CHAPTER

7

Intelligence of Things = IoT + Cloud + AI

With the Internet of Things (IoT) and artificial intelligence, one is the enabler and the other is the disruptor. Both of these technologies, individually, are transforming businesses and lives.

The Internet of Things (IoT) is a network of physical objects embedded with sensors and connectivity, so that they can exchange information with other connected devices in the network. In simple terms, IoT is about taking the inert and making it "smart," or even smarter, by connecting it to well, everything. It's exactly what it sounds like—things that have Internet! You take any object, embed sensors in it, attach a unique digital tracker to it, and then enable it to send and receive information without human interactions. You got your own IoT.

When objects can sense and communicate, it changes how and where decisions are made. Cheap sensors, improved wireless connectivity, and scalability through cloud computing have all made it possible to cost-effectively collect and process lots of data, analyze it, and act on it instantaneously. As a result, everything around us (animated, non-animated) is becoming connected

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and smart. If you extend the concept of IoT to industrial scenarios such as manufacturing and supply chain management, you get the Industrial Internet of Things (IIoT). If you extend the concept of IoT to individual consumption scenarios in our daily life such as wearables, home appliances, personal assistants, smart thermostats, etc., you get Consumer IoT.

It is projected that IoT (and IIoT) will lead to the next-generation of smart operations at scale. For example, take a highly mechanical and physical intensive set up like a factory. It can be transformed into a "smart factory" where machines ("intelligent assets" or "smart machines") are capable of "talking" to each other and "making decisions" independent of human interference based on the data they collect and communicate. The result? Improved production times, improved cost-efficiency, reduced waste, and top-notch quality.

IoT doesn't only apply to M2M (machine-to-machine) communications; it extends to any task where close integration between people, processes, and machines (virtual and real worlds) is required.

With IoT alone, we can talk and listen to machines, but to understand machines and make them intelligent, we will need AI. AI provides us with the capabilities to learn and infer patterns from the vast amount of data collected through IoT.

What happens when we combine IoT and AI? It's a step-change transformation in everything—from machines to factories to automobiles to wearables to kitchens to buildings, and many more.

Let's explore a few scenarios to appreciate the transformative power of IoT and AI, combined.

Making Homes and Buildings Smart

A smart home usually consists of a central control unit (maybe physical or on the cloud) that reads information from every type of sensor spread throughout the home. Motion sensors, temperature sensors, and the like generate information every second and send it to the central unit. The central unit makes decisions based on the information sent to it by these sensors. Therefore, the entire home is connected and smart.

- Proximity sensors placed in refrigerators sense the stock inside and send data to the central unit. The central unit processes the data and places replenishment orders online based on your consumption patterns.
- Motion sensors in the house include facial recognition to recognize thieves and respond accordingly by sending a message to nearby authorities.

- Temperature sensors maintain the temperature of the home, according to the weather outside.
- Power consumption sensors keep tabs on usage trends and automatically turn devices/lights on or off based on the presence of people in the rooms.

Keeping Your Car Running

Imagine your car was fitted with all kinds of sensors, streaming data about the wear and tear, engine performance, and your own driving patterns, and that everything is collected through IoT gateways and pushed to the cloud. The AI running on the cloud continuously analyzes this data and generates predictions. AI reaches out to your Alexa when it thinks the car needs maintenance, and Alexa checks your calendar and talks to your favorite mechanic to find the earliest suitable schedule, and then asks you to confirm verbally. You'd never get into situations where you are oblivious to the fact that your car badly needs attention.

Keeping the Power On

When it comes to electricity supply, we are more affected by brownouts than blackouts. A blackout refers to complete power loss that impacts a large area, whereas a brownout happens when a sudden surge in demand forces your utility company to reduce line voltage in a few areas to manage the demand and supply better. The unintended consequences of a brownout are voltage fluctuations, which can severely damage electrical appliances.

Now consider home thermostats that sense the environment and temperature patterns and transmit data to your utility company, in real time. If it is an exceptionally hot day and there is a possibility of brownouts, the AI system on the cloud can see how many devices are operational, and then proactively turn the thermostat up a few degrees, while keeping the thermostat stable in temperature-sensitive facilities such as hospitals, thereby avoiding the brownout situation.

Making Sure You Stay Alive

There is more to the Apple Watches than a status symbol. Your wearables can do more than just read your heart rate and determine how much you have walked today. Imagine that your wearable sends an alert to the AI system when it detects that you might be having a heart attack. The AI system receives the alert, then goes into a mission-critical mode by triggering several actions in real time. It sends your location data to the closest ambulance, notifies the

closest hospital to prepare ahead of time, alerts your doctor and recommends the fastest and shortest route to reach you or the hospital. Adding AI to IoT could mean the critical minutes that keeps you alive.

Making Sure You Stay Safe

We are concerned about the safety of our loved ones. This is the primary reason why we have gone to lengths to ensure our homes are protected. We install CCTV cameras all around the perimeter and intrusion detection systems that are connected to the law enforcement agency control room. Imagine if the data from your CCTV camera and your intrusion detection control system was continuously being pushed to the cloud, where the AI system was not only assessing the situation at real time but also applying vision recognition algorithms to correctly identify the intruder by checking against the criminals database and guiding the law enforcement officers on the next best actions.

Of course, there are data privacy concerns related to all of these examples. However, some people think the benefits clearly outweigh the risks.

The impact of IoT, the cloud, and AI, combined, requires a vivid imagination. We can apply the transformative power of these technologies to pretty much anything and everything.

IoT, the Hybrid Cloud, and AI Work Together

The examples discussed previously are no doubt are fascinating. But the key question is how would you build these kind of integrated applications? What are the technology building blocks?

The convergence of IoT and AI is simply not possible without an enabling platform and architecture. That's where the hybrid cloud steps in. All companies exhibit a unique technology landscape that has been built for and suited to their individual business needs and growth. The hybrid cloud is a disruptive technology and a business opportunity at the same time. To understand this disruption requires a deeper understanding of the converging architecture involving the hybrid cloud, IoT, and AI.

There are devices all around us that are collecting and transmitting data all the time. All of this data must be quickly analyzed for the next best action. When there's a delay, the data loses its value. This zero latency requirement necessitates incredible distributed collection and storage capabilities closest to the source. This means the edge of IoT must exhibit instantaneous capabilities to parse and analyze streaming data for the next best actions, at the same time pushing the bulk of the data to the cloud for deeper analysis.

AI, on the other hand, calls for immense compute power to operate on massive data sets. Speed and performance are additional considerations for AI systems, since decisions made by AI need to be fed back quickly to the IoT devices to make the predictions actionable.

The following list explains a few examples that highlight the AI specific requirements:

- Self-driving emergency response vehicles immediately respond to life-saving search and rescue operations such as floods, fire, etc.
- Medical devices can automatically defibrillate and send an alert notification to the nearest hospital.
- Financial crime detection systems include credit card swipes.
- On-demand recommendations for streaming video services.
- Apple's Siri and Amazon's Echo give instantaneous responses at the edge.

There are many more examples spread across industrial needs as well as consumer needs. In all these examples, one thing is common, the AI requirements not only involve lots of data but also real-time decisions (see Figure 7-1).

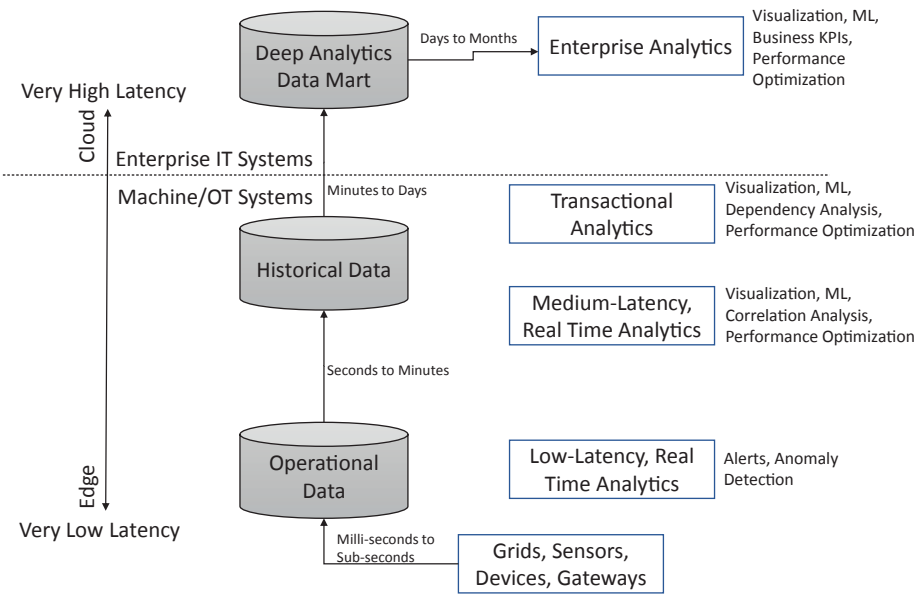

Figure 7-1. Data value chain and decision latency for IoT

Data collected by IoT can improve the prediction capabilities of AI; however, there are many tasks in the value chain (from raw data from devices to predictions, to outcomes) that need to be orchestrated well to deliver the final outcome. Figure 7-2 shows a conceptual view of the different components that make up an IoT analytics platform.

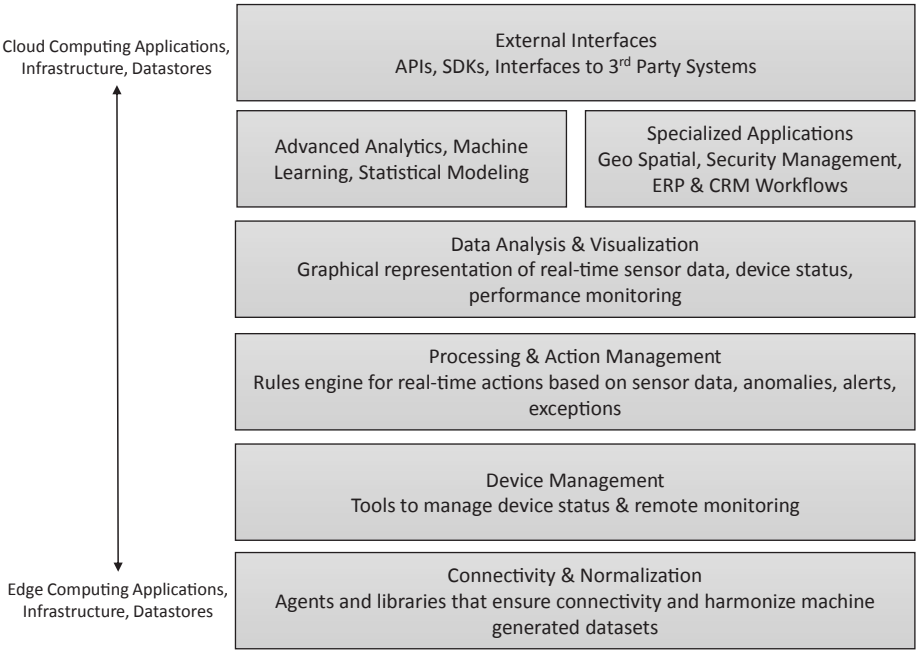

Figure 7-2. IoT analytics platform components

While just doing IoT is transformative by itself—at least you will get complete visibility into your operations and machine performance and you can make decisions—to become predictive, you need AI capabilities to function in tandem with IoT and the cloud.

Avoiding Costly Unplanned Downtime

Unplanned downtime resulting from equipment breakdown can be expensive. By applying machine learning algorithms to sensor data generated from machines, we can predict equipment failure ahead of time. The AI system can then trigger alerts to the field operator and schedule maintenance procedures.

Increasing Operational Efficiency

In factories, assembly line operations demand precision and strict quality controls adherence in everything. Take the example of spillage during the production process. Every 1% reduction in spillage can mean thousands of dollars in savings. By using IoT and machine learning, companies can significantly reduce leakages. Streaming data captured from sensors embedded in the machines can be analyzed at the edge itself in real time, thus sending alerts to human specialists to control spillage.

Enabling New and Improved Products and Services

IoT coupled with AI can form the foundation for improved product designs and in some cases even conceptualize entirely new products and services. For instance, by analyzing machine performance data, we can help spot patterns and gain operational insights—how is the machine working, is it able to perform based on the design specifications, is the real-world usage different from the usage considered during design, is there an opportunity to launch a new line of products, and so on.

Enhancing Risk Management

A number of applications that pair IoT with AI are helping organizations better understand risks and prepare them for rapid response, better manage worker safety, and cyber threats.

For instance, by using machine learning on wearable devices, we can monitor workers' safety and prevent accidents. Banks have begun evaluating AI-enabled real-time identification of suspicious activities from connected surveillance cameras at ATMs. Vehicle insurers have started using machine learning on telematics data from connected cars to accurately price usage-based insurance premiums and thus better manage underwriting risk.

The Role of AI in Industry 4.0

The prevalent notion around Industry 4.0 is to connect every asset and create digital environments. This is not entirely a true state. Industry 4.0 is more of an evolution than a revolution. There are several phases that you need to go through to achieve the desired level of maturity. The first phase begins with connecting all the assets together, which includes instrumentation, connectivity, and data collection. The next phase is to figure out how to make sense out of all this data. The final phase is to bring in automation to the entire lifecycle. Manufacturing agility is key to success for Industry 4.0 and AI has a critical role to play throughout the whole "create, make, and deliver" value

chain to optimize and improve every process in order to achieve the best outcome regardless of external circumstances.

Industry 4.0 talks invariably steers into several technologies: edge computing, cloud computing, AI, IoT, platforms, etc. Even though each of these technologies has a role to play, the most critical components are its data and prediction capabilities.

Digital Twins

Modern manufacturing companies are leveraging IoT platforms to capture data from their machines and other sources to create a "digital twin," which is a digital model of an actual, physical object (see Figure 7-3). Digital twins enables us to visualize the real-life operational aspects of a machine. Sensors on the machine transmit data to its digital counterpart, mimicking the physical machine in action, then machine learning algorithms analyze the digitally transmitted data to optimize product performance and recommend the next best actions for the physical system. With digital twins, we have the ability to predict the physical world scenarios, optimize the asset performance, reduce maintenance costs, reduce downtime SLAs, and explore opportunities to monetize data and build new service offerings.

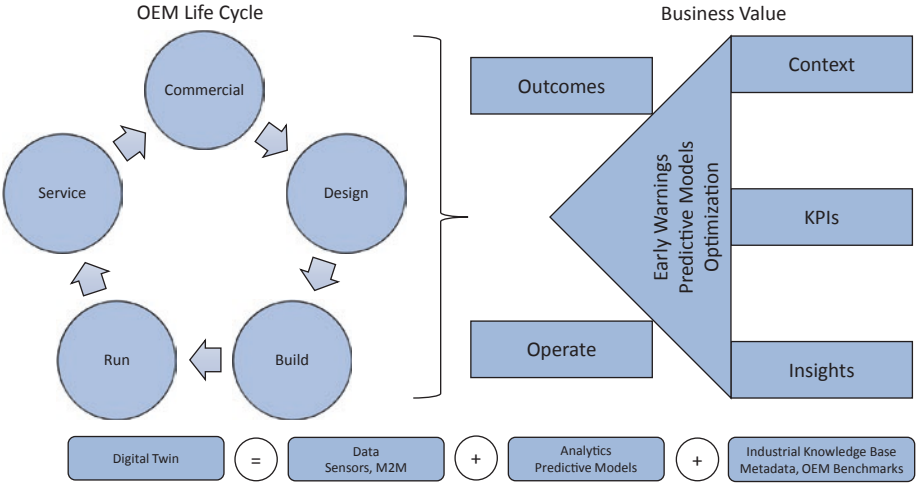

Figure 7-3. Conceptual view of digital twins

In essence, a digital twin is the convergence of the physical system, the digital mirror, and the underlying data that bridges them both.

How could a digital twin deliver transformational business outcomes?

First, digital twins—or rather the converging technologies of IoT, the cloud and AI—offer the possibility to optimize processes and apply effective usage of machines and resources. While these solutions are primarily aimed at lowering the cost of production, customers expect the end product to be inclusive of value-added services, like a dashboard, usage patterns, alerts for maintenance, etc.

Second, smart devices acquire extensive data about the real usage of the product at the customer location. When you analyze this invaluable data across your install base, you will be able to infer not only individual customer-install base patterns but also a world view of how other customers are using it, how successful they are, what challenges they are facing, and whether there are whitespace opportunities to launch new products or value-added services at a premium.

Third, because now you are not just selling a machine but a "machine as a service," you can change the entire business model in which your customers won't mind a premium insurance fee if you can guarantee the quality of their products and services. With digital twins, you can measure the health and performance of your machines. You are able to remotely manage the usage of these machines and predict possible outages. You are able to monitor machine utilization and recommend better capacity planning and production schedules, etc. All these insights mean that you can actually play a larger role in customer's business outcomes, and if you can commit to reduced downtime SLAs, surely your customers will be willing to pay you a premium.

How would you create a profitable digital twin strategy for your business?

If you are purely an industrial manufacturing company, you have three options:

- *Become an enabler*: Start developing and embedding IoT technology, such as endpoint networks, edge computing, and cloud infrastructure, into your products and offerings. This will enable you to cross-sell pieces of digital twin components to your customers and gain market share. Your customers then have to take external help of building in-house capabilities to architect digital twins relevant to them. However, on the cautioning side, beware that this market will be dominated by a small number of global giants who can deliver the entire stack at a fraction of the cost.
- *Become an engager*: Besides manufacturing world-class products equipped with sensors and compute power, you can venture into designing, creating, integrating, and delivering value-add services to your customers. The value-add services could be like adding a real-time dashboard, trends of historical machine performance,

alert notification based on thresholds, etc. These offerings may not give you a distinct advantage because traditional software companies specialize on delivering such capabilities; however, you will certainly be able to develop customer intimacy by offering digital services over physical machines.

- *Become an enhancer*: Here, the goal is to provide enriched end-user engagement and offer new services using the data from the customers themselves and third-party sources. This is where digital twins, monetizing data, and new revenue models come into play. The value-added offerings need to be machine specific and industry specific to raise the entry barrier for others to replicate.

What Is Your Intelligence of Things Strategy?

The use cases involving AI and IoT convergence are evolving so rapidly that in a short span of time, almost all "dumb" devices will have to become intelligent.

Here are a few considerations to keep in mind for your intelligence of things architecture:

- There will be an ensemble of many IOT devices and they need to communicate and work together throughout the organization. Depending on the product and services, this ensemble may be with a person (with wearables or personal devices), a house, a vehicle, a project, or a factory.
- The number of devices and the number of manufacturers will proliferate. Consequently, there will be no standard way to achieve machine-to-machine communication. Hence, choosing the right cloud partner will be crucial so that the devices can work together in a roundabout way of machine-to-cloud-to-machine. There will be a need to establish "APIfication" of devices as well.
- An integrated view of data across IoT and other enterprise data sources, as well as external data such as weather patterns, is required to achieve the full potential of prediction and autonomous decision.

Similarly, here are a few considerations to keep in mind for identifying the opportunities for innovation with IoT, the cloud, and AI:

- *Customer experience*: Identify possible innovation on the customer experience side by reimagining how a customer uses a product or service and how the ultimate value to the customer is created, distributed, consumed, and serviced. Is there an opportunity for a better customer journey by collecting new data, adding to the mix of existing processes data and creating new processes and partnerships?
- *Product and services*: Identify possible opportunities for a product to provide more value for users by leveraging a combination of IoT, the cloud, and AI (with the mix of infrastructure, processes, policies and people). Imagine new features to the product or enhance current features to perform better. This is more about the function and form factor, and not about the enabling technology.

  On the services side, identify the opportunities on the service and the ultimate consumption by customers, i.e., how, what, and when a service is offered and consumed. Imagine if a product were to be transformed into a service.
- *Enabling technology*: Innovation on the enabling technology is not necessarily specific to a product or service, but it's more about the adoption of technology to deliver on the reimagined customer experience, product, or service and business model. This is where the mix of IoT, AI, and the cloud and its adoption for your specific business needs to be carefully evaluated.
- *Business model*: Identify the opportunity to enhance the current business model to create and deliver value to existing customers (or entirely new customer base), by putting it all together. Imagine a new customer experience with new or enhanced products and services created by adopting and enabling a technology mix of IoT, the cloud, and AI.

Figure 7-4 shows AI and IoT convergence use cases across industries.

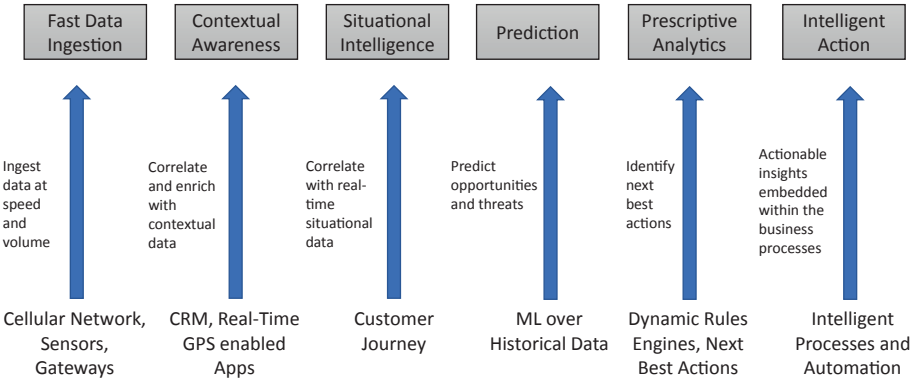

Figure 7-4. IoT analytics value chain

Here are a few more industry-specific examples.

- *Aircraft*: For airlines, zero downtime means higher revenues. Today, aircraft engine manufacturers are fitting millions of sensors, and the main goal is to not only understand how the aircraft is performing during each flight but also to become predictive about engine wear and tear. The result? Higher safety and fewer downtimes.
- *Oil rigs*: The machines deployed for drilling are capital intensive, thus the oil companies must keep improving on their operating costs. When these machines break down, companies incur huge losses, but it's not economically viable to keep expensive machines on standby. The solution? Make the machines smart so that their utilization, performance, and conditions can be continuously monitored and analyzed. Predictive maintenance and conditions based monitoring significantly reduces operating costs.
- *Manufacturing*: Manufacturers are investing to make their factories and plants smart so that their machinery and assembly lines can lead to the creation of autonomous factories in the future.

While at one end, the convergence of IoT, AI, and the cloud enables businesses with stronger value propositions, both in the B2B and B2B2C space, there are several challenges that businesses need to be aware of, especially in the context of managing the volume, velocity, and variety of data. Every disruption establishes newer opportunities and markets that did not previously exist; however, instead of taking the plunge, you need to assess what is relevant to your industry and define your own intelligent of things strategy.

Best Practices to Develop Your Intelligence of Things Strategy

Develop and Articulate Your Own Value Proposition

IoT and AI, combined, present a broad range of transformative opportunities. However, you need to carefully evaluate use cases before succumbing to the lure of putting sensors in everything and expecting magic to happen. IoT as a technology is still maturing; there are issues in connectivity all the time, and sensors may get damaged or malfunction due to harsh weather conditions. They may also just stop responding due to power fluctuations, hence success of your IoT initiatives depends on how well you have evaluated the whitespaces, complementary technologies available in the market, and the problems you are going after.

You need to develop a good understanding of the megatrends and competitive forces at play in your industry. What are the analysts saying about the application of IoT in your industry? At which point in the value chain are the customers getting frustrated? What additional data or which events, if made responsive, will significantly improve customer experience? Taking these data points, you need to develop your own SWOT analysis and business cases for your IoT initiatives.

Evaluate Customer Needs

For any business, it is crucial to get as many details about customer needs (explicit or implicit) as you can. In case of IoT, being an unchartered territory and novel, you need to go beyond the typical customer survey type of approaches and adopt a wide range of techniques, such as customer personas and customer journeys, to develop a roadmap of offerings and services that will be well accepted in the market.

Conduct Value-Chain Analysis and Profitability Analysis

The next step is to create a value-chain analysis and profitability analysis of your industry. Instead of taking a narrow constraints based view of your business, you should take a broad view of the industry. In some cases, this may result in diversifying to create a completely new line of business, but that is the key to come up with a competitive edge and differentiations.

Collaborate to Partner

It would be foolish to think and act as if you will have the wherewithal to do everything on your own. The technology is evolving at a rapid pace, customer needs are changing every day, and the market trends have significant implications. It is important to understand the solutions providers in your market and monitor their progress and challenges. This map will provide you with enough clarity to collaborate and partner in scenarios where you can gain speed to market with less cost.

Evaluate the Technology and Do a Fit-Gap Analysis

There are many vendors and solutions in the market. Some are very narrow but do the job very well, some are broad and offer greater flexibility to try new things. It is important to understand all these offerings and develop a fit-gap analysis specific to your goals and objectives. If your organization is new to the field of connected devices, your success largely depends on how quickly you can launch pilots and establish ROIs for business functions.

IoT, AI, and the cloud are fast-evolving technologies, hence your technology architecture needs to be flexible and componentized. In the overall architecture, the components may seem to be low in maturity today, but tomorrow they will attain sufficient maturity or some components may completely become outdated. Hence, it is important to keep an eye on the technology trends, including how fast they are evolving, what other complementary technologies are coming into play, and how cost-effective they are.

We have listed a few important areas you need to focus to develop a robust technology roadmap covering data, analytics, recommendations, performance, and overall cost-effectiveness.

For example, under "Insights," it's important to answer questions like the following:

- What data would give you clear views about your product usage and performance tracking?
- What data would be valuable for your business functions?
- What data would enrich the customer experience?
- What additional data do you need to collect to deliver these insights?

Analytics questions may include the following:

- What insights, if embedded into your products/offerings/processes, will make your company more responsive to customers or market scenarios?
- How complex will the "math" be? Do you have to buy specialized packages like optimization libraries or deep learning libraries?
- How would you manage and administer these insights?

Performance questions might include these:

- What is the data processing performance criteria?
- What are the consequences of not doing data processing at the edge (versus moving everything to the cloud)? If the cloud is the answer, would you lose a few key actions?
- How real time would you like your offering to be?

Operating requirements questions might include these:

- What operating conditions (temperature, moisture, pressure, access, and vibration) will you focus on?
- What are the different scenarios you will enable your security and access control for? The rest you will leave to customer-specific asks.

As you build your technology roadmap, you need to put on a pragmatic lens. Simply creating an intelligent solution will not bring you success, especially if the cost of building such a solution outweighs the commercial and implementational easiness aspects.

Build Your Intelligence of Things Roadmap

Once you've done all of the mentioned activities, you will have all the desired components to develop your intelligence of things roadmap (see Figure 7-5). The roadmap will help you plan and communicate to the stakeholders within your company, your partners, and employees the timelines, initiatives, pilots, changes, and expected outcomes.

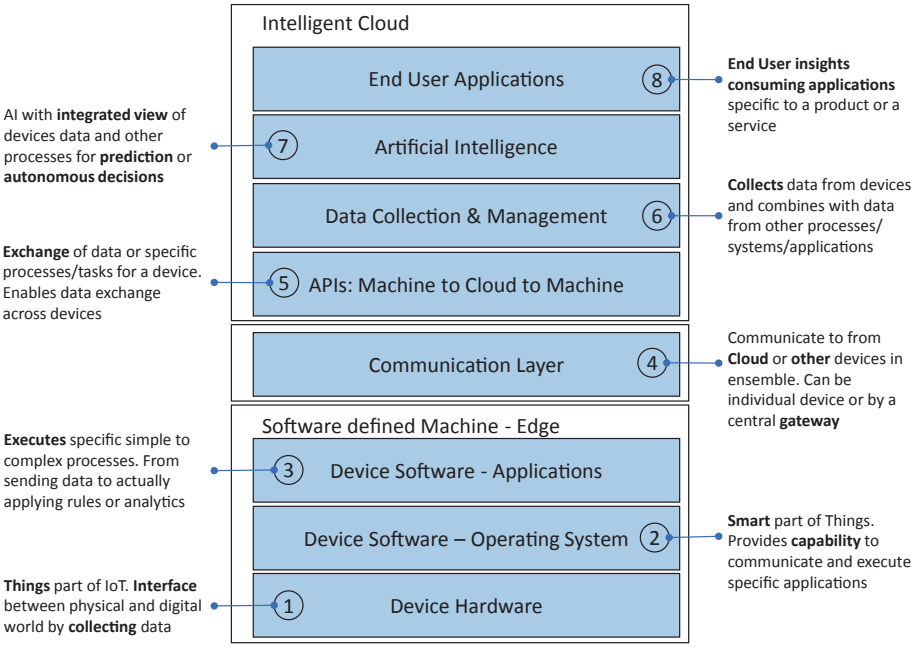

Figure 7-5. Multi-layered intelligence of things architecture

One of the best ways to develop your roadmap is to embrace Amazon's flywheel strategy. Start with a big vision, not necessarily a big capital intensive and complex bet. You need to start small, focusing on pilots that are easy to experiment to test your thinking. This can further evolve to create a minimally viable product to launch early in the market and gain the early movers advantage or you can identify customers who are willing to co-innovate with you in a profit-sharing model.

There are three methods that can help you articulate your roadmap to your business stakeholders, employees, and customers:

- *The future press release*: Start with the end in mind and develop a press release for your product or service offering. Since this is going to be a market facing announcement, you will be forced to articulate the uniqueness of your offering, which will in turn help you to solidify your vision.
- *An FAQ for your plan*: Come up with the potential questions you may face from the market, investors, employees, business stakeholders, and partners. The frequently asked questions (FAQ) and corresponding answers will help you socialize your offering in a much more acceptable way than a black box that people need to figure out by themselves.

- *A user manual*: Successful companies believe in a crowdsourcing model, wherein the users can create more and more utilities using your offering. This helps in significantly gaining market share in less time. Develop a user manual, DIY videos, APIs, and tutorials for end users to build smart apps.

Conclusion

What does the advancement of new technologies like AI, IoT, and the cloud mean for the vast number of people employed in industrial manufacturing setups?

AI, IoT, the cloud, and the other emerging fourth industrial revolution technologies are here to stay. They are changing forever the way things are designed, manufactured, and delivered. These technologies are making everything smart in the entire manufacturing lifecycle (buy, make, sell, and service) with additional complexities of managing smart devices, smart agents, and in some cases completely autonomous processes.

The key question is, will the role of managers, technicians, machine operators, and factory floor workers change dramatically? If yes, companies need to find ways to monitor and track activities in which more and more human-machine collaborations will become the norm to executing projects.

In this chapter, we discussed the art of possible by combining the capabilities of IoT and AI to improve our way of life as well as transform industrial sectors. In the next chapter, we discuss how AI can improve and transform IT operations.

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