Hype Cycle for Smart City Technologies and Solutions, 2021

Published 21 July 2021 - ID G00747414 - 123 min read

By Analyst(s): Bettina Tratz-Ryan, Bill Finnerty

Initiatives: Government Digital Transformation and Innovation

A smart city is designed to achieve holistic objectives, achieving an intelligent urban ecosystem. This research helps local government and business IT leaders assess emerging technologies and solutions to deliver sustainable societal outcomes.

Additional Perspectives

- Summary Translation: Hype Cycle for Smart City Technologies and Solutions, 2021 (10 August 2021)

More on This Topic

This is part of an in-depth collection of research. See the collection:

- Applying AI in Industries

Analysis

What You Need to Know

Smart cities and intelligent urban ecosystems are poised to deliver quick and contextualized citizen, government and business services to support current needs as well as long-term societal strategies. The roadmap of smart city services are based on an orchestrated use of data sources and collaboration.

The COVID-19 recovery will show its impact far into the coming years. Local government CIOs and urban ecosystem partners will have to prioritize their roadmap with digital citizen equity and new industrial development, subsumed into a “smart resilient and sustainable cities concept.” In many regions, social disruptions have carved a demographic dissonance that has led to a societal equity crisis in cities. CIOs, therefore, are not only planning for scale in infrastructure efficiency and sustainable applications for service availability, but also data for good. Those approaches can link isolated events in our current disconnected environment into a story for citizens, using disruptive enablers like artificial intelligence (AI) and chatbots.

The Hype Cycle

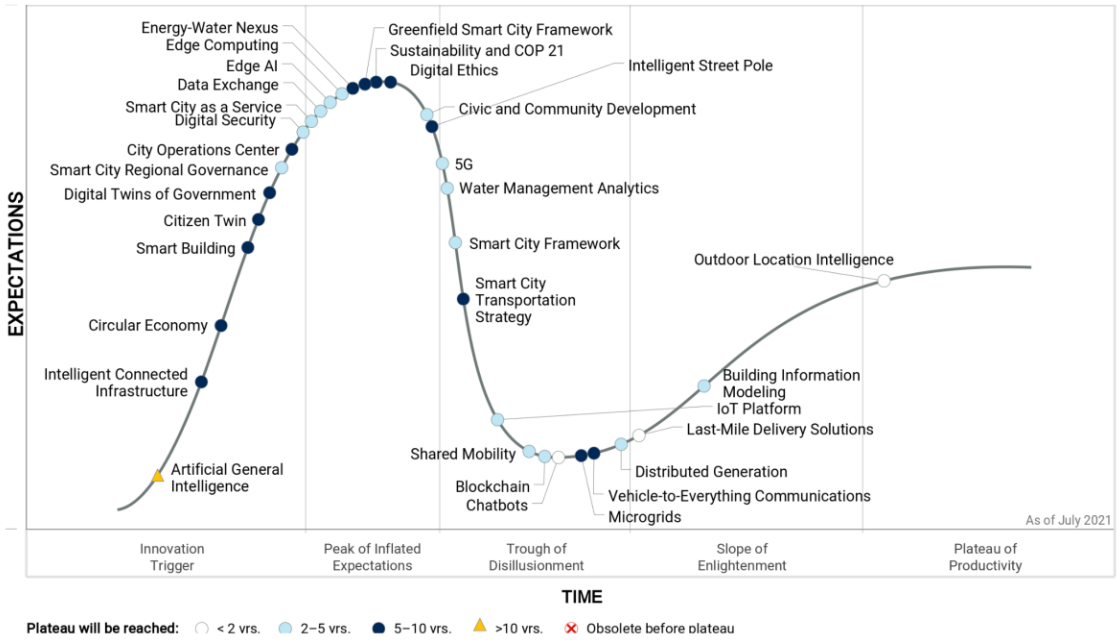
The 2021 Hype Cycle for Smart City Technologies and Solutions focuses on the holistic ecosystem approach available through data exchanges and digital twin use cases. Analytics at the service delivery point, last mile logistics, mobility and building options are opening the door for an experience delivery at the edge of the network, therefore calling for 5G and broadband rollouts.

Digital ethics, together with approaches on sustainability- and community-driven strategies, are peaking, while digital security is morphing into a framework, and therefore, expiring before reaching the plateau. Intelligent street poles are evolving from smart lighting and street efficiency to improved citizen environments and safety.

Mobility and urban transportation strategies have moved into the Trough of Disillusionment, as platforms and service offerings are extended from citizens to last-mile logistics. Before COVID-19 struck, mobility services were a remedy for congestion and air pollution. Nowadays, mobility services and transportation strategies have to include location-based information, including passenger velocity, while maintaining service levels. Often, shared mobility, like bike sharing, can also improve the sustainability aspects of the city.

Innovation profiles like water management, microgrids, energy-water nexus and sustainability and COP 21 experience a high priority in the smart city framework discussion around cities' climate change charters. Initiatives by the World Economic Forum seek to rebuild society after COVID-19 with a "Great Reset" facilitated through the Fourth Industrial Revolution in urban centers, and project that sustainability and business development, especially in cities, will increase. It provides an extension to the circular urban environment approach. As in previous years, the maturity of the technology solutions and platforms is further ahead than the business and city outcomes that they are promising to generate. Internet of Things (IoT) platforms, blockchain, chatbots and building information modeling are moving toward the Slope of Enlightenment, becoming mainstream options for intelligent use cases.

Figure 1: Hype Cycle for Smart City Technologies and Solutions, 2021



Source: Gartner (July 2021)

Downloadable graphic: Hype Cycle for Smart City Technologies and Solutions, 2021

The Priority Matrix

Many technologies have a transformational or high impact on smart cities, but will take a longer time to achieve their benefits. Consequently, city CIOs and urban planners will implement the solutions over longer periods to generate outcomes and ROI. Many of the benefits can be supported using data analytics and data exchange to optimize city operations, together with the intelligent urban ecosystem, or to drive long-term sustainable and inclusive outcomes.

Innovation profiles like data exchanges, blockchain and chatbots will provide transformational experiences to cities services and will be mainstream in the next five years. Becoming mainstream means that rapidly increasing automated transactions will support contextualization of service delivery at the location where the service is needed. For example, this acceleration is needed for smart buildings, city operations centers or vehicle-to-everything communications. Those will be maturing, together with the circular economy, in 10 years or less.

High benefits will be generated in up to five years from innovation profiles such as 5G, in conjunction with IoT platforms, or building information modeling in smart buildings and campuses. CIOs will require those technologies to capture data and to analyze this data for operational efficiency (for example, in transportation and shared mobility), and for energy and resource management. Digital representation of urban situations through digital twins will show benefits over an extended period of time of up to 10 years, as joint governance on urban objectives and vision turn into actionable roadmaps.

Table 1: Priority Matrix for Smart City Technologies and Solutions, 2021

(Enlarged table in Appendix)

Benefit	Years to Mainstream Adoption			
	Less Than 2 Years	2 - 5 Years	5 - 10 Years	More Than 10 Years
Transformational		Blockchain Data Exchange Distributed Generation Edge AI Edge Computing Smart City Framework	Circular Economy City Operations Center Greenfield Smart City Framework Smart Building Sustainability and COP 21 Vehicle-to-Everything Communications	Artificial General Intelligence
High	Chatbots Last-Mile Delivery Solutions Outdoor Location Intelligence	5G Building Information Modeling Civic and Community Development Digital Security IoT Platform Smart City as a Service Smart City Regional Governance Water Management Analytics	Citizen Twin Digital Ethics Digital Twins of Government Intelligent Connected Infrastructure Intelligent Street Pole Microgrids Smart City Transportation Strategy	
Moderate		Shared Mobility	Energy-Water Nexus	
Low				

Source: Gartner (July 2021)

Off the Hype Cycle

The following technologies were included in other innovation profiles:

- Micromobility moved into shared mobility
- Connected home split into building information modeling and smart building

Robotic process automation was dropped because of the maturity of the hype.

On the Rise

Artificial General Intelligence

Analysis By: Farhan Choudhary

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Artificial general intelligence (AGI) is the hypothetical intelligence of a machine that has the capacity to understand or learn any intellectual task that a human being can. AGI is also often attributed to functionalities within computer programs that enable them to exhibit self-preservation, awareness, sentience, sapience and consciousness similar to human beings.

Why This Is Important

As the lines between human-machine interaction blur, AGI for some extremely narrow and controlled use cases could start to emerge, which will allow even better decision-making capabilities in those systems. AGI can be viewed as important for pushing the overall boundaries of learning systems as we know them today.

Business Impact

- AGI is unlikely to emerge in the next 10 years or even more, although research will continue. If it does finally appear, it will probably be the result of a combination of many special-purpose AI technologies.
- The form under which it might emerge could be radically different from what people expect.
- Some of the economic, social and political implications will be disruptive — and highly controversial.

Drivers

- Considerable hype is driven by the applications developed through reinforcement learning, neuro-symbolic reasoning, simulation approaches, evolutionary algorithms, ambient intelligence and knowledge representation.

- Vendors such as Google, IBM, NNAISENSE, OpenAI and Vicarious are also actively researching the field of AGI.
- AGI can be used to experiment with mundane tasks that are highly narrow and constrained use cases. However, that defeats the notion of an all-encompassing AGI and becomes narrow AI.
- The innate desire of mankind to "shoot for the stars" is also a major driver to AGI. At one point in history, humans wanted to fly by mimicking bird flight. Today, airplane travel is a reality. The inquisitiveness of the human mind to take inspiration from nature, from itself, is not going to fizzle out.

Obstacles

- AGI at its core exhibits self-preservation, awareness, sentience, sapience and consciousness. These traits have a moral dimension and, therefore, open up a bevy of legal rights of AI and a social contract for AI (for instance, in Isacc Asimov's principles).
- The current simulation-based and neural-network-based approach is far from adequate to achieve AGI. Significant breakthroughs and revisiting the fundamentals will be required to even think of an AGI future.
- There's a lack of consensus on the definition of intelligence itself. Flamboyant representations through science fiction create a disconnect from reality.
- We have just started to take baby steps in controlled experiments, and we are debating on whether or not we'll be able to sustain them. Furthermore, we are inadvertently creating AI in our own image, without fully understanding our own selves, and expecting AI to be better.

User Recommendations

- Ignore AGI until researchers and advocates demonstrate significant progress. Until then, dismiss any suppliers' claims that their offerings have AGI or artificial human intelligence — these are generally illusions created by programmers.
- Focus on narrow AI, not on AGI. Special-purpose AI will have a huge and disruptive impact on business and personal life. Deliver business results enabled by applications that exploit special-purpose AI technologies, both leading-edge and older.

- Identify business results enabled by applications that exploit a broad range of AI techniques, represented in this Hype Cycle.
- Experiment with less-proven AI technologies that have precedents of success and give you differentiated advantage.

Sample Vendors

Google; IBM; NNAISENSE; OpenAI

Gartner Recommended Reading

Maverick* Research: Creativity Is Dead, Long Live AI Creativity!

Maverick* Research: Artificial Intelligence Will Make Us Dumber Unless We Can Teach It to Teach Us Back

Intelligent Connected Infrastructure

Analysis By: Venecia Liu, Ivar Berntz

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Embryonic

Definition

Intelligent connected infrastructure (ICI) is an integrated mesh of technologies to enable the transportation infrastructure to exchange data with surrounding entities, such as vehicles, technicians and equipment. The mesh is made up of elements such as AI, IoT, cloud, analytics, edge computing, telecommunications and autonomous technologies. The transportation infrastructure can include ports, bridges, roads, airports and airways, and highways.

Why This Is Important

CIOs can use ICI as a technology vision roadmap for how technologies can be used in combination to further improve business operations and impact the business. ICI also provides a mechanism for how data assets can be linked to other data assets.

ICI could help achieve better safety, less congestion, shorter wait times and better asset utilization.

Business Impact

Benefits of ICI can improve traffic flows, safety, infrastructure maintenance and notification of asset conditions to avoid hazardous conditions, accidents and roadblocks. Smart ports would benefit from ICI in optimizing operations and improving terminal management by communicating with cranes, rails, port authorities and trucks. Smart airports would benefit from an increased capacity enabled through better orchestration and coordination of members in the airport ecosystem.

Drivers

- Stand-alone technologies such as IoT or AI have provided some benefit to the transportation industry. However, a force multiplier can be achieved when technologies come together to communicate and exchange data to provide combined insights and to empower decision making to execution.
- ICI combines diverse data sources to provide a more holistic view. ICI can also improve asset utilization.
- Asset-intensive industries have been using sensors to track assets and predict maintenance failures. With ICI, they can further impact the business by taking the data and communicating it to other business operations, sharing it with external partners or leveraging the insight to communicate relevant information to passengers.
- Transportation CIOs are pressured to do more with less, and the advantages of ICI inspire methods for how asset data can be further applied to other business scenarios to become data-driven.

Example ICI use cases include:

- Notifying drivers about different road conditions (such as ice or obstacles)
- Monitoring vehicles going into, or currently inside, tunnels, parking lots, facilities, and restricted-access areas and 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

Obstacles

- ICI is still an emerging area, since it requires digital mesh orchestration and collaboration to be realized across the transportation infrastructure and across various technology touchpoints and entities in the ecosystem.
- The investment to tie all the technologies together is challenging, and it requires coordination by different entities with different reporting structures and goals.
- 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 can facilitate hacking. These will need to be considered in the design, development, implementation and operation of resilient ICI components.

User Recommendations

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

- Identify stakeholders in your ecosystem who could benefit from better data insight, such as truck drivers waiting for unloaded cargo, pilots, tugboats, crane operators, rail cargo, shipyard equipment, shippers and emergency services.
- Assess existing data sources, and identify areas where data collection (such as maintenance, planning, forecasting, safety and traffic flow) can impact other business operations.
- Build a technology roadmap with this ICI vision to ensure edge computing or 5G implementations can be leveraged in multiple ways as a data exchange to multiple stakeholders.

Sample Vendors

Alibaba Cloud; Bosch Group; Cisco; Ford Motor; Huawei; IBM; Mercedes-Benz; Qualcomm; Rolls-Royce Motor Cars; Siemens

Gartner 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 Networks Infrastructure, 2020

Hype Cycle for Connected Vehicles and Smart Mobility, 2020

Market Trends: Monetizing Connected and Autonomous Vehicle Data

Circular Economy

Analysis By: Sarah Watt, Kristin Moyer

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

The circular economy is a practice that decouples growth from the consumption of finite raw materials. This concept is based on three principles: design out waste, keep materials in use at their highest quality as long as possible, and return material to the environment in a way that has a positive impact. The concept can be applied to products, supply chains, industry sectors or cities, enabling improved resource utilization, and in many instances, reduced environmental impacts.

Why This Is Important

The circular economy is an emerging trend, with the potential for rapid acceleration through mechanisms such as the EU Green Deal. It enables enterprises to improve raw material security and increase customer centricity through new business models. When embedded across an ecosystem, it enables goods to be kept in the economy at their highest value through innovative business models.

Business Impact

- **Value:** Circular economy drives value, allowing products to be returned, refurbished and placed back on the market, generating new revenue opportunities. For example, product-as-a-service business models extend the duration of touchpoint from a one-off sale to an ongoing customer lifetime relationship that goes beyond the life of one particular product.
- **Materials management:** As a minimum, the circular economy improves materials security by creating an ecosystem of raw materials.

Drivers

- **Financial drivers:** There are two financial drivers for the circular economy. First, in a constrained economic environment, customers may not have the appetite for large capital expenditure or the interest in owning assets, making new dematerialized or as a service business models more attractive. Second, in an uncertain and constrained trading environment, the circular economy provides access to another stream of raw materials, helping manage material price volatility.
- **Regulators:** Increased demands for state raw material security are being seen through public policy, such as the U.S. executive order on America's supply chains. The EU Green Deal includes a Circular Economy Action Plan, with a targeted sectoral approach to increase the utilization of resources.
- **Citizens:** Citizen consciousness on sustainability is high, with some being reflected in values-based procurement choices. Citizen movements are likely to increase pressure on governments and businesses to take proactive action on climate change. Circular products typically have a lower footprint than primary products.
- **Startup disruption:** Startup organizations using direct-to-consumer models with circular economy attributes have the potential to disrupt incumbents, tapping into consumer sentiment. For example, Remedichain takes back unused prescriptions, donating them to those in need.
- **Societal ecosystems:** Cities and intelligent urban landscapes are being created to bring business, local government, industry and citizens together, putting in place policy to manage resources, waste and urban assets. Many cities have committed to circularity through the circular cities declaration.

Obstacles

- **Design for circularity:** Poor design hinders circularity, as it increases end-of-life management costs associated with processing. Enterprises are putting in place circular economy design guides, such as Nike and IKEA.
- **Data alignment:** The circular economy creates a raw material ecosystem as opposed to a linear flow of material. Technology and data are needed to enable decision making about product processing routes so that material is returned to market as quickly and cost-effectively as possible.
- **Cannibalization of market share:** A common barrier to moving circular economy projects beyond the pilot phase is concerns about cannibalization of market share. Enterprises must define how circular products will complement new, and in which markets these will be deployed to grow market share.
- **Orchestration:** The circular economy requires a different skill set, with the ability to orchestrate across the enterprise and with industry partners; creating joint value to achieve common outcomes.

User Recommendations

- **Pilot-to-scale:** Pilot circular economy initiatives address business concerns regarding market share cannibalization by modeling and demonstrating how circular products can be sold in new markets, creating value.
- **New business models:** Explore new business models, which will increase customer centricity, but also enable the enterprise to plan for when it will receive returned products.
- **Design:** Use product design guides to prompt circular economy attributes to be included in the design process to enable ease of refurbishment, parts harvesting and recycling.
- **Partnerships:** Identify strategic partners, suppliers, startups and waste contractors, building alliances to create joint value and benefit from circular economy activities.
- **Data:** Build circular economy requirements into the enterprise's digital strategy. Define where data and automation can enhance decision making and speed up return of product to market.

Gartner Recommended Reading

Supply Chain Executive Report: Close the Loop to Create Future-Fit Raw Material Strategies

Employ Digital Technology to Enable a Circular Economy

Sustainable and Circular Supply Chain Evolution or Revolution

Video: Accelerating the Circular Economy at HP Inc.

Video: Lenovo — ONE Planet, ONE Goal Circular Economy and Innovative Packaging

Smart Building

Analysis By: Gavin Tay, Rashmi Kotipalli

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

A smart building is a facility where multiple functions cooperate to achieve sustainable outcomes. Such outcomes include automation, efficiency, experience, sustainability and security 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.

Why This Is Important

Much of what has made a building “smart” (mostly operational efficiency) has been heavily reliant on building management systems (BMSs). Due to the legacy nature of how BMSs are implemented, adoption rates are fairly slow. Hardware for HVAC and lighting implemented with new construction has a lifetime of 10 to 20 years. System failure retrofits are now more regular postpandemic, with stringent standards of safe management accelerating the importance of experience, well-being and safety.

Business Impact

- Optimize building performance and improve predictive and preventive maintenance by learning real-time human preferences based on activities, emotions and reactions. Smart buildings respond to change, resulting in healthy, delighted and productive occupants.
- Insights come from multiple sources of information further calibrated by understanding occupant journeys. Formulating such holistic solutions will stretch alignment of cross-functional teams to address work-life ambience and sustainability.

Drivers

- Postpandemic, 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 it remains difficult for data residing in various custom-made BMS repositories to interact with one another. The demands and expectations of workers are shifting from merely going to an office that has good air, temperature and now hygiene to a place where they have work-life ambience. As this shifts, a smart building experience requires the exploitation of an ever-growing number of IoT business solutions.
- IoT and AI have 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 to an older system.

Obstacles

- CIOs assembling smart buildings with IoT business solutions must possess two qualities: a clear vision of the architectural building blocks comprising the IoT platform, and an understanding of the privacy and data security implications. Delivering digital experience, given limited exposure to governing moving parts and the flow of activities in smart buildings, can be diverse and complex. CIOs must become accustomed to managing the complexity of a multivendor IoT landscape and technology architecture.

- By 2028, Gartner estimates 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.

- There will be no dominant IoT platform in any smart building, so CIOs must compose end-to-end IoT solutions from multiple providers.

- Coordinating varied expectations, use cases and budgets from different stakeholders such as facilities, HR and security adds to existing complexity.

User Recommendations

- Recover energy inefficiencies by using real-time data from the IoT and IT infrastructure to enable communication between the different BMS in a building. According to ENERGY STAR, average buildings waste 30% of their energy through inefficiencies in lighting, heating and cooling areas that are not occupied.

- Leverage the significance of IoT to build holistic, engaging experiences while increasing building efficiency and competitiveness.

- 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 (e.g., energy management contracts).

- Alleviate the potential business and technical challenges of creating a piecemeal smart building. Gartner predicts by 2022, IoT will save consumers and businesses $1 trillion a year in maintenance, services and consumables.

Sample Vendors

Eutech Cybernetic; GE; Honeywell Forge; Intel; Johnson Controls; Schneider Electric; Siemens; Signify; Spacewell; Terminus

Gartner Recommended Reading

Pivot Your Smart Building Value Proposition to Address the New Normal

Competitive Landscape: IoT-Enabled Smart Building Management Platforms

Emerging Technology Analysis: Smart Spaces

Emerging Technologies and Trends Impact Radar: Internet of Things

Emerging Technologies and Trends Impact Radar: Artificial Intelligence

Citizen Twin

Analysis By: Alfonso Velosa

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

A digital twin of a citizen is a digital representation of an individual. National, state and local governments use citizen twins to support citizen services such as health or safety management. The citizen twin core elements are the model, data, a unique one-to-one association, and ability to monitor it. It integrates data into the twin from siloed sources such as health records, credit scores, phone location logs, criminal records, customer 360 records and infrastructure such as cameras.

Why This Is Important

Governments are developing digital twins of citizens to monitor the environment citizens live in and address health, safety, travel and social media impacts on society. The spectrum of complexity of the models and tools can help governments make better decisions for monitoring and supporting patients, prisoners, passengers or the elderly. Some governments, such as China's, are building a scoring methodology. Aggregated citizen twins can help map broad patterns and drive resource allocation.

Business Impact

- Governments will use digital twins to better orchestrate citizen services and other digital services, and even manage crises, such as pandemic protection.
- Aggregate data can help citizens access and expedite government services
- Citizens or governments can drive citizen-twin-based crowdsourcing sentiment analysis to assess government services in near to real time.
- Integrate government services to other systems including the Chinese social credit systems and shopper tracking solutions.

Drivers

- Proliferation of both structured and close-to-structured data on creating digital citizen journey maps.
- Increased integration of government, financial and commercial systems and interest in creating citizen 360 models.
- Citizen interest in systems that help drive their health and safety, such as vaccination passports or solutions to monitor elderly patients using IoT-enabled trackers.
- An increased desire for personalized services from government and other organizations.
- The need to implement proactive services, such as healthcare, mental health, fraud detection, and so forth, with a particular driver for government services for COVID-19 pandemic responses.
- Investment by a broad range of law enforcement, justice and corrections authorities, for example for smart camera monitoring systems that track to a specific police officer, or inmate tracking solutions under home arrest.
- The flexibility of digital twin models from simple to complex models, and the ability to integrate data from siloed services enable governments agencies to build out citizen services both in aggregate as well as servicing individuals.
- The need for both real-time services customized to citizens, for example for emergency medical services, and longer term, more complex solutions that serve elderly patients or inmates.

Obstacles

- Strong concern for privacy and the merits of government access to citizen data is leading to grassroots citizen pushback or government regulations such as the EU Privacy Directive or California Consumer Privacy Act (CCPA) to limit access to citizen data.
- Cost and scope slither without clear benefits to citizens or government agencies, as government bureaucracies increase the types and quantity of data collection.
- Government curation of aggregated citizen data creating a security risk for government data and a potential privacy and safety risk for the individual citizen.
- Conflicting government agencies' objectives, political infighting on data rights, and incompatible regulation on the use of citizen data, and on how to respect rights to privacy.
- Incompatible systems across different government, financial, commercial and healthcare silos driving exorbitant costs for integration, analytics and visualization.
- Lack of skills in the government agencies to drive the use of the citizen twin.

User Recommendations

- Build robust privacy and digital ethics policies that clarify what data is collected, who has access to it, how it is protected, and what citizen remediation actions exist or comply with existing remediation processes.
- Establish clear benefits to citizens such as certifying all passengers on an airplane or train are healthy or vaccinated, simplifying medical triage to get a citizen to medical care, or aligning toll payments to a citizen's car for use of a toll road or during city congestion fees.
- Test IoT sensor and analytics capability to ensure accuracy and validity for the physical part of a citizen digital twin.
- Invest in integration skills to connect into a heterogeneous set of applications and data sources.
- Build data exchanges to protect data, while enhancing the granularity of citizen data support personalized and contextualized citizens services through the government ecosystem.

Sample Vendors

Alibaba Cloud; Apple; Google; Tencent; Vantiq

Gartner Recommended Reading

Getting Started With a Digital Twin of Government

Top 10 Plausible Directions Resulting from COVID-19

Top Trends in Government for 2021: Hyperconnected Public Services

Top Trends in Government for 2021: Data Sharing as a Program

Top Trends in Government for 2021: Multichannel Citizen Engagement

Digital Twins of Government

Analysis By: Bill Finnerty, Milly Xiang

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

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 include a single point of visualization and access to supporting data, APIs for issuing commands to things and processes, and the ability to execute scenario planning and urban modeling. A mature digital twin of government is a system of systems, requiring strong integration capabilities.

Why This Is Important

Having a single view of the multiple, interdependent systems that impact the operations of a jurisdiction has long been a struggle for governments. Digital twins of government address this challenge, providing a single interface to the operations of a jurisdiction, and are starting to be used by governments around the globe. Many digital twins of government often start as GIS models; a fully realized future state will:

- Include command-and-control capabilities
- Drive scenario planning at scale

Business Impact

- In the short term, governments need to identify a focused business use case for piloting a digital twin of government.
- In the midterm, governments will leverage digital twins for command and control of operations, frequently enabling greater automation.
- Over time, digital twins will be used to model and test scenarios related to policy, legislation, and infrastructure rollout and changes.

Drivers

- There are three drivers to the increased adoption of digital twins of government. The first driver is advances in vendor solutions, including both advances in technology and the number of vendors providing solutions. The second driver is progress on government programs intended to establish national standards and adoption of digital twins. The third driver is the growing application of digital twins to real-world problems, providing a research base on which to justify future investments.
- In addition to a larger number of vendors entering the market for digital twins of the built-world, many providers are expanding their capabilities. These vendors are increasingly including easier, low-code integration to IoT datasets; integration with indoor GIS, BIM and computer-aided drafting solutions; and inclusion or extension to AI and ML capabilities.
- Progress on governmental standards in Australia, China, the U.K. and other countries is establishing national working groups and standards for digital twins of the built world, including those used for government. These programs are further advancing the interoperability of digital twins of government, an essential component of their future use across jurisdictions.

- The number continues to grow of prominent digital twins of government being developed, used to solve problems and integrated with other capabilities, such as data marketplaces. They provide examples and inspiration for other governments to consider developing a twin. They include Virtual Singapore, New South Wales government's Spatial Digital Twin, Shanghai's digital twin, the Dutch government's digital twin of The Hague, Helsinki's Kalasatama Digital Twin and Boston's digital twin of the city.

Obstacles

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, and silos are an ongoing challenge for governments. This requires both coordination on data standards and integration capabilities.
- In many jurisdictions, expectations of digital twins of government are high. However, sustaining interest, budget and business unit participation in developing a digital twin of government will require focus over multiple administrations.
- CIOs planning for digital twins of government will need to address fundamental questions of any emerging technology — privacy, ethics and business value. This will ensure that the question asked is not, "Can we do this?" but, "Should we do this?"
- The skills to develop digital twins are limited in most markets. Thus, governments will need to compete with other entities for the available talent.

User Recommendations

CIOs leading the development of a digital twin of government:

- Engage elected officials and program leaders in defining the vision in business terms to maximize understanding and buy-in.
- Use future planning exercises (that is, scenario planning) to develop use cases that can demonstrate the "art of the possible" and prioritize investments.
- Establish a guiding principle to protect citizen data by implementing privacy controls and end-to-end encryption.

- Make a digital manifestation of a single aspect, particularly in early states. The digital twins of government need not be a complete clone of the jurisdiction. For instance, transportation-related digital twins have been created for rail stations in China and for city mobility in Colombia.
- Access relevant 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.

Sample Vendors

Cityzenith; Esri; Estudios GIS; Eutech Cybernetic; IBM; Idrica; OSIsoft; Worldsensing

Gartner 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 City Regional Governance

Analysis By: Bill Finnerty, Cathleen Blanton, Bettina Tratz-Ryan

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition

Smart city regional governance implements decision making to coordinate evolution of systems that extend across the intelligent urban ecosystem in a region, such as public safety or transportation, and may involve both public- and private-sector organizations. Regional collaboration enhances opportunities to coordinate initiatives and hold participants accountable for achieving smart city goals and objectives that make a region a better place to live, work and play.

Why This Is Important

Constituents want seamless services as they move from home to work to social events. To meet this need, governments must coordinate across the intelligent urban ecosystem, traversing the political and organizational boundaries that blur into a metropolis. Smart city regional governance provides an approach to engage the public and private sectors in cross-jurisdictional, intragovernmental and cross-organizational initiatives to establish common goals.

Business Impact

Smart city regional governance provides the mechanism to improve lives of those who live, work and play throughout a region through improved constituent experience, streamlined coordination of services and the better use of data in decision making across the ecosystem. Smart city regional governance supports a more-focused, productive dialogue across civic, city, government, business and citizen leadership.

Drivers

Cities are not established solely by the government, but instead include a variety of organizations such as education, healthcare, nongovernment organizations and private-sector companies that define the quality of life available to residents and visitors. Additionally, few areas are governed by a single political jurisdiction but instead consist of a range of municipalities and different tiers of government. Coordinating across these various partners requires a concerted effort and being driven by:

- **Opportunities for scale:** Effort to research solutions, solution providers and procurement can benefit from being executed at a regional level, providing communities to share expertise and buy at scale.
- **The need for accountability in regional smart city efforts:** Regional efforts that fail to establish and maintain trust among partners often struggle to achieve their mission. Smart city regional governance engenders trust across the ecosystem by building on an explicit foundation of shared goals and metrics that are discussed and developed among the partners. This provides a framework for holding each other accountable in achieving the desired intelligent urban ecosystem.
- **Regional need for smart city efforts:** Transportation, safety, environmental and economic issues do not generally begin or end at jurisdictional boundaries. Taking a regional approach is necessary to have a meaningful impact on the quality of life for all residents.

Examples of efforts that benefit from regional governance include:

- Multimodal ticketing for end-to-end smart transit
- Real-time crime centers that coordinate multiple agency responses
- Smart education initiatives to drive next-generation employment opportunities
- Air quality monitoring to improve health conditions for residents
- Homelessness response efforts that can benefit from regional data-sharing marketplaces

Obstacles

- Receiving value from participating in the smart city digital ecosystem also requires that participants trust each other. Some have competing interests, and most have different missions.
- Siloed government funding can prevent cross-program and multijurisdictional use of these funds to support regional smart city efforts.
- Perceived or actual imbalances in cost of services and value received by communities participating in regional efforts can result in mistrust among partners.
- Concerns about political sovereignty can result in local governments not participating in regional efforts.
- Competing interests and priorities among jurisdictions and other potential ecosystem partners can make establishing common goals difficult.
- Leadership changes, in both the public and private sector, can result in loss of support for regional efforts.

User Recommendations

- Improve outcomes for communities by establishing regional governance to coordinate smart infrastructure, IoT and data projects.

- Establish an ecosystem model that documents the participants, rules of engagement, shared capabilities and value exchange for all involved. The defined value exchange needs to ensure that the private sector is motivated to participate and can maintain competitive advantage, the government's investments are fair and effective, and citizens benefit without undue risk or cost.

- Design and implement the governance processes to empower decision-making efforts through the lenses of cost, value and risk, and hold participating members accountable through establishing smart city KPIs.

Gartner Recommended Reading

Turning Smart Cities Into Intelligent Urban Ecosystems

At the Peak

City Operations Center

Analysis By: Bettina Tratz-Ryan, Bill Finnerty

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

A city operations center refers to a platform that helps government officials manage smart city environments with a city solution encompassing a comprehensive and holistic viewpoint. The solution delivers operational insights to optimize the city operations' efficiency and quality of citizen life through visualization. It is also referred to as command and control.

Why This Is Important

In smart city environments, speedy and seamless data exchange and information for city issues — such as traffic congestion, air pollution, energy and water consumption, safety and security conditions, and natural disasters — are required between different sectors and processes. The city operations center connects different data sources and orchestrates user- or citizen-facing engagements and the ideal view of situational awareness.

Business Impact

The smart city operations center facilitates data-driven decision making. The primary business impacts of a city operations center are to support routine operations management, resource monitoring and optimization, automated decision making, multidimensional visualization for both macromanagement and micromanagement and data sharing. It will have an impact on how emergency response can be executed in a timely manner, and it increases situation awareness and escalates decision making.

Drivers

- The level of adoption varies by the technical and data requirements of local governments to consolidate multiple management platforms. Very often, operations centers work together in systems approaches to align processes for emergency response, resilience, mobility management and many other objectives. To enable scale and integration, the operations center is cloud-based and linked to other platforms that may feed and exchange data and insights with it.

- In this regard, operations centers will morph from decision making into urban platforms that create an interactive engine for application development and data visualization. This will lead it to become the interface for a city digital twin, like Virtual Singapore, where city officials and ecosystem can view, develop and simulate based on the platform. In addition to control and command centers, for instance, FIWARE standards provide a framework environment that allows an urban open-source migration path for standardized service, data and process management.

- In a smart city strategy, different datasets are now joined from various operating management platforms and systems across government entities, districts and neighborhoods. Drivers incorporate the orchestration of massive amounts of data from IoT implementations and in-use data to extract value for operations control and city management. The delivery of KPIs for optimization of maintenance routes, asset wear and tear, and real-time decision making will be assessed in city operations centers to identify efficiency and asset instability. The analytics in the operating platform also involve event and situational data.

Obstacles

- As there is no common standard and common framework on city operations platforms, the platforms will need to be aligned based on operating procedures and APIs. Operating platforms need data to be connected with data warehouses, data lakes of subsystems, creating the IT and OT challenges of incompatible systems and different data formats and structures.

- The lack of data governance will impede the resources needed to visualize smart city impacts and services and derive real-time decisions and actions.

- There is limited financing of the operations center and limited ROI based on operational efficiency, grievance detection and fast communication on remedies.

User Recommendations

Local government CIOs supporting smart city efforts must:

- Define the operations center as a platform for management decisions that can be leveraged across specific environments that span ecosystem objectives and partners.
- Establish data governance and management capabilities to provide solid data fusion and visualization in support of urban operations and contextualized constituent services.
- Prioritize investments in technology and data integration based on ecosystem objectives and available funding. Use an interactive approach to grow the capabilities of the city operations center.
- Work with ecosystem partners leading the implementation and management of operations centers, such as a traffic operations center or real-time crime center, to determine points of integration necessary to support collaborative response efforts. Stress-test this integration using standard operations procedures through regular exercises.

Sample Vendors

Alibaba; Fluentgrid; Hitachi; Huawei; IBM; Microsoft; NEC; NTT Data; NXN; Oracle

Gartner Recommended Reading

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

Predicts: Smart City Resilience and Citizen Experience Will Drive Sustainability and Urban Attractiveness

From Smart City to Intelligent Urban Ecosystem — Unlocking Data Value Is the Key to Cities' Industrial Partnerships

Establish an Urban Data Exchange for Smart Cities

Digital Security

Analysis By: Mark Atwood

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Definition

Gartner defines “supply chain digital security” as a holistic and integrated approach to protecting the supply chain from malware, implants, viruses, ransomware or other similar threats. Another term could be “integrated supply chain cybersecurity.” Supply chain digital security aims to protect data and IT, product, and “connected things” such as Internet of Things (IoT), cyber-physical systems, operational technology (OT) and physical technology (PT).

Why This Is Important

Supply chain cyberattacks continue to occur, and according to some reports, they are only growing. The latest data from the Identity Theft Resource Center (ITRC) indicates that there has been a “a 42% increase in the number of supply chain attacks in Q1 2021 versus Q4 2020.” It appears this data is specifically related to the software supply chain because it mentions specifically Accellion and SolarWinds. However, we clearly see spillovers into the “physical” supply chain, recent examples being Colonial Pipeline and JBS Foods. Supply chain leaders need to understand the extent of the threat and some mitigation techniques.

Business Impact

Failure can be crippling. There is a wide variety of highly undesirable outcomes that can result from a supply chain susceptible to a cyberattack. These include disruption of the actual operation of the supply chain, significant damage to brand and reputation, impact on product safety and integrity, loss or theft of IP, and substantial fines and fees.

Drivers

- Continued occurrence of threats impacting a variety of supply chains
- Automation and digitization of supply chains
- High costs associated with operational shutdowns
- Media visibility/awareness of some of the attacks
- Other roles in the supply chain becoming more aware of the threats in addition to CSCO, especially procurement and manufacturing

Obstacles

- Breadth of data and technology in need of protection
- Need for a joint response from supply chain and IT/information security
- Pace of threat expansion
- Lack of supply chain talent knowledgeable in this area
- Fragmentation of the security tools and solutions currently available
- Volume of upstream, downstream, and IT partners that present potential third-party cyber-risk to the supply chain

User Recommendations

- Partner with CIOs and IT security and risk management leaders to develop a governance model for identifying, assessing and addressing the various cyberthreats to the supply chain.
- Work across the supply chain to include cybersecurity strategy into the overall supply chain risk management approach.
- Assess the cyber talent need and required skill set for the supply chain organization.Become familiar with industry mitigation frameworks applicable to supply chain cybersecurity. Utilize the updated identify, protect, detect, respond and recover phases of the NIST CSF (April 2018) with IT to collaboratively protect and defend supply chain assets.
- Map the flow of high-value supply chain data and assets across systems outside their core IT systems, including equipment in manufacturing operations or logistics networks as well as software and hardware components within products. Assess their risk and security posture.
- Become familiar with the Cybersecurity Maturity Model Certification (CMMC) from the U.S. Department of Defense. This is a new compliance framework for doing business with the DoD, and supply chain leaders will need to adhere to this eventually when doing business with the DoD at any level.
- Conduct cybersecurity penetration testing exercises on your supply chain operations.
- Define security specifications with their high-value supply chain partners, then extend those to the extended network.
- Implement partner assessment and audit and ranking.
- Explore network segmentation, especially of the cyber-physical systems in the manufacturing networks.
- Identify those offerings that can be integrated to provide a complete supply chain cyber-risk management solution. Understand that few, if any, of the providers tackle all of the digital risk areas described above, yet are useful as they each address pieces of the overall puzzle.

Gartner Recommended Reading

Supply Chain Executive Report: Weathering the Storm — Supply Chain in an Age of Disruption

Top Emerging Risks for Procurement Entering 2021

The 2020 Top Strategic Technology Trends for Manufacturing Operations

Supply Chain Emerging Risk Prioritization Tool

Use Multitier Mapping as a Foundation for Supply Chain Resilience

Emerging Technologies and Trends Impact Radar: Security in Manufacturing

Fundamentals of Risk: Supply Chain

Smart City as a Service

Analysis By: Bill Finnerty

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition

Smart cities as a service (SCaaS) is an approach in which ecosystem partners provide smart cities with technology and data leveraging a subscription model. Governments, nongovernment organizations and private companies are able to leverage these offerings without having to invest in the infrastructure to generate the related service or data. The provider is able to spread the risk and investment related to establishing and maintaining the capabilities across the broader market.

Why This Is Important

Governments often face challenges related to prioritization and funding for both infrastructure and technology projects. This makes it difficult to establish a roadmap to invest in new jurisdictionwide smart city solutions and keep smart city infrastructure current. This struggle for resources is particularly difficult during times of austerity, such as many governments are facing in the recovery from the pandemic. Procuring smart city solutions as a service reduces risk and cost entry points.

Business Impact

- Cities struggle to obtain the budget and expertise to build and maintain a jurisdictionwide IoT infrastructure. SCaaS allows organizations to focus on procuring data, rather than implementing infrastructure.
- SCaaS requires providers to rethink their approach to smart city implementations. Direct investment in smart city infrastructure presents new opportunities to maximize the data collected and services offered as part of a single network connection and real estate procurement.

Drivers

- Governments facing financial challenges in implementing smart city infrastructure can accelerate their smart city initiatives by becoming a SCaaS consumer.
- Governments can focus the use of data to improve outcomes without investing in the related infrastructure, elevating concerns such as talent, security and budget for supporting large IoT deployments.
- Providers, particularly those communications service providers deploying 5G, are seeking additional recurring revenue streams to offset costs and increase profits. Digital business models that support new revenue through the reuse of a multipurpose sensor pack or reselling the data to multiple parties provide such an opportunity.

Obstacles

- Light poles are not always owned by the local government, so rather than having a willing partner who is set to gain from implementation of SCaaS, providers may find third parties are now requiring reimbursement for access to their assets.
- Many cities are considering the aesthetics of IoT sensors and policies to ensure that sensors and enclosures do not become eyesores.
- Nongovernment and private sector organizations may have to pay for access to data from sensors, that if implemented by cities would be available as open data.

User Recommendations

Implementation and proliferation of SCaaS will increase collaboration and engagement between government jurisdictions and ecosystem players.

Government CIOs:

- Engage planning and architectural review boards in developing smart-city-friendly regulation to encourage private-sector investments.
- Engage providers about their roadmaps and SCaaS offerings, adjust smart city plans accordingly.
- Examine public-private partnerships for SCaaS offerings to accelerate initiatives while sharing the risks and rewards with partners.
- Evaluate the risks of consuming SCaaS datasets for which vendors do not achieve anticipated market growth as offerings may increase in price or be abandoned.

Providers:

- Establish a cross-industries team to identify use cases for common smart city datasets (i.e., air quality, traffic).
- Develop business models that increase profit by extending SCaaS products to markets beyond city government.
- Evaluate financial and reputational risks of PPPs where markets do not materialize.

Sample Vendors

CIMCON; Hitachi; NTT DATA; NXN; VALO

Data Exchange

Analysis By: Bettina Tratz-Ryan

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition

Data exchanges in intelligent urban ecosystems have been developed from the data marketplace concept that drives the flow and exchange of data between the smart city stakeholders. The value of data will be determined through the context and significance of developing and executing on valuable data streams for various public and private use cases. The value of data exchanges is measured by the impact and usefulness of data collaboration and its outcome of business cases.

Why This Is Important

In an intelligent urban ecosystem/smart city, data access and its exchange are key by orchestrating data streams from multiple sources and interconnecting them with ecosystem stakeholders. The acceleration of data marketplaces for industry and government sectors on financial bases into data exchanges with various transaction mechanisms is based on cities collaborating with ecosystem partners to find a “system of systems” approach that potentially offers data exchange as a service.

Business Impact

An intelligent urban ecosystem can only work when there is a valuable data exchange between stakeholders, with a clear win-win strategy between citizens, businesses and governments. For example, smart campuses, industry parks and downtown areas develop mobility, service enhancements for concierge or health, and retail and office services by accessing data exchanges. In addition, data exchanges create an innovation thrust for new digital business models by cross-referencing the environment.

Drivers

- By associating big data with people or situations, city managers can provide responsive services that apply predictive and prescriptive capabilities to anticipate unfolding events in real time.
- The exchange of business or industry datasets, together with prioritization on quality of assessments for modeling or real-time decision making, becomes a critical enabler of service quality for the entire urban ecosystem.
- The speed of adoption has been changed to five years, given that many cities are building out data orchestration around data generated by government agencies, citizens, assets and businesses, and operations management data resulting from urban infrastructure and operations.
- With interactions between public and private sectors, cities and smart communities have opportunities to create service and market response agility by identifying market data for digital knowledge sharing and management, including crowdsourcing insights that could support communities to develop civic entrepreneurship.
- Organizations like Google Sidewalk Labs are showing interest in ecosystem data in smart districts to leverage curbside or data-exchange data for new service models. That can lead to data monetization acceleration.

Obstacles

- Data literacy is a critical enabler for data exchanges because it helps to create skills in using data for all business activities, inadvertently turning to trust in the data-exchange mechanism. Without literacy and trust, the ecosystem will be challenged to tap into good data for business development, especially in relation to privacy grounds.
- The value and market price of enriched data are determined by the business opportunity that is represented and on the certifiable quality of the data itself to cities and the wider industrial ecosystem. Its adoption rate will vary based on the ability to convince the data owners of the value of data orchestration and sharing. It also requires the technical interoperability of data layers and analytics systems.
- The ability to contextualize data with data orchestration requires data collection and dissemination based on a city's understanding and skill of industrial data governance, which needs to be applied across the ecosystem.

User Recommendations

- Examine standardization or adaptive governance models to feed open-source application and delivery models as they plan to integrate their application operation systems and platforms. The ability to interface with middleware underlying a proposed ecosystem will be critical.
- Engage with third-party developers or other entities to enable solutions in automotive, environmental development and journey mapping to be built on your platform, if unable to drive scale and usability across all ecosystem partners.
- Engage in discussions with the business and knowledge communities and collaborate with them on digital rights management, data attributes required and privacy issues. In the long term, develop a roadmap for connecting a “system of data marts” that embed open data portals and warehouses in an algorithmic business environment.
- Appraise chatbots and smart machines for creating automatic and machine learning insights.

Sample Vendors

Cloudera; HERE Technologies; Hitachi; IBM; Insait; NTT DATA; NXN; Opendatasoft

Gartner Recommended Reading

Turning Smart Cities Into Intelligent Urban Ecosystems

Establish an Urban Data Exchange for Smart Cities

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

Edge AI

Analysis By: Alan Priestley

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Edge AI refers to the use of AI techniques embedded in IoT endpoints, gateways and edge servers, in applications ranging from autonomous vehicles to streaming analytics. While predominantly focused on AI inference, more sophisticated systems may include a local training capability to provide in-situ optimization of the AI models.

Why This Is Important

An increasing number of edge computing use cases are latency sensitive (autonomous navigation), data intensive (video analytics), and require an increasing amount of autonomy for local decision making. This creates a need for AI-based applications in a wide range of edge computing and endpoint solutions. Examples include video analytics which, driven by the rapid growth in use of surveillance cameras and the need for real-time interpretation of captured video, is starting to see adoption.

Business Impact

The business benefits of deploying edge AI include:

- Improved operational efficiency, such as manufacturing visual inspection systems.
- Enhanced customer experience.
- Reduced latency in decision making, with the use of local analytics.
- Communication cost reduction, with less data traffic between the edge and the cloud.
- Increased availability even when the edge is disconnected from the network.
- Reduced storage demand through a more reactive exploitation of the data.
- Preserved data privacy at the endpoint.

Drivers

- Increasing demand for the deployment of DNN-based data analytics close to or at the point of data capture, either in edge computers or endpoint devices.
- Edge AI implementations are impacted by application and design constraints of the equipment being deployed; this includes form factor, power budget (i.e., battery powered versus mains powered), data volume, decision latency, location, and security requirements.
- AI systems can be hosted within an edge computer, gateway or aggregation point and data captured at an IoT endpoint may need to be transferred. In this architecture, the IoT endpoint is a peripheral to the AI system. The endpoint acts as a data gatherer that feeds this data to the AI system. An example of this is environmental sensors deployed for a smart agriculture application.
- AI embedded in the IoT endpoint. In this architecture, the IoT endpoint is capable of running AI models to interpret data captured by the endpoint and drives some of the endpoints' functions. In this case, the AI model (e.g., a machine learning model) is trained and updated on a central system and deployed to the IoT endpoint. An example is a medical wearable that leverages sensor data and AI to help visually impaired people navigate the world in their daily lives.
- R&D into training AI models at the edge for decentralized machine learning.

Obstacles

- Systems deploying AI techniques can be nondeterministic. This can limit the ability to control and replicate analysis results, and may impact applicability in certain use cases, especially where safety and security requirements are important.
- The autonomy implicit in an AI deployment can lead to questions of trust, especially where the operation of the AI models is not transparent.
- The deployment of edge AI solutions can raise governance and privacy concerns. While analyzing data at or close to its point of capture can alleviate some privacy concerns, it may not mitigate them completely.
- Training DNNs is a compute-intensive task, often requiring the use of high performance chips with corresponding high power budgets. This can limit deployment locations, especially where small form factors and lower power requirements are paramount.

User Recommendations

- Determine whether the new AI developments are applicable to their IoT deployments, or whether traditional centralized data analytics and AI methodologies are adequate.
- Evaluate when to consider AI at the edge versus a centralized solution. Applications that have high communications costs are sensitive to latency or ingest high volumes of data at the edge are good candidates for AI.
- Assess the different technologies available to support edge AI and the viability of the vendors offering them. Many potential vendors are startups, which may have interesting products but limited support capabilities.
- Use edge gateways and servers as the aggregation and filtering point to perform most of the edge analytics functions. Make an exception for compute-intensive endpoints, where AI-based analytics can be performed on the devices themselves.

Sample Vendors

Baidu; Google; Intel; Microsoft; NVIDIA; Qualcomm

Gartner Recommended Reading

Emerging Technologies: Neuromorphic Computing Impacts Artificial Intelligence Solutions

Emerging Technologies: Critical Insights on AI Semiconductors for Endpoint and Edge Computing

Forecast: AI Semiconductors, Worldwide, 2019-2025, 1Q21 Update

Emerging Technologies and Trends Impact Radar: Artificial Intelligence

Edge Computing

Analysis By: Bob Gill, Philip Dawson

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Definition

Edge computing describes a distributed computing topology in which data storage and processing are placed in an optimal location relative to the location of data creation and use. Edge computing locates data and workloads to optimize for latency, bandwidth, autonomy and regulatory/security considerations. Edge-computing locations extend along a continuum between the absolute edge, where physical sensors and digital systems converge, to the "core," usually the cloud or a centralized data center.

Why This Is Important

Edge computing has quickly become the decentralized complement to the largely centralized implementation of hyperscale public cloud. Edge computing solves many pressing issues, such as unacceptable latency and bandwidth requirements, given the massive increase in edge-located data. The edge-computing topology enables the specifics of the Internet of Things (IoT), digital business and distributed IT solutions, as a foundational element of next-generation applications.

Business Impact

Edge computing improves efficiency and cost control through processing close to the edge (e.g., better automation and quality control), and more business opportunities and growth (e.g., customer experience and new real-time business interactions). Early implementations have succeeded in enterprises that rely on operational systems and data outside core IT, such as the retail and industrial sectors.

Drivers

Drivers to the adoption and implementation of edge computing include:

- Growth in cloud adoption has exposed the disadvantages of extreme centralization. Latency, bandwidth requirements, the need for autonomy, and data sovereignty or location requirements may be optimized by placing workloads closer to the edge and data produced at the edge, rather than centralizing in a hyperscale data center.
- Data growth from interactive applications and systems may not be economically funneled into the cloud.
- Applications featuring customer engagement and analysis favor local processing for speed and autonomy.
- IoT use cases are expanding from the industrial sector to other verticals, driving a move toward a hierarchical and distributed model.

Obstacles

- Extreme diversity of devices and application types amplify complexity issues
- Widespread application of the topology and explicit application and networking architectures are not yet common outside vertical applications, such as retail and manufacturing
- Lack of understanding of benefits/use cases
- Lack of standards
- Although the physical infrastructure for edge is maturing rapidly, the overall management and orchestration challenges of distributed applications are beyond vendor-supplied, component management offerings. The tasks of managing, securing, maintaining and updating the physical infrastructure, software and data requires considerable development before management and orchestration can be considered mature.

User Recommendations

- Create and follow an enterprise edge strategy by focusing first on business benefit and holistic systems, not solely pointing to technical solutions or products.
- Establish a modular, extensible edge approach through the use of emerging edge frameworks and architectures, which allow for the mixing and matching of technologies based on enterprise direction, not simply “what comes with the vendor solution.”
- Accelerate time-to-benefit and derisk technical decisions through the use of vertically aligned system integrators (SIs) and independent software vendors (ISVs) that demonstrate an understanding of and ability to implement and manage the full orchestration stack from top to bottom.
- Evaluate the deployment of “edge as a service” options, which promise to deliver “business-outcome-based solutions” that adhere to specific SLAs, while shifting deployment, complexity and obsolescence risk to the provider.

Gartner Recommended Reading

2021 Strategic Roadmap for Edge Computing

Cool Vendors in Edge Computing, 2021

Energy-Water Nexus

Analysis By: Bettina Tratz-Ryan

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Emerging

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.

Why This Is Important

According to the UN-Water facts, 129 countries are off track to have sustainably managed water resources by 2030, of which less than 10% is consumed residentially, the remaining 90% is consumed by industry and agriculture. The energy-water nexus is impacted by:

- Supply and water quality
- Water demand and climate change
- Desalination (highly energy intensive), and black and gray water treatments are energy expensive, exposing the poor and vulnerable communities to a water crisis

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. Cost of operations to produce water as well as desalination-induced energy consumption based on industrial water use presents the potential stigma or a reputational risk. Reporting, transparency and communications will mitigate the concerns for depletion or water quality risk relative to business operations.

Drivers

- Analytics and data generation through the 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.
- As sustainability measures such as UNSDG or GRI frameworks go mainstream, they are exposing industry players to reputational risk. For instance, the fracking industry in the southern U.S. is experiencing mitigation issues, as it 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 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. Or, in a more disruptive approach, calculate the total cost of water including the entire life cycle of production and water treatment. Companies like Nestle and Unilever are setting their internal water prices to ensure true price of water throughout the operations.

Obstacles

- While sustainable management of water and energy addresses sustainability-environmental risks, the absence of a true water price is hindering investment in management. Regions and countries with increasing cases of droughts and shifts in water allocation are challenged in their economic and industrial performances, especially with those regions highly dependent on oil and natural gas.
- The population growth in urban regions and rapid industrialization in developing countries are also major contributors.

User Recommendations

CIOs in water-intensive industries:

- Invest in a water management tool that will dashboard, simulate and manage the water life cycle across the operation. This will include water price costing for internal water use and mapping the price volatility of energy in case of desalination.
- Apply or evaluate technology solutions such as sensors, IoT and analytics together with modeling and simulation for energy use.

IT leaders in industry:

- Perform real-time tracking of energy price volatility by analyzing data through smart city, water and energy management platforms. End users need to involve new energy sourcing that includes waste to energy and circular economy principles.
- Explore the business benefit of microgrids, distributed grids and energy management with dispatchable pump loads that can leverage process buffers such as storage in critical peak periods.

Sample Vendors

ABB; ADASA; Black & Veatch; Deloitte; Fujitsu; Hitachi; Schneider Electric; SUEZ

Gartner Recommended Reading

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

Maverick* Research: Water Will Become the World's Most Precious — and Disruptive — Commodity

Industry Insights: Sustain the Future of Water With Utility Digital Business

Greenfield Smart City Framework

Analysis By: Bettina Tratz-Ryan

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition

A greenfield smart city framework is a strategic plan used to build a new urban area or district with limited or no existing infrastructure, such as communications, electrification and resource supply. All government and industry sectors link to community, district and industry collaboration platforms through IT and digitalization to build a sustainable ecosystem with little legacy or existing infrastructure.

Why This Is Important

Greenfield smart cities are increasingly gaining attention from conglomerates of urban real estate developers in emerging countries that want to create digital and intelligent smart city projects. Those greenfield programs require a holistic framework that connects national, business and society goals with urban or regional development.

The greenfield framework is often built on a city operations center sharing information across the ecosystem looking to benchmark performance and delivery KPIs.

Business Impact

Adoption is slow as the business of building an ecosystem to configure a greenfield smart city framework is immense; interoperability is needed between data exchanges, technology platforms and the Internet of Things (IoT). Real estate developers of greenfield smart cities seek to develop self-sufficient and environmental knowledge centers, and implement operations to curb inefficiencies in the infrastructure and through citizen communications and service platforms.

Drivers

- Adoption is evident in examples such as India's announcement that smart cities will be the core of urban, industrial and social development. Neom, Toyota's Woven City and Chicago's Lincoln Yards are examples of new housing districts or even entire cities being built from the ground up through public and private ecosystems.
- Standardization of greenfield services will come from an urban control center sharing information and business models across the ecosystem and looking to benchmark KPIs on performance and delivery.
- Many investments will depend on reaching the goals of institutional investors like the World Bank Group, which will provide governance in these projects.
- Business leaders determine the ownership of implementing vision and methodology and develop easy-to-use profitable business services. These services will be available through smart city application stores or city marketplaces.
- Governance will be required by institutions like the World Bank to create transparency in the investment process, as well as in the U.N.'s sustainable development goals. In addition, many emerging cities are eligible for the COP21 climate change funds when their infrastructure is delivered, due to climate change considerations.

- From an ecosystem perspective, the thrust toward digitalization across industry, business and society can be channeled in greenfield districts as innovation districts or corridors. That can include sensors, autonomous assets and mobility, data-driven service models, or new green tech development. This requires leaders to build a holistic, secure and scalable infrastructure foundation to enable capacity-intensive use cases and applications.

Obstacles

- The complexity of master planning often faces issues between being a political showdown with innovation and tech at the heart, and building a community with demographic diversity at the heart.
- City governments have neither experience nor knowledge on how to design, construct and operate the smart city.
- Technology and infrastructure experts often prioritize development, while data-driven platforms deliver district and urban services. These must come to an agreement on which urban objectives should go first.
- Many greenfield environments will derive value for commercial ecosystems through widespread access to users' and citizens' data. Data privacy issues need to be considered and well-communicated — failure to do so will lead to mixed adoption and low citizen approval.

User Recommendations

- Build digital business models for greenfield smart cities, leveraging lessons from the industrial ecosystems that have built transaction or collaboration platforms. Focus on best practices for process and data exchange, including financial and risk-sharing models.
- Design citizen experiences around work-life balance, digital work, citizen entrepreneurship, culture, traditional lifestyle, or sustainable living, because you need citizens' buy-in for data exchanges across the variety of ecosystem participants delivering the experience and outcome. Otherwise, you may get entangled in privacy discussions.
- Ensure flexibility when implementing the project to cope with changes. The development of a greenfield framework will take considerable effort. The ability to report financing and investment strategies to banks and investors is critical to validate the KPIs of the smart city solutions to be deployed.

Sample Vendors

Accenture; Arup; Atos; Capgemini; Cisco; Fujitsu; Hitachi; IBM; NTT DATA; NXN

Gartner Recommended Reading

Turning Smart Cities Into Intelligent Urban Ecosystems

Sustainability and COP 21

Analysis By: Bettina Tratz-Ryan

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition

Cities are becoming environmental and sustainability centers of excellence due to commitments made to the U.N. Framework Convention on Climate Change in 2015 to limit global warming to 2 degrees Celsius. The 450 cities that made this commitment are focusing on climate change risk management and opportunity identification.

Why This Is Important

Cities face climate-change-related challenges in the form of rising sea levels, rising temperatures and biodiversity loss. In addition, the COVID-19 pandemic's aftermath has exposed social issues, including sustainability inequality. City governments around the world are addressing these issues with "resilience strategies" to rebuild infrastructure, support sustainable industries and ensure holistic citizen engagement through focusing on sustainable development goals (SDGs).

Business Impact

Smart cities demand more user-focused environmental services and experiences. COP 21 declarations of city leaders and nonstate parties such as R20, ICLEI and C40 offer CIOs opportunities to innovate by linking technology projects to green initiatives. Data becomes instrumental for policy decision making, and CIOs can develop architectures and shared infrastructure that balance services with the related greenhouse gas emissions from IT itself.

Drivers

- For example, the European Green Deal is making carbon emission reductions and circular economy as key enablers for sustainable living. The diversity of political and demographic environments will, however, change the momentum for local governments due to funding and economic discussions, which leaves this innovation profile in the same place on the Hype Cycle as it was in 2020.
- 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, 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 address cities' distinctive needs, cities will outpace countries and regions in sustainability and environmental momentum and execution.

Obstacles

- The climate crisis expresses itself in climate change, loss of biodiversity, pollution and the loss of resources. The intelligent urban ecosystem can manage sustainability impacts only if there is good data on primary and secondary material impacts on the city and citizens. Those datasets are rarely available in scale from the industry and need to be standardized, especially for Scope 3 GHG.
- Data sharing needs to include GHG emission data so that industry partners from insurance, real estate development, banking, and logistics and supply chain organizations can model their impacts to avoid a business risk. It also involves consideration of data security.
- Reaching sustainability goals needs to become more transparent, which provides CIOs with options for frameworks such as STAR Communities and World Bank Group's CityStrength diagnostic to orchestrate data.

User Recommendations

- Apply technology to understand operational efficiency, data sharing and business process alignment to condense the urban asset footprint, while visualizing this impact in various channels. Support the development of collaboration and dashboarding of sustainability-minded citizens who will engage in environmental activities such as restricting high-emission vehicles in city centers and offering energy conservation and green energy options for streetlights and buildings.
- Define the KPIs of smart city initiatives in sustainability terms. Create advisories on the use of IoT by citizen advisory boards for measuring emissions, air pollution, waste and recycling rates. Cooperate in public-private partnerships with utilities, waste management companies and consumer goods providers to create business awareness and end-to-end circular city life cycle applications in microgrids, recycling, and smart building and home ecosystems.

Sample Vendors

Deloitte; E.ON; Esri; The Nesting Co.; Sphera

Gartner Recommended Reading

Leading Sustainability Ambition, Goals and Technology in the 2020s

Predicts: Smart City Resilience and Citizen Experience Will Drive Sustainability and Urban Attractiveness

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

Digital Ethics

Analysis By: Pieter den Hamer, Frank Buytendijk, Svetlana Sicular, Bart Willemsen

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition

Digital ethics comprise the systems of values and moral principles for the conduct of electronic interactions among people, organizations and things.

Why This Is Important

Digital ethics, and in particular privacy and bias, remain a growing concern. The voice of society and AI-specific ethical considerations are rapidly coming into focus for individuals, organizations and governments. People are increasingly aware that their personal information is valuable; they're frustrated by lack of transparency and continuing misuses and breaches. Organizations act to mitigate the risks involved in securing and managing personal data, and governments are implementing strict legislation in this area.

Business Impact

Digital ethics strengthens the organization's positive influence and reputation among customers, employees, partners and society. Areas of business impact include influencing innovation, product development, customer engagement, corporate strategy and go-to-market. Intention is key. If ethics is simply a way to achieve business performance, it leads to window dressing. The goal to be an ethical company serves all parties and society more broadly and leads to better business trust and performance.

Drivers

- Despite the hype around digital ethics, many organizations are still ignoring it. They think it doesn't apply to their industry or domain without giving it a deliberate consideration.
- Board members and other executives are sharing concerns about the unintended consequences that the innovative use of technology can have.
- There is frequent, high-profile press coverage of stories that concern the impact of data and technology on business and society more broadly.
- With the emergence of artificial intelligence, for the first time the ethical discussion is taking place before — and during — a technology's widespread implementation. AI ethics and other responsible AI steps are a foundation to reverse the negative popular sentiment around AI and lead to a more responsible use of its powers.
- Government commissions and industry consortia are actively developing guidelines for ethical use of AI. Examples include Ethical Framework for Artificial Intelligence In Colombia, New Artificial Intelligence Regulation in the EU and Using Artificial Intelligence and Algorithms in the U.S.
- Over the past year, a quickly growing number of organizations declared their AI ethics principles, frameworks and guidelines. They have a long way to go from declaration to execution, although some organizations already have digital ethics practices.
- Gartner predicts that by 2024, 30% of major organizations will use a new "voice of society" metric to act on societal issues and assess the impact on their business performance. The voice of society will put more pressure on governments and public and private organizations alike to ethically use technology. "Big tech" is already a negative stereotype in societal jargon.
- More universities across the globe are adding digital ethics courses and launching programs and centers to address ethical, policy and legal challenges posed by new technologies.

Obstacles

- Digital ethics is seen as a moving target because of confusion on what society expects. It might even lead to opposing the majority's opinion, based on an organization's position and beliefs.
- Digital ethics is too often reactive and narrowly interpreted as compliance, or confined to the technical support of privacy protection or viewed as explainable AI only.
- AI ethics is an emerging area in overall digital ethics. Early high-level guidelines are inconsistent and will evolve over time.
- The voice of society is a new metric where digital ethics should be present, but its weight is still to be understood. Insufficient attention leaves organizations exposed to lost business, higher costs and increased risk.
- Opinions differ across people, regions and cultures on what constitutes "good" and "bad." Even in organizations where ethics have been recognized as an important issue, consensus between internal and external stakeholders (such as customers) remains sometimes difficult to achieve.

User Recommendations

Business and IT leaders responsible for digital transformation in their organizations:

- Identify specific digital ethics issues and opportunities to turn awareness into action.
- Discuss ethical dilemmas from diverse points of moral reasoning. Ensure that the ethical consequences have been accounted for and that you are comfortable defending the use of that technology, including unintended negative outcomes.
- Elevate the conversation by focusing on digital ethics as a source of societal and business value, rather than simply focusing on compliance and risk. Link digital ethics to concrete business performance metrics.
- Ensure that digital ethics is leading and not following digital transformation. Address digital ethics early "by design" to move faster by knowing methods to resolve ethical dilemmas.
- Organize training in ethics and run workshops to create awareness within all AI initiatives about the importance that AI design and implementation require an ethical mindset and clear accountability.

Gartner Recommended Reading

Digital Ethics: From Compliance Duty to Competitive Differentiator

AI Ethics: Use 5 Common Guidelines as Your Starting Point

Every Executive Leader Should Challenge Their Teams on Digital Ethics

Digital Ethics by Design: A Framework for Better Digital Business

Data Ethics and COVID-19: Making the Right Decisions for Data Collection, Use and Sharing

Use Privacy to Build Trust and Personalize Customer Experiences

Civic and Community Development

Analysis By: Bettina Tratz-Ryan

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Civic and community development in smart cities aims to support the social and community issues identified in a social cohesion strategy. Platforms and applications are used to develop a collaboration mechanism to engage stakeholders, establish trust and open dialogue between societal and demographic parties. As a result, civic development is generating empowerment toward quality of life for a future-ready community, including efforts in healthcare, wellness, and social care and services.

Why This Is Important

Community engagement can be accelerated by the availability of open data from the community and government as it enables stakeholders to connect the dots between community issues and sentiments. Citizens, businesses, nonprofits and technologists can all engage in a contextualized way, creating and utilizing neighborhood maps during pandemic times, providing support through social engagement or analyzing user journeys to generate demographically based applications.

Business Impact

The business impact of civic and community development aligns a contextualized communications approach with dedicated applications for different demographics. Many of the industrial engagement platforms, including communities on consumer applications such as Facebook and Google, show that community identification significantly increases the satisfaction rate with surroundings — that is, city or urban management. It will also provide Inclusion as it is connecting citizens to opportunities.

Drivers

- The speed of adoption of civic and community engagement and development has increased due to the differentiated demographic needs related to postpandemic social requirements. With pandemics and other direct life-changing events, disadvantages through the digital divide have appeared globally at different scales. This demographic and social inclusion trend includes older generations, migrants and millennials in community participatory research. It will apply different use patterns of communications and engagement technologies and their impact on the city environment.
- Cities will build citizen engagement and civic outreach through special departments, but will also be using NGOs to engage with citizens consistently. Those NGOs have been working as conduits in many cities to facilitate connections between city police and teenagers, for instance — something that can be also supported through a broad civic environment.
- Inclusion in community, labor markets, environment, education and health need to be provided with single identity management that will create trust in data sharing, and will improve quality of life in obtaining more comprehensive services. A data trust will cater to sentiments and citizen issues, and citizen engagement will address issues of “social cohesion,” which is defined as the ability of a community to create an equal, safe and prosperous community.
- Improvements in social platforms, smartphones, e-commerce and analytics will lower the barriers for citizens to interact and transact with one another. Those engagements are developing from the bottom up, leading to participatory engagement by, for instance, linking citizen science to environmental health.
- Digital equity and inclusion is now measured through community engagement KPIs and policy outcomes with service delivery of the civic and community development platforms.

Obstacles

- The acceleration of civic and community engagement frameworks, platforms and applications depends on citizens and communities trusting government activities. Community development is sustainable when communities feel empowered to advance not only on various issues, but also on personal perseverance.
- The level of adoption varies based on regional or communal trust regarding access to safe data, data privacy and security. This includes GPS and user-centric data collected through IoT, as well as more formalized citizen ID, or e-ID engagements, with General Data Protection Regulation (GDPR).

User Recommendations

- Moderate constituents and public and private entities on the use of data and technology by applying an information hub or platform for citizen developers and community NGOs. CIOs could apply augmented reality, AI and chatbots to understand native language suggestions and digitize citizen issues so they can be pushed through the government service environment.
- Use gamification and collaboration tools to crowdsource social media engagement for trending sentiment. For example, hackathons could allow civic groups to be involved in innovation projects.

Sample Vendors

CitizenLab; Esri; Indra (Minsait); Tableau

Gartner Recommended Reading

Postpandemic Scenarios: The Future of Digital Government Transformation

Government APIs Are About Delivering Outcomes, Not Technology

Intelligent Street Pole

Analysis By: Bettina Tratz-Ryan

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition

An intelligent street pole is an asset that hosts a variety of different IoT and networking devices, cameras, monitors and displays. It is controlled and monitored from a single operator, and enables EV charging, interactive lighting, parking management and crowd control. It can provide the backbone for a citywide Wi-Fi or 5G network that can enable computing and communications for intelligent street and district services.

Why This Is Important

Intelligent street poles are an evolution of smart street lighting, which moved rapidly into mainstream adoption. Compared with light posts, street poles host a variety of different city- and ecosystem-relevant sensors and technologies, and enable a concerted aggregation of location-based data. The maturity of context-based analytics will be accelerating around parking options, asset management in the vicinity of smart buildings and real estate, and retail locations in downtown areas.

Business Impact

Intelligent street poles are expected to become valuable real estate, as their location and the ability to connect many sensors can avoid multiple installations and provide cost-efficiencies. New designs of street poles may include charging stations, parking meters and other consolidated road management systems. Business momentum will come from the transparency and value generation through data exchanges between ecosystem partners, such as retail, parking and e-charging, and advertisements.

Drivers

- As the postpandemic activities in locations in cities increase, especially in heavily frequented spaces, intelligent street poles will become the center of monitoring and communications platforms. User experiences in tourism and public safety will highly benefit from situational awareness mapped to location- and user-centric data. Cities like Amsterdam and Los Angeles are using the availability of data analytics to manage lighting, music, public messaging, and other features directly mapped to crowd or vehicular movement.
- Street poles, as well as devices mounted on the poles, are owned by public works, utilities or private-sector stakeholders and, therefore, serve a variety of different business purposes. Many urban planning decisions that are on spatial development and services for micromobility, climate change and green spaces, last-mile logistics, and development of new business districts, can evaluate smart street poles. The poles can serve as valuable urban real estate for a 5G base station, EV parking and concierge services, and private-sector curb pricing for property insurance or retail per square foot of curb space.
- Business momentum will be triggered by the gains from managing the data complexity that will drive ROI and future-proof implementation in greenfield locations and districts. CIOs and their teams in urban ecosystems have to determine location, connectivity and compute power to gain ROI and value streams. Google Sidewalk Labs is measuring the location value of curbs by square feet, with all the assets that belong to this area.
- Smart street poles will be deployed in parking garages or as part of smart real estate development from the private sector. Urban leaders could apply them to revitalize locations or create innovation hubs by offering data from street poles to ecosystem partners, with new AI and video analytics technology.

Obstacles

- Obstacles to ecosystem development include the complexity of ownership and the volatile expectations of ROI benefits.
- Issues around management of assets mounted on poles, together with maintenance, data orchestration and cybersecurity, need to be addressed to enable scalability and drive adoption. Utilities, CSP and real estate developers emerge as deployment stakeholders.
- Privacy concerns should be managed upfront, with the understanding that intelligent street poles will initially be available as lampposts.

User Recommendations

- Classify sensor data and insights gained from the street pole through analytics to generate value for smart city, smart street or district deployments. Develop scenarios to calculate the connectivity, computing and powering requirements for multiple IoT sensors and other products on the pole. This is critical, as cyber-physical systems and mesh technologies may define and execute on the linked data analytics or data graphing off the post.
- Manage upfront how you will mitigate privacy concerns. For example, inform others that intelligent street poles will initially be available as lampposts.
- Enforce digital security at the individual asset level of the pole, as well as at the edge gateway and transmission to the core of the street pole ecosystem. With the increasing mesh of interactions and value generation, access is increasing for potential digital intrusions, as well as privacy violations.

Sample Vendors

Acuity Brands; CIMCON Lighting; Fluentgrid; GE; Signify

Gartner Recommended Reading

Turning Smart Cities Into Intelligent Urban Ecosystems

From Smart City to Intelligent Urban Ecosystem — Unlocking Data Value Is the Key to Cities' Industrial Partnerships

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

Sliding into the Trough

5G

Analysis By: Sylvain Fabre

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition

5G is the next-generation cellular standard by the 3rd Generation Partnership Project (3GPP). The standard targets maximum downlink and uplink throughputs of 20 Gbps and 10 Gbps respectively. Latency is as low as 4 milliseconds in a mobile scenario and can be as low as 1 millisecond in ultra-reliable low-latency communication scenarios, and massive scalability. New system architecture includes core slicing as well as wireless edge.

Why This Is Important

5G is key for industry digital transformation, with 162 operators rollouts (Source: GSA, April 2021), 20% of mobile networks (up from 9% one year ago). 3GPP 5G standards releases deliver incremental functionality:

- R15: Extreme mobile broadband
- R16: Industrial IoT (massive IoT, slicing and security
- R17: MIMO enhancement of MIMO, Sidelink, DSS, IIoT/URLLC, bands up to 71GHz, nonterrestrial networks and RedCap
- R18: Under definition

Business Impact

- Material impact on multiple industries and use cases by enabling digital transformation.

- 5G enables three main technology deployment and business scenarios, which each support distinct new services, and possibly new business models (such as latency as a service), namely enhanced mobile broadband (eMBB) supports high-definition video, mMTC supports large sensor and IoT deployments, and URLLC covers high-availability and very low-latency use cases, such as remote vehicle/drone operations.

Drivers

- Increasing device penetration: Gartner estimates that 5G-capable handset penetration will reach 87% in 2023 in Western Europe, similar to North America.
- Operational cost savings for industry use cases.
- Agility — in particular, in oil and gas and manufacturing.
- Requirements from industrial users value 5G lower latency from ultra-reliable and low-latency communications (URLLC) and expect 5G to outperform rivals in this area.
- Demand for massive machine-type communications (mMTC), to support scenarios of very dense deployments up to 5G target of 1 million connected sensors per square kilometer.
- Increased availability of industry-specific spectrum options (e.g., CBRS).
- mMTC addresses the massive scale requirements of IoT.

Obstacles

- Availability of spectrum, in particular for industrial private networks, in some countries.
- Security concerns over certain vendors, and when using 5G in critical industrial scenarios.
- Readiness of R16 solutions; availability and pricing of networks and modules.
- Use of higher frequencies and massive capacity requires very dense deployments with higher frequency reuse.
- Uncertainty about use cases and business models that may drive 5G for many CSPs, enterprises, and technology and service providers (TSPs).

- Different dynamics by regions: where in many parts of Africa for example, 5G would not be the next step up from lower bandwidth services, and handset cost may be an inhibitor for lower-income subscribers. Adoption is more aggressive in APAC and NAR, with Europe cautiously enthusiastic — and the developing world lagging.
- Feedback from some industrial clients mentioned that the majority of their use cases could be serviced by a 4G private network, and/or NB-IoT and other LPWA such as LoRa.

User Recommendations

- Enable a diverse network that can offer adequate and cost-effective alternatives to 5G for many use cases (e.g., LPWA, NB-IoT, LoRa, Wi-SUN).
- Enable 5G for temporary enterprise connectivity, mobile and FWA secondary/tertiary use cases for branch location redundancy, as long as 5G is not the primary link for high-volume or mission-critical sites, unless there are no other options.
- Provide clear SLAs for network performance by testing installation quality for sufficient and consistent signal strength, signal-to-noise ratio, video experience, throughput and coverage for branch locations.
- Ensure backward compatibility to 4G devices and networks, so 5G devices can fallback to 4G infrastructure.
- Focus on architecture readiness — such as SDN, NFV, CSP edge computing and distributed cloud architectures, and end-to-end security — in preparation for 5G.
- Build their ecosystem of partners to target industry verticals more effectively with 5G.

Sample Vendors

Cisco; Ericsson; Huawei; Mavenir; Nokia; Qualcomm; Samsung; ZTE

Gartner Recommended Reading

U.S. Telco 5G Plans Take Shape

Emerging Technologies: 5G Technology Spending, 2020 Survey Trends

5G as a Service: Deployment Scenarios of Private Networks in the 5G Era

Market Guide for 5G Network Ecosystem Platform Providers

Creating Your Enterprise 4G and 5G Private Mobile Network Procurement Strategy and RFQ

Water Management Analytics

Analysis By: Bettina Tratz-Ryan, Aanchal Mair

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

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

Why This Is Important

Water management requires a differentiated set of technology and service skills to cater effectively for: distribution for residential and commercial customers; water pollution, water treatment and recycling; rainwater runoff and natural disasters. Water management data will require more solution capabilities related to an entire management cycle that includes operations, user billing and monitoring, and forecasting of demand and quality.

Business Impact

Consolidating data points to manage and control water issues — from supply to reuse and recycling — provides water suppliers and municipalities with the ability to achieve cost-effective potable water quality. It improves the interface between asset tools for pumping stations, meters and monitors for better customer services, with fewer water-supply failures and better water quality. Partnerships with IT and water operations have to be built to connect data and information sources.

Drivers

- Artificial intelligence (AI) is being used to address an infrastructure resilience issue. Adoption is accelerating as emergency response around water crises in drought and flooding, relative to shifts in weather patterns, has captured the attention of local governments and utilities from a risk perspective.
- Water quality issues triggered by agriculture fertilization are driving up water prices in cities by 50% year over year in countries like Germany. That is accelerating the deployment of new water management solutions and increasing the time to deliver water to customers.
- Climate change priorities are shifting toward water sustainability, capturing the attention of industry players. Government initiatives and the developments in pricing of water will also drive water management — once meters are installed to monitor true consumption.
- Water management is a growing application area for industry and business uses, including touristic sites like beaches and lakes. It also offers insights into disaster recovery for water-related issues in manufacturing operations.
- Cities are applying Internet of Things (IoT) sensors across wastewater infrastructure to measure COVID-19 hot spots and epidemiology through the wastewater streams, like Vienna in Austria or Stafford County in Virginia.
- Residential water needs will compete with business needs, and analytics will be needed to resolve it. South Africa and the state of California are examples for this competition.

Obstacles

- The position of the profile has moved slowly in 2021 in the Hype Cycle because water management has developed more complex use cases.
- While local utility and freshwater supply is experiencing more water intelligence, shortage of climate-related resources and natural disruption is not priced in the supply, thus artificially keeping the delivery cost low.

User Recommendations

- Evaluate the implementation of data management and analytics for water infrastructure and quality. Users (industries and commercial) and suppliers (municipalities) must report, or comply with, tightening wastewater regulations, while improving efficiency and reducing loss and waste-disposal costs.
- 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.
- Develop an adaptive and flexible water management strategy, integrating the legacy of IT and OT. IT professionals in utility and municipal contexts can develop strategy based on intelligent information received from environmental sensor and satellite networks, smart water meters and deep computing, and analytics engines.

Sample Vendors

ABB; ADASA; Arcadis Gen; Atos; EcoExam; KISTERS; Schneider Electric; SUEZ

Gartner Recommended Reading

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

Maverick* Research: Water Will Become the World's Most Precious — and Disruptive — Commodity

Industry Insights: Sustain the Future of Water With Utility Digital Business

Vital Digital Technology Investments for Water Utilities

Smart City Framework

Analysis By: Bettina Tratz-Ryan

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition

A smart city framework guides the development of a service experience by connecting into an intelligent urban ecosystem to improve its citizens' lives, stimulate its economy and protect its environment. The ecosystem of actors is facilitated with algorithmic business, legal frameworks and policies, and data marketplaces. They define and measure the impact of technology through data and analytics to create a user-focused and contextualized experience.

Why This Is Important

Since the pandemic, we have seen many intelligent urban ecosystems and cities accelerate the development of a smart city framework based on mobility, social development, economic recovery and safety issues, rather than solely on technology they could invest in. Local governments are now including data exchanges to generate data-sharing-enabled ecosystems by building digital business services and experiences for customers and citizens.

Business Impact

The business impact of smart city frameworks is driven by the ability to automate and deliver better service experiences through data exchange, and citizens' experience and their data trust. Open data portals and data marketplaces will provide transformational access to an urban context that will be used to drive more use cases and user-specific ambient services, including demographic changes, digital skills, knowledge exchange and sustainability-related ambience.

Drivers

- The digitalization of daily life and urban operations, especially with the increasing flow of data, is driving the architecting of a city framework.
- Governance and engagement structures will be established by local governments that will manage and support the interactions and the winning formula between city, economy and society.
- Contextualized data will come from preferences and movement data of residential and business users that map to real-time data from infrastructure and services.
- The smart city framework will be empowered through technology approaches such as cloud and big data management. As cities work together as regions, a holistic platform approach with a system of systems is being developed that allows interoperability and data governance of new services including city algorithms as a service.

Obstacles

- Blending smart data will add to privacy and safety discussions in specific use cases, all the way up to local government.
- With increasing data analytics and AI utilization, the challenge of the perception of security in storage and management of data is increasing, and the framework needs governance. Therefore, digital equity, data laws and AI ethics need to be included, leading toward a data vault and trust factors.
- Building a framework requires all stakeholders to agree on a common mission. That includes not only the definition of urban development, but also the holistic social, demographic and economic objectives as embedded in a sustainable smart city environment. Articulating the outcome and benefits often hinges on political, financial or short-term priorities, rather than long-term vision.

User Recommendations

- Operate and manage the city perception of residential and business citizens as depicted in the framework by developing a data-driven decision roadmap.
- Develop guidelines and a governance mechanism for data trust, ethical AI and data privacy issues.
- Share insights and data orchestration with other smaller cities or regional partners by developing a synchronized network of best practices for cities, avoiding the duplication of infrastructure, IoT platforms or data analytics. This could become a system-of-systems approach or smart city as a service.
- Apply a technology inventory that will support the set of objectives, as well as the information and data exchange requirements for the city, along with public-private initiatives.

Sample Vendors

Accenture; Arup; Cisco; Fujitsu; IBM; Microsoft; NXN; SAP; Schneider Electric; Siemens

Gartner Recommended Reading

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

Smart City Transportation Strategy

Analysis By: Pedro Pacheco, Bill Finnerty

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition

Smart city transportation strategy defines goals for a sustainable and holistic technology and data exchange collaboration between different transportation- and mobility-related urban ecosystem stakeholders. This collaboration includes a variety of mobility, local transport, parking and new last-mile logistics applications.

Why This Is Important

A transportation strategy can help cities address fluctuating mobility and transportation requirements of urban ecosystems, especially during postpandemic recovery. For instance, while public transport is often coping with less passengers and more individual journeys, last-mile logistics is booming in different form factors, like drones and e-bikes.

Business Impact

A smart city transportation strategy supports a future-proof investment plan for governments in parking, street and intersection domains, together with the designation of carriers for passengers in public transport. It takes into consideration congestion and travel velocity for commuters, logistics, tourism and other travel forms. Data platforms and analytics will be key to develop sustainable and carbon-neutral transportation options, as well as social and equitable mobility concepts.

Drivers

- Smart city transportation strategy is approaching the Trough of Disillusionment. Urban ecosystems and local governments have realized the need for a revised comprehensive postpandemic approach as mobility and transportation behavior will affect investment strategies. However, a certain lack of strategic planning capabilities from a number of transit agencies will lead smart city transportation strategy to dip into the Trough of Disillusionment before it can reach the Plateau of Productivity and an advanced level of maturity.
- These local governments have also started to address themes like spatial planning, data sharing and management of solutions. For instance, several cities are starting to take steps toward the creation of their own mobility as a service (MaaS) ecosystems and platforms. This is a decisive step toward the deployment of a fully integrated mobility strategy in a user platform. In some cases, there are also projects to build an open data ecosystem encompassing the entire transportation ecosystem — something that can provide major future benefits by enabling an overall improvement of transportation at several different levels.
- Cities are dealing with increasingly complex problems — like congestion and pollution. These highlight the growing need for technology investments — in transportation and other areas — as a way to solve these complex problems. These demand advanced planning and technological foresight, both incorporated into a smart city transportation strategy.

Obstacles

Local transit authorities with the power to develop smart city transportation strategies usually encounter the following obstacles:

- Limited know-how or skepticism hinders transit planners when defining long-term investments into innovative transportation technologies.
- Changes in political power sometimes create a problem of continuity for the fulfillment of a long-term strategy.
- Local transit authorities often cannot define long-term targets or KPIs that are specific, measurable, attainable, relevant or time-bound. As such, this generates major obstacles in defining a clear strategic course.

User Recommendations

- Set the policies and governance to enable a transportation open data ecosystem. This will enable, later on, major gains in terms of transportation planning and an overall improvement of transportation services.
- Ensure your smart city transportation strategy assesses the impact of these socioeconomic changes and defines appropriate action. COVID-19 will bring permanent changes to cities, like people moving out of urban centers due to remote work.
- Develop an overall transportation strategy around specific, measurable and time-bound targets. This will make it easier to choose the right technology to enable reaching those targets. Focus on KPIs and other references like ISO 37120 or ITU-T.
- Build a technology radar to provide visibility of all major transportation technologies coming up in at least the next10 years. This enables a greater understanding on how technology can best help your organization fulfill its smart city transportation strategy.

Sample Vendors

MaaS Global; Mott MacDonald; Optibus; PTV Group

Gartner Recommended Reading

COVID-19 Scenarios for Automotive and Transportation CIOs

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

IoT Platform

Analysis By: Alfonso Velosa, Eric Goodness

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition

An Internet of things (IoT) platform enables the connection and capture of data from IoT-enabled assets or endpoints to develop, deploy, and manage business solutions that improve operations such as monitoring remote assets or optimizing maintenance. Capabilities include device management, integration data management, analytics, application enablement and management, and security. It may be delivered as edge or on-premises software, or cloud IoT platform as a service, or a hybrid combination.

Why This Is Important

Enterprises continue adding IoT capabilities to assets and products, seeking benefits such as cost optimization, process optimization, improved customer experience, and new opportunities such as product as a service. The sophistication, scale and business value of these interactions call for specialized technology resources, most often implemented as an IoT platform. While all verticals are deploying IoT, spend is highest in asset intensive industries such as manufacturing or oil and gas.

Business Impact

IoT platforms are usually required to implement IoT-enabled assets in order to make better business decisions from the data and information generated by connected products. Goals include:

- Differentiated smart products
- Cost optimization strategies centered on improved maintenance
- Process improvement by using assets at their best state
- Opportunities to sell new services and data products

Drivers

- Proliferation of IoT projects since IoT is widely proven across many industries to improve business outcomes — see Survey Analysis: Focus on Practical Outcomes for IoT Projects.
- IoT platforms are fit-for-purpose PaaS and on-premises software offerings that specifically help software teams to accelerate and improve the quality of IoT products while consolidating and structuring the data.
- Enterprises leverage their IoT assets to drive differentiation, lower costs, improve processes and enhance worker safety.
- Technology providers are driving marketing and sales efforts to engage their customers with IoT platforms. In parallel they invested in improved ecosystems and channel partners to make it easier for companies developing IoT enabled solutions to achieve business value.
- In parallel, technology providers continue to invest in their IoT platform technology to ensure they can deliver business solutions at scale for their customers.

Obstacles

- IoT platforms require extensive customization to achieve business outcomes for large-scale deployments, driving up cost and schedule.
- Many enterprises approach IoT projects as technology projects, instead of as business projects that use IoT platforms to achieve business outcomes.
- Many enterprises operate in siloed fashions, adopting different IoT platforms for each use case, limiting their ability to scale, and adding complexity.
- Projects that use IoT platforms drive greater volumes of data, complicating existing processes and overwhelming employees and other stakeholders. They often lack training or process changes to absorb this new data — leading existing systems and people to reject the output of the IoT platform.
- IoT technical complexity, security and integration challenges remain barriers to scale at enterprises.
- Technology providers have yet to develop a clear value proposition and sales strategy that helps their customers leverage their platforms on scaled up levels.

User Recommendations

- Start with smaller IoT projects that help the business unit and IT organization acquire implementation lessons, identify IoT platform strengths and weaknesses, and verify alignment to business and finance KPI requirements.
- Identify the range of IoT projects for your enterprise, and segment them by their focus (internal vs. external), complexity and business objectives. Use these insights to establish a distributed deployment and a platform of platforms architecture.
- Use a skills gap for IoT projects and IoT platforms to build a plan to improve the IT organization's capabilities such as integration or digital twin model development.
- Prioritize vendors you already work with for their IoT platform. Evaluate candidate vendors on their fit-to-your-business objectives and technology. Key evaluation criteria include: proofs of value projects (for tech and business), the ability to drive operational-scale deployments, vertical market expertise and a partner ecosystem.

Sample Vendors

Alibaba Cloud; Amazon Web Services; AVEVA; ClearBlade; COVACSIS Technologies; Detechtion Technologies; Knowledge Lens; Microsoft; Siemens

Gartner Recommended Reading

Magic Quadrant for Industrial IoT Platforms

Critical Capabilities for Industrial IoT Platforms

Use the IoT Platform Solution Reference Model to Help Design Your End-to-End IoT Business Solutions

Use 4 Building Blocks for Successful Digital Twin Design

Shared Mobility

Analysis By: Michael Ramsey

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition

Shared mobility encompasses the use of ride-hailing or other on-demand mobility models that manage the pickup and drop-off of customers, primarily through a mobile application. These platforms often offer cars, but could offer bikes, scooters, boats and even helicopters.

Why This Is Important

Shared mobility has fundamentally created an entirely new channel and methodology for travel and for the use of transportation assets. By creating an IoT platform that can schedule, book, route and manage payment of travel, consumers have lower-cost options to get around in urban areas, and drivers are more able to use their vehicles to make money. In addition, these same platforms have been leveraged to offer micromobility services, such as floating bikes or e-scooter shares.

Business Impact

Shared mobility — primarily through Uber and other ride-hailing platforms — has had a huge impact on transportation, which is likely to continue. Although the model suffered in 2020 after the onset of lockdowns, usage has snapped back. Shared mobility has created new ways of getting around in urban areas, but its impact hasn't been all good. Traffic in city centers has sometimes increased as people have traded walking, riding public transportation and biking for inexpensive ride-hailing.

Drivers

- The end of the COVID-19 pandemic will have a significant positive impact on shared mobility as people return to work in urban centers and begin to do more entertainment and travel, which helps to increase shared-mobility usage.
- Shared mobility may be positively affected by the rise in electric vehicles as their price drops. In addition, the cost of operating ride-hailing cars should fall as more vehicles use electricity rather than fuel. This also could also reduce pollution concerns in urban centers where the increase in traffic from ride-hailing initially raised concerns.
- The rise of autonomous vehicles (AVs) could also increase shared mobility because the AV is ideally suited to perform mobility services.

Obstacles

- The economics of shared mobility have always been a problem. Many shared mobility platforms have been unprofitable, and it is difficult to see an easy path toward profitability.
- Changes in culture around working from an office versus at home, as well as the uncertainty around when the pandemic will recede, could impede shared mobility.
- Laws in certain regions that require ride-hailing providers to be considered employees or limit them against taxi operators may change the structure of the primary companies offering services and make it more difficult to expand.

User Recommendations

- Look for ways to connect these services into a holistic transportation strategy, enabling payment or scheduling options that complement public and private transportation options.
- Be wary of investing in, or connecting with, services that skirt city regulation, because the services could quickly be frozen out for an individual town.
- Create transportation plans as a means to improve traffic congestion, to address pollution concerns and to even provide lower-cost transit.
- Look for ways to use shared mobility to provide transportation options for people who feel uncomfortable in public transportation as a result of the pandemic or who aren't able to use public transport, like the elderly.
- Set up data exchanges for mobility and related ecosystem datasets that can be combined for new services on last-mile logistics, as well as adjacent service potentials in touristic, health and insurance business sectors for CIOs working for industrial and commercial clusters and real estate development.

Gartner Recommended Reading

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

Turning Smart Cities Into Intelligent Urban Ecosystems

Market Trends: 5 Smart City IoT Deployment Trends to Drive Innovation Opportunities

3 Ways Transportation CIOs Can Shape a Mobility-as-a-Service Ecosystem Effectively

Blockchain

Analysis By: David Furlonger, Christophe Uzureau, Rajesh Kandaswamy

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition

A blockchain is an expanding list of cryptographically signed, irrevocable blocks of records shared by all participants in a peer-to-peer (P2P) network. Each block of records is time-stamped and references links to previous data blocks. Anyone with access rights can historically trace a state change in data or an event belonging to any participant. Distributed ledgers are design-limited and lack decentralized and tokenized elements.

Why This Is Important

Blockchain fundamentally changes how commerce is conducted and value is exchanged by enabling:

- The creation, use and representation of assets in new forms
- Different kinds of autonomous, machine-based interlocutors to make decisions
- The redesign and automation of rules and processes governing transactions and interactions, changing the competitive landscape
- The development and deployment of new digital infrastructures that will redefine citizen, enterprise, industry and geopolitical relationships

Business Impact

Gartner's blockchain spectrum anticipates disruptions evolving over this decade. Blockchain-complete solutions start to enter the mainstream over the next two years via developments in areas such as:

- Tokenization of digital and physical assets
- The decentralization of finance and business ecosystems
- Software-designed and -defined business process interaction and execution

- Partnerships and collaborations based on a more decentralized governance
- Self-sovereign identity management and portability

Drivers

- Opportunities are becoming clearer and experiments continue, especially for blockchain-inspired or enterprise distributed ledger solutions that focus on process efficiency and cost management.
- The COVID-19 pandemic has caused executive leaders to accelerate digital business activities, and this is propelling a renewed focus on blockchain and growth opportunities afforded by a more programmable economy.
- Blockchain is seen as a way to address multiple problems that other technologies cannot easily address, such as audit and compliance, oversight of public fund distribution, healthcare passporting, food security and financial inclusion — via CBDC and ESG.
- Blockchain is being perceived as a potential foundational infrastructure for capturing new growth opportunities via fractional ownership via decentralized finance (DeFi) and NFT, customer engagement through enhanced loyalty, and rewards.
- The emergence of new digital infrastructures, such as in China with the development of the BSN and DCEP, is now more directly linking supply chains to payments and financing. The integration of synergistic technologies such as AI, NFC, 5G and IoT with blockchain could also fuel digital infrastructure development (which will heighten geopolitical tensions), as well as enterprise project investments and vendor solutions.

Obstacles

- Immature standards
- Establishing effective governance for consortia and alliances
- Geopolitical tensions surrounding emerging technologies
- Cybercrime/warfare
- Immature UX
- Executive leader education and awareness gaps
- Demand-side intransigence/apathy
- Shifts in government regulations
- Shortcomings in the evolution of some of the core technologies and proliferation of scalability problems
- Lack of interoperability technically and from siloed business projects
- Difficulty integrating with and retiring legacy systems
- Data management complexity
- Lack of blockchain talent
- Organizational obstinacy and lack of user experience and education
- Security and privacy challenges — especially relating to cross-border activities
- Organizational concerns about decentralized operations
- Negative enterprise perceptions concerning digital assets, tokens and cryptocurrency generally
- Shift in investments due to COVID-19
- Short-termism created by cryptocurrency valuations

User Recommendations

- Educate executive leaders about the opportunities and threats that blockchain capabilities introduce by using workflow models of value exchange.
- Use clear language and definitions in internal discussions about how distributed ledgers may or may not improve existing systems and processes.
- Continue to develop proofs of concept (POCs) — especially in the context of market ecosystems.
- Identify integration points with existing infrastructures including: digital wallets, core systems of record, customer service applications and security systems, artificial intelligence (AI) and Internet of Things (IoTs).
- Ensure sufficient innovation capacity is applied to the evolution of distributed ledgers and blockchains outside of your immediate industry.
- Read The Real Business of Blockchain: How Leaders Can Create Value in a New Digital Age.

Gartner Recommended Reading

Non-Fungible Tokens (NFTs) Create New Digital Products and Business Models

Shape Your Digital Strategy With Central Banks' Intentions Toward Digital Currencies

Accelerate Financial Ecosystems to Keep Up With Digital Giants

What Is Ethereum 2.0 and How Does it Relate to Digital Business Acceleration and a New Programmable Economy?

Take Control of Your Digital Acceleration by Focusing on How Value Flows Through Ecosystems

Use 4 Business Currencies and 5 Archetypes to Evaluate Blockchain Initiatives

Executive Leaders Should Embrace Social and Economic Decentralization

Understanding the Gartner Blockchain Spectrum and the Evolution of Technology Solutions

Chatbots

Analysis By: Magnus Revang

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Early mainstream

Definition

Chatbots are domain-specific or task-specific conversational interfaces that use an app, messaging platform, social network or chat solution for conversations. Chatbots range in use-case sophistication from simple, decision-tree-based, to implementations built on feature-rich platforms. They are always narrow in scope. A chatbot can be text-based or voice-based, or a combination of both.

Why This Is Important

Chatbots represent the No. 1 use of artificial intelligence (AI) in enterprises. Primary use cases are in customer service, human resources, IT help desk, self-service, scheduling, enterprise software front ends, employee productivity and advisory. Offerings in the market include developer self-service platforms, managed products, middleware offerings, integrated offerings and best-of-breed approaches.

Business Impact

Chatbots are the face of AI and will impact all areas with communication between machines and humans. Customer service is an area where chatbots are already very influential and will have a great impact on the number of service agents employed by an enterprise and how customer service is conducted. The change from “the user learns the interface” to “the chatbot learns what the user wants” has implications for onboarding, training, productivity and efficiency inside the workplace.

Drivers

- Chatbots in social media, service desk, HR or commerce, as enterprise software front ends and for self-service, are all growing rapidly.
- For enterprises, the main challenge with chatbots has been scaling and operationalizing them out of the proof-of-concept phase. As COVID-19 has accelerated adoption of chatbots, vendors seem to have “cracked the code” on operationalization. Vendors are now able to deliver multiple bots for multiple use cases, with no-code environments allowing multiple roles to participate in operationalization. This is creating a market for enterprise conversational AI platforms fueling the next generation of chatbots.

Obstacles

- Scaling and operationalizing still remain a challenge in some cases, due to lack of dedicated internal teams to work on continuous improvements.
- Figuring out the composition of teams, and the methodologies to iterate effectively, are still emerging practices with strong vendor dependency.
- Technology is improving at an astounding pace, but best practices on adoption and use of these technological advancements are still trailing, resulting in a lot of trial and error for enterprises.
- Selected vendors are sometimes unable to keep pace with the technology and the market dynamics.
- The vendor landscape comprises over 2,000 vendors, despite some consolidation during 2020. However, this is composed of many subcategories, majority of which are tactical. With this many vendors, the majority of chatbots will have to switch their underlying technology in the near to midterm future. Still a category of enterprise-grade platforms has emerged, with an estimated 120 vendors. These enterprise-grade platforms are becoming suitable as a more tactical choice.

User Recommendations

- Select an enterprise-grade platform to develop multiple use cases with orchestration of the assets needed.
- Focus on operationalization of chatbots as a product, with the necessary organization and roles in place, to evolve and maintain chatbots over time.

Sample Vendors

Amazon; Amelia; Cognigy; Google; IBM; Kore.ai; Microsoft; Pypestream; ServisBOT; Uniphore

Gartner Recommended Reading

The 3 Decisions You Must Make Before You Begin a Chatbot Project

Consolidate Your Chatbot Initiatives Into a Single Enterprise Strategy

When Should I Use Embedded Conversational Assistants?

Microgrids

Analysis By: Ethan Cohen

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition

Microgrids are efficient, small-scale versions of the centralized power system that generate, distribute, store and regulate the flow of electricity to consumers and in which sources are colocated with loads. Microgrids comprise groups of interconnected controllable loads, distributed energy resources and storage that act as single, controllable entities within a grid. They have two operation modes: connected to the main power network or “island mode.”

Why This Is Important

Microgrid uses include remote rural electrification and residential or community power networks in addition to commercial, industrial, municipal, hospital, campus and military base power grids. Microgrids offer a compelling alternative to traditional energy generation and distribution, using IoT to enable integrated control of distributed power generation assets, either parallel to or “islanded” from the main power grid.

Business Impact

Microgrids impact utility generation and distribution and energy retailing domains. Their role is becoming more important as utilities create new energy ecosystems and expand their offerings. Microgrids are also examples of energy technology consumerization, challenging the traditional business model of utility-provisioned energy delivered as a cloud service. By facilitating consumer integration into the energy market, microgrids are contributing to the geodesic transformation of the energy delivery infrastructure.

Drivers

The deployment and operation of microgrids offer advantages to customers and utilities by improving energy efficiency, reducing transmission and distribution losses, improving reliability, reducing environmental impact and providing a more cost-efficient electricity infrastructure compared to the traditional distribution grid.

Microgrids also:

- Provide local options regarding the choice of electricity generation source and supply, such as distributed renewable energy sources.
- Enable energy consumers to collaborate or partner with utilities to achieve specific outcomes. Companies with large campuses as well as universities, communities, airport operators and military bases often own — or own and operate — their own microgrids. Third-party and mixed-ownership microgrids are also appearing in the marketplace along with new variations of microgrid financing, operating and service models.
- Support renewable energy and energy efficiency through a viable approach to local grid modernization while incorporating local distributed energy supplies and storage technologies to meet the specific needs of their constituents while networking with the main grid.
- Deliver benefits to utilities by supporting the central grid in handling sensitive loads and the variability of renewables locally and supplying ancillary services to the bulk power system.

Obstacles

- Although microgrids offer benefits such as improved reliability and distribution efficiency, they do not have the same economies of scale and the coincident load factor of the centralized grid.
- Microgrid energy tends to be more expensive than central-grid-provided energy — though some technology and operating costs are decreasing.
- The commercial integration of microgrids into energy markets will require a platform for the energy-sharing economy and other emerging ecosystems.
- Central electricity network operation impacts for microgrids require new utility systems, such as distributed energy resource management systems and advanced distribution management systems, which can be costly and complex to deploy.
- Microgrids must have mechanisms to regulate voltage and frequency in response to changes in load and system disturbances. This is because all power in microgrids comes from distributed generation resources and controllable loads within the microgrid, which typically require investment in operational technology (OT) to perform distributed control. While these OT systems may be well-suited to the microgrid in island mode, interconnection and integration to the central grid may need yet more OT, a cost overhead that is not easily or automatically absorbed by utilities.

User Recommendations

As microgrids progress into mainstream utility CIOs should:

- Observe market developments in microgrid use cases, and evaluate what kinds of offerings might be advanced to develop new revenue, enhance resilience and improve energy provisioning.
- Enable the utility to quickly and thoroughly evaluate microgrid development and/or operation by developing minimum viable products for microgrid cases. Despite the significant promise and industry excitement about the concept, relatively few fully commercialized state-of-the-art microgrids have been deployed by utilities in many regions.
- Dedicate some investment to a microgrid design authority to improve microgrid operations reliability, security and self-healing capabilities in intelligent grid operation for electricity distribution.

Sample Vendors

Eaton; GE Power; Ormat Technologies; Saft; Schneider; Siemens

Vehicle-to-Everything Communications

Analysis By: Jonathan Davenport

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Vehicle-to-everything (V2X) communications support the wireless transmission of data directly between vehicles and other road users or infrastructure. Messages are transmitted over either dedicated short-range communications (DSRC) or cellular (4G or 5G) technology. Vehicles send messages to and receive messages from other vehicles (V2V), external infrastructure (V2I), pedestrians (V2P), cyclists (V2C), the home (V2H) and the power grid (V2G).

Why This Is Important

Two use case examples:

- V2V safety messages can be sent using low-latency communications. Vehicles communicate with one another over an ad hoc mesh network. Combined with V2P and V2C messages, this will improve driving performance, which will have a tremendous impact on public safety if implemented on a large, interoperable scale.
- V2I functionality could be used for innovative traffic management systems and help improve traffic flow.

Business Impact

- Automakers can market V2V communication as an additional safety feature, which will provide drivers with supplementary data warning of hazardous road conditions, collisions and changes in traffic patterns.
- For governments, V2I communication could be used for innovative traffic management systems and help improve traffic flow.
- V2G will allow electric vehicles to help balance peak network loads by either ceasing to charge or by selling electricity back to the grid.

Drivers

- Automakers that wish to comply with the Euro New Car Assessment Programme (NCAP) 2025 Roadmap will need to implement V2X by 2024. Car manufacturers want to ensure their vehicles score well in Euro NCAP's test program, which is an important data source for consumers.
- For autonomous vehicles, V2V communication technology provides additional safety input that cannot be captured by conventional vehicle sensors, thus allowing the vehicle to adjust its driving strategy and initiate emergency maneuvers to ensure the safety of passengers and other traffic participants.
- While V2X is not essential for autonomous driving, significant benefits will be delivered to autonomous vehicles if they can communicate with the infrastructure around them. Active sensors in autonomous vehicles, such as camera, radar and lidar, can be supplemented with additional insights from V2X, especially non-line-of-sight data points, effectively allowing vision beyond the sensor range and enabling vehicles to see around obstructions.
- V2I communication will help keep vehicles moving, thus minimizing the time spent idling at junctions and traffic signals. Passenger journey times should improve, as should fuel efficiency, which leads to potential environmental benefits.
- Some V2X use cases are already proven. For example, DSRC-based electronic road tolling is a commercially deployed technology for established applications, such as electronic road tolling. Deployments are based on aftermarket, rather than embedded solutions.
- Competition for V2X communication may intensify following Volkswagen's announcement to incorporate DSRC-based technology into mass-market vehicles.
- China will likely establish C-V2X as its technology for V2V, creating an important global shift that may well tip the scale in favor of C-V2X over the long term.
- Governments have allocated (expensive) radio spectrum to V2X applications. That spectrum is currently idle and, if not harnessed, is vulnerable to being diverted to other use cases.

Obstacles

- V2X is an emerging technology that is being extensively tested, but it is not yet widely deployed.
- DSRC and C-V2X technologies aren't compatible. The future technological evolution of V2X has yet to gain global consensus. Momentum had been building for C-V2X; however, Volkwagon's decision to use DSRC added further confusion to which technology will "win" in Europe.
- V2X technology is most useful when there is a large installed base of vehicles, but rollout of the technology has been slow and limited to disparate geographic regions.
- Automakers continue to lack direction from a regulatory standpoint.
- Direct willingness of consumers to pay for the technology is extremely limited.
- Early cellular-based vehicle-to-network-to-infrastructure solutions are also emerging, which communicate over the standard cellular network — bypassing the need for direct low-latency communications. Audi has started using Green Light Optimized Speed Advisory data, which reports traffic signal status.

User Recommendations

Automakers and Tier 1s should:

- Lobby governments to push for a regional V2X standard.
- Prepare to utilize different communication technology, depending on regulatory mandates and local market adoption trends.
- Consider how use cases that do not rely on low-latency messages can be delivered using vehicle-to-network-to-everything.

Governments should:

- Help improve road safety by consulting on regulatory mandates that will help drive adoption.
- Seek advice about investment costs for roadside units and highway infrastructure for both DSRC and cellular solutions. Use this research to help guide policy decision making

Communications service providers should:

- Lobby governments and automakers to push for the cellular standard.
- Ideate possible revenue models that could be used to generate income from low-latency-based use cases.
- Ensure that revenue is generated when spectrum assets are used for V2V communications, even when messages do not travel across the cellular network.

Sample Vendors

Autotalks; Ericsson; HARMAN; !important; Panasonic; Qualcomm; u-blox; Vodafone Group; Volkswagen

Gartner Recommended Reading

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

Toolkit: Top 10 Trends in Automotive and Smart Mobility for 2020

Market Trends: 5G Opportunities in IoT for Communications Service Providers

The Top 10 Wireless Technologies and Trends That Will Drive Innovation

Market Insight: How Mobile Operators Should Accelerate 5G Impact on Autonomous Vehicle Design

Distributed Generation

Analysis By: Zarko Sumic

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Definition

Distributed generation (DG) is an energy supply method that situates generation at or near load. These may include a mini-hydro, diesel, biofuel, wind, solar or fuel cell, and may be consumer-owned. DG is a subset of distributed energy resources (DERs), which also include on-site storage. Wider adoption of DG transforms centrally managed, radial delivery networks requiring advanced hybrid engineering control and an economic-incentive-based distribution network operating modes.

Why This Is Important

Consumers' desire to reduce cost and to increase reliability of supply leads to greater DG adoption. Innovation in consumer energy technology, resulting in grid parity in many markets, has contributed to

a decentralized supply trend. Larger commercial consumers or groups of residential consumers (such as community solar customers) are adopters and drivers of DG. DG adoption is challenging current business and operating models for utilities, raising questions about how the grid will be operated and monetized.

Business Impact

DG deployment has transformational implications for utilities. DG gives energy consumers more choices, and increases the installed base of environmentally and economically sustainable generation — reducing greenhouse gases and encouraging or directly supporting improved energy efficiency. However, DG creates significant challenges to grid operations while improving grid resiliency. DER, in general, and DG, in particular, are the main drivers for energy transition and are creating structural changes in energy systems.

Drivers

- According to the Bloomberg New Energy Outlook 2019 report, the cost of solar declined by 85% from 2010 to 2018 — close to low-triple-digit price performance improvement in less than a decade. That price performance improvement is the main driver behind rapid DG adoption by consumers. Exponential technology advances at the grid edge are making it simpler, easier and cheaper for businesses and consumers to begin self-generation. They are also making it easier for consumers to actively manage their interaction with energy markets by controlling when to buy, store or sell energy back to the grid.
- Locales where renewable portfolio standards apply, and where regulatory incentives such as feed-in tariffs and net metering arrangements are available, are more conducive to DG deployment. For example, California expects that one-fourth of new-generation resources will come on the customer's side of the meter (mostly rooftop solar). The IEA World Energy Outlook forecasts that incremental solar PV deployments will account for more than 70 GW of the combined future capacity additions through 2040 — the largest share of total additional capacity by type.

Obstacles

- Integrating DG into electric distribution networks is a significant challenge and will require electric delivery operations knowledge, and expertise in software and hardware design. Integrating DG into utility business operations will be challenging as the industry learns how to serve a more dynamic, decentralized grid and respond to diverse prosumer and business partner ecosystems.
- Most utilities have had little incentive from their regulators to pursue DG, even when it can provide business value. Few utilities have an organizational structure ready to coordinate and facilitate a vast array of third parties with interests in DG expansion. This slow response has created opportunity for new entrants, such as community solar providers or entities, offering power purchase agreement contracts to large commercial and residential customers.
- DG interconnection standards are maturing in particular following release of IEEE 2030.5 standard; however, regulatory oversight is still a patchwork of interconnection rules. Issues with sitting and permit costs still limit adoption.

User Recommendations

- Look for transmission and distribution (T&D) asset deferral benefits, but have backup plans if the DG technology has an unplanned outage.
- Propose incentives to regulators that would help them support cost-effective alternatives to traditional utility wire infrastructure but still adhere to their service mandate.
- Consider the information management and communication effects of DG growth, such as the need to expand communications networks and historian systems. Because a significant percentage of DG will be deployed by customers in the form of renewable generation, it will also enable consumer participation in carbon dioxide abatement.
- Treat DG as a part of overall DER strategy. That will require investment in distributed energy resources management systems (DERMS) or modification of advanced distribution management systems (ADMSs) to address the need of DG orchestration.

Sample Vendors

Ballard Power; Bloom Energy; Capstone Green Energy; Caterpillar Energy Solutions; ITM Power; Plug Power; Tesla

Gartner Recommended Reading

The Energy Transition Question: Do We Need the Grid?

Energy CIOs: Get Ready to Operate Under Multiple Energy Provisioning Business Models

Industry Vision: Utilities as Platform Providers for the Energy-Sharing Economy

Top 10 Trends Driving the Utility Industry in 2021

Market Guide for Distributed Energy Resource Management Systems

Climbing the Slope

Last-Mile Delivery Solutions

Analysis By: Bart De Muynck, Carly West

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition

Last-mile delivery solutions enable the execution of the last mile, providing real-time communication between routing applications and drivers/vehicles to track their activities and locations, and when necessary, to reroute them in transit while on the go. These solutions are the next generation of delivery solutions, and mainly focused on last-mile deliveries to businesses and consumers, adding additional capabilities such as customer experience management.

Why This Is Important

Last-mile delivery solutions are an evolution of the more traditional, dynamic and even batch-oriented vehicle routing and scheduling solutions, grown due to the huge increase in e-commerce and last-mile deliveries. Whereas traditional routing solutions focused primarily on over-the-road fleets and movements for first mile, middle mile and last-mile to businesses, these new last-mile delivery solutions mainly focus on deliveries to consumer homes.

Business Impact

These solutions will not only provide benefits to e-commerce companies and other shippers focused on the last mile, but also add incremental benefits to mature users of routing and scheduling, reducing costs and improving customer service in dynamic environments. These solutions also allow users to source transportation from third party fleets through API connectivity.

Drivers

- Robust last-mile delivery solutions are emerging that can automatically and proactively adapt to unforeseen events. For example, as traffic-monitoring solutions emerge and become pervasive, routing systems could receive notifications of traffic congestion that will delay drivers and may warrant rerouting. The system could dynamically recalculate the route and communicate the new route to drivers in real time.
- The goal is not only to make the fleets more efficient, but also to communicate updated ETAs with the consumer who is increasingly focused on the delivery experience when selecting an e-commerce or online retail vendor. As businesses have become more dynamic and customers more demanding, companies need to balance the trade-offs between optimal and feasible routes. They should consider changes throughout the day as variables of change continue to increase and click to door times continue to decrease.
- As consumerism takes hold, meeting on-time appointment windows for delivery to home or office is becoming not only more important, but more plentiful and difficult. Consumers are seeking flexibility in delivery slots and are increasingly prone to changing the date and time of delivery according to their changing needs. Missed appointments require more dynamic updating of both routes and notification to customers of changed appointments. The solution also needs to manage the customer experience providing insights into the whole delivery cycle and use these insights to improve future deliveries.
- Many of these solutions use AI and machine learning to speed up the optimization process and predict occurrences and impacts based on real-time information. Support for pieces of this technology, such as automated vehicle locating, is becoming more mature and commonplace.

Obstacles

- Not all users will need last-mile delivery solutions. Traditional vehicle routing and scheduling solutions will suffice for those users who are more first- and middle-mile-focused or who do not require to cover B2C use cases with focus on customer experience.
- Many of these solutions have not yet developed capabilities for all segments of transportation (first, middle and last mile). So, we see end users struggling to figure out their entire transportation network with a common organization, process and technology. Many end users will continue to use multiple solutions, like TMSs, along with more traditional vehicle routing and last-mile solutions.

User Recommendations

- Focus on high levels of change over the course of a delivery horizon or have a large focus on last-mile delivery to the consumer, to be the best candidate for last-mile delivery solutions.
- Define specific use cases before investigating solutions to ensure the solutions they consider fit the needs of their operations.

Sample Vendors

Bringg; Descartes; DispatchTrack; FarEye; Locus; LogiNext; Milkman; OneRail; Onfleet; Wise Systems

Gartner Recommended Reading

Market Guide for Vehicle Routing and Scheduling

Key Trends and Considerations for Vehicle Routing and Scheduling and Last-Mile Delivery Solutions

Toolkit: RFP for Vehicle Routing and Scheduling

Building Information Modeling

Analysis By: Marc Halpern, Bettina Tratz-Ryan

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition

Building information modeling (BIM) is the discipline supported by software to capture, organize and manage information needed to design, create, evolve and operate facilities from earliest conception to demolition.

Why This Is Important

Organizations in many industry sectors including construction, government, manufacturing and retail need better means of organizing and accessing content about their facilities to streamline facilities design, construction, management, operations, modernization and demolition. Increases in regulations governing facilities design, construction, operations and maintenance compounded by the number of roles involved in these activities require better means of managing and accessing information.

Business Impact

BIM delivers the following benefits:

- Reduces lost time and unnecessary costs associated with using wrong or out-of-date content throughout the life cycles of facilities
- Improves ability to find and access content to support any activity such as facilities design, construction, operation, upgrade, maintenance and demolition of facilities
- Improves collaboration across many roles responsible for the life cycles of facilities
- Enhances sustainability and circularity over the life cycles of facilities

Drivers

- As the costs of constructing and operating facilities continue to rise, facilities owners, construction firms and operators seek means to make life cycle activities more efficient, reducing cost and time.
- Product development team members working from remote locations, instead of at a central location, need a platform with rich collaboration capabilities that also includes requisite design and engineering functionality.
- Technology advances and growing experience with BIM encourages more companies to adopt it.
- Prevalence of SaaS for other business software encourages cloud-native BIM.
- Manufacturers, utilities and architectural engineering and construction firms seek better means of complying to a growing number of regulations that they believe BIM will support more efficiently.
- Stakeholders in facilities seek to reduce costly mistakes with BIM by enabling better access to more timely and accurate information.
- BIM enables improved collaboration across roles participating in life cycle activities from remote locations.

Obstacles

- Manufacturers are deeply invested in their current culture and processes, making it difficult to adapt to new ways of working that BIM requires.
- Reaching consensus on BIM priorities and architecture proves challenging given the number of roles both inside and outside an enterprise involved.
- BIM champions struggle to make compelling business cases for the investment.
- Building BIM content in proprietary design software formats will decrease its utility over time, cause vendor lock-in and increase the cost to maintain BIM.
- BIM projects will fail if scope creep creates higher-than-expected costs and lower-than-expected ROI. Insufficient supplier, partner and customer participation in BIM initiatives can lead to gaps in key content. Inflexible or incorrect BIM model design undermines future usefulness or possibly makes them obsolete before the end of a facility's service life.

User Recommendations

- Reduce the risk of failed BIM implementations by phasing the implementations into smaller, focused projects that build upon each other.
- Structure BIM initiative using governance or maturity models (see How to Achieve Better Business Model Strategies With Industry Data Governance). Use both the BSI Levels 0 through Level 4, and incorporate 2D BIM to 7D BIM categories of data as the company moves from one level of BIM maturity to the next.
- Address BIM data architecture challenges by assigning IT architects to work with key BIM stakeholders.
- Encourage BIM adoption by redefining job performance metrics that encourage potential users to adopt BIM.
- Assign a BIM lead to run a project defining corporate standards for creating and modifying BIM models, and establish a training program to educate the user community.

Sample Vendors

Autodesk; Bentley Systems; Hexagon (Intergraph); Nemetschek Group; RIB Group

Gartner Recommended Reading

Innovation Insight for Model-Based System Engineering

Predicts 2021: Manufacturing Digitalization Roadmap for Agility and Revenue Generation

How to Achieve Better Business Model Strategies With Industry Data Governance

Entering the Plateau

Outdoor Location Intelligence

Analysis By: Bill Finnerty

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition

Outdoor location intelligence (OLI) is the process of deriving meaningful insight from geospatial data relationships — people, places or things — to solve particular challenges like demographic analysis, store placement, asset tracking, people movement and contact, environmental analysis. and traffic planning. OLI consists of a combination of GIS software, web mapping solutions, geospatial services and platforms, position technologies such as GPS, and location-based data.

Why This Is Important

Location is one of the most significant means of contextualizing user and sensor data. OLI, founded in geospatial and location intelligence, presents an ever-growing set of use cases in marketing, smart cities, Industrie 4.0, healthcare and other sectors.

Cloud, whether PaaS or SaaS, and web mapping solutions provide expanded opportunities for organizations to leverage and scale OLI at competitive prices, making the entry point for experimentation within reach of a larger number of organizations.

Business Impact

OLI can reveal previously unidentified opportunities, based on location and spatial relationships, for business and government. Opportunities manifest as improved operations, new approaches to marketing and engagement, and enhanced decision making. Cases can be found across many sectors, including government, retail, hospitality and transportation — for example, combining business and location data to visualize customer and revenue data on maps to identify sales and marketing opportunities.

Drivers

- Increasing amounts of spatially contextualized data, frequently generated by IoT sensors, provides enhanced opportunities to leverage geospatial and location intelligence to improve service, engagement and decision making. Access to this spatial data through open data portals, data marketplaces and location intelligence platforms is growing, generating more opportunities for its use.
- Maturing OLI tools increasingly support business line functionality. In addition to GIS vendors and those embedding OLI in applications, business intelligence and other data visualization solutions regularly provide OLI capabilities. Solutions frequently enable “citizen analysts” to leverage OLI data for spatial analysis to improve operations, discover new business and service delivery opportunities, and communicate with customers and constituents.
- Through the growth of location intelligence platforms, a larger number of organizations are able to use machine learning capabilities to analyze the vast amount of spatial data available to them. These machine learning capabilities are driving the development of more-advanced location intelligence solutions, such as improved routing and traffic analysis that benefits commuters, logistics companies and public safety organizations.

Obstacles

- Privacy and data laws, although being challenged as part of the pandemic response, require organizations to be mindful of their use of personal data in OLI initiatives or face societal backlash.
- The cost of data can price projects without a clear ROI beyond an organization’s reach. However, data-as-a-service offerings can provide some controls.

User Recommendations

- Empower business units in leveraging OLI by providing the platform to improve decision making, service delivery and business processes.
- Inspire business stakeholders to leverage OLI in new ways by providing relative examples and use cases, while also insisting that they clearly define the business value or ROI for any initiatives.
- Establish a spatial data management strategy, or include spatial data in an existing data strategy, to improve quality and use of spatial data. Use the strategy to expose data catalogs to maximize data reuse and promote data sharing.

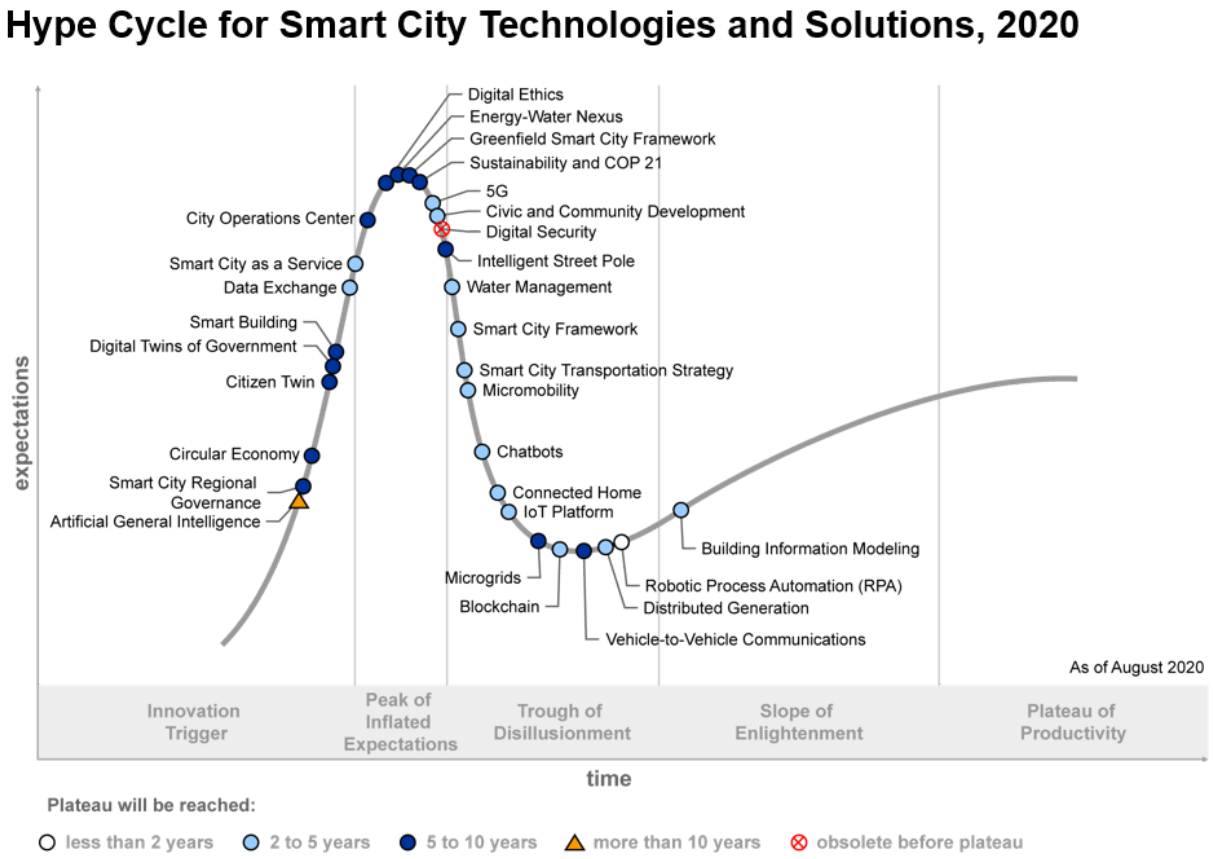
- Include spatial data in existing data governance processes.
- Create a framework for determining the best means for acquiring data. Include options for using open data, developing new datasets, utilizing data as a service or purchasing new data.
- Grow the skills of citizen analysts to improve understanding of spatial analysis and relative capabilities by establishing a spatial data and analysis training program.

Sample Vendors

Alteryx; CARTO; Descartes Labs; DECE Software; Esri; HERE Technologies; Mapbox; Microsoft; Planet; Qlik

Appendixes

Figure 2. Hype Cycle for Smart City Technologies and Solutions, 2020



Source: Gartner
ID: 450328

Gartner

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 2: Hype Cycle Phases

(Enlarged table in Appendix)

Phase	Definition
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media 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 innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation 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 innovation'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 innovation 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 innovation to reach the Plateau of Productivity.

Source: Gartner (July 2021)

Table 3: 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 2021)

Table 4: Maturity Levels

(Enlarged table in Appendix)

Maturity Levels	*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 2021)

Document Revision History

Hype Cycle for Smart City Technologies and Solutions, 2020 - 4 August 2020

Hype Cycle for Smart City Technologies and Solutions, 2019 - 2 August 2019

Hype Cycle for Smart City Technologies and Solutions, 2018 - 1 August 2018

Hype Cycle for Smart City Technologies and Solutions, 2017 - 2 August 2017

Hype Cycle for Smart City Technologies and Solutions, 2016 - 15 July 2016

Hype Cycle for Smart City Technologies and Solutions, 2015 - 27 July 2015

Hype Cycle for Smart City Technologies and Solutions, 2014 - 22 July 2014

Hype Cycle for Smart City Technologies and Solutions, 2013 - 29 July 2013

Hype Cycle for Smart City Technologies and Solutions, 2012 - 30 July 2012

Hype Cycle for Smart City Technologies and Solutions, 2011 - 28 July 2011

Recommended by the Authors

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

Understanding Gartner’s Hype Cycles

Create Your Own Hype Cycle With Gartner’s Hype Cycle Builder

Tool: AI Use Cases for Smart Cities and Intelligent Urban Ecosystems

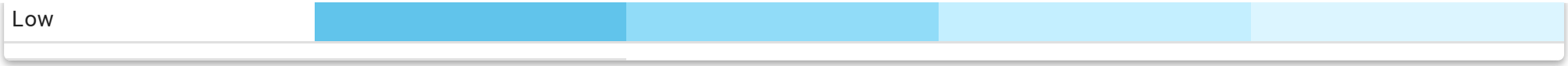
Postpandemic Scenarios: The Future of Smart Cities

From Smart City to Intelligent Urban Ecosystem — Unlocking Data Value Is the Key to Cities’ Industrial Partnerships

---

Table 1: Priority Matrix for Smart City Technologies and Solutions, 2021

Benefit	Years to Mainstream Adoption			
	Less Than 2 Years	2 - 5 Years	5 - 10 Years	More Than 10 Years
Transformational		Blockchain Data Exchange Distributed Generation Edge AI Edge Computing Smart City Framework	Circular Economy City Operations Center Greenfield Smart City Framework Smart Building Sustainability and COP 21 Vehicle-to-Everything Communications	Artificial General Intelligence
High	Chatbots Last-Mile Delivery Solutions Outdoor Location Intelligence	5G Building Information Modeling Civic and Community Development Digital Security IoT Platform Smart City as a Service Smart City Regional Governance Water Management Analytics	Citizen Twin Digital Ethics Digital Twins of Government Intelligent Connected Infrastructure Intelligent Street Pole Microgrids Smart City Transportation Strategy	
Moderate		Shared Mobility	Energy-Water Nexus	



Source: Gartner (July 2021)

Table 2: Hype Cycle Phases

Phase	*Definition*
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media 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 innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation 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 innovation'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 innovation 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 innovation to reach the Plateau of Productivity.

Phase ↓	Definition ↓

Source: Gartner (July 2021)

Table 3: 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 2021)

Table 4: Maturity Levels

Maturity Levels ↓	*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 2021)