice: City planners and technical professionals in waste management organizations, as well as property managers may focus on the following advice, and prioritize use cases where they can generate best results contributing to the sustainability of the cities. They should gradually introduce smart technologies to enhance the efficiency and productivity in waste management and recycling, while reducing staffing and transportation costs, and driving up innovation.

- Garbage pick-up route optimization by the level of waste monitored on a real-time basis, through bins equipped with wireless sensors, and databased management and logistics platforms.
- Real-time fleet monitoring and improvement by mounting smart devices to the waste management trucks. In the meantime, this same system can be used to track problems on the roadways and report back to city officials to improve city infrastructure management.
- Pneumatic waste conveyance system in housing estates to reduce the need for workers and trucks to collect household waste.
- Manage specific waste, such as plastics, batteries and e-waste. An example is using near infrared technologies for material identification and selection.
- Waste collection robots and autonomous driving waste collection trucks can be used to replace manual collection methods and logistical processes.

As smart technologies are getting broadly used in the entire cycle of waste management, government officials can leverage big data and analytics to better analyze and manage their waste data. Waste collection and recycling companies can use the data to analyze citizen behaviors for a rational distribution of waste bins and staffing.

Business Impact: For local governments, waste management is posing great impact to the overall citizen experience and environmental sustainability. For waste collection companies, the adoption of smart technologies in waste collection process could result in increased efficiency and productivity, reduced logistics costs and lower carbon emissions from the trucks. Waste and recycling companies that proactively adopt these innovative and smart technologies would be able to gain a competitive advantage over the laggards.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: Ecube Labs; Huawei; Locision Technology; New H3C Group; XiaoHuanggou Environmental Protection Technology; Zoomlion Environmental Industry

Recommended Reading: "Product Managers Should Incorporate Human Factors in IoT Solution Design and Development for Smart Cities"

"Market Guide for Vehicle Routing and Scheduling"

"Market Guide for Transportation Mobility Technology"

Cybersecurity

Analysis By: Sandy Shen; Jie Zhang

Definition: Cybersecurity is the domain facilitating the protection of confidentiality, integrity, availability and privacy of information as well as the safety of people and environment of an organization. Providing cybersecurity via a program means providing a set of sustainable controls to protect against the need to run a business.

Position and Adoption Speed Justification: China's Cybersecurity Law has been backed by a number of guidelines and measures such as the Privacy Standard, Multi-Level Protection Scheme (MLPS), Cybersecurity Inspection Method and other policies and measures of standardizing the security practices of information technologies and network infrastructure. This has not only increased awareness of cybersecurity but also pushed organizations to set up formal security and risk management programs. Ant Financial, Tencent and Baidu are among the first group of companies being certified for privacy protection, and many businesses have obtained classified protection certification.

However, Chinese organizations have uneven security and risk management practices, and investment is lagging at the global level. Gartner's 2019 CIO Survey shows that 26% of Chinese CIOs plan to increase investment in cybersecurity technologies, compared to 40% at the global level. In addition, there is a lack of attention from senior executives especially at the board level. The same survey shows that only 6% of Chinese organizations' board of directors are accountable for cybersecurity, while the global is at 24%. Furthermore, many organizations don't have structured security programs and skills that sufficiently cover the scope of vulnerability management, identity and access management, incident response and business continuity. Some industries such as financial services have more established security practices partially due to regulatory requirements and comprehensive risk management practices as required by the business. Investments in cybersecurity by industries regulated from outside don't provide adequate skills, processes or technologies. Improving this state will take time. As China is investing in more advanced technologies such as IoT and AI that typically involve a huge amount of data, and as COVID-19

sees many businesses scrambling to support remote working and build online presence without thorough planning involving security leaders, cybersecurity incidents can have widespread damaging impact on the society. Gartner expects it will take more than 10 years for Chinese organizations to address these challenges.

User Advice: We recommend:

- Educate business executives of cybersecurity and the importance of their sponsorship and input as often their jobs are on the line in the event of major cyberincidents and compliance violations. Create an urgency to put in place security and risk management programs to defend the organization.
- Engage business leaders to establish a set of sustainable controls to balance between growing the business and providing cybersecurity.
- Create a security process catalog covering major and relevant security aspects such as vulnerability, privacy, identity and access management, incident response and business continuity.
- Develop skills and communication tools so that security leaders can effectively convey risk postures and improvement targets.

Business Impact: Cybersecurity is more than a regulatory requirement and has implications for sustainable growth. At the basic level, it ensures business continuity so organizations can provide reasonable level of services without being interrupted by unexpected attacks. It also protects organization's highly valued digital assets so they can retain competitive advantage. As customers are using more digital products and services and more organizations are supporting remote working, organizations face mounting pressures to protect and use customer data in a responsible and ethical way. This helps build trust with customers which will in turn increase customer loyalty and encourage repeat purchases. In addition, as more organizations are supporting remote working for a larger portion of the workforce, they need to have tools and governance to ensure the integrity of their own data to continue doing business and remain competitive.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Bangcle; Huawei; Inspur; Qihoo 360; Qinglianyun; Sangfor Technologies; Synopsys; Tencent Cloud; Thales-Gemalto; Tongdun Technology

Recommended Reading: "Address Chinese Cybersecurity Law With This Playbook"

"China's Data Privacy Standard Unfolds Measures for Its Cybersecurity Law"

"Security Operations Primer for 2020"

Energy-Water Nexus

Analysis By: Bettina Tratz-Ryan

Definition: Energy production and water use are closely interdependent. The energy-water nexus is a term for the complex interplay of cause and effect between water and energy supply and consumption in smart cities, industries and homes.

Position and Adoption Speed Justification: According to the UN-Water directive, by 2020, half the world's population will be living in countries with water supply shortages. Factors that contribute to the shortage include:

- Water is critical to energy supply, such as hydrothermal as well as nuclear power plants.
- 70% of freshwater available globally is used for agricultural purposes, 22% for industrial use and 8% for residential consumption.
- The biggest loss of water is in transport and distribution.
- Although there are new technologies on desalination (removing the saline from saltwater to turn it into freshwater), the process consumes high amounts of energy (approximately 15 kWh to 17.1 kWh per 1,000 gallons of water produced).
- Water is integral for shale gas production.

While sustainable management of water and energy seem battling the risk for many organizations, the lack of true water pricing relative to the cost of delivery distorts the value perception at large. Analytics and data generation through Internet of Things (IoT) opens the insights into which processes in generation and use of water and energy can be optimized for sustainable societal development. Regions and countries with increasing cases of droughts and the shifts in water allocation are challenged in their economic and industrial performances, especially with those highly dependent on oil and natural gas. The uncontrollable increase of population and rapid industrialization in developing countries are also major contributors.

User Advice: CIOs in different water-intensive industries need to build the capital expenditure (capex) of water management tools, the critical factor of price volatility of energy, and the cost related to channel and supply water into their IT procurement models. CIOs must work with city leaders to make the gap between holistic investments versus price of water delivery visible

IT leaders in the industry need to track volatility in real time by analyzing data through smart city, water- and energy-management platforms and boards. End users need to look to involve new energy sourcing that includes waste to energy, circular economy to generate energy and broader energy-generation models in microgrids and distributed grids.

CIOs in emerging economies should apply or evaluate technology solutions such as sensors, IoT and analytics together with modeling and simulation for energy use. They should also network with solutions that create water sustainability and quality of water harvesting and management as they are key concerns for developed markets as well. CIOs should also explore using sensors to prevent water leakages in pipelines and storage tanks.

Business Impact: Business is greatly affected by the availability and cost of energy and water as well as by the competing sources for other industries such as agriculture and food production in addition to water supply to cities. Cost of operations to produce water as well as energy based on competitive uses presents significant issues, and the potential stigma of using water for industrial uses instead of civic uses could prove a reputational risk. Transparency and public relations have to be shown to disperse the concerns for depletion or risk relative to operations. For example, the fracking industry in the southern U.S. is using water from urban centers to bring it to the fracking locations, causing discussions about droughts and water availability in the community. In different industries, the energy-water nexus has caused businesses to change their business processes. The textile industry is dyeing without water, saving the water and, in addition, also energy as the textiles do not need to be dried.

For organizations operating in countries in which the water prices are subsidized, the exploitation of water should be positioned more about responsible use versus scarcity that may lead to economic penalty.

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: ABB; Accenture; Adasa; Black & Veatch; Deloitte; Fujitsu; GE Energy Connections; Hitachi

Recommended Reading: "Digitopia 2035 Scenario: A Sustainable Society — How to Increase Your Digital Ambition"

"How CSCOs Should Lead a Response to the Water Scarcity Challenge"

"Video: Kimberly-Clark's Water Strategy — Risk Management to Value Creation"

Food Safety and Traceability

Analysis By: Andrew Stevens; Milly Xiang

Definition: Food safety and supply chain traceability solutions are a developing portfolio of technology functionality including hardware, software, communications protocols and services Their central purpose is to ensure robust physical product security, integrity and transparency across each stage of the supply chain journey of a food product (for example, meats, fruits, vegetables, grains).

Position and Adoption Speed Justification: Food safety is a long haunting issue for the Chinese government and consumers. The tainted baby milk scandal from 2003 still has ramifications today for the domestic marketplace and food counterfeiting continues to be a significant problem. China's large geographical size and population, huge number of food growers and distribution enterprises, and lack of comprehensive regulations have made food safety a more pervasive problem than in other countries. In October 2015, China officially launched a food traceability system, mandating

food manufacturing enterprises to adopt necessary technologies to ensure food safety. In October 2017, China's State Council released guidelines promoting innovation to establish a smart supply chain covering major industries by 2020. These recent government actions combined with advancing Internet of Things (IoT) and supply chain analytics technologies will push food safety and traceability toward the peak of the Hype Cycle rapidly. However, the supply chain for food in China is very complex and dynamic and consumers remain distrustful, so it will be quite some time before we reach widespread adoption of these solutions. Expectations for solutions increasingly require them to span the end-to-end supply chain (farm-to-fork) levels of operations.

User Advice: Food safety and traceability in China represents a significant opportunity for current and emerging supply chain technology solutions in areas such as digital, visibility, IoT and security. In recent years, blockchain pilots and proof of concepts (POCs) (both within China and globally) have emerged to help address food traceability and safety concerns. There are even mobile applications emerging where food tracking data can be accessed by consumers to inform purchase decisions and where they can provide feedback or rate sources and retailers. A broad range of emerging technologies can be strategically positioned (or combined) to meet objectives centered on food safety and traceability but they will need to be carefully incorporated across a broader roadmap focused on risk assessments of products and protecting the brand at each stage of the supply chain journey.

Industrywide collaboration spanning government entities down through to individual growers will be paramount to enforce food safety and traceability across the supply chain and help in developing authentic solutions that can mature and scale effectively .Since China's image has been negatively impacted by food product quality, counterfeiting, substandard products and safety issues, there is strong motivation to address these issues across the ecosystem:

- Early segmentation exercises and risk assessment across extended physical product criteria are recommended for being able to assess the more appropriate technology solutions for immediate high-risk objectives. For example, dry good products with long shelf lives versus fresh fruit products.
- Organizations involved in China's food supply chain must understand the broader concept of food traceability requirements outside of the four walls of their own business operations, as well as certifications and regulations from the government, suppliers and customers to have context for identifying appropriate technologies and solutions.
- Organizations implementing food traceability projects should leverage the falling technology costs (for example RFID, sensor) and an increasing provider competition to enable better business results and robust project outcomes.

Food traceability projects often incorporate key sensor measurements including temperature, humidity, location, inertia and biologics for which different categories of food products will determine the best aligned sequence of solutions.

Business Impact: There are several vertical and horizontal market implications stemming from a wave of high-profile food safety incidents that largely align with the concepts of the overall food value chain and farm-to-fork models.

- Food value chains increasingly take a broader, product-centric approach to the full life cycle brand protection by consolidating traditional agricultural sourcing supply chains (Agri-tech) in addition to final production, distribution and services provision of the food products .Naturally, any government mandates will be a boon to the food safety use cases for IoT and the associated technology and service providers.
- Farming and agriculture will be impacted from IoT through optimizing food production and enhancing food quality, as will food processors and manufacturers. Transportation — both on the supply chain and across distribution — will be impacted by cargo being monitored for temperature and other environmental factors that affect food quality and safety as well as product freshness.
- Retailers including markets, grocers and restaurants will be impacted by improved shelf life, enhanced quality, reduced consumer returns and significantly reduced liability for selling unsafe food to consumers.

Ultimately food safety and traceability is a shared and collaborative responsibility across an ecosystem of companies and stakeholders and developing solutions in this area will need to continually reflect this in solutions and services offered especially for onboarding, governance and interoperability.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: FoodLogiQ; HarvestMark; Kezzler; Oritain; PAR; Sourcemap; SupplyShift; Transparency-One; TraQtion; Zest Labs

Recommended Reading: “Use Gartner’s Framework for End-to-End Supply Chain Traceability”

“Supply Chain Brief: Improve Your Competitiveness Through Ingredient Traceability”

“Supply Chain Brief: Employ Data Governance to Enhance Food Traceability”

“The 2020 Strategic Supply Chain Technology Trends”

Sustainability and COP 21

Analysis By: Bettina Tratz-Ryan

Definition: During the 21st Conference of the Parties (COP 21) to the U.N. Framework Convention on Climate Change in 2015, around 450 cities and city states pledged to reduce carbon and GHG emissions to contribute to the 2% global warming limit. Since then, cities are becoming environmental and sustainability centers of excellence.

Position and Adoption Speed Justification: Cities face climate-change-related challenges in the form of rising sea levels, rising heat levels and droughts, and challenges to food systems. A large

and growing number of city governments around the world are addressing these challenges with "resilience strategies" that also create opportunities to build new collaboration and infrastructure, sustainable industries, and more holistic citizen engagement. With the aftermath of the COVID-19 pandemic, cities are linking resource resilience, sustainable development goals (SDG) and climate change together to create a sustainable social and business model moving forward. For example, the European Green Deal is putting carbon emission reductions as well as circular economy as key enablers for a sustainable living. The diversity of political and demographic environments will, however, change the momentum on local government due to funding and economic discourse, which leaves this Hype Cycle entry at the current location from 2019.

The momentum and adoption rate are being driven by citizen and business concerns about climate change. Interest groups such as C40 for cities and European Green Capital share insights on carbon reduction and sustainability initiatives and KPIs to measure impact. Based on some local impacts and the social cohesion and contextualization of the urban service environment generated through projects that solve cities' distinctive needs, cities will outpace countries and regions in sustainability and environmental momentum and execution.

User Advice: CIOs in cities like Copenhagen, New York City, Dubai, Singapore and Santiago de Chile have all started to support or develop a sustainable smart city strategy. They are using Internet of Things (IoT) and a range of operational efficiency, data sharing and business process alignment elements to condense the urban asset footprint, while visualizing this impact in various channels. CIOs can support the development of collaboration and dashboarding of like-minded citizens who will engage based on the visibility of environmental activities such as restricting high-emission vehicles in city centers and energy conservation and green energy options for streetlights and buildings.

CIOs have the opportunity to define the key performance measurements of smart city initiatives, while mapping those to sustainability goals, including COP 21 commitments. CIOs need to create advisories on the use of IoT by citizen advisory boards for measuring not only emissions and air pollution, but also waste and recycling rates. This includes starting to cooperate with public-private partnerships with utilities, waste management companies and consumer goods providers to create business awareness and end-to-end life cycle applications in microgrids, recycling, and smart building and home ecosystems.

CIOs can build their city operations centers to orchestrate differing datasets that can link public safety to air quality and critical infrastructure resilience and mobility changes impacting reduction of emissions from combustion engines and uptake of electric vehicles. The centers can even enable citizen and social crowdsourcing of green ideas with citizen engagement and feedback. Using the available data, citizens will gain a perspective on data privacy, as they will see that their data is instrumental in contributing to more-efficient management of the overall environment. When CIOs have good ethical and privacy governance on data usage, citizens will engage with governments.

Business Impact: The impact to the local government CIO is profound: Smart cities demand more user-focused services and experiences, as identifying business impacts that influence environmental impacts has become more transparent. COP 21 declarations of city leaders and other nonstate parties such as R20, ICLEI and C40 create opportunities for CIOs to connect to

industry and cross-jurisdictional governments to build innovation projects that support cities as incubators for green initiatives and new technologies.

In addition, as data becomes an instrumental conduit for transparency and decision making for policy and user experiences, CIOs will be able to build data and shared infrastructure services to connect urban layers to spatial development. CIOs can also share valuable GIS data to insurance, real estate development and banking, as well as to logistics and supply chain organizations to indicate climate change impact on cities and regions, which is posing a business risk.

Reaching sustainability goals needs to become more transparent, which provides CIOs with options to look for frameworks such as STAR Communities and World Bank Group's CityStrength Diagnostic to orchestrate data and create traction.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Deloitte; Esri; Sphera

Recommended Reading: "Digitopia 2035 Scenario: A Sustainable Society — How to Increase Your Digital Ambition"

"Predicts 2019: Smart Cities Will Mitigate Social and Resilience Risks and Reward Digital Opportunities"

"How to Build a Business Case for Sustainability and Social Responsibility in Supply Chain"

"How Can CIOs Keep the COVID-19 Pandemic From Overshadowing Their Sustainability Efforts?"

"Predicts 2020: Resilient Smart City Development Requires Data-Driven Engagement of Citizens and Businesses"

5G

Analysis By: Peter Liu; Sylvain Fabre

Definition: 5G is the next-generation cellular standard by the Third Generation Partnership Project (3GPP). The standard targets maximum downlink and uplink throughputs of 20 Gbps and 10 Gbps respectively, latency below 5 milliseconds and massive scalability. New system architecture includes core slicing as well as wireless edge.

Position and Adoption Speed Justification: Seventy-three operators have announced 5G rollouts (Source: Global mobile Suppliers Association [GSA], April 2020), just under 9% (up from 5% one year ago) of mobile networks. 3GPP Release 16 freeze date has been postponed due to the COVID-19 pandemic, with a freeze target date of mid-2020. 5G encompasses a range of 3GPP standards focused on different functionality:

- R15: Extreme broadband (5G NSA and then 5G SA)
- R16: Augmentations for Industrial IoT (massive IoT, slicing and security improvements)
- R17: Augmentations for wider ecosystem expansion (freeze target date end of 2021)
- R18: Additional augmentations (for example, extra territorial 5G systems, railway smart station services)

Due to this phased introduction, and the time required from the vendors' ecosystem to build standard compliant networks and grow silicon and device availability, Gartner expects the full potential for 5G use cases to materialize first in 2022.

Use of higher frequencies and massive capacity, will require very dense deployments with higher frequency reuse. Here we see regional differences, whereby mmWave will be leveraged in the U.S. but not elsewhere. Gartner expects many 5G deployments to initially focus on islands of deployment, without continuous national coverage.

Uncertainty about the nature of the use cases and business models that may drive 5G is currently a source of uncertainty for many CSPs, enterprises, and technology and service providers (TSPs). We are seeing different dynamics by regions, adoption is more aggressive in APAC and NAR, with Europe cautiously enthusiastic — and the developing world lagging.

China did launch 5G Nov 2019 and with a massive 5G network roll out plan across the country in 2020. China Mobile recently prepared to start the second phase of its 5G rollout — deploy more than 232,000 base stations across 28 provinces and autonomous regions in 2020 (see "Nokia Misses Massive China Mobile 5G Tender"). China Unicom will partnership with China telecom and plan to deploy no less than 250,000 base stations nationwide in 2020.

In addition, Chinese operators wants to be quickly deploy 5G Stand Alone (5G SA), which allows them to enable more innovative opportunities and enterprise services. China will lead 5G deployment, thanks to factors such as large mobile user base, LTE maturity, government policies support, and leading device manufacturers. With operators and enterprises forging ahead in the development of 5G services, and growing consumer excitement, china will accelerate the 5G maturity.

In addition, china also lead the 5G devices deployment. 2019 MWC Shanghai, CMCC executive mentioned that CMCC mandate their vendors to support NSA and SA from January 2020.

User Advice: Enterprise business leaders should:

- Identify use cases that definitely require the high-end performance of 5G; these may be few or even nonexistent for many verticals.
- Evaluate the multiple alternatives currently available that may prove adequate and more cost-effective than 5G for many use cases (for example, low power wide area [LPWA] such as NarrowBand Internet of Things [NB-IoT], long range [LoRa], Wireless Smart Ubiquitous Networks [Wi-SUN]).

CSP product managers should:

- Ensure backward compatibility to preceding generation (LTE) devices and networks. This is necessary because 5G coverage may be limited, so new 5G devices need to be able to seamlessly transition to 4G infrastructure as a fallback.
- Focus on related architecture initiatives — such as software-defined network (SDN), network function virtualization (NFV), CSP edge computing and distributed cloud architectures, as well as end-to-end security in preparation for 5G.
- Provide solutions where new frequency allocations (preferably) should be used for the latest technology — 5G — to benefit from lower cost per byte, higher bandwidth and more capacity.
- Have a clear understanding of specific verticals and their use cases for more effective consultative selling of their 5G solutions.
- Build their ecosystem of partners to target verticals more effectively with 5G.

Business Impact: Gartner Enterprise 5G surveys indicate that vertical use cases with 5G would be first motivated by operational cost savings. In addition, the vertical users for 5G appear to value lower latency from ultrareliable and low-latency communications (URLLC) and expect 5G to outperform rivals in this area.

5G enables, principally, three technology deployment and business scenarios, which each support distinct new services, and possibly new business models (such as latency as a service):

- Enhanced mobile broadband (eMBB) supports high-definition video.
- Massive machine-type communications (mMTC) supports large sensor and IoT deployments.
- Ultrareliable and low-latency communications (URLLC) covers high availability and very low latency use cases, such as remote vehicle/drone operations.

URLLC and mMTC will be implemented after eMBB. Only eMBB addresses the traditional mobile handset requirement of ever higher throughput. URLLC addresses time critical industrial applications such as automation, with latency around 1ms over a limited range for a limited number of connections — where reliability and latency requirements surpass bandwidth needs. Finally, mMTC addresses the scale requirements of IoT. mMTC may not be required in most locations for some years, with NB-IoT and other LPWA such as LoRA being sufficient for a while.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Sample Vendors: Cisco; Ericsson; Huawei; Mavenir; Nokia; Qualcomm; Samsung; ZTE

Recommended Reading: “Market Guide for 5G New Radio Infrastructure”

“Assessing 5G Mobile Technology for Organizations”

“How to Select 5G NSA/SA Migration Paths”

“Forecast: Communications Service Provider Operational Technology, 1Q20 Update”

“Market Trends: Strategies Communications Service Providers Can Use to Address Key 5G Security Challenges”

“Reduce Privacy Risks When Using 5G Products and Services”

Sliding Into the Trough

Water Management

Analysis By: Bettina Tratz-Ryan; Aanchal Mair

Definition: Water management describes a solutions approach using information to holistically monitor water throughout the hydrological cycle. Water management solutions include water sourcing and rainfall forecasting, groundwater monitoring, water analysis for water supply, water treatment plants and wastewater treatment facilities as well as water-loss analysis throughout the transportation cycle.

Position and Adoption Speed Justification: Water management requires a differentiated set of technology and service skills to cater effectively to:

- Distribution for residential and commercial customers
- Water pollution, water treatment and recycling
- Natural disasters (such as flooding and drought)

These skill sets include reporting and management tools for infrastructure and sensors, database and information aggregation and assessment tools. Water management is still in the emerging phase of grid discussion. With priorities shifting by regional or national basis, the topic has captured the attention of industry players due to government initiatives as well as the developments in pricing of water — once meters that monitor true consumption are installed. The position of the Hype Cycle entry has not moved again in 2020 in the Hype Cycle because water management has developed more-complex use cases. While local utility and freshwater supply is experiencing more water intelligence, the imbalance of climate-related resource shortage and natural disruption is still not priced in the supply, therefore artificially keeping the delivery cost low. Water management is also growing for applications with industry and business uses including touristic sites like beaches and lakes. In reverse, it also offers insights into disaster recovery for water-related issues in manufacturing operations. In the future, residential water needs will be computing with the business needs and analytics will be needed to bring balance together. South Africa and the state of California are examples for this competition.

But there is also an infrastructure resilience issue which solutions are addressing now with artificial intelligence (AI). Adoption is accelerating as emergency response around water crises in drought

and flooding relative to shifts in weather patterns has captured businesses from a risk perspective. Water quality issues through agriculture fertilization are driving water prices in cities up by up to 50% year over year in countries like Germany. That is accelerating the deployment of new water management solutions as well as the time to deliver water to customers.

User Advice: Users (industries) and suppliers (municipalities) need to evaluate the implementation of data management and analytics for their water infrastructure and water quality. This is particularly true when they must report or comply with increasing wastewater regulations, while improving efficiency and reducing loss and waste-disposal costs. Especially in emerging smart city planning scenarios, the build-out of smart grid and meter data management, together with water management data analytics, can provide a real-time view of natural or managed hydrological resource consumption. Intelligent water meters on consumers' premises enable water suppliers and municipalities to monitor consumption and create incentives for more efficient water usage as well as identify potential customer service problems due to poor water pressure or quality. Remember to implement security standards in the water management process, the physical infrastructure and the privacy policy on consumer data. For municipal water utilities or sewage plants, water management dashboards will assist in providing real-time data on water quality. In addition, sensor-based water management systems can detect water leakages in dams and pipes, especially important in projecting flooding or contamination situations for heavy rainfalls or during monsoon seasons. In addition, assess processes that are triggered through emergency response events in terms of not only viability of infrastructure but also quality and contamination issues. IT professionals in utility and municipal contexts need to include the opportunity to develop an adaptive and flexible water management strategy, cognizant of the legacy of IT and operational technology (OT) integration. The strategy should be based on intelligent information received and analyzed from environmental sensor and satellite networks, smart water meters and deep computing and analytics engines.

Business Impact: Consolidating previously fragmented data points and tools to manage and control water issues, from supply to reuse and recycling, provides water suppliers and municipalities with the ability to reduce costs. It also improves both the interface between asset tools for pumping stations, meters and monitors, as well as customer service with fewer water supply failures and better water quality. Partnerships with IT and water operations have to be built to connect the different data and information sources for a consistent analytics framework. As data will be the driving source for business models, it will be important to build financial models with asset management and new service models, especially in smart ecosystems — including cities. Leveraging geospatial and hydrological models will assist not only with the right workforce allocation but also with water rationing and quality control. It also supports scenario planning for communities that need to manage competing interest groups and disaster preparedness.

The complexity of water management data will also require more solutions capabilities related to an entire management cycle that includes operations, user billing and monitoring, and forecasting of demand and quality.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: ABB; Adasa; AquamatiX; Arcadis (SEAMS); Atos; Ecology Examination; GE; IBM; KISTERS; Schneider Electric

Recommended Reading: "Predicts 2019: Smart Cities Will Mitigate Social and Resilience Risks and Reward Digital Opportunities"

"10 Critical Actions Water Utility CIOs Should Take to Move Digital Initiatives Forward"

Smart Parking

Analysis By: Roger Sheng

Definition: Smart parking uses various sensors, IP cameras and third-party service providers' data to identify available and occupied parking spots, recognize the cars' number plate and aggregates user information to offers the parking service via mobile apps. Sensors can be installed in the entrance/exit, a parking surface and/or in parking meters as well as in parking garages. The collected parking data analytics can improve the efficiency of parking and link to relevant commercial services.

Position and Adoption Speed Justification: China is the largest market of automobiles with 250 million passenger vehicles right now. In the large cities such as Shanghai and Beijing, parking in the downtown area has become one critical issue to the car users. It drives the demand of smart parking, which can provide effective solution to maximize parking service efficiency.

Driven by the government's smart city initiatives and venture capitalist's investment, smart parking systems are being deployed widely in some large cities. The smart parking service is usually linked to a mobile payment platform to collect the parking fee automatically. In areas adopting smart parking systems, vacant parking information is apparent and users can even find their car by positioning sensors. Additionally, users can get promotion information or a discount coupon when the smart parking system is linked to digital business platform in the shopping mall or commercial building. For example, the expense can be transferred to free parking coupons to encourage consumer spending more in the shopping mall or restaurant.

AI technology is adopted in the smart parking system to recognize the number plates by compute vision and manage the parking slots efficiently. The smart parking service has higher penetration in indoor parking spaces such as shopping malls, hospitals, schools and transportation terminals because of the high demand of a parking service. One major local vendor, ETCP, had already cooperated with more than 10,000 parking lots with over one million parking lots covered by their smart parking services. It reports there are more than 33 million users registered its apps to use ETCP's parking service solutions.

The adoption of NB-IoT network will provide a cost-effective communication technology for off-street smart parking systems, which is still low in China. More cities and provinces including Hangzhou, Jiangsu, Shanghai and Jiangxi announced a plan to increase the off-street smart parking service via the smart parking system.

User Advice: The smart parking systems will include many heterogeneous systems with various standards and protocols to be connected. It will raise the challenges to system integration. Automotive organizations, service providers, IT providers and government CIOs should prioritize smart-parking-related investments because of their high potential to reduce congestion, decrease fuel consumption and develop local merchant business.

As for better return of investment, end users need to realize the importance of addressing business related aspects to link with the digital business platforms among multiple organizations (for example, parking garage owners, parking application providers, real estate management service providers and commercial merchants) and prepare incentive programs to promote the service to car owners by installing smart parking apps in their smartphones or follow service accounts in the Alipay or WeChat.

With the growth of smart parking penetration, city governments might face some challenges. For example, fewer ticketing laborers are needed, as the system can cover a wider range of parking spaces. Another issue is that drivers may not be familiar with the mobile apps for parking payment. City governments and commercial parking service providers should invest to promote and encourage the car owners to use the smart parking service by more attractive prices. Also, the security issue should be considered to protect smart parking lots by a surveillance system.

Business Impact: Smart parking can lead to new revenue sources and optimized resource management for cities, solution providers and end users (for example, drivers and fleet operators). Local governments can share the street parking system API with service providers' mobile apps to improve the utilization of parking spaces and create new business opportunities. It is convenient for car drivers to identify available parking spots, regardless of whether they are public or private. The apps can adopt AI technology to realized business automation. The impact will be further significant if city governments can implement parking sharing and parking reservation systems. Shanghai and Beijing have worked with third-party companies on a pilot project in small residential areas where parking owners release parking spaces for sharing when they aren't using them and earn a parking fee from anyone who reserves the space and pays by the length of leasing period. Additionally some parking lots in the commercial buildings can offer a "night parking" service to nearby resident areas where don't have enough parking spaces. This increases the utilization rate of parking spaces. Consumer interest in such applications and services is high because of the potential user benefits of enhancing the driving and ownership experience.

Requirements for infrastructure and technology investments, the development of new business models, and the need to offer reliable and ubiquitous real-time parking information will take time to evolve. For the long term, the impacts are not only better traffic and less environmental pollution but also new revenue sources from facilitating new business models from mobile apps and staying engaged with citizens.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: DingdingTingche; ETCP; Fangle Technology; Gemtek Technology; Huawei; Roblox (Ecaray); ZTE

Recommended Reading: "Hype Cycle for Smart City Technologies and Solutions, 2019"

"Market Trends: Collaboration Is the Key to Service Providers' Success in Smart City Projects"

"Connected Cities: Road Traffic Management — IoT Opportunities Include Road Tolling and Smart Parking"

Government Open Data

Analysis By: Uko Tian

Definition: Open data is data that is made freely available for others to use, combine and redistribute as they wish, without discrimination or intellectual property restrictions. It may be made available by individuals, businesses or government organizations. Open data in government makes information available to the public.

Position and Adoption Speed Justification: Open data is an important initiative in the Chinese government's digitalization plan aiming to improve its management and service capability. By 2019, more than 100 provincial or city-level governments have established dedicated portals to share a wide variety of data. Big data administration organizations at all levels are promoting open sharing of data, including breaking data silos, opening up data to the public, developing guidelines, classifications and standards for government open data.

COVID-19 provides an opportunity to test government open data effort. Higher data transparency has helped the government to establish higher citizen trust and more effective policymaking and implementation. It also enables third parties to develop new kinds of digital applications and value-added services. It has successfully demonstrated the value of open data in government administration. Open data is expected to gain greater penetration and will expand to data pertaining to the environment, transportation, healthcare and public security.

However, challenges remain, such as weak data governance and data protection (especially privacy compliance management), which hinders the further openness of government data, as well as participation willingness of private sectors. So far, China lags behind in overall consciousness on the ethical use of data. It may take a longer time to construct data governance mechanism across all entities than technology.

User Advice:

- Government should build up data governance mechanisms, including drafting standards on data classification, data quality, data trading and defining security levels of data. Based on this, the government should continue to drive further openness and the sharing of data horizontally and vertically.

- Local governments should build a scheme on open data, set clear objectives, and explore possible use cases and business models to accelerate adoption.
- Enterprises should explore innovation opportunity in products, services, and business models, and improve decision-making by leveraging the government's open data.

Business Impact: Two major benefits could be derived from open government data:

1. Open data enables third parties to leverage government data through development of applications and services that address public and private demands. Businesses may take advantage of government open data to launch new products, services and business models.
2. Making government data available to the public increases government transparency and accountability; meanwhile support local technological innovation and economic growth, enhance citizen engagement with the government.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Group; China WiSERV Technologies; FiberHome Telecommunication Technologies; Global Big Data Exchange; Inspur; JUSFOUN Big Data Information Group; Sugon

Recommended Reading: "7 Ways to Maximize the Impact of Open Government Data: Lessons From France"

"4 Steps to Drive Sustainable Value for Government Shared Data Initiatives"

Internet of Things in Smart Cities

Analysis By: Milly Xiang

Definition: The Internet of Things (IoT) is the network of dedicated physical objects that contain embedded technology to communicate and sense or interact with their internal states and/or the external environment. IoT comprises an ecosystem that includes assets and products, communication protocols, applications, and data and analytics. In the context of a smart city, the key area of IoT deployments including various use cases across city infrastructure management, public transportation, sustainability, healthcare, utilities and so on.

Position and Adoption Speed Justification: In China, the number of smart cities IoT projects is significantly increasing. In a short term, there are areas witnessing early deployment and benefits from IoT, including public safety, road toll and traffic management, street and outdoor lighting, smart metering, air quality, waste management and so on. Especially, during the outbreak of COVID-19, a range of IoT innovations has been inspired to help slow down the spread of the virus. These include homestay quarantine monitoring, bio-sample storage, transport and lab test, contactless elevator control, thermal imaging temperature test, smart trash bins for contagious wastes, driverless courier services, among others.

Cities are increasingly realizing that the value of IoT deployment lies in the enablement of more applications and explore more insights out of data to transform city operation and core service delivery. Leading cites in China start to shift from an infrastructure-centric toward a data-centric approach in their IoT strategies. However, this transformation is not without challenges. Changing work culture, tackling conflicting interest and breaking the organizational and data silos may take time. This Hype Cycle entry is on its way moving into the trough as cities continue to address the abovementioned challenges, while restrategize and reprioritize the investment and use cases toward higher openness and resilience after COVID-19.

User Advice: Targeting a scaled IoT deployment and optimization in smart cities, below are recommendations for city CIOs and IT leaders by Gartner:

- Work across departments to build a holistic IoT strategy to support the city's smart city initiatives and priorities by engaging the city stakeholders to identify short and long-term projects.
- Lead to build a more transparent public bidding process with a clear benchmark and requirement to build and encourage the private sector participating in smart city development.
- Build a base of well-governed data, partnership and sustained commitment from leadership by engaging with city leaders for support on bridging cross departmental IoT effort, breaking data silos, and for influence on ecosystems coordination.
- Focus on the "city" and the "people" in IoT projects, in areas of equal accessibility and user experience by designing for them and help them fully understand how to leverage and benefit from these projects.
- Educate government organizations and alert them for potential events around social, legal and ethical issues. Review strategy and policies in this area on a regular basis. Especially in China, this area is even more immature with limited guidance in terms of laws and regulations.
- Retrain government workforce to leverage these new technologies, so that the benefit of IoT can be fully realized, by helping them handle the challenges of disrupted work processes and policies, different skills and toolsets requirements as a result of IoT solutions.
- Invest in integration capabilities and tools from different internal data sources, as well as third-party data through data exchanges programs, coupled with a holistic plan on data storage and analytics strategy.

Business Impact: A success IoT deployment in smart cities enhances overall collaboration and participation of urban ecosystem through getting city infrastructure and people connected and tied up with the common goal of improving city operations and the quality of urban living. IoT deployment in smart cities is potentially impacting the entire urban ecosystem:

- Government organizations leverage IoT to increase the visibility of the city infrastructure status and improve decision-making based on data generated through these connected infrastructures for optimized and human-centric government management.

- Citizens will benefit from IoT deployments which have potential to irrevocably change their environments in momentous ways, in all aspects of urban experience and government services including living, commute, entertainment, food, among others.

Local industry will be able to harness the opportunity of the data that will be made available to optimize their business models. It could also help in analyzing user behavior data gathered through different sensors.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Cloud; Baidu; China Mobile; China Telecom; China Unicom; Digital China Information Service; Hikvision; Huawei; Terminus; ZTE

Recommended Reading: "Market Trends: Smart City IoT Deployment Trends in Asia/Pacific"

"3 IoT Innovations That Should Be on Your Smart City Solution Roadmap"

"Product Managers Should Incorporate Human Factors in IoT Solution Design and Development for Smart Cities"

Mobility as a Service

Analysis By: Pedro Pacheco

Definition: Mobility as a service (MaaS) is a platform that provides users seamless planning and booking of different means of transportation — vehicles, planes, boats, bikes, scooters and other transport modes — to go from A to B. Supporting systems enable providers to deliver services to the customer efficiently. This is done by providing intelligent, real-time, context-aware data exchange and service offerings between conveyances, operators, passengers, assets, routes, timing and traffic patterns for the customer.

Position and Adoption Speed Justification: MaaS is falling toward the Trough of Disillusionment. Its adoption has been growing, with several cities embracing MaaS solutions — either through the hands of private companies like MaaS Global or through initiatives of local transport authorities. One good example is Jelbi, launched last year by Berlin's transport authority (BVG), which claimed that Jelbi was the world's largest MaaS app due to the diversity of mobility solutions offered. MaaS is a key solution for large city planning and transport authorities by helping move people more efficiently and with less dependence on personal cars. The impact on smart cities is substantial, particularly to transportation. Benefits can also be derived by leverage of contextual information about residents, businesses and mobility needs mapped against real-time data such as time of day, number of vehicles and travelers, pricing of road traffic per time of day and user, and environmental impacts (for example, pollution, noise, productivity and environmental quality). These services are also being integrated with public transportation, providing subsidized, on-demand rides in areas where regular service is not practical.

However, COVID-19 is heavily impacting passenger volume on public transport and taxi or ride hailing. This factor can slow down the adoption of MaaS solutions in the near future.

User Advice: CIOs in transportation should invest in MaaS as an important component of future city planning and an enabler for further reduction in urban emissions. However, CIOs in MaaS and city transport authorities should pivot their strategy to adapt to the postpandemic world. As travelers may be less keen to adopt public transport due to fear of infection, MaaS developers should strengthen their offer in the field of shared mobility, including shared cars, e-scooters and bicycles.

In order to fight possible headwinds, MaaS developers should consider new ways to monetize their solutions. MaaS for goods delivery and advertising may be good ways to achieve that. For instance, public transport could also be used to deliver packages in urban areas in parallel. In addition, policymakers need to be cognizant of implications on regulations to ensure openness, interoperability, fair competition, safety and privacy. CIOs across both the private and public sectors will have to discuss the issue of data ownership and privacy when systems tap into data from the various transport modes. While those datasets are critical to creating more contextualized service offerings, there should also be enough focus on ensuring a high level of data protection.

City planners should also adopt MaaS models to further benefit the urban environment in terms of reduction of traffic and emissions but favoring the most effective solution for each situation. For instance, evidence today suggests companies like Uber and Lyft have reduced use of public transportation and increased the number of miles driven on city streets. Such situations undermine some of the advantages brought by MaaS, hence demanding a more holistic management of the overall efficiency of MaaS.

Business Impact: MaaS impacts numerous markets, ranging from smart cities to core transportation producers (for example, cars, trucks, trains, planes, ships and bikes). With technologies ranging from wireless communications (LPWA to 5G) to virtual reality and shared economy trends leading to further innovation and operational optimization, we will continue to see usage models changing. MaaS will broadly impact efficiency and effectiveness, mobility options, economic development, safety, security, population urbanization, proximity of people's homes to work and climate change initiatives. The innovation behind MaaS in terms of technology and business models will both benefit and challenge public transportation. For example, MaaS can improve the appeal of public transportation by making it more efficient, yet draw demand away from it — referring again to the examples of Uber or Lyft. It can also have the effect of enhancing and lowering the cost of private options (such as private ride-sharing and car-sharing services). When this happens, citizens may forgo public transport and, thereby, reduce city revenue and increase traffic congestion (as observed in Massachusetts in the U.S.). This could be offset by productivity gains from city assets and cost savings from reduced infrastructure wear and tear; however, cities must carefully consider the overall implications of MaaS. MaaS will also have an impact on other areas of government, such as human services, where MaaS will offer alternative transportation options that will require adjustments on how funding can be used for paratransit.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: DiDi Chuxing; Lyft; MaaS Global; Mobike; Ola; Uber; Zipcar

Recommended Reading: "3 Ways Transportation CIOs Can Shape a Mobility-as-a-Service Ecosystem Effectively"

"Use Scenarios to Plan for the Future of Mobility 2025: The Scenarios"

"What CIOs Need to Know About Micromobility"

Computer Vision in Smart Cities

Analysis By: Tracy Tsai

Definition: Computer vision (CV) is the process of capturing, processing and analyzing images and videos to extract meaningful, contextual information. CV includes a variety of applications, including face recognition, video analytics for user behavior, autonomous vehicle and many other video and image analytics use cases.

Position and Adoption Speed Justification: The adoption of computer vision in China was initially driven by face recognition and surveillance, transportation, or education. Due to the recent outbreak of COVID-19, the hype for computer vision in China is further sliding into the trough driven by applications in supporting social distancing and citizen health and safety monitoring. For example, the infrared thermostat measuring, face recognition with mask wearing, computer-vision-enabled camera on the drones to monitor citizen's quarantine and social distancing

The most common smart cities computer vision applications are traffic management (for example, congestion, crash detection, vehicle classification) and transportation. Next in priority is law enforcement, such as facial recording, number plate recognition, forensic video search, among others and after which things like citizen experience (such as people counting, queue management and so on) come into play. These types of application have been around a long time and will still be there after COVID-19.

However, it still takes time for the technology to reach maturity as the applications for CV are quite diverse and taking time to build the data and models. For example, the use of CV in medical image diagnostics will still take time. Many tech providers are collaborating with academic research centers at hospitals to obtain and label the image data. But it takes time to build learning models to meet regulatory requirements and get National Medical Products Administration (NMPA) approvals.

User Advice: Government and enterprises adopting computer-vision-enabled applications should start with smaller scope of project before launching in a larger scale deployment. The purpose is to have enough communication and agreement on what objective to achieve among subject domain expert, IT staff and data scientist. For example, how to define the accuracy of the result or what specific information we are trying to obtain. Taking the social distancing monitoring as an example, how to define the space between people as good or bad distance. As behavior is moving constantly, the result can also change constantly. The false alarm creates unnecessary hassles and discourages users in adopting the behavior analysis.

Validation of vendors' claims about the high accuracy of their models is also difficult because there isn't any standard or benchmark available in the market. The best way to validate vendors' claims and capabilities is to test the CV models with your own data within your organization. The minimum testing period is from one days to one month to see the actual performance results of the vendors' retrained model based on your own data and scenarios.

When evaluating vendors, requirement for data privacy security is important to ensure the captured data is probably encrypted and protected without revealing individual identity.

Business Impact: Post COVID-19, governments will increase their investment on public healthcare to prevent disease outbreak again. The benefits of computer vision to support public healthcare will impact not only citizen health and safety, but also society and economy. Surveillance remains the top priority safety. However, business impact will be an increasing concern for individual privacy. Along with more and more internet protocol cameras everywhere in public or commercial space, how government and enterprise ensure the captured images are protected without being able to track the individual's private information is an issue. For other vertical industries, such as medical, the image diagnosis could fill the gap of medical resources at lower-tier cities. In the next 12 to 24 months, we anticipate vendor efforts for more domain specific CV applications in manufacturing, healthcare, retail, consumers and government.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Group; Baidu; Hangzhou Hikvision Digital Technology; IBM; MEGVII; Microsoft; SensingTech; Tencent; YITU Technology; Zhejiang Dahua Technology

Recommended Reading: "Market Guide for Computer Vision in China"

"Market Guide: China AI Startups"

"Competitive Landscape: AI Startups in China"

"Venture Capital Growth Insights: Computer Vision"

"Market Trends: Facial Recognition for Enhanced Physical Security — Differentiating the Good, the Bad and the Ugly"

"Video Analytics Functionality Spectrum: Competitive Advantage Lies in Basic Performance and Unique Features"

Advanced Metering Infrastructure

Analysis By: Uko Tian; Milly Xiang

Definition: Advanced metering infrastructure (AMI) is a composite technology comprising several elements — consumption meters, a two-way communications channel, a data collection engine (headend) and a data repository (meter data management). Jointly, they support all phases of the meter data life cycle — from data acquisition to final provisioning of energy consumption information to utility applications, corporate users or end customers.

Position and Adoption Speed Justification: AMI in this document focuses on subsectors of utility industry (electricity, gas and water).

Among the three areas, electricity is the most advanced in AMI adoption, driven by continuous investment from State Grid and China Southern Power Grid (the only two grid infrastructure companies in the country). Despite the high penetration rate of smart meters, AMI has not yet fully realized its promised benefits in the power grid due to weak connection and communication coverage. In addition, grid companies must transform their business models from today's planning systems and become more market-oriented or consumer-oriented. This shift is greater than the technical challenges.

AMI's adoption in gas and water has grown rapidly. Being an essential part of a smart city, "smart water" has been listed on many cities' agendas, which has therefore driven the adoption of AMI in water management. Mega large cities such as Beijing, Shanghai and Shenzhen are making rapid progress in the deployment of smart water meter. The implementation of stepladder gas prices has directly led to increasing demand for smart gas meters and AMI. In the coming years, the demand for AMI in water and gas will continue to be strong.

Communications, including network coverage, costs associated with communication module and usage used to be a barrier for AMI adoption. The three telco operators have increased NB-IoT network coverage and lowered the module cost, which eased users' concern on AMI's adoption. Meanwhile, grid companies are also proactively exploring alternative technologies, such as LoRa, LTE230 in addition to the currently widely used HLPC.

Most AMI players are traditional smart meter providers that have industry know-how and can transform into system integrators with a total solution of front-end devices, connections, platforms and application development. They have developed solutions through the integration of emerging ICT technologies, such as cloud, IoT and big data.

User Advice: Enterprises should realize that advanced metering with frequent meter readings will help them understand energy consumption, pricing and potential savings in aggregate or in specific situations. Data readings from advanced metering will integrate into facility management or home-area networking to establish the ability to manage energy consumption from a volume perspective and a pricing perspective. Corporate IT leaders should focus on those offerings as they promise energy cost savings and management control.

Business Impact: AMI enables dynamic pricing for grid companies and enables business innovation in value added services, as AMI provides two-way communications. For enterprises, AMI allows them dynamically plan based on energy usage and pricing so as to optimize business operation and energy management.

AMI is an indispensable solution to stabilize the energy demand and supply to manage different network loads.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: Goldcard Smart Group Co.; Itron; Suntront Technology; Wasion Group; Xylem

Recommended Reading: "Market Guide for Meter Data Management"

"10 Critical Actions Water Utility CIOs Should Take to Move Digital Initiatives Forward"

"Top 10 Trends Driving the Utility Industry in 2020"

Electric Vehicle and Charging Infrastructure

Analysis By: Roger Sheng

Definition: Electric vehicle (EV) and charging infrastructure are both in the new energy vehicle application domain. EVs use battery-stored electricity to power car engines and can be recharged with a public or home power socket. Plug-in hybrid EVs (PHEVs) have both rechargeable battery and conventional gas-powered engine in one vehicle. Charging infrastructure provides the electric charging service in public or residential areas in China.

Position and Adoption Speed Justification: Due to the large reduction of subsidy in the second half of 2019, the sales of EVs and PHEVs in China saw the first time year-over-year decline (~4%), which was approximate 1.2 million in 2019. However, China still kept as the largest EV/PHEV market, which had market proven technologies and emerging charging infrastructure. In 2019, the power charging stations and piles were over 1.2 million in operation, which saw around 50% growth over the previous year.

Chinese local automotive companies are the major vendors in the EV/PHEV market, but most of the EVs are A00/A0 classes, which are small and inexpensive. After the reduction of subsidy, consumers are moving to more luxury cars such as Tesla, NIO and other luxury brands. From the end of 2019, Tesla started production of Model 3 in its giga-factory in Shanghai, which helped Tesla had strong growth in the Chinese market. It will accelerate the competition in the market and drive the ASP up because Chinese consumers are seeking for high performance cars.

In 1Q20, China experienced almost more than one month lock-down due to the COVID-19 crisis. The pandemic seriously impacted the car market but EVs had better performance than traditional gas cars because the Chinese government decided to extend the subsidy policies for EV/PHEV market until 2022, which was planned to be terminated in 2020. Also, the Chinese government decide to increase the investment in the charging stations and piles as one of new infrastructure to stimulate the economic rebound from pandemic impact.

The emerging on-demand vehicle rental service is one outstanding use case for EVs. The service providers such as EV card offer the renting service to the consumers by providing low cost EVs in the city where it is not convenient to drive their own car. It works with infrastructure and parking service providers to get the power charging service. However, the business model was not profitable in the past three years so the service providers were consolidated in 2019.

In the large cities, the free license plate is a very effective policy for the EV market. Local governments plan to aggregate various service providers' systems in a uniformed platform for charging service. It will improve the user experience by offering standard service in different charging stations. However, the shortage of parking areas for residential apartment areas in megacities is one major challenge to get EV/PHEV buyers to set up power charging in their homes. It is the key fact that PHEVs has high demand in big cities because it can use stand-alone gas engines when their batteries run out of power.

User Advice: For EV/PHEV manufacturers:

- Engage with local partners to build local factories close to the target market. It can help the vendors to influence the local supporting policy for better subsidies.
- Develop innovative business models such as car rental business models as a part of smart transportation service for smart city initiative. Car-sharing service providers can use IoT technologies to analyze driving data, which will be important to provide efficient transportation service and vehicle operation to reduce the operation cost.
- Cooperate with relevant internet automotive service providers to implement connected functions and implement an advanced driver assistant system (ADAS) on new platforms preparing for the transformation of a smart car service provider.

For power-charging service providers:

- Work with digital map and navigation service providers to provide location information for EV/PHEV users.
- Develop a price matrix for different kinds of PHEV/EV users (individual, commercial or public) and for different charging places (residential, commercial or public areas) to ensure the return from infrastructure investment.
- Adopt sharing business model for power-charging stations to increase the utilization.
- Plan a supportive business model to fulfill the demand from power charging.

Business Impact: EVs and PHEVs will affect all parts of the energy value chain and transportation infrastructure service in the smart city framework. It will force energy companies to change the revenue model by providing differentiated power charging service. The grid companies should plan a supportive business model to fulfill the demand from power charging. EV charging will generate big demand on power and balance the power usage in the nighttime versus daytime (assuming more individual EV/PHEV users will charge over the night).

EV rental as a service will be one of the options to reduce traffic density in big cities. Well-organized and connected EVs, car-parking and charging services, users and automotive services will change the usage modes of personal transportation in the smart city framework.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: BYD; EVCARD; SAIC MOTOR; State Grid; Tesla

Recommended Reading: "Government Policies Will Drive Further Electric and Plug-In Hybrid Vehicle Market Growth in China"

New-Type Smart City Framework

Analysis By: Milly Xiang

Definition: The "New-Type Smart City" initiative is part of the Chinese central government's new-type urbanization planning in the 13th five-year plan (2016 to 2020). A new-type smart city framework is guided by this initiative to create a virtual or physical platform of engagement between government entities, citizen groups, entrepreneurs and businesses to improve citizens' life, stimulate economy and protect environment.

Position and Adoption Speed Justification: COVID-19 is a stress-test of China's smart city efforts in the past few years. It has shown the importance of data sharing and it has put infrastructure and legislative frameworks to the test. For example, Hangzhou outshine other Chinese cities during COVID-19 in prevent and rebound from the epidemic through data-driven decision at the right time, the right place, for the right people. As Chinese governments of all levels learn from the COVID experience, they will continue to shift investment to streamline smart cities toward resilience in urban development. This translates into transparency and openness, service quality, horizontal and vertical collaboration and integration guided by new-type smart city framework. This will support city administration to manage the next black swan event in a more agile and resilient manner.

Greater penetration of new-type smart city framework is expected to be in three to five years. City governments encounter several challenges in their new-type smart city initiatives, including lack of capability and resources for top design, business model and funding model innovation, avoiding vendor lock-in, platform integration, data analytics and governance, and so on.

User Advice: The new-type smart city framework execution requires actions from multiple participants, aka an ecosystem, who need to realign their strategies to address these changes:

- Local governments need to promote city-level open data sharing across departments. They need to enforce data governance standardization and avoid being locked in by a single vendor or vendor ecosystem. They should focus on creating win-win models to encourage private

sector's participation in smart city initiatives. In the meantime, local governments need to work on developing capabilities to better leverage the data they are collecting.

- Provincial governments need to create an environment of data sharing among different departments and cities, even across public and private sectors. In the meantime, supervise and inspect the progress of bridging the gap in sharing data and information, in terms of both technology and nontechnical angles.
- National governments need to accelerate standardization process and issue guidelines to guide openness and collaborative development of smart city projects. In the meantime, push ministry-level coordination to enhance cross-departmental data collaboration.
- Enterprise operating in various industries in different-level cities need to understand how to leverage the city's open data to optimize their business. On the other side, they need to build their internal strategy, to support and contribute as part of the smart city ecosystem for the cities they operate in.

Business Impact: The deployment of new-type smart city framework will bring changes to the smart city ecosystem environment in terms of better standards, greater collaboration within government organizations and across citizens and ecosystems. It enables open data and ecosystem data exchange with the ability to demonstrate shared benefits for all stakeholders involved. Focus on service equally will force city governments to reducing digital divine, to make sure smart city initiatives benefits greater audience. Smart city increasingly goes beyond government and potentially influence every single industry within the city territory, such as retail, transportation, healthcare, education, tourism, industrial, among others.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Cloud; Baidu; China Mobile; China Telecom; Digital China Information Service; FiberHome Telecommunication Technologies; Founder Group; Huawei; Tencent

Recommended Reading: "Establish an Urban Data Exchange for Smart Cities"

"Smart City Funding Models: It's Time to Be Creative"

"The Urban Data Exchange Will Be an Engine of Community and Ecosystem Innovation"

Blockchain in Government

Analysis By: Arnold Gao

Definition: Technically, blockchain is an expanding list of cryptographically signed, irrevocable transactional records shared by all participants in a network. Each record contains a time stamp and reference links to previous transactions. Conceptually, blockchain refers to a broader, decentralized

architecture that has the potential to disrupt, for example, data sharing, business model transformation or governance.

Position and Adoption Speed Justification: China is very pro-blockchain technology as the government seeks to lead in innovation worldwide. In 2016, Blockchain has become part of country's 13th five-year plan and helped to make China the country with the single most blockchain patents filed in 2017. In 2019, Blockchain was designated as a "national priority" while local governments such as Guiyang and Xiong'an have prioritized Blockchain as part of its smarty city and digital government initiatives.

Blockchain is still facing challenges in massive adoptions although local government has published white papers and established labs. As the technology itself is still nascent, many government led applications can be built by Blockchain but also by other alternative technology solutions. While the government has determined to forge forward with Blockchain, there are limited use cases that have truly exploited the value from this technology.

User Advice: China is very pro-blockchain technology as the government seeks to lead in innovation worldwide. In 2016, Blockchain has become part of country's 13th five-year plan and helped to make China the country with the single most blockchain patents filed in 2017. In 2019, Blockchain was designated as a "national priority" while local governments such as Guiyang and Xiong'an have prioritized Blockchain as part of its smarty city and digital government initiatives.

Blockchain is still facing challenges in massive adoptions although local government has published white papers and established labs. As the technology itself is still nascent, many government led applications can be built by Blockchain but also by other alternative technology solutions. While the government has determined to forge forward with Blockchain, there are limited use cases that have truly exploited the value from this technology.

Business Impact: Blockchain can be used as a tool to enable data sharing among various government bodies and to build a technology infrastructure to support the smart city and digital government initiatives. More importantly, Blockchain can create the next-generation governance model based on game theory. It is a consensus system with multiple participants. The consensus is the result of an incentive mechanism that can reward or punish — those who obey the rules will be rewarded, while those who break them will be punished or even removed from the system. In this model, government can play a key role to define the initial rules and refine them based on the results of the competitions among the participants. This will help achieve consensus more efficiently.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Ant Financial Services Group; Hangzhou Qulian Technology; Tencent; WeBank

Recommended Reading: "Evaluate Promising and Maturing Blockchain Use Cases in Government"

"Blockchain Will Fundamentally Change How Boards Operate and Govern"

"Blockchain Reimagined — Apply Game Theory to Unleash Its Potential"

Digital Government

Analysis By: Peter Liu

Definition: Digital government is a government designed and operated to take advantage of digital data in optimizing, transforming and creating government services. It is the technology framework of the digital interactions between citizens and government (C2G), government agencies (G2G), government and employees (G2E), and government and business/commerce (G2B).

Position and Adoption Speed Justification: The imperative for governments to close the technology-enabled innovation gap with the private sector has never felt more urgent. Government CIOs face increasing pressure and expectations from their leadership and their constituents to deliver better, more efficient, more readily usable digital experiences. Meanwhile, the boundaries of government have become increasingly porous, blurring the distinction between government and public service providers such as healthcare, transportation, public security services, among others.

Digital government concepts are emerging in the marketplace, while the scope of digital government is still open to interpretation. While many vendor products aspire to fit Gartner's definition, most of their features aren't yet capable of delivering all those benefits consistently and completely. Consequently, solution choices can be daunting.

Digital government platform at the national and sub-national levels in China are evolving at a rapid pace. With the first generation of basic digitization of government operations now complete, Chinese authorities are looking at how leading-edge technologies and big data can further improve the performance of government, both in terms of data-driven decision making and public services. The construction of digital government has been accelerated all over the country since 2019. A national integrated online government service platform was put into trial operation in November 2019, which has promoted connectivity, data sharing and business collaboration of government service platforms among various regions and departments, according to the report. The platform brought better experience for citizens and businesses and make their lives easier though improving efficiency.

Another key message is the encouragement to build the ecosystem through third-party platform. Many municipal governments have started to partner with technology or cloud service providers, such as Alibaba Group, Baidu, Hikvision, Huawei, Inspur and Tencent, to build their digital government platform. Leveraging these companies' expertise in social networking, big data, Internet of Things (IoT), AI, facial recognition and data analytics capabilities will help agencies and municipal governments to further improve online service quality, public safety measures and citizen interactions. This collaboration drive innovation in digital government services. For example,

leveraging the data from the commercial sector to complement government owned data to offer more comprehensive services.

Digital government transformation is one of the mission-critical priorities for china government in 2020 due to the COVID-19 outbreak. The COVID-19 outbreak will impact that in several ways, ranging from changing priorities and fund reallocation, to the need to accelerate certain developments to face the threats.

User Advice: IT head of government agencies should:

- Connecting and federating proven technology enablers such as cloud, mobile, data analytics, APIs and the IoT. Government CIOs must bring together diverse, cross-functional teams to maximize outcomes when adopting emerging trends such as digital twins, conversational platforms, machine learning and blockchain.
- Strengthen the partnership with OTT and Public cloud provider, leveraging their expertise in social networking, big data, IoT, AI capabilities to improve services quality and user experience.
- Make rational decisions considering all aspects of digital government, including total cost of ownership, risks, and vendors' expertise and service capability, when partnering with external internet and cloud service providers.
- Build an internal team with expertise in architecture design and project management. Otherwise, a government agency will pay high costs for vendor coordination and integration. In addition, CIOs should take a multivendor approach to avoid being locked into a single vendor or an ecosystem surrounding a specific vendor.

Government agencies who sponsor digital government should:

- Remove the roadblock of cross-unit data sharing internally by first building a framework or guidance on data sharing across different government departments. Working with external analytics solution providers may help to exploit the data to maximize the value. They also need to be aware of regulations, security issues and the ethics of data usage, and they should implement governance processes to avoid data leakage and misuse.
- Pursue a citizen-centric approach that leverages citizen experience and metrics to drive success of the government portal. They should use human-centered design principles, analytics, and a variety of user testing and user feedback methods to continuously improve the citizen experience.

Business Impact: Digital government helps improve the efficiency and effectiveness of government services by breaking the system silos and standardize the data flow. It also able to improve transparency and collaboration.

Digital government can also be a bridge between the government and its citizens. The government can leverage this channel to get firsthand feedback from people and use it to issue policies and regulations based on a more factual basis.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Group; Baidu; Beijing Teamsun Technology; DC Holdings; H3C; IBM; Inspur; Lenovo; Microsoft; Tencent

Recommended Reading: "Tool: Digital Government Maturity, Urgency and Readiness Assessment"

"Digital Maturity in Government: Lofty Ambitions Seldom Lead to Tangible Impacts"

"Getting Started With a Digital Twin of Government"

"Turning Smart Cities Into Intelligent Urban Ecosystems"

"Predicts 2019: Establish the Foundations for Next-Generation Digital Government Success"

"Business Trends in Government in 2019-2020: Digital Equity"

Government Cloud

Analysis By: Kevin Ji; Evan Zeng; Tao Wu

Definition: Governments around the world are questioning the efficacy of existing migration efforts or planned adoption of cloud computing. In China implementations, government cloud is driven by digital government initiative to achieve the major incident transparency, daily operation efficiency and service delivery convenience. In current practice, it is a form of community cloud that is hosted by either the government's on-premises data center or in an authorized colocation most likely in local carrier's facility.

Position and Adoption Speed Justification: Government cloud in China is a combination of complex procurement processes, diverse organizational responsibilities, multiple funding source and different type of IT operational modes, which drives complicated technology adoption under any circumstances.

For complex procurement process, government agencies have a solid and complex open bidding process in order to mitigate the risk. We observed government cloud bidding transform from a capital asset allocation model to a service consumption model. Government agencies prefer to pay cloud service usage costs per annually rather than massive infrastructure capital costs. This process introduces uncertainty during the bidding process.

For organizational readiness, in order to mitigate the risk on shared ownership, many cities built the big data agency as centralized department dedicated to take the responsibility on digital government initiative, which includes government cloud solution.

For funding challenge, in order to make efficient progress on digital government initiative, big data agency may engage into every government IT budget approval process to validate the feasibility. It drives many government agencies to start using government cloud and migrate data into cloud platform. But this also generates extra cost on migration.

Furthermore, compared with enterprise IT, government IT operation capability is relatively weak and relies on outsourcing companies. In some successful government cloud use cases, the big data agency also built a strong team or leveraged a third party to gain new IT operations capability.

Based on COVID-19 impact, we expected the acceleration of government cloud adoption in China, since it is part of new infrastructure which can enable the digital government and strengthen the government service.

User Advice: IT leaders from Government need bring the lessons learned from early adopters and be aware on the items below:

- Align digital government result with stakeholders and build high business value things first. It is easy to set procurement priority accordingly.
- Build the suitable IT principle to support digital government initiatives. This approach reduces the communication complexity, since every agency needs to create the business justification to align with digital government initiatives.
- Build suitable data governance to consolidate and share the data with authorized agencies or apps for citizens.
- Change the resource funding process from asset procurement (capital cost) to a service consumption model (operational cost), in order to fit the new cloud service usage model.
- Build solid project management governance based on multivendor coordination, as government agencies are accountable for the delivery result.

Business Impact: Government cloud is the foundation of a digital government platform to support new cross-agency services such as the One-Stop Initiative.

The One-Stop Initiative is a well-known flagship government solution in China. Through this initiative, citizens can apply for government services through a website or an application, and only come to the government once to get the services. In the past, citizens spent a great deal of time raising several requests to different government agencies. This transformational initiative drives the government's role from controlling the economy to enabling the economy.

In addition, the digital government initiative is not only driven by city mayors but also vertical government agency such as China custom, supreme court of judicature. The vertical government agency also has plan to make data transparency and process efficiency through government cloud. Some agencies have built the foundation already.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Alibaba Cloud; China Mobile; China Telecom; H3C; Huawei; Inspur; Tencent

Recommended Reading: "The Challenges for Government Private Cloud to Deliver Value"

"Building a Government Cloud: Lessons From Singapore"

"Government CIOs Eliminate Technology Gaps to Maximize Efficiency"

Entering the Plateau

Smart Lighting

Analysis By: Nick Jones

Definition: Gartner defines smart lighting as a lighting system that is connected to a network and can be monitored and controlled from a centralized system or via the cloud. Advanced smart lighting systems include controls, connectivity, analytics and intelligence. They usually exploit LED technology for energy efficiency.

Position and Adoption Speed Justification: Smart lighting is being rapidly adopted. It is driven by energy savings, which can approach 70%, compared with conventional lighting. Application areas include offices, homes, industrial plants and city street lighting. Lighting may be controlled and connected in several ways, including Power over Ethernet (PoE), and wireless or wired networks. Advanced smart lighting systems integrate with building management systems to optimize illumination and energy consumption using a combination of light management and building controls, such as sun blinds. Modern smart lighting systems that support programmable color can provide features, such as circadian lighting, where subtle color variations are claimed to improve worker well-being.

The sensors used by smart lighting systems can also support other applications, such workspace optimization. Vendors are exploiting opportunities to integrate other features, such as Li-Fi, location tracking, occupancy counting and Bluetooth beacons, into light fittings. Basic smart lighting for energy-saving purposes will advance rapidly through the Hype Cycle, because it's a well-developed technology, although advanced features (for example, circadian lighting and workspace optimization) will develop more slowly.

User Advice: In indoor situations, CEOs, CFOs, facilities managers and CIOs should explore opportunities for smart lighting to save money and provide safer and more effective working conditions. Buyers should look for opportunities to integrate smart lighting with building management and integrated workplace management systems to achieve additional benefits. Organizations responsible for retrofitting smart lighting into existing buildings or streets that wish to minimize capital expenditures (capex) should explore lighting-as-a-service models. In such cases, contractors replace and operate lighting hardware, which is funded by a long-term subscription or a percentage of electricity savings.

City planners should explore smart street lighting to save energy and to improve citizen safety and quality of life using contextual dynamic controls. Smart street lighting systems can also provide the physical and networking infrastructure to support other smart city sensors and initiatives.

Sophisticated smart light fittings may include additional features, such as Bluetooth beacons, which can help support initiatives including indoor navigation when used in conjunction with a mobile app. Users should be cautious before adopting smart lighting with integrated data transmission technologies, such as Li-Fi, which we expect to achieve limited market traction through 2023.

Organizations should also explore how analytics can be applied to the data generated by smart lighting systems — for example, to better understand and optimize office space usage or pedestrian/traffic behavior in streets.

Business Impact: The benefits of smart lighting include energy savings, improved working conditions, better space utilization and reduced operational expenditures (opex).

Smart lighting can save more than 70% of the lighting energy bill, compared with incandescent lighting. Secondary benefits include improved productivity from superior or safer working conditions, cost savings from optimizing office space utilization and improved levels of citizen services. However, we do not expect Li-Fi integrated with smart lighting to be widely adopted, because the business value is limited.

Indoor and outdoor smart lighting also provides operational savings in areas such as inspection and maintenance — for example, because smart lights can test themselves so emergency lighting doesn't need expensive regular manual inspections. In specific situations, such as street lighting, there may be additional benefits. These include the ability to increase illumination in the event of incidents to aid first responders, and savings from reducing the cost of secondary functions, such as cleaning lights. (Small increases in illumination are less expensive than manual cleaning.)

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Sample Vendors: Acuity Brands; American Industrial Partners (Current); Digital Lumens; Enlighted; OSRAM; Panasonic; Signify; Telensa; Tridonic

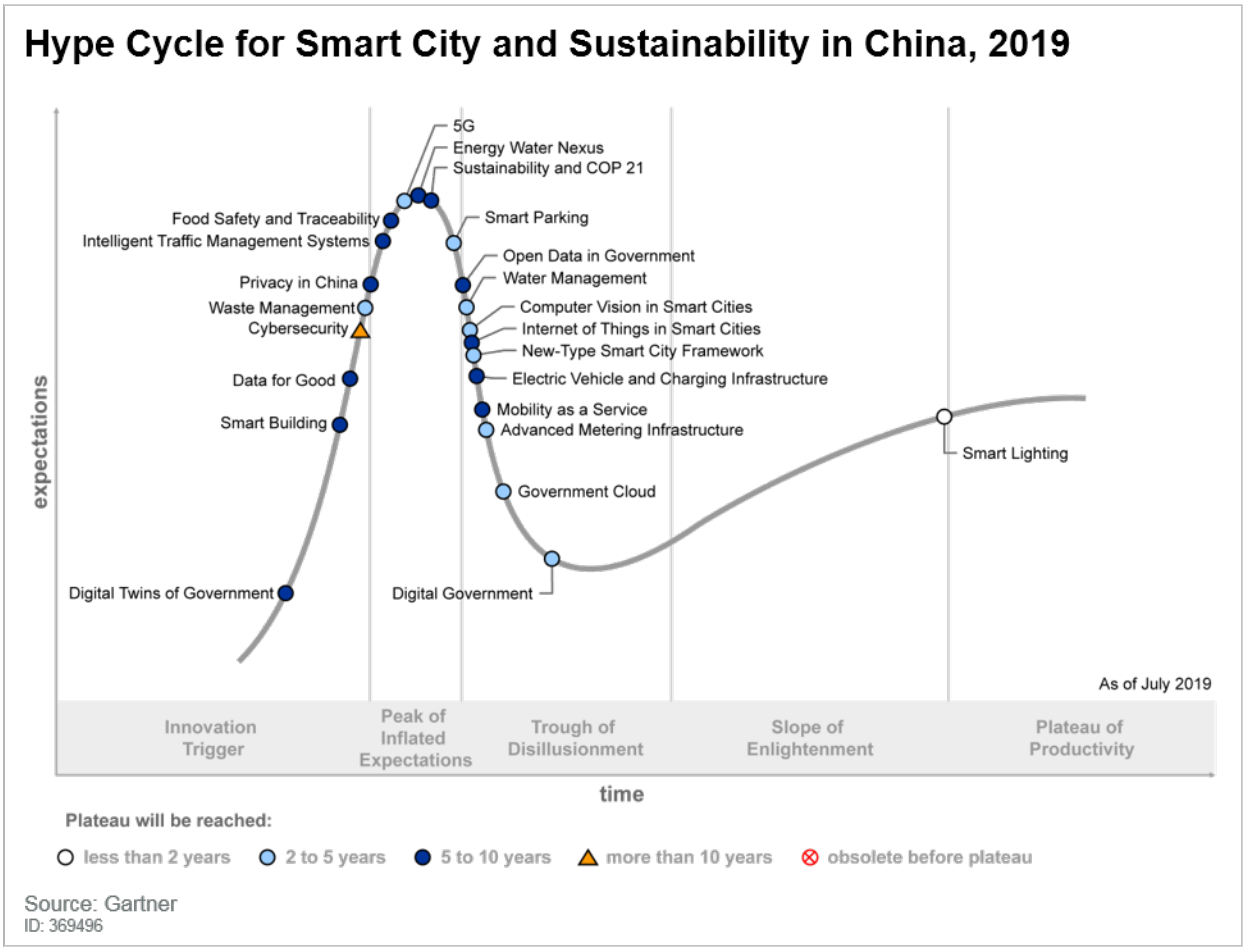
Recommended Reading: "Evolve Your Smart Building Solutions in the IoT Era"

"Turning Smart Cities Into Intelligent Urban Ecosystems"

"Emerging Technology Analysis: Approach Li-Fi With Caution Because Adoption Will Be Slow"

Appendixes

Figure 3. Hype Cycle for Smart City and Sustainability in China, 2019



Source: Gartner
ID: 369496

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 1. Hype Cycle Phases

Phase	Definition
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant press and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the technology is pushed to its limits. The only enterprises making money are conference organizers and magazine publishers.
Trough of Disillusionment	Because the technology does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the technology's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the technology are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the technology to reach the Plateau of Productivity.

Source: Gartner (July 2020)

Table 2. Benefit Ratings

Benefit Rating	Definition
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (July 2020)

Table 3. Maturity Levels

Maturity Level	Status	Products/Vendors
Embryonic	■ In labs	■ None
Emerging	■ Commercialization by vendors ■ Pilots and deployments by industry leaders	■ First generation ■ High price ■ Much customization
Adolescent	■ Maturing technology capabilities and process understanding ■ Uptake beyond early adopters	■ Second generation ■ Less customization
Early mainstream	■ Proven technology ■ Vendors, technology and adoption rapidly evolving	■ Third generation ■ More out-of-box methodologies
Mature mainstream	■ Robust technology ■ Not much evolution in vendors or technology	■ Several dominant vendors
Legacy	■ Not appropriate for new developments ■ Cost of migration constrains replacement	■ Maintenance revenue focus
Obsolete	■ Rarely used	■ Used/resale market only

Source: Gartner (July 2020)

Gartner Recommended Reading

Some documents may not be available as part of your current Gartner subscription.

Understanding Gartner's Hype Cycles

Establish an Urban Data Exchange for Smart Cities

Market Trends: Smart City IoT Deployment Trends in Asia/Pacific

Predicts 2020: Resilient Smart City Development Requires Data-Driven Engagement of Citizens and Businesses

3 IoT Innovations That Should Be on Your Smart City Solution Roadmap

How to Plan the Role of 5G in Your Smart City Initiatives

The Urban Data Exchange Will Be an Engine of Community and Ecosystem Innovation

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