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TDWI IoT Data Readiness Guide

Interpreting Your Assessment Score

By Fern Halper and Philip Russom

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About the Authors

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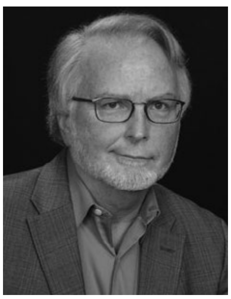

PHILIP RUSSOM, PH.D., is senior director of TDWI Research for data management and is a well-known figure in data warehousing, integration, and quality, having published over 550 research reports, magazine articles, opinion columns, and speeches over a 20-year period. Before joining TDWI in 2005, Russom was an industry analyst covering data management at Forrester Research and Giga Information Group. He also ran his own business as an independent industry analyst and consultant, was a contributing editor with leading IT magazines, and a product manager at database vendors. His Ph.D. is from Yale. You can reach him by email (prussom@tdwi.org), on Twitter (twitter.com/prussom), and on LinkedIn (linkedin.com/in/philiprussom).

About TDWI Research

TDWI Research provides research and advice for BI professionals worldwide. TDWI Research focuses exclusively on analytics and data management issues and teams up with industry practitioners to deliver both broad and deep understanding of the business and technical issues surrounding the deployment of business intelligence and data management solutions. TDWI Research offers reports, commentary, and inquiry services via a worldwide membership program and provides custom research, benchmarking, and strategic planning services to user and vendor organizations.

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Cloudera sponsored the research for this TDWI IoT Data Readiness Guide and its accompanying Interactive Assessment Tool.

Foreword from the Authors

The Internet of Things (IoT) is a vast network of connected devices that work together to collect and analyze data over the Internet and other networks. Capturing IoT data and leveraging it for business advantage is a growing trend as well as a business imperative. At TDWI, we see increasing interest in IoT. For instance, a recent TDWI survey indicates that IoT data collection by organizations is set to grow by 200 percent in the next few years. Twenty-five percent of respondents collect IoT data today; over 60 percent plan to collect it in the next few years.[1]

Back in 2016, we introduced an IoT Readiness Assessment to help our audience understand IoT and the critical factors that affect the success of IoT implementations, with a focus on data and analytics for IoT. The results of that assessment indicated that organizations were somewhat ready to begin IoT deployments. They had strong commitment from management; however, they often lacked some of the organizational and technical components needed to make IoT successful.

Some of the issues these organizations faced were around getting ready for IoT from a data perspective; IoT data readiness had some of the lower overall scores in our first assessment. IoT data is often streaming from multiple data sources. It can be noisy. It can vary greatly. It often needs to be collected, processed, and analyzed in real time. It is often distributed. For this reason, we decided to focus the latest IoT Readiness Assessment on data readiness.

This guide accompanies TDWI's IoT Data Readiness Assessment Tool, an online survey that helps respondents understand how prepared their organizations are to leverage an IoT implementation to change their business model, improve operations, and improve the customer experience. When you complete the online questionnaire, the assessment tool immediately provides you with scores that quantify your organization's IoT data readiness.

This Readiness Guide provides an updated primer on IoT and IoT data readiness, an explanation of the Readiness Model, and tips for interpreting your assessment scores. We recommend that you read this guide before taking the assessment so you are prepared to interpret the scores displayed at the end of the questionnaire; however, the guide and the tool can each be used independently, so you can work with them in either order.

Thank you for reading this Readiness Guide and using the IoT Data Readiness Assessment Tool. We trust you will find both useful.

Fern Halper,
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for Advanced Analytics

Philip Russom,
TDWI Sr. Director Research
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[1] See the 2017 *TDWI Best Practices Report: Advanced Analytics: Moving Toward AI, Machine Learning, and Natural Language Processing*, online at tdwi.org/bpreports

IoT Primer

Before discussing IoT data readiness, let's review IoT (with a focus on the data aspects of IoT) for those readers less familiar with the topic.

IoT Overview

Industry estimates put the number of interconnected devices between 20 and 50 billion by 2020.

IoT is hot. Industry estimates put the number of interconnected devices (i.e., "things") between 20 and 50 billion by 2020.[2] These "things" have embedded hardware and software that generate, receive, and collect data and can communicate internally and externally. Many of them are inexpensive. They provide command-and-control functionality and include a CPU, often with limited power and memory (although many newer devices have more memory). IoT is not a future scenario. These devices—including sensors, RFID tags, and more—are in your home in smart appliances; you're wearing them for health and wellness. They are on factory floors, in office buildings, on farms, and much more.

There are numerous use cases for IoT in production today. On the consumer side, sensors are everywhere—from the cars people drive to the appliances they use and the phones in their pockets. For example, if a part is about to fail in a washing machine, an alert can be sent to the manufacturer to send out a repair crew. IoT is being used in smart homes, smart meters, and smart cities. IoT analytics can even alert people to potential health risks via wearable fitness monitors.

On the business side, predictive maintenance is a very popular use case for IoT. Here, data from sensors and other devices is being used to determine when a part failure might occur. IoT enables manufacturers to improve production quality through continuous monitoring of assembly lines, and it allows energy utilities to anticipate and consequently eliminate power outages by monitoring power usage across a broad network of smart meters. Sensors track the temperature of a railway car transporting fruit to ensure freshness upon arrival at the grocery store. In agriculture, sensors monitor soil conditions. They are being used to offer promotions to customers based on where they are in a store—and much more.

IoT can involve information and logic pushed outbound. This might include instructing a truck driver to turn left for a more efficient route or a new pickup or providing automatic software updates on the thousands of control devices that IoT entails in utilities and manufacturing. Machine learning might be used to make automated decisions at great distances, such as rerouting service on a power grid or lowering the temperature of a vat in a chemical manufacturing plant.

From these examples, it is clear that IoT is all about the data. Devices produce data that needs to be processed and analyzed. Depending on the use case, this can involve massive amounts of data that may be generated in real time. Much of this data arrives in streams. Your organization will need a way to manage this data. That may involve capturing multiple streams for later analysis or processing and analyzing one or more streams in real time, for example to only capture data that deviates from the norm. The route that an organization takes will depend on the use case.

[2] In 2011, Dave Evans from Cisco made this prediction in his white paper, "The Internet of Things: How the next evolution of the Internet is changing everything." https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf. Since then, he has scaled back his predictions somewhat.

Components of IoT Applications

There are many components in an IoT application, including sensors, devices, gateways, routers, network infrastructure, the cloud, servers, analytics platforms, and analytics algorithms, as well as other data-related technology. For example, the figure below illustrates a preventive maintenance IoT application in the oil and gas industry, although the same principles hold for other industries. The diagram provides some insight into the various components of an IoT deployment and what kinds of data issues an organization needs to address before embarking on IoT.

In this example, sensors are used to collect data from various machinery on the rig. Sensors might measure temperature of a part, number of vibrations per second of other parts, viscosity of the oil, and so on.

All of this data is collected by a gateway device on the rig. This data is then sent to a data center on premises or to the cloud where data from all machinery on the rig (and perhaps across other rigs) is analyzed to determine what factors precipitate a part failure. That information is then encoded into a set of rules (or a model) and pushed back down to the gateway. As new data is generated, the rules are applied to the data. When an alert condition is met, that alert will be sent to the rig supervisor's mobile device or to headquarters.

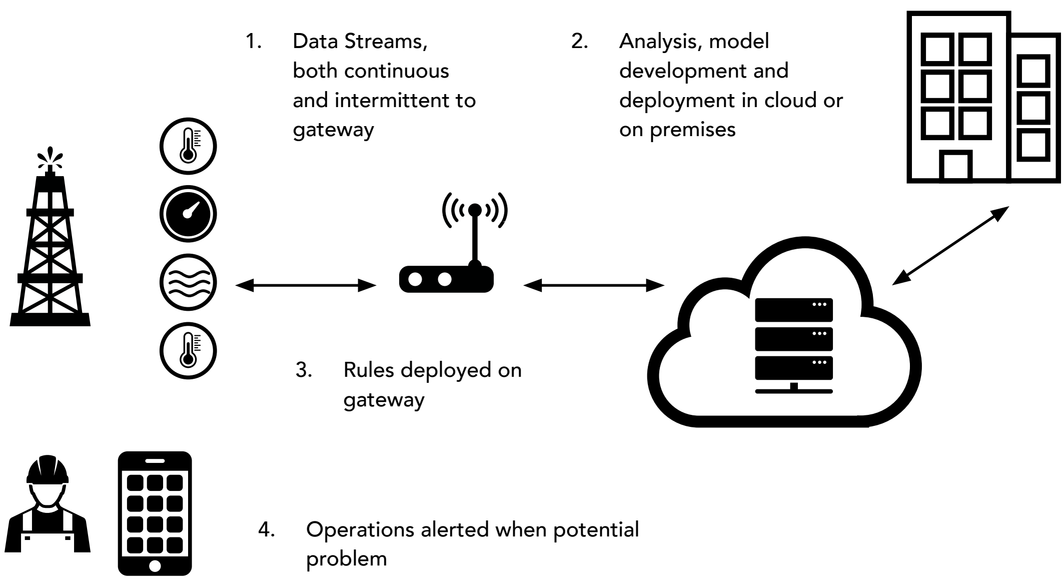

Figure 1: An illustration of a preventive maintenance IoT application.

Of course, this is just one way that the deployment might occur. The IoT data might be enhanced with other data in the data center. Many organizations are now looking to the edge device itself to collect the data and do some of the processing. In some of these cases, the analytics is being pushed out to the edge as well.

This example illustrates the range of data issues that must be addressed when embarking on an IoT deployment. Some issues include (but are certainly not limited to):

- Identifying data sources that need to be collected
- Frequency of data collection

- Identifying where, in the network, the data should be collected (edge, gateway, on premises)
- Defining processes for data ingestion and filtering (e.g., does all data need to be collected or perhaps just deviations?)
- Determining if various data streams need to be synchronized
- Determining which data sources need to be integrated and how and where to integrate them
- Determining how data should be processed, including profiling, quality, metadata management, and lineage
- Identifying data storage
- Defining data security requirements
- Determining what analytics to use against the data (e.g., descriptive, predictive)
- Analytics deployment considerations, including where the analytics is deployed—on an edge device, on the gateway, in the cloud, or at an on-premises data center

Of course, there are people and process issues, too. For instance:

- How will an IoT implementation and the analytics function support the strategic direction of the company? Are desired outcomes clear?
- How will operations be impacted by IoT implementations?
- Has everyone bought into this (IT, operations, business users, etc.)?
- Are there security or regulatory concerns that must be considered?
- Are there members of the organization who can deal with security concerns?

Data Readiness for IoT

The successful handling of data from IoT devices and communications infrastructure assumes a rather hefty portfolio of data management capabilities at the level of participating companies and other user organizations. These capabilities fall into a few categories, and the list can provide a checklist for IoT data management readiness:

As data comes from IoT devices, each item must be triaged to determine what kind of action should be taken.

TRIAGE, WORKFLOW, AND REAL TIME. As data representing events, messages, transactions, sensor readings, etc. comes from IoT devices, each item must be triaged (i.e., examined for urgency and relevance to existing workflow processes) to determine what kind of action should be taken (if any) and to which workflow the new information should be routed. For example, a recurring temperature reading from a thermometer may need immediate action (via a command to a freezer controller or an alert to a human), whereas intermittent readings from RFID chips on shipping pallets rarely need immediate action (even if the reading shows that a pallet arrived at the wrong location).

The good news for data management professionals is that operational applications typically handle time-sensitive triage and workflow functions, and the data management infrastructure receives triaged data somewhat latently after its creation, even in overnight bulk loads. This is fully appropriate to the "after the fact" analytics that most firms are performing with IoT data today.

However, data management professionals should assume that the future will demand far less latent arrival and processing of data—achieving or approaching real time—as firms mature into real-time analytics and reporting for IoT processes. For this reason, some data warehouse and analytics teams are planning to bring into their environments tools for service buses, complex event processing (CEP), and real-time data capture (with a strong interest in Spark as a preferred technology).

INGESTION. The Internet of Things is diverse in the extreme, involving a long list of device types, which in turn communicate with many types of applications over infrastructure that ranges from LAN/WAN to Wi-Fi to telephony, radio, and satellite systems. Incoming data rarely comes from devices directly to your data management tools; increasingly, data management tools must reach upstream to poll operational applications and monitor message buses through a long list of open or proprietary interfaces. Put all that together and capturing IoT data demands an "ingestion array" consisting of many approaches to data integration, application integration, middleware, and communications protocols to cover the many interface types, data structures, and latencies that are common with even the simplest IoT implementations.

PERSISTENCE. Once data from IoT devices comes into a data management environment, it is eventually persisted to disk, whether for temporary landing, permanent storage, or both. Again, IoT is diverse in the extreme, which means that your portfolio of data storage platforms—i.e., databases, cloud storage, and Hadoop or other file systems—may need to be equally diverse. For example, supply-chain-driven IoT may involve data typical of that business use case, such as XML, EDI, and JSON documents; for these cases, some IoT users store the documents in Hadoop, which excels with file-based data. As another example, freight and logistics companies capture IoT data almost exclusively via multiple wireless, Internet, and satellite media, so it makes sense to persist data on cloud-based platforms. For decades, data management professionals have matched the choice of data platform to the requirements of data and its use cases. IoT is the same kind of decision, only with different data types and today's long list of modern platform options.

Once data from IoT devices comes into a data management environment, it is eventually persisted to disk.

Zero-landing data pipelining is one new option. It treats server memory as a staging area for data integration operations, such as table joins, transformations, and sorts. This requires server "big memory," which is still expensive. However, depending on the configuration, pipelining can avoid, minimize, or delay the performance-killing I/O that persisting to disk usually entails. Pipelining has IoT applications, as when incoming IoT data would benefit from fast transformation, whether on a per-event basis or a bulk-load basis. The speed of pipelining can also bring IoT analytics closer to real time.

Persistence and ingestion are obviously related, and the two come together in the data lake. A hallmark of the data lake is that it forgoes or delays data transformation and quality operations to ingest data into persistence as fast as possible. One reason is to make fresh data available as soon as possible for reporting and analytics, at scale with diverse data. Another reason is to capture data in its original raw form so all its details and structure are retained for future use cases we cannot foresee. Given the newness of IoT and its data—and the relentless evolution of device data—the data lake is a good choice for a raw data repository for IoT data. Increasingly, data lakes are deployed on clouds, which is a good choice when IoT data originates from cloud sources or is transported over the Internet.

ANALYTICS. We say "analytics" as if it were a single monolith. Actually, analytics is a long list of methods and enabling technologies, including those for mining, clustering, predictions, machine learning, OLAP, and extreme SQL. Each approach has its own requirements, based on its needs or preferences for how data is either stored or presented in real time, raw or transformed, from a single source or from many, the preferred interfaces of analytics tools and users, and so on. Furthermore, in the past data was moved from one storage area to another before analyzing it; we do that far less today due to the size of big data and the new options for analytics processing in database and storage platforms. In other words, it's not just the diversity of IoT data that is driving up the diversity of your data platform portfolio; the diversity of IoT analytics is an equally strong driver.

The TDWI Data Readiness Model for IoT

Based on conversations with many users, consultants, and vendors, we have identified the most fundamental success factors relative to readiness.

The IoT Data Readiness Model is essentially a compact catalog of success factors for being ready to start an IoT project from a data perspective. Based on conversations with many users, consultants, and vendors, we have identified the most fundamental success factors relative to readiness. Note that the catalog is compact for a reason. One goal is to shorten the assessment tool's questionnaire (which is based on the Readiness Model) so as many users as possible will complete it. The primary goal, though, is to focus users and their organizations on the highest priorities—namely, the most common and the most fundamental success factors critical for IoT data readiness. Note, too, that the model is focused on IoT data and associated data analysis. As such, we do not ask specific questions about sensors or networks.

Dimensions and Metrics for IoT Data Readiness

The model (depicted in Figure 2), consists of dimensions and metrics. The dimensions are the top-level categories that are important for being data-ready for IoT deployments. These are IoT Organizational Readiness, IoT Data Readiness, IoT Data Infrastructure Readiness, IoT Analytics Readiness, and IT/Operations Readiness. Beneath each of these dimensions is a series of metrics that are quantified based on answers to a set of questions for each.

In TDWI's online IoT Data Readiness Assessment Tool, there are one or more questions per metric, thus there are several questions per dimension. In other words, the online tool itself and the scores provided after completing the assessment are based on the hierarchical structure of dimensions and metrics, as defined in the IoT Data Readiness Model found in Figure 2.

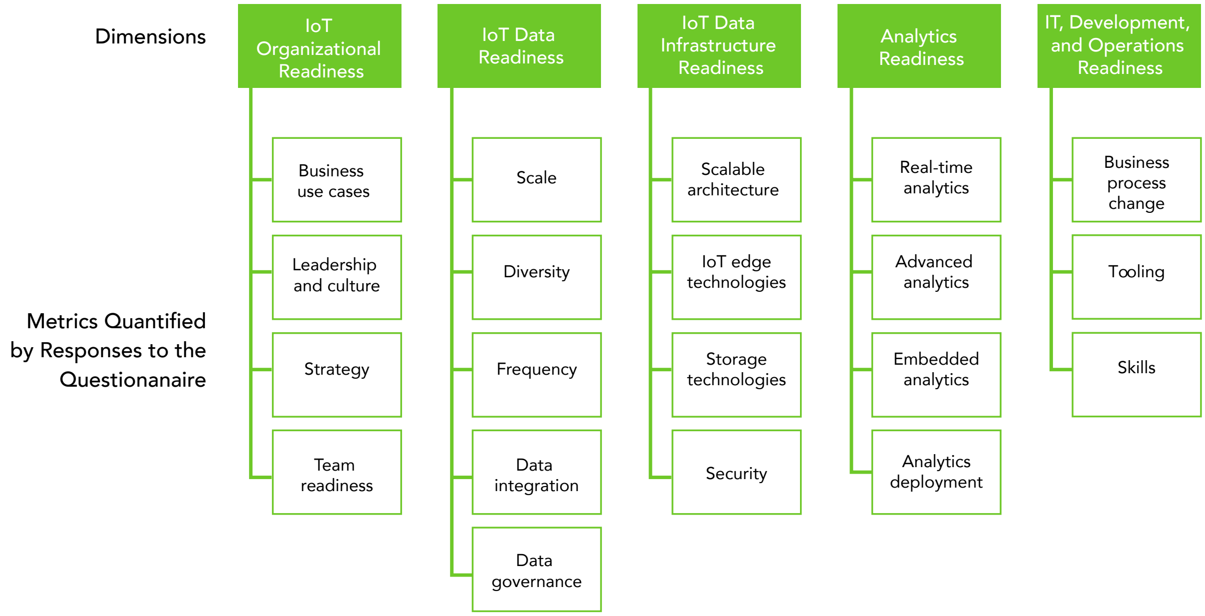

Figure 2: The IoT Data Readiness Model consisting of dimensions and metrics.

What follows is a general description of each dimension, with a few examples of the questions that the Assessment Tool asks in order to quantify IoT data readiness.

- **ORGANIZATIONAL READINESS.** In order for IoT to succeed, the organization must be committed to it and project goals should be tightly aligned with business goals and metrics. Have use cases for IoT that will drive business value been identified? Are these aligned with business goals? Is there a culture that supports new ideas? Are teams in place? Funding?
- **DATA READINESS.** There are many data issues related to IoT. Does the organization have experience with data at scale? Can it deal with real-time and streaming data? Disparate data? Can it deal with data ingestion, timing, and quality? Data integration? Does it have data governance in place to deal with data provenance and lineage issues? What about metadata?
- **INFRASTRUCTURE READINESS.** The IoT data infrastructure is also important. Does the organization have an architectural plan in place for IoT data? What data platforms does the organization have experience with? Has it thought through network and edge topologies for data collection and processing? Does it have a plan for data storage? IoT data security?
- **ANALYTICS READINESS.** Collecting IoT data is important, but analyzing and acting on it is often where the value lies. Does the analytics team have experience analyzing disparate data types? Does it have experience analyzing real-time data? Does it have expertise in more sophisticated analytics such as predictive analytics? Can it take action on analytics? What deployment experience does the organization have with real-time analytics?
- **IT/DEV/OPS READINESS.** IoT projects often include other parts of the business. How ready are the technical teams deploying and owning IoT data and analytics? Do they have the tools they need? Do they have the skills? Have they planned changes to systems? Processes?

How the Readiness Assessment Tool Quantifies Metrics and Dimensions

When you select answers to questions in the Readiness Assessment Tool, the score for particular dimensions is calculated. For many questions, the multiple-choice answer you select determines the score for that question.

When you take the online assessment, resist the urge to inflate your score by answering the questions based on aspirations for the future. For your assessment to be accurate and useful for IoT data planning, you should answer all questions as accurately and honestly as you can.

The greatest score for each single dimension is 20. Multiplying 20 by the five dimensions yields 100 as the greatest possible score overall.

At the end of the assessment, the IoT Data Readiness Assessment Tool displays your scores per dimension (out of 20) and overall score (out of 100), plus the average dimensional and overall scores of all respondents. That way, you have context for determining whether your organization is ahead of or behind the curve. You will also see the average for your industry and company size.

If your organization is completely prepared to leverage IoT data today, your score across all dimensions might tally to 100, but that's rare; most overall assessment scores will fall between 40 and 70. An overall score of 60 is a reliable watershed benchmark. Above that, users should proceed with IoT and further preparation can be successfully executed concurrently with the implementation. Below that, there are likely improvements you should make to use-case commitments, data management, and technical infrastructure before you undertake an IoT implementation. The questions in the assessment provide guidance for getting ready for IoT from a data perspective.

Interpreting IoT Data Readiness Scores

As mentioned earlier, the online tool will show you your scores after you complete your session, as well as an average of scores across all assessment respondents. That way, you can "benchmark" your scores against those of your peers at organizations that are also contemplating an investment in IoT. It will also provide information in a graphical form—the radar chart (see Figure 3 below for an example).

Based on previous TDWI IoT research, we see certain patterns when it comes to IoT data readiness. First, some organizations are ready across the board. They score high across all dimensions and are most likely already deploying or about to deploy IoT. These organizations typically have experience managing and analyzing disparate data at scale.

There are other common patterns as well. These are detailed below.

Scenario One: Potential strength in data warehousing and BI

These respondents are typically still at the early stages of maturity when it comes to data and analytics.

There were a number of respondents to our previous assessment who were lackluster across all dimensions. These respondents are typically still at the early stages of maturity when it comes to data and analytics. This group deals mostly with structured data in the warehouse and typically has some experience with descriptive analytics—perhaps even using some self-service visual analytics. They may be quite good at what they do; however, they have not yet really thought through what an IoT deployment would look like or how to handle that kind of data or put the organizational structure in place to get started.

Figure 3 illustrates the output from this kind of respondent. Because the organization is not particularly strong in any dimension, the pentagon's edges are below 10 on the chart, which denotes room for improvement.

STRENGTHS: The organization represented in Figure 3 is at the starting point for new data and analytics such as IoT. It may have experience with large volumes of data, but this data is typically structured and batched before going to the warehouse. The organization may not be quite ready, but there are steps it can begin to take (see below).

OPPORTUNITIES: Organizations at this stage of readiness are most likely starting to realize that they will need to collect more diverse data types and support more advanced analytics. This will involve extending or evolving the current warehouse environment to support increasing amounts of disparate data. These organizations may turn to new platforms such as the cloud or data lakes. This may involve new features such as real-time functions.

RECOMMENDATIONS: First, it may be necessary to reevaluate the data warehouse platform. Moving toward IoT may involve capturing, managing, and delivering data with speed and scale. Growing your data can mean extending your data environment to what TDWI refers to as a multiplatform data architecture. The architecture is a large-scale design pattern and can include numerous diverse platform types woven together in a fabric. This includes newer systems such as cloud-based databases, columnar databases, and systems that employ Hadoop or Apache Spark or Kafka. This will also involve aligning with business goals and working with different parts of the business.

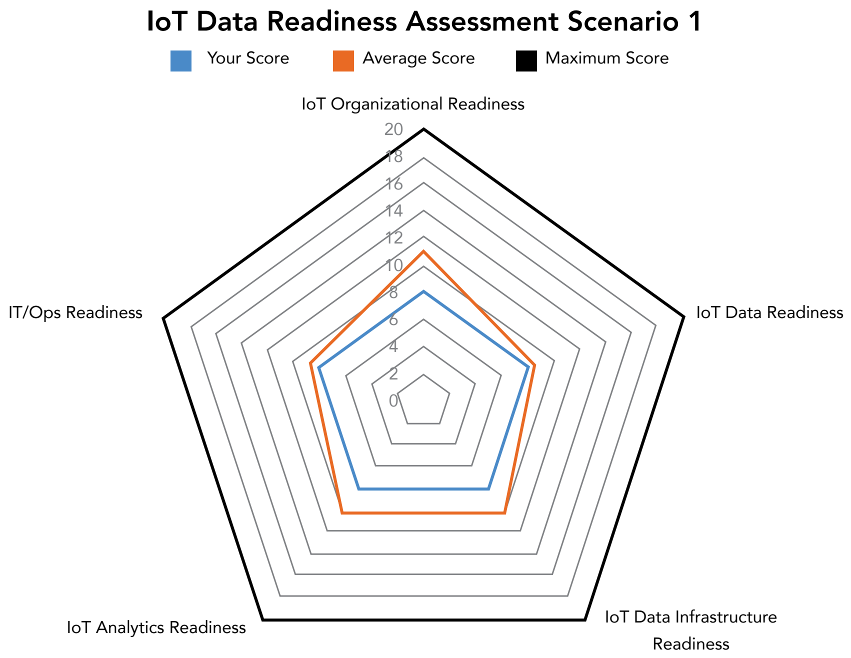

Figure 3: Possible scores for organizations with potential strength in data warehousing and BI.

Scenario Two: Strong analytics capabilities

Some organizations might be strong in analytics but lack experience managing data at scale or real-time data. For instance, they might be strong in certain advanced analytics, such as predictive analytics or natural language processing, but they are not used to performing this analysis against large amounts of data in a distributed environment or dealing with putting models into production for real-time analysis. They may be building complex models for pricing, risk, or marketing, but these models are used to inform decisions rather than take action. These respondents also typically have organizational support, including leaders who support analytics and a culture of insight. They may have a center of excellence (CoE)—consisting of business analysts and data scientists as well as possibly IT personnel—that manages the data warehouse.

Some organizations might be strong in analytics but lack experience managing data at scale or real-time data.

These organizations might score high in some of the analytics and organization categories, but IT or another part of the organization may not be prepared for some of the complexities of new IoT data (e.g., real-time ingestion, streams, quantity, diversity, etc.).

Figure 4 illustrates the output from this kind of respondent. Because the organization is strong in analytics with a culture that supports analytics, the pentagon's edges are near the outer edge of the radar chart, which denotes strength in these categories. Some of the other categories are located more toward the center of the chart, which denotes a weakness—such as lacking a data infrastructure to support real-time, big, diverse data or the processes and skills to deal with the data.

STRENGTHS: The organization represented in Figure 4 is lucky to have strong technology and skills for analytics. This is a good starting point for IoT. If they are sophisticated in analytics, then they are probably also well positioned to frame the right questions for IoT analytics. They may also have executive support for analytics, which will be important to get an IoT project off the ground and identify the right business use case.

OPPORTUNITIES: Getting started with IoT doesn't demand large volumes of diverse real-time data—smart cities that are monitoring bridge integrity might only get a few hundred sensor measurements a day per bridge. However, the reality is that at some point, some sort of big data infrastructure may be needed—perhaps a data lake, some sort of stream-processing engine, or one of the other platforms listed earlier. The company will have to build skills in these technologies and learn new platforms.

RECOMMENDATIONS: If analyzing IoT data makes sense for the organization, then someone (perhaps the executive in charge of analytics) will need to make the business case for "new" data so that the project can get off the ground and the other needed people can get involved. That will include developing a data strategy to determine how to deal with large volumes of multistructured data and extending the warehouse environment and architecture to support new data types. It will also include planning for data integration.

Teams will need to be created including IT, operations, the business, and analytics. If a center of excellence already exists, it may be leveraged to support IoT data initiatives. CoE team members could be tasked with how to approach analytics for IoT in production, how to think about operations using IoT results, or how to keep an eye on the road map.

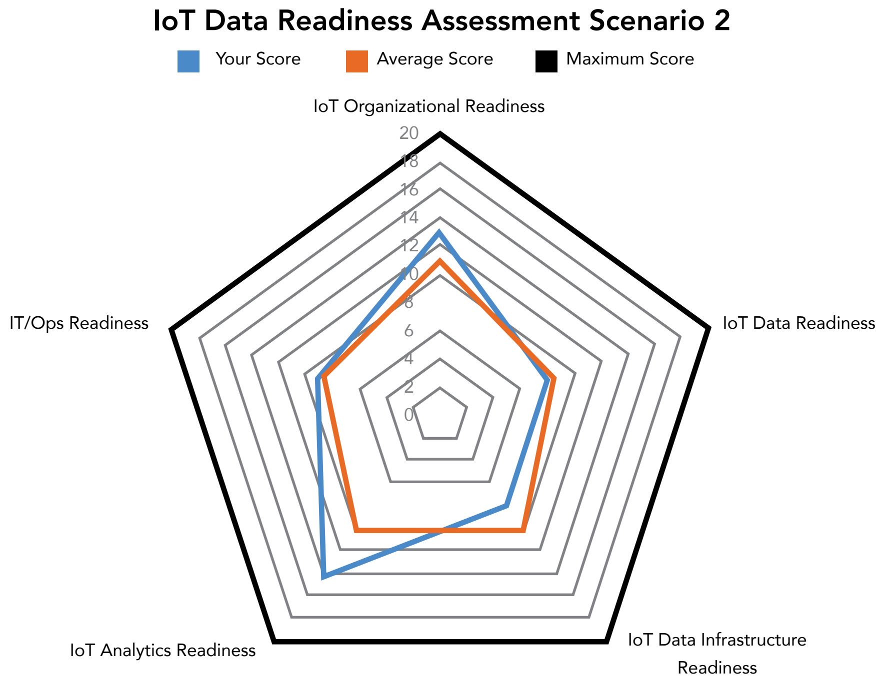

Figure 4: Possible scores for organizations that are analytically strong.

Scenario Three: Strength in data and data infrastructure

Some organizations have dealt with large amounts of real-time data.

On the flip side, there are organizations that have strength in dealing with large amounts of disparate, real-time data, although they may not have direct IoT data experience. For instance, an organization may have experience collecting large amounts of website browsing data or credit card transactions, which may require housing the data and even processing and analyzing it—perhaps even in real time.

However, this data is not connected "thing" data. There is no physical object involved. IoT data often involves instrumentation that the IT department is not familiar with. Additionally, we see that some of these organizations are often not that strong in more advanced analytics against this kind of data. Figure 5 illustrates the potential output from a respondent with this profile. The figure reflects that the primary strength is in the data readiness dimension.

STRENGTHS: On the upside, the organization represented in Figure 5 is already committed to capturing, governing, and analyzing massive amounts of disparate data, so they should already have competencies in big data management and governance (including lineage and provenance). They may also have some competency in technologies such as stream processing and in embedding analytics for action. They may be using the cloud to perform some of their data analysis or as part of their data management infrastructure. This organization is ready to start onboarding new kinds of data from IoT devices.

OPPORTUNITIES: On the downside, the weakness in IT, operations, and infrastructure readiness is probably due to a lack of experience with specific IoT technologies and the development of IoT applications. There may also be some weakness in analyzing this kind of data or putting it into production for real-time action.

RECOMMENDATIONS: Priority should go to beefing up teams that support IoT data infrastructure to learn the skills, acquire the tools, and deploy the infrastructure needed. This may involve training or partner support. Additionally, the organization thinking about deploying an IoT project should start communicating with development and operations and any other groups involved. Otherwise, these organizations are in good shape to start their IoT analytics deployments.

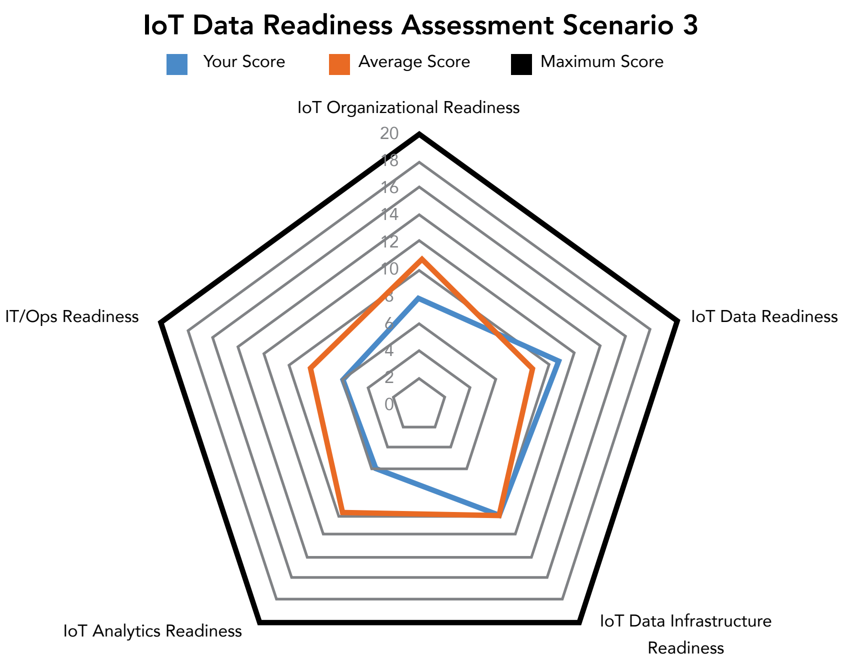

Figure 5: Possible scores for an organization that has experience with large amounts of disparate data.

Summary

The TDWI IoT Data Readiness Assessment provides a quick way for organizations to assess their readiness for IoT data and to compare themselves in an objective way against others. The assessment is based on the TDWI IoT Data Readiness Framework, which consists of approximately 35 questions across five dimensions. Although this assessment serves as a relatively coarse measure of your readiness, we believe you will find it useful.

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