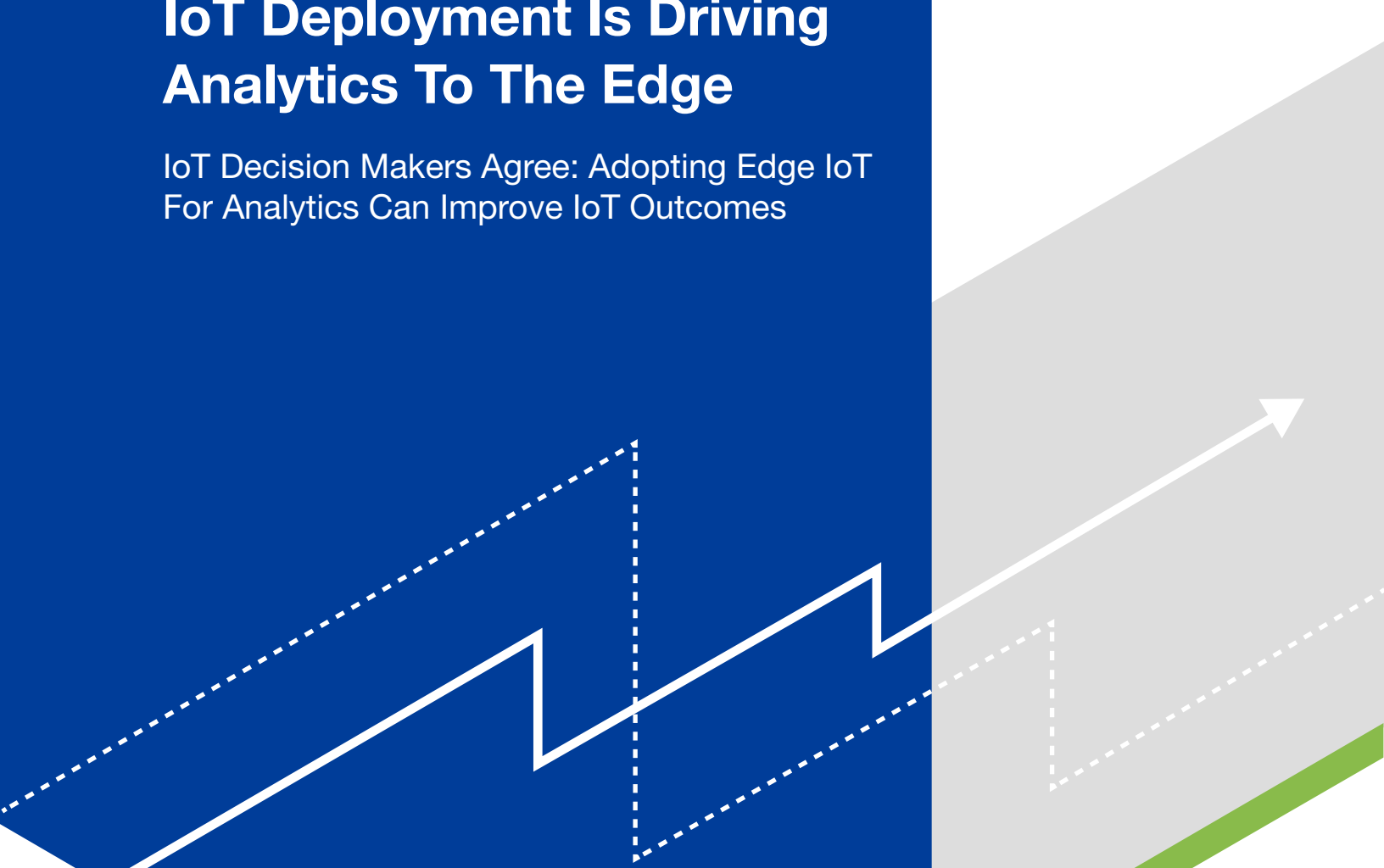
A Forrester Consulting
Thought Leadership Paper
Commissioned By Dell Technologies
and VMware

January 2019

IoT Deployment Is Driving Analytics To The Edge

IoT Decision Makers Agree: Adopting Edge IoT For Analytics Can Improve IoT Outcomes



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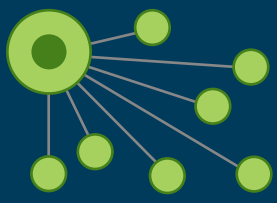
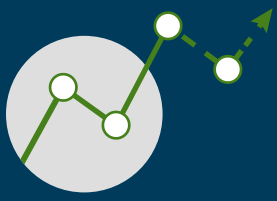


Incorporating edge IoT for analytics can help organizations overcome the limitations of a fully centralized analytics approach.



69% say that prioritizing edge IoT for analytics for certain use cases would improve their ability to meet IoT objectives.

Executive Summary

Many organizations have embraced internet-of-things (IoT) solutions to optimize operational processes, differentiate products and services, and enhance digital capabilities. However, as companies deploy a diverse array of IoT projects and use cases — each with specific requirements — many encounter challenges with using centralized cloud-based and data center analytic strategies. To transform large streams of IoT data into insights in a fast, secure, and cost-effective way, organizations must revisit their IoT architecture, skills, and strategies.

In the fall of 2018, Dell Technologies and VMware commissioned Forrester Consulting to evaluate organizations' IoT strategies with a focus on understanding their interest in, and adoption of, edge IoT for analytics — a technique that takes analytic computations for certain IoT use cases out of the cloud or data center and moves it as close to the data sources as is necessary and feasible to enable real-time decisions, reduce costs, and mitigate security and compliance risks. To explore this topic, Forrester conducted an online survey with 300 global information technology (IT) and operations technology (OT) professionals with responsibility over IoT decisions at their companies.

KEY FINDINGS

- **Organizations face limitations with IoT data analysis in the cloud.** Many firms have used cloud platforms to analyze their IoT data by applying advanced analytics models and leveraging clouds' extensive processing power, connectivity, and storage capabilities. However, survey respondents identify limitations to cloud analytics which are particularly important for successful IoT use case deployment including: security or compliance concerns, high data transit costs, and lack of real-time analytic capabilities.
- **Some companies are taking a customized approach to analytics.** While just a minority (29%) of firms have expanded their analytics strategies to include edge IoT for analytics, many others indicate they will likely follow soon — 22% have plans to implement in the next 12 months; another 38% express interest.
- **Low latency requirements signal an edge IoT for analytics opportunity.** It may not always be clear which use cases would benefit most from edge IoT for analytics. Respondents in our research rated a variety of criteria according to how important each is in their decision to deploy edge IoT for analytics. Topping their list were requirements for real-time response and impact on customers' experience — the greater the importance of these factors for any given use case, the greater the likelihood that edge IoT makes sense for that use case.

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Organizations Are Leveraging A Powerful Source Of Insight: IoT Data

Digital transformation — a companywide effort to use technology to serve customers by improving experiences, enhancing offerings, and enhancing operational agility — is sweeping through enterprises across all industries. IoT solutions often enable digital transformation by extending software control of physical assets and providing a rich source of data including location, status, and presence of connected assets, products, and processes. Results from this study show that 56% of surveyed global enterprises have already adopted or are expanding deployment of IoT solutions; another 17% of enterprises are currently piloting IoT programs. These IoT initiatives are implemented by enterprises across geographic regions in various industries and spanning a wide range of use cases.

73% have already implemented or are currently piloting IoT programs across a wide variety of use cases.

Enterprises achieve significant benefits from deploying IoT initiatives, including optimizing processes and assets to enhance flexibility; differentiating products and services to drive business growth; and deploying new business models and services.[1] Stakeholders in manufacturing, utilities, natural resources (e.g., agriculture, mining, oil or gas extraction), transportation, government, retail, and healthcare firms are transforming operations using IoT solutions.[2] Success in these industries often depends on managing and optimizing physical asset use (e.g., vehicles, equipment, machinery, land, buildings), and enhancing operations by implementing various IoT use cases:

IoT provides opportunities to optimize assets, differentiate products, and reimagine business models for strategic advantage.

- **Some IoT use cases provide benefits to a wide range of organizations.** Broadly applicable IoT uses cases including smart building, energy management, and security and surveillance are relevant to companies in many vertical markets. These IoT use cases help to improve operational efficiency and safety (see Figure 1.1). Other IoT use cases — including fleet management, predictive/condition-based maintenance, and track and trace — can provide organizations with meaningful strategic advantage.[3]
- **Specialized IoT use cases provide benefits to specific organizations.** Particular IoT uses cases solve focused problems facing companies in specific industries while also providing opportunities to differentiate products, processes, and experiences (see Figure 1.2).[4] For instance, utility companies can use sensors and connected equipment to automate, control, and optimize the distribution of power or water flow and to ensure efficient, safe, reliable, and cost-effective service. Transportation companies use IoT solutions to analyze passenger traffic to understand the impact of passenger movement on facilities and luggage logistics. In addition, manufacturers can use IoT-enabled quality and compliance solutions to analyze machine data and external data in real time to help deliver actionable insights, limit exposure, and reduce the impact of compliance and quality issues that arise in the manufacturing plant.

Figure 1.1

"Which of the following IoT-enabled use cases is your organization deploying or planning to deploy?"

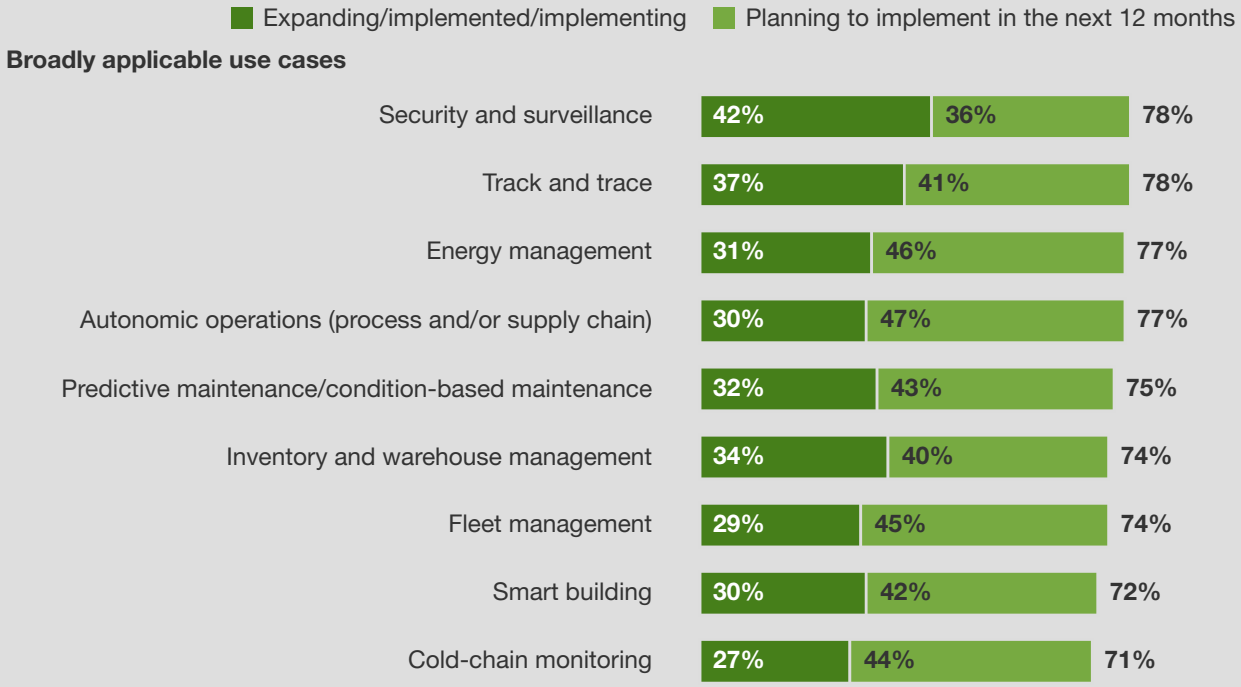
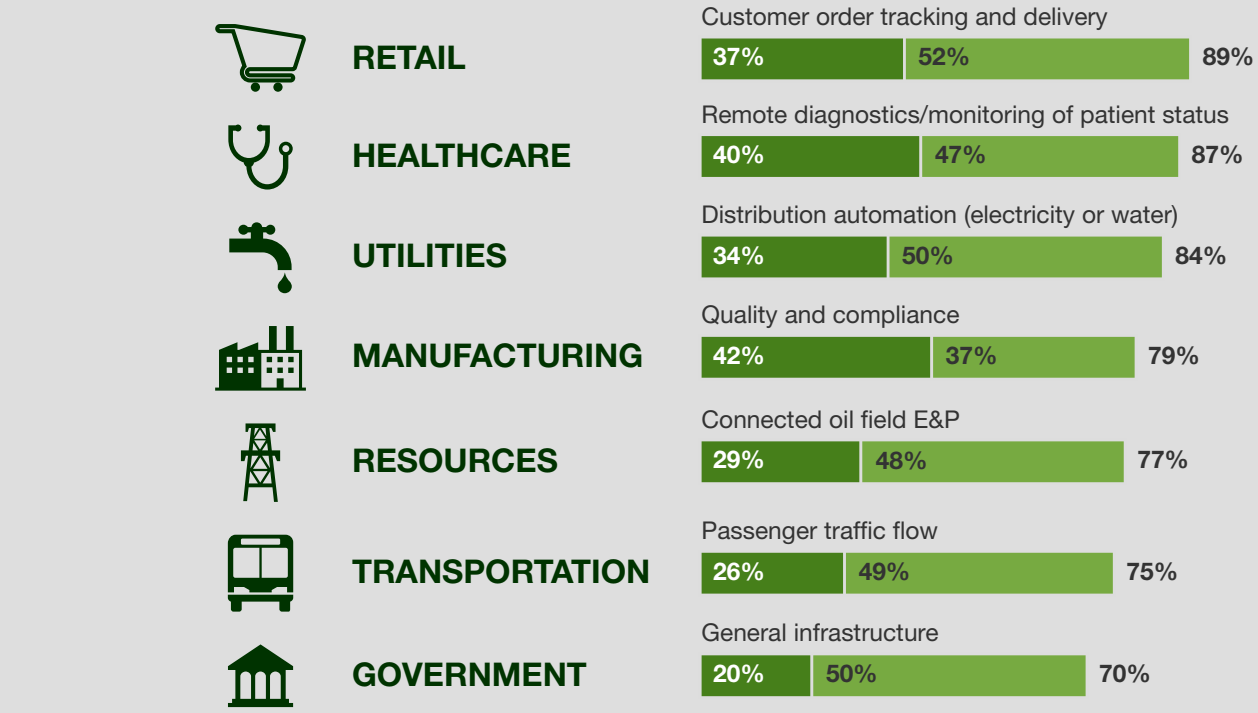


Figure 1.2

Select specialized use cases



Note: See Appendix C for use case definitions
Base: variable; global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

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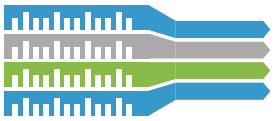
Addressing IoT Data, Analytics, And Security Issues Remains A Challenge

The proliferation of interconnected IoT devices coupled with continued innovation in chipsets, device form factors, and battery life enable firms to collect an unprecedented amount of IoT data.[5] The value of this data lies in the ability of enterprises to analyze it, draw insights, and improve actions and outcomes.[6] However, a number of internal and external obstacles keep firms from fully realizing this vision. IoT deployment momentum brings with it challenges for firms that must identify strategies and methods to secure, manage, and support the rapidly growing number of smart, connected IoT devices and solutions.

Nearly all (97%) of our surveyed IoT decision makers state that data analysis obstacles are keeping them from successfully executing on their IoT objectives (see Figure 2). Key IoT data analysis barriers include:

› **Gaps in analytic skills.** The most frequent challenge identified by nearly half (49%) of survey respondents is the lack of analytics skills that could be used to transform IoT data into actionable insights. Analytics professionals are comfortable gathering data in resource-rich data centers, or in the cloud, where power, compute, storage, and network connectivity is virtually limitless.[7] However, with IoT solutions, stakeholders must analyze and transform streams of structured and unstructured data in real time to identify actionable insights, as well as manage the heterogeneous characteristics of captured data due to varying bandwidth, storage, and compute limitations of different edge devices.[8]



97% identified one or more IoT data analysis challenges; 27% reported more than five.

Figure 2

"Which of the following IoT data analysis challenges are obstacles to the successful execution of your IoT objectives?" (Select all that apply; showing top responses)

Base: 300 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Dell Technologies and VMware, November 2018

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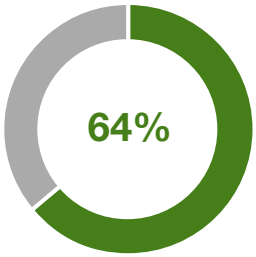
- **Security concerns.** The vast quantities of IoT data collected across the expanding array of IoT use cases pose considerable cybersecurity, compliance, and even safety risks. It comes as no surprise that many enterprise stakeholders are concerned with addressing security, privacy, and regulatory issues. Advanced security capabilities to help firms identify, isolate, and protect captured IoT data, regardless of storage location, are paramount.
- **Real-time data analysis challenges.** While an analytic skills deficit was the mostly commonly cited barrier, decision makers describe real-time analysis of data or telemetry as the most challenging. Certainly, these two issues are related. But another factor that influences the ability to analyze IoT data in real time is *where* that data is analyzed. Sixty-four percent of surveyed decision makers say that identifying the best location (e.g., sensor/device level, cloud environment, data center) to analyze IoT data to address IoT compute latency requirements for specific use cases is important to the success of their IoT initiatives. Yet, 76% of firms state that identifying the ideal location for these analytic activities is challenging for their firm (see Figure 3).

64% describe identifying the best location to analyze data for different IoT uses cases as important, but 76% also find it challenging to do.

Figure 3

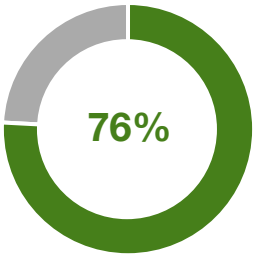
"How <u>important</u> is the following to the success of your IoT initiatives?"
(Showing "important" to "very important")



Identifying the best location to analyze data for specific IoT use cases

Base: 300 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

"How <u>challenging</u> is it for your organization to address the following?"
(Showing "somewhat challenging" to "very challenging")



Identifying the best location to analyze data for specific IoT use cases

Base: 294 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

CENTRALIZED CLOUD ANALYTICS FALTER IN CRITICAL AREAS

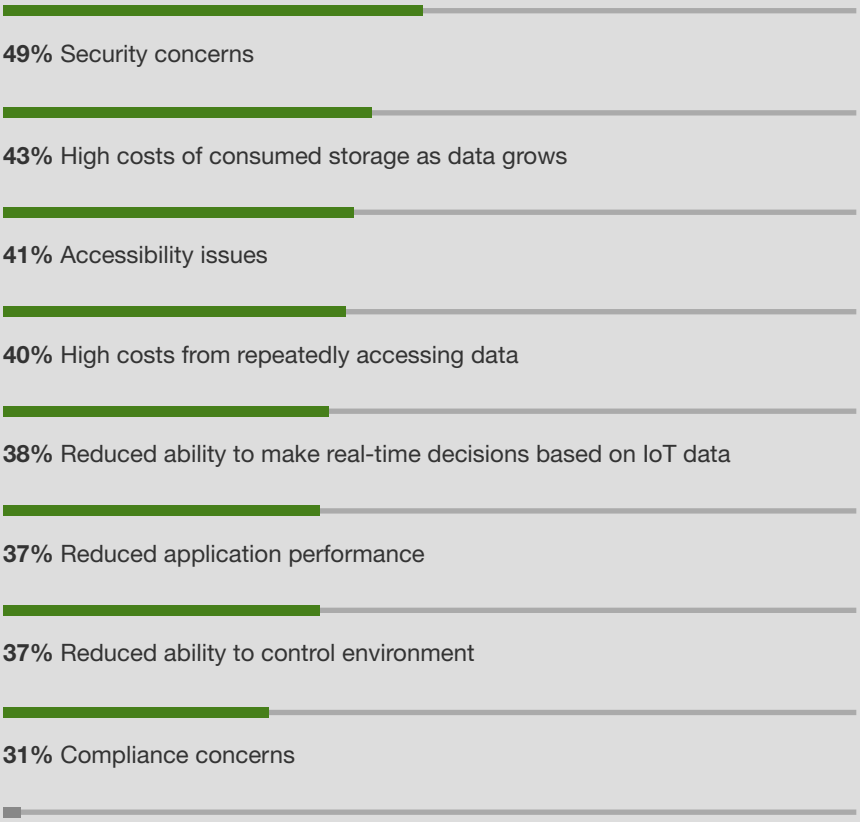
Many organizations have turned to cloud platforms to connect low-cost, elastic global infrastructure with rich device data. This approach initially allowed companies to ramp up their development of connected products and industrial internet solutions. However, as companies expand their IoT efforts, fully centralized or cloud-only approaches are likely to stumble. IoT use cases often have unique real-time data analysis needs and it's not always practical, economic, or even lawful to move, store, and analyze IoT data into a core cloud infrastructure.[9]

Respondents in our research recognize these limitations and many cite security concerns, high costs, and reduced accessibility and ability to make real-time decisions as the top downfalls of analyzing IoT data in the cloud (see Figure 4).

98% cite challenges with analyzing IoT data in the cloud.

Figure 4

"Which of the following are potential limitations to analyzing IoT data in the cloud?"
(Select all that apply)



Base: 300 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

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Proactive Firms Deploy Edge IoT For Analytics Strategies

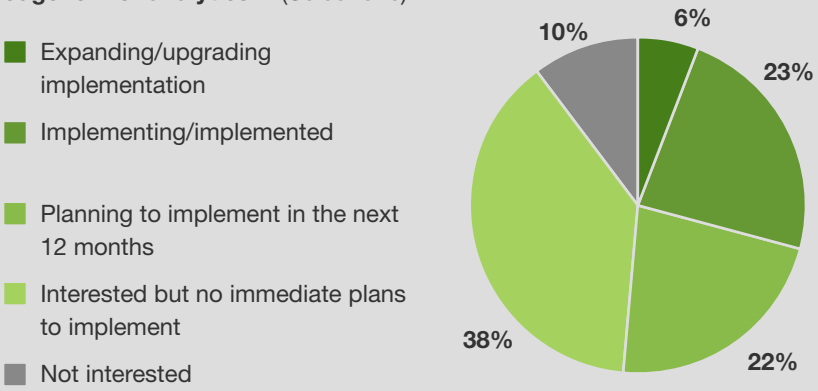
Often, it is ideal to perform complex IoT data analysis in the cloud or in the data center as part of a comprehensive solution. However, a centralized cloud-based or data center analytics approach is often insufficient to analyze captured data and generate real-time insights necessary to ensure seamless experience for those engaged in many mission-critical and strategically important IoT use cases. Requirements to process the expanding scope and diversity of captured data for some IoT use cases requires compute functions to be moved to the IoT device level.[10] Edge computing solutions, which converge hardware and software into increasingly small servers and devices that can run smarter analytics onboard, enable enterprises to move compute and analytics functions as close to data sources as is necessary and feasible, enabling real-time decisions and insights.[11]

Currently, 29% of surveyed firms have implemented or are expanding implementation of edge IoT for analytics. Momentum for edge IoT for analytics solutions will accelerate, as 22% of firms plan to implement these solutions in the next 12 months, and another 38% of firms express interest (see Figure 5).

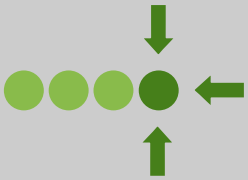
Edge computing refers to moving compute as close to the data sources as is necessary and feasible, enabling real-time decisions and insights to drive better outcomes.

Figure 5

"Which of the following best describes your organization's adoption of edge IoT for analytics?" (Select one)



Base: 300 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018



29% of surveyed firms have already implemented or are expanding implementation of edge IoT for analytics.

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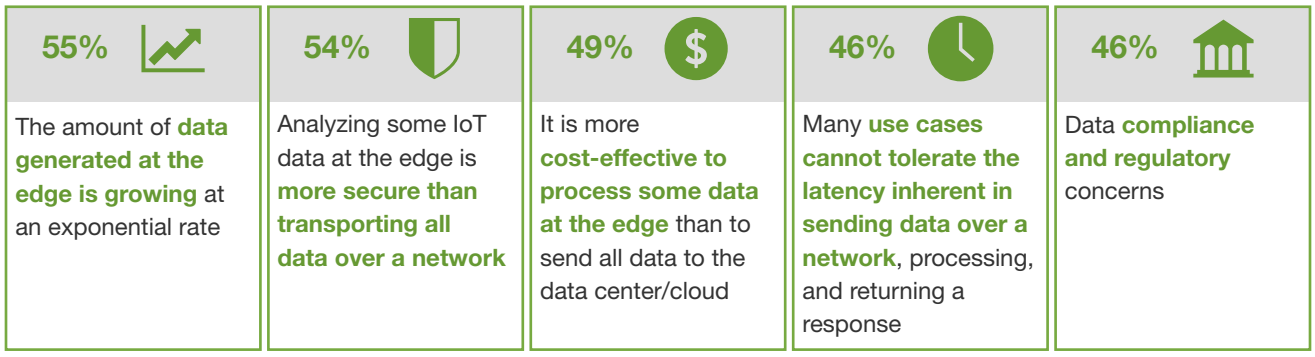
DECENTRALIZED ANALYTICS STRATEGIES SUCCEED WHERE A CENTRALIZED APPROACH FALLS SHORT

We asked firms who have already implemented edge IoT for analytics to identify the factors that drove their organizations to deploy these solutions. Many of their drivers align with scenarios where cloud-based analysis falls short (see Figure 6):[12]

- **High data volumes.** Fifty-five percent of edge IoT for analytics users point to exponential growth of data at the edge as a key factor in their decision to adopt. IoT devices are often small and have power limits — transmitting all this data to cloud servers is not always feasible and may drain the power source. In addition, firms must ensure they have invested in wireless network infrastructure necessary to export the high volumes of data.
- **Security and compliance constraints.** Over half of edge users believe analyzing some of this data at the edge, close to where it's captured, is more secure than transporting it over a network where there are more potential points of failure along the data path. In addition, regulatory considerations may prevent firms from moving the data at all — for example, certain data privacy laws prohibit the transfer of data across national borders.
- **Data transport and processing expense.** Forty-nine percent adopted edge IoT for analytics because it was more cost-effective for them to process some data at the edge than to send it to the cloud or data center. Moving data can be expensive, and that expense only increases with data volume. In cases where data has limited value, it is advantageous to enrich and analyze the data at the source, or discard it, rather than paying for it be moved.
- **Real-time analytics requirements.** The value of IoT insights is perishable. Forty-six percent of edge users say many of their use cases cannot tolerate the latency inherent in sending data over a network, processing it, and then returning a response. This is especially true for use cases where an instant response is needed, such as for mission-critical or life-impacting situations.

Figure 6

"Which of the following factors drove your organization to deploy edge IoT for analytics?" (Select all that apply; showing top responses among those that have already adopted/are expanding adoption of edge IoT for analytics)



Base: 89 global IT and OT professionals with responsibility for IoT initiatives at their organizations that have already adopted edge IoT for analytics
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

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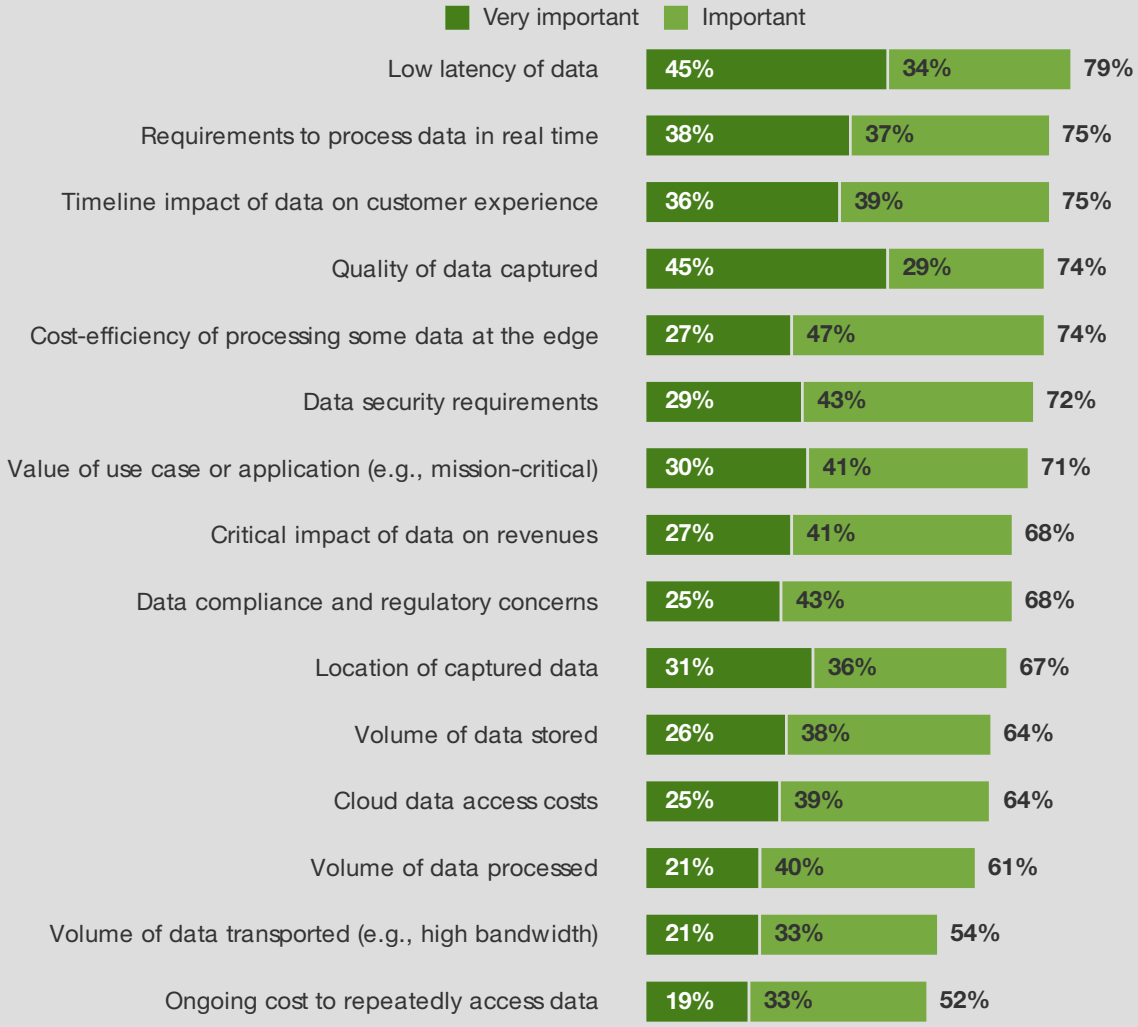
USE SPECIFIC CRITERIA TO IDENTIFY RELEVANT EDGE IOT FOR ANALYTICS USE CASES

Organizations have deployed IoT in a diverse array of use cases; it may not always be obvious which ones are most appropriate for edge IoT analysis. Also, what is right for one company may not be for another.

However, there are specific factors that firms can use to uncover opportunities for edge IoT for analytics. We asked IoT decision makers to rate a number of these factors according to how important each is in their decision to deploy edge IoT for analytics (see Figure 7). Not surprisingly, the more important real-time response or the impact on customers' experience, the greater the likelihood that edge IoT makes sense for any given use case.

Figure 7

"How important are the following factors in driving your firm to deploy edge IoT for analytics?"
(Showing top responses)



Base: 300 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

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The opportunity to analyze at the edge is amplified when a use case meets two or more of these important decision criteria. For instance, consider latency and data volume. Each, on their own, are powerful signals for edge analysis. But when a use case has high requirements across both dimensions, that use case becomes an especially good candidate. Decision makers in our study, representing a range of industries, rated the use cases they've already implemented or are interested in implementing across these two dimensions. The use cases on the high end of both of these factors emerge as ones where the opportunity for edge IoT for analytics is especially pronounced (see Figure 8).

Figure 8

"For each use case, how important is latency and data volume when determining your requirements for deploying edge IoT for analytics?"
(Showing "important" to "very important")

1. Cold-chain monitoring
2. Smart street lighting*
3. Inventory/warehouse management
4. Omnichannel operations*
5. Customer order and delivery tracking*
6. Quality and compliance*
7. Smart building
8. Agriculture field monitoring*
9. Energy management
10. Predictive maintenance
11. (V2V)/(V2I)*
12. Connected oil field E&P*
13. General infrastructure*
14. In-store contextualized marketing*
15. Freight monitoring*
16. Smart lighting*
17. Autonomic operations
18. Fleet management
19. Environmental monitoring detection*
20. Security and surveillance
21. Track and trace
22. Passenger traffic flow*
23. Distribution automation (electricity or water)*
24. Production asset management*

*Specialized use case shown to select respondents
Notes: Respondents were only shown use cases that were relevant to their industry. See Appendix C for use case definitions. Remote diagnostics and traffic management uses cases not shown due to low sample.
Base: variable; global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

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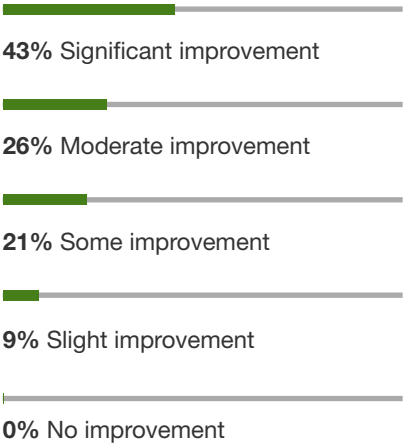
EDGE IOT FOR ANALYTICS DELIVERS BUSINESS AND OPERATIONAL BENEFITS

Regardless of their level of adoption, all IoT decision makers agree: Prioritizing edge IoT for analytics for certain use cases can improve their ability to meet their IoT objectives; 43% describe the level of improvement as significant (see Figure 9). While users are more likely to appreciate some of the benefits than nonusers, both groups associate many advantages with edge IoT for analytics, chief among them (see Figure 10):

- **Cost reductions.** Over half of users and nonusers say that the ability to reduce costs — such as those incurred to send to or to store large volumes of data in the cloud — is the top business benefit of edge analysis. While cost reduction wins can help advance the business case for edge IoT for analytics, organizations should not overlook the strategic value of other benefit areas cited. Improved products, services, and experiences, as well as advanced security and privacy and products capabilities, can support sustainable competitive differentiation.
- **Improved real-time decision-making.** In contrast to a fully centralized approach which creates barriers for real-time analysis, both users and nonusers agree that real-time analysis is the No.1 operational benefit of using edge IoT for analytics. Real-time analysis supports other operational benefits also, including improved business processes, safety, and visibility.

Figure 9

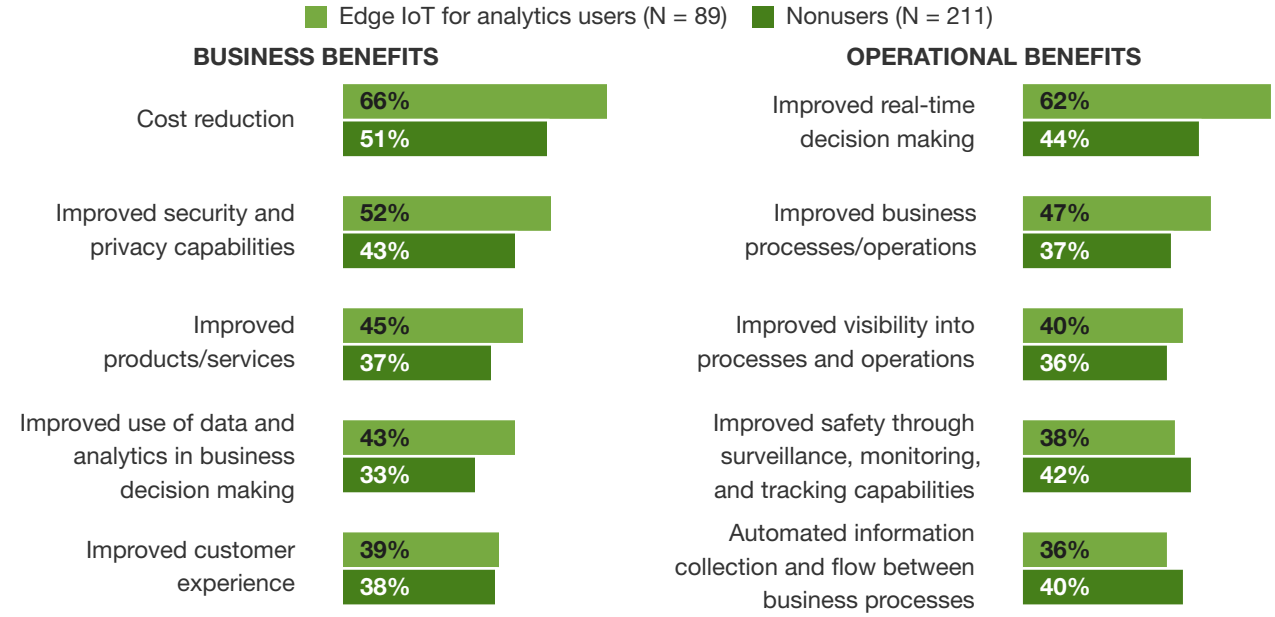
"What impact would prioritizing edge IoT for analytics for certain use cases have on your ability to meet your IoT objectives?" (Select one)



Base: 300 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

Figure 10

"Which of the following business or operational benefits have you have realized or would expect to realize by deploying edge IoT for analytics?" (Select all that apply; showing top responses)



Base: 300 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

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Key Recommendations

Enterprises in various industries are proactively deploying a diverse array of IoT use cases to enable digital transformation initiatives which address mission critical processes, enhance operations, and differentiate customer relationships. Stakeholders are often challenged with analyzing large volumes of real-time IoT data and information in a secure, cost-effective manner using centralized analytic solutions.

Forrester's survey of global IoT decision makers yielded the following recommendations:

Facilitate coordination between IT and operations to identify IoT use case and architecture requirements. As newer IoT solutions that run on and connect with broader business technology platforms replace legacy siloed technology, line-of-business executives representing many different roles (e.g., plant operations, manufacturing, supply chain, facilities management, or product development) must increasingly work with IT teams to implement IoT solutions. Business, operations, and security colleagues must work together to surface critical dynamics such as scalability, security, and network architecture.

Identify IoT use cases to address your firm's current and future business transformation goals. Enterprise stakeholders must identify relevant digital transformation initiatives to address their firm's short-term and long-term priorities focused on individual operational processes, industry-specific priorities, and strategic goals. IoT use cases are often used to enable these digital transformation initiatives by powering new business models, delivering personalized customer experiences, and enhancing operational processes. As your IoT use case deployment expands, so too will the amount and variety of captured data. It is important to evaluate the implications of evolving IoT data characteristics and use cases on edge architecture requirements.

Consider your requirements for edge-based IoT data analytics. IoT use cases and solutions often create a deluge of structured and unstructured data including video images and audio content at the device level, which must be evaluated at the source of the captured data in a real-time manner. For example, utility companies can use sensors and connected equipment to automate, control, and optimize the distribution of power or water flow. Companies can aggregate and filter device data to remove insignificant data points, or to identify the most valuable data to transport to the cloud. Gateways can collect data from edge devices and use applications or algorithms to determine whether more complex analyses is required, or to help companies comply with regulatory requirements that dictate local storage.

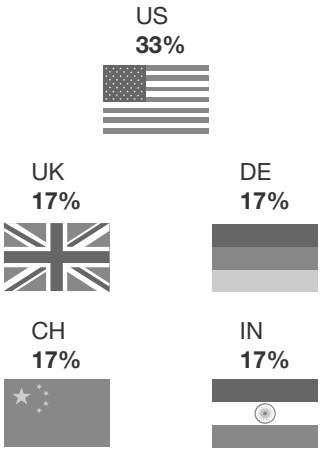
Seek assistance from partners to accelerate your edge IoT initiatives. Many firms have gaps in key skill sets necessary to capture insight and achieve benefits from deploying IoT solutions requiring edge-based IoT analytics solutions. Third-party partners can help fill in these skills gaps. Surveyed organizations often look for partners with analytics skills, IT infrastructure, and application developers with IoT experience in their specific industry and/or IoT use case. Other important partner capabilities include offering scalable solutions and strong solution integration expertise.

Appendix A: Methodology

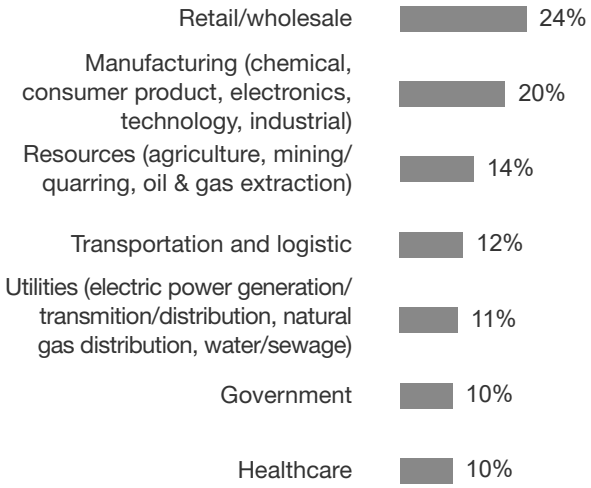
In this study, Forrester conducted an online survey of 300 IT and OT professions at manufacturing, utilities, resources, retail/wholesale, transportation, healthcare, and government organizations in the United States, the United Kingdom, Germany, China, and India to evaluate their IoT analytics approach and their adoption of edge IoT for analytics. Survey participants included decision makers responsible for IoT initiatives at their organizations; a large majority also had IT and/or OT security responsibility. Questions provided to the participants asked about adoption of various IoT uses cases, areas important to the success or their IoT projects, analytic challenges, and the potential value in applying edge IoT for analytics. Respondents were offered a small incentive as a thank you for time spent on the survey. The study fielding began in October 2018 and was completed in November 2018.

Appendix B: Demographics

Country



Industry



No. of employees

17% 500 to 999

49% 1,000 to 2,499

24% 2,500 to 4,999

10% 5,000 or more

Seniority

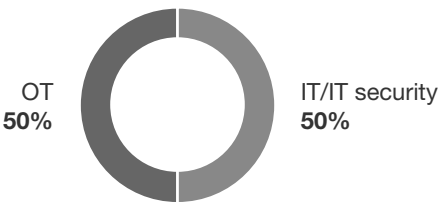
22% C-level

13% VP

16% Director

49% Manager

Department



NOTE: Percentages may not total 100 due to rounding
Base: 300 global IT and OT professionals with responsibility for IoT initiatives at their organizations
Source: A commissioned study conducted by Forrester Consulting on behalf of Dell Technologies and VMware, November 2018

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Appendix C: Use Cases Evaluated

USE CASES SHOWN TO ALL RESPONDENTS:

Autonomic operations (process and/or supply chain): Real-time assessment of current demand and capacity availability continuously and intelligently re-sequences work.

Smart building: IoT technology that utilizes advanced automation and building systems integration to measure, monitor, control, and optimize operations. The end goal is optimization — the deployment of a set of building systems capable of adapting in real time to both internal policies and external signals.

Track and trace: For smaller things such as tools and for high-value customer shipments, tracking location and condition.

Cold-chain monitoring: Monitoring and controlling conditions (e.g., temperature and humidity) of perishable food, chemicals, and other products when they are in storage or in transit.

Energy management: Monitoring, managing, and reporting usage of water, electricity, and other energy resources.

Security and surveillance: Security and safety monitoring and surveillance.

Inventory and warehouse management: Tracking inventory levels and managing warehouse operations.

Fleet management: IoT system that tracks transportation assets (trucks, railroad cars, ships) and determines/controls optimal routes.

Predictive/condition-based maintenance: Monitoring and managing equipment operation, wear, and status to optimize maintenance for revenue and cost.

USE CASES SHOWN TO SELECT RESPONDENTS:

Production asset management: IoT scenario that helps a company to remotely track, monitor, and maintain industrial manufacturing devices that are part of the production value chain.

Quality and compliance: Informed analysis of potential failures through simulation and historical performance of machine data that can leverage unstructured information and external data; this can be applied in real time to help deliver actionable insights, limit exposure, and reduce the impact of compliance and quality issues that arise.

Environmental monitoring detection: Using meteorological, chemical, biological, radiological, nuclear, and explosive sensors to make informed decisions: from stopping or diverting traffic, limiting access to certain geographical areas, or triggering immediate actions if harmful substances are detected in certain areas so that inspectors can go out and identify the source of pollution to put remediation in place, or to plan for emergency services if there is an immediate or future danger.

General infrastructure: Sensors, cameras, transponders, and other systems that allow government agencies to track the structural health and use of transportation infrastructure including intersections, signals, tolls, parking, and transportation management systems as well as sensors that track the structural integrity of the infrastructure itself.

Smart street lighting: Outdoor IP-connected lighting that is remotely programmed, controlled, and optimized through regular information communication of energy consumption and billing. Smart street lighting is intelligently managed to improve municipal operational costs, citizen safety, and road infrastructure management.

Distribution automation (electricity or water): Sensors and connected equipment used to control and optimize power or water flow to ensure efficient, safe, reliable, and cost-effective service.

Agriculture field monitoring: This use case advances the state-of-the-art technology that supports farming and permanent crop cultivation through soil management. Improved crop yield, pest management, and soil management are direct benefits of this technology.

Connected oil field E&P: Investments made in oil rig-based processes involving drilling, extraction, and wellhead instrumentation. Investments are directed toward improving equipment reliability, optimizing operations, and creating new value from field-based oil exploration and initial extraction assets in both onshore and offshore settings.

Customer order and delivery tracking: Enabling customer visibility into the status of orders and deliveries.

Smart lighting: Optimized lighting systems for commercial buildings to provide high energy efficient outcomes using sensors and software.

Omnichannel operations: Supports the evolving multichannel retail strategy to provide a seamless consumer experience through any shopping channel.

In-store contextualized marketing: IoT that enables interactive shopping by capturing continuous, real-time streams of data from mobile devices, online customer activity, in-store Wi-Fi routers/beacons and video cameras that give retailers insight into customer behavior and desires.

Vehicle-to-vehicle (V2V)/vehicle-to-infrastructure (V2I): Revolves around increasing situational awareness and reducing or eliminating crashes. V2V/V2I assist in vehicle safety assurance and act as an infrastructure enabler for other connected vehicle use cases (emergency, security, infotainment).

Freight monitoring: IoT for freight management (air, railroad, land, or sea) that is based on the technology of radio frequency identification (RFID), global positioning system (GPS), GPRS, and GIS, and creates an intelligent, internet-connected transportation system.

Passenger traffic flow: Passenger traffic flow envisions the location and movement of passengers throughout an airport to improve understanding of logistical impact to facilities, gate arrival and departure, luggage logistics, and shopping and retail insights.

Remote diagnostics/monitoring of patient status: Providing the ability to monitor patient's vital signs and medical status (e.g., blood pressure, heart rate, or glucose level).

Traffic management: System of closed and open loop networked traffic control systems used for road vehicle traffic management especially public road traffic lights.

Appendix C: Endnotes

[1] Source: "Untangle Your IoT Strategies," Forrester Research, Inc., September 21, 2017.

[2] Source: "Internet-Of-Things Heat Map 2018," Forrester Research, Inc., April 23, 2018.

[3] Ibid.

[4] Ibid.

[5] Source: "The IoT Attack Surface Transcends The Digital-Physical Divide," Forrester Research, Inc., October 13, 2016.

[6] Source: "IoT Applications Require Distributed Analytics," Forrester Research, Inc., March 29, 2017.

[7] Ibid.

[8] Ibid.

[9] Source: "Amazon Moves To The Edge Of The Internet Of Things," Forrester Research, Inc., December 2, 2016.

[10] Source: "IoT Applications Require Distributed Analytics," Forrester Research, Inc., March 29, 2017.

[11] Source: "Amazon Moves To The Edge Of The Internet Of Things," Forrester Research, Inc., December 2, 2016.

[12] Source: "IoT Applications Require Distributed Analytics," Forrester Research, Inc., March 29, 2017.