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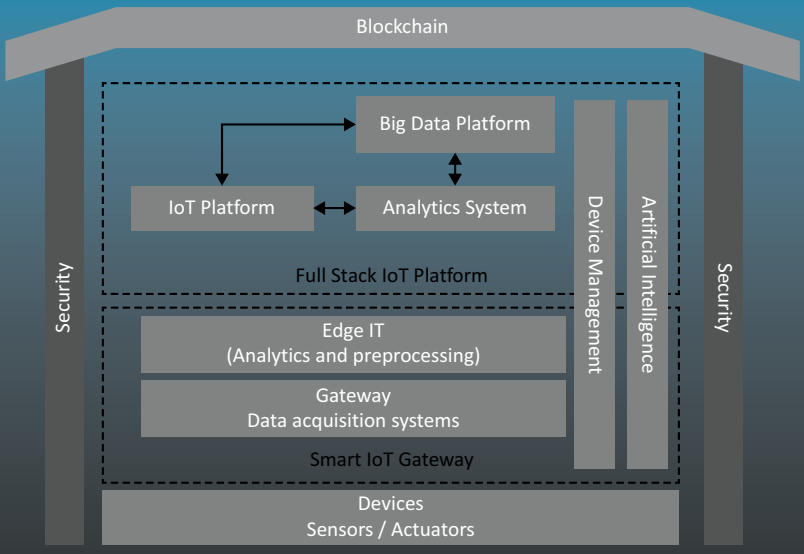

IoT Standards with Blockchain

Enterprise Methodology for Internet of Things

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Venkatesh Upadrista

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About the Author

Venkatesh Upadrista specializes in driving growth for digital and analytics business and is currently working as a delivery leader for UKI portfolio for a large IT services company. He has been a guest lecturer at Rutgers Business School (USA) and board member to several start-ups in the past. He is currently on the board of Futurelight Technologies acting as their Digital Advisor. Futurelight Technologies is a digital services and products company which operates with design thinking to deliver a portfolio of next-generation products and services with a blend of deep domain expertise in Internet of Things and Artificial Intelligence. Apart from his professional achievements, Mr. Upadrista has so far authored six books on topics ranging from business lead digital transformation, Agile, cloud, Internet of Things, and vendor management. He is recognized as an exceptional digital talent leader by UK Tech Nation and speaks at industry conferences on digital transformation topics covering Agile, cloud, data analytics, and Internet of Things.

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Massimo Nardone has more than 22 years of experience in security, web/mobile development, cloud, and IT architecture. His true IT passions are security and Android.

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He holds a master of science degree in computing science from the University of Salerno, Italy.

He has worked as a project manager, software engineer, research engineer, chief security architect, information security manager, PCI/SCADA auditor, and senior lead IT security/cloud/SCADA architect for many years.

Introduction

Digital transformation is the transformation of business and organizational activities, processes, competencies, and models to fully leverage the opportunities of a mix of digital technologies and their accelerating impact across industries in a strategic and prioritized way, with present and future shifts in mind.

Digital transformation is not about technology, but it is a way for enterprises to do business and operations differently to remain competitive and be disruptive in their marketspace. To achieve this change, technology is utilized. Being digital requires enterprises to be open to reexamining their entire way of doing business and understanding where the new frontiers of value are and how technology can play a key role in bringing this value faster. In practice, end-to-end customer experience optimization, operational flexibility, and innovation are key drivers and goals of digital transformation, along with the development of new revenue sources and information-powered ecosystems of value, leading to business transformation and new forms of digital processes.

The Internet of Things (IoT) is one of the most widely spoken digital technologies that promises a lot of benefits to enterprises. IoT is all about connecting devices and factory equipment over the Internet. In other words, it is the convergence between Operational Technology (OT) and Information Technology (IT).

OT is about (heavy) machineries, safety of people, and so on. There is almost zero tolerance toward downtime, errors, and safety. This is one of the core reasons why OT has always operated in a highly risk-averse manner. Another aspect of OT is that the machineries deployed at the factories cannot be upgraded or replaced at the same pace as IT systems,

and these are the ones that will remain for years once purchased. This becomes a hurdle to deploy new innovative ideas on these machineries to make them more efficient. From a people perspective, these two departments (IT and OT) have traditionally and culturally not spent a lot of time together. A typical IT department is measured on system uptime, availability of applications and IT infrastructure, number of security breaches, and reducing costs of IT. On the other hand, the OT department constitutes of the factory managers, production managers, and even agriculture farmers. These are the folks who produce food, control the oil and gas process, or pump oil from the ground. An OT department is measured on entirely different success criteria, such as what is the yield of the crop, how much water is being used to create that yield, what is the production uptime of the factory, and so on.

IT and OT departments are two different worlds, and each department is measured very different on success. With IoT, both these departments need to come together, and this is where connecting people becomes equally important along with connecting things. Successful IoT use cases have provided several benefits to enterprises such as opening up new business opportunities and increased revenue along with powering enterprises with an ability to perform better operations and become more productive, more protected, and more profitable. A classic example is the smart fridge. Using IoT, a fridge could tell us it was out of milk, text us if its internal camera saw there was no milk left, or that the carton was past its expiry date. The benefits of IoT to enterprises are enormous if applied carefully, and this is one of the reasons why IoT has become so popular. However, IoT is in a very early stage of maturity, and several guidelines and ways of working are still being defined to bring standardization in IoT projects.

Though IoT is a relatively new area for many enterprises, this cannot stop us on our journey toward excellence with IoT. The good news is that there are several guidelines, mature practices, tools, and technologies that have already been developed, and by carefully choosing the right

ones, enterprises can achieve success with IoT. This book is one such step toward standardizing an end-to-end IoT implementation approach and is based on several best practices and successes in IoT that have been achieved in the past across multiple industries.

This book defines an enterprise digital transformation framework for IoT, called IoT Standards, that will enable enterprises to do business better and achieve operational benefits using IoT.

This book is intended for all chief executives, technology leaders, and business leaders who intend to successfully embark on an IoT-led digital transformation journey with business as the core driver for the transformation for their enterprise.

This book is an outcome of multiple successful engagements in IoT which I have led during the last several years. Finally, this book is also an outcome of my learnings and those of my colleagues on failed IoT projects – a combination which had helped me to define a solid methodology to execute large-scale enterprise-level IoT use case implementation.

Before officially releasing this methodology into the market, IoT Standards were implemented at several organizations. The methodology has demonstrated superior benefits when compared to any other guidance available in the industry today. There are several case studies described in the book, all of which are from experiences with real companies, but their names have been changed to disguise their identity.

PART I

IoT Business Strategy

This part provides a perspective on the importance of digital transformation using IoT for enterprises, along with the successes and failures many enterprises have achieved from digital transformation in the last few years.

We will also discuss about the business strategies for enterprises to adopt and remain relevant in the marketspace based on which the digital transformation road map using IoT can be defined.

CHAPTER 1

Getting Started

Technology has been in existence for many years, and over the course of time, new age technologies have completely revolutionized the IT industry.

The modern age is referred to as the "digital age" since more and more technologies are stacking onto each other and developing into something greater. Consumers and businesses alike are expecting to see more opportunities for growth as future technology develops further.

For some enterprises, being digital is solely concerned with technology. For others, being digital is a new way of engaging with customers, whereas for a small minority it represents an entirely new way of doing business. Although all these definitions of digital are correct in their own sense, often such diverse perspectives trip up leadership teams since they reflect a lack of alignment and common vision regarding the direction their business needs to go. This often results in piecemeal initiatives or misguided efforts that lead to missed opportunities, lackluster performance, or even false starts.

Enterprises and business executives need to have a clear and common understanding of exactly what digital means to them and what they want to achieve. As a result of this, they need to understand what it means to their business based upon which digital strategies or digital transformation initiatives should be defined to drive business performance. Digital transformation is all about doing business better or bringing efficiencies in their operating model using modern technologies.

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Although digital is becoming mainstream for many enterprises, it is essential to understand that for many enterprises legacy is going to remain and cannot be completely eliminated. Digital is all about using modern technologies (also called as digital technologies) and integrating it with legacy to make modern and legacy work together coherently to deliver business results. As an example, legacy machinery are there to live in the factories for the next several decades, and using digital technology, enterprises should be able to bring value by applying modern technologies alongside these legacy machinery with minimal changes.

Being digital requires enterprises to be open to reexamining their entire way of doing business and understanding where the new frontiers of value are and how technology can play a key role in showcasing this value faster.

Digital for enterprises is all about rethinking how to use new capabilities, tools, and technologies to improve how customers are served while at the same time reducing IT costs and overall working more efficiently.

To understand how to better serve the customers as an example, one needs to understand each step of a customer's purchasing journey – regardless of channel – and think about how digital capabilities can design and deliver the best possible experience, across all parts of the business. For example, the supply chain is critical to developing the flexibility, efficiency, and speed to deliver the right product in a way the customer wants. By the same token, data and metrics can focus on delivering insights about customers that in turn drive marketing and sales decisions.

To improve efficiency, enterprises can use digital technologies to understand their current operations and bring in automation. As an example, real-time monitoring of energy using the Internet of Things allows manufacturers to detect off-hours consumption, optimize manufacturing production schedules, identify anomalies, and capitalize on opportunities for savings. In another example, by benchmarking similar

pieces of equipment or comparable locations, manufacturers uncover systems that are not functioning properly to detect hidden operational inefficiencies and energy waste.

On reducing the cost of IT, enterprises need to understand how the existing IT landscape stacks up on value vs. cost and what drivers in the market exist that can reduce their CAPEX and OPEX costs, with cloud, for example, being the biggest opportunity to do just this. Aside from cost reduction, automation plays a pivotal role in ensuring that operational efficiencies are improving over a period of time. As more and more automation is enabled (be it in customer journeys, business process flow automation, operations, or development), enterprises will see increased efficiency in their business and reduction of the total cost of ownership. There will be lesser defects due to human errors, and enterprises will move away from active monitoring to active auditing. Ultimately, this means there will be less efforts spent in day-to-day monitoring of services by humans, and to ensure things are going right, more time will be spent in auditing.

Definitions

Active monitoring *means that there is a full-time team who continuously monitors for errors. In contrast to active monitoring,* ***active auditing*** *means that checks are performed at certain predefined intervals for errors. Active auditing does not need a dedicated team since most of the checks are automated and performed by machines. If an error is identified, resolution is automated so that the same error does not occur in future.*

Development *is the process of creating a new software or product or an infrastructure. This goes through a process of planning, creating, testing, and deploying an information system.*

Maintenance *or* ***Operations*** *is the process of maintaining the developed software or product or infrastructure. Operations is not just about fixing defects but modifying a software product or an infrastructure after delivery to correct faults, as well as to improve performance. Small enhancements are also performed as part of operations.*

Digital is not about delivering a one-off customer journey or a one-off improvement in total cost of ownership. It is about continuous improvements where processes and capabilities are constantly evolving based on inputs from the industry or the customer. This fosters ongoing product or service loyalty, and to enable this, enterprises need to create the right digital foundation that will allow the organization to achieve their business goals.

Digital foundation is all about utilizing technology and organizational processes that allow an enterprise to do their business with full agility.

Designing Business for Future

There are four pillars that are critical to guide organizations' thinking when they are assessing strategies for business transformation. These can be found in the following:

- The right business model – Becoming digital is not simply about taking existing products or customer interactions and experiences and putting them online. Enduring success in the digital economy means fundamentally rethinking how business is conducted today. The way in which organizations get products to market through centralized catalogues and move to deliver entirely new consumption models (such as

pervasive digital services and subscriptions rather than one-off purchases) in addition to how consumers now purchase and use offerings is fundamental.

- The right partners – Businesses that work together with digital partners across industry borders achieve far beyond what any individual business could do on its own in the ever-changing digital world. To achieve this, businesses must now integrate with a myriad of existing and third-party systems, streamline and simplify business processes, and develop efficient improvements that decrease operational risks and expenses. The sharing of knowledge and unique experiences to develop new applications, products, and services will become essential.
- The right technology – Not all platforms are created equal, and that will become painfully evident to those that do not choose wisely and bravely. The cost of legacy system infrastructure maintenance, integration, and operations will become prohibitive when digital competitors operate at a fraction of the cost. Not all legacy can be replaced however, and there is a right balance to be made between legacy and digital for every enterprise.
- The right mindset – Providing evolved customer experiences regardless of who those customers are, from consumers to vendors to partners, is vital to digital success, but it is only half the equation. To survive and (most importantly) flourish, a digital culture must be integrated at all levels of the organization to instill the mentality of agility and continuous learning the digital economy demands. This requires a change to the enterprise workforce and operating model.

There is no one-size-fits-all approach to digital transformation; each strategy will be unique to each organization. However, a focus on balancing activities across these four pillars provides the compass to guide a successful transformation.

The Internet of Things As a Digital Enabler

The Internet of Things (IoT) is one of the most widely spoken digital technologies that promises a lot of value to enterprises. IoT is all about connecting devices over the Internet, allowing them to talk to each other and many different systems, applications, and so on. A classic example is the smart fridge. Using IoT, a fridge could tell us it was out of milk, text us if its internal camera saw there was no milk left, or that the carton was past its expiry date. All this is possible with IoT, and this is one of the reasons why IoT is becoming so popular. When we talk about IoT, it is a combination of both hardware and software talking to one another.

The hardware utilized in IoT systems includes devices for a remote dashboard, devices for control, servers, a routing device, and sensors. These devices manage key tasks and functions such as system activation, action specifications, security, communication, and detection to support specific goals and actions.

The software used in IoT includes systems that collect data from the hardware devices. IoT software addresses key areas of networking and action through platforms, embedded systems, and middleware. These individual applications are responsible for data collection, device integration, real-time analytics, and application and process extension within the IoT network. They exploit integration with critical business systems (e.g., ordering systems) in the execution of related tasks. These terms will be explained further later.

IIoT (Industrial IoT) and IoMT (Internet of Medical Things) are other most widely used phrases in the IoT world. IIoT is the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of Things, and cloud computing. Industry 4.0 creates what has been called a "smart factory." IoMT is all about the Internet of Medical Things. The IoMT is a connected infrastructure of medical devices, software applications, and health systems and services.

Whether we talk about IIoT or IoMT, integrating IT systems with operational technologies always comes first. In short, this is called IT-OT integration.

Gartner, Inc. forecasted that the enterprise and automotive IoT market[1] will grow to 5.8 billion endpoints in 2020, a 21% increase from 2019. By the end of 2019, 4.8 billion endpoints were expected to be in use, up 21.5% from 2018. An endpoint, from an IoT perspective, is a physical computing device that performs a function or task as part of an Internet-connected product or service. An endpoint, for example, could be a wearable fitness device, an industrial control system, an automotive telematics unit, or even a personal drone unit.

Utilities will be the highest user of IoT endpoints, which have totaled 1.17 billion endpoints in 2019 and have increased 17% in 2020 reaching 1.37 billion endpoints. Electricity smart metering, both residential and commercial, will boost the adoption of IoT among utilities is the prediction. Physical security, where building intruder detection and indoor surveillance use cases will drive volume, will be the second largest IoT use case in 2020.[2]

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[1] www.gartner.com/en/newsroom/press-releases/2019-08-29-gartner-says-5-8-billion-enterprise-and-automotive-io#:~:text=Gartner%2C%20Inc.,a%2021%25%20increase%20from%202019.&text=Utilities%20will%20be%20the%20highest,to%20reach%201.37%20billion%20endpoints

[2] www.gartner.com/en/newsroom/press-releases/2019-08-29-gartner-says-5-8-billion-enterprise-and-automotive-io

The four core elements that make up an IoT ecosystem are depicted in Figure 1-1.

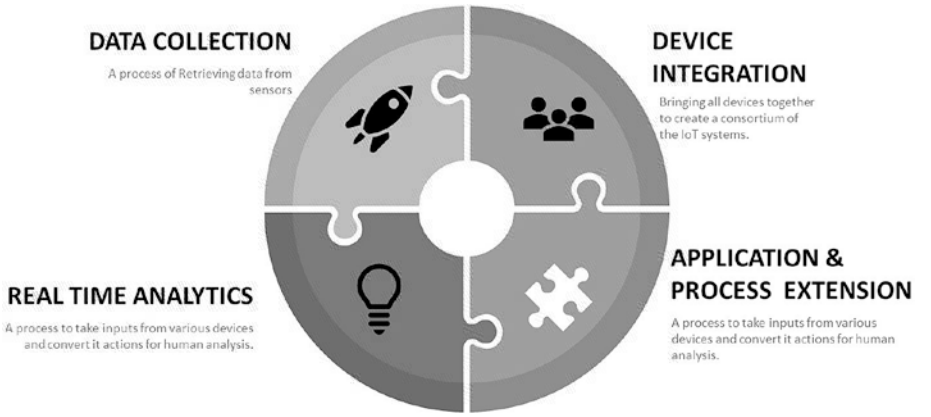

Figure 1-1. *Four core elements in an IoT ecosystem*

Data collection – This is the process of retrieving data from sources such as sensors. It uses certain protocols to aid sensors in connecting with real-time, machine-to-machine networks. It then collects data from multiple devices and distributes it in accordance with settings. It also works in reverse by distributing data over devices, and the system eventually transmits all collected data to a central server.

Device integration – Device integration software brings all the devices together to create a consortium of the IoT systems. It ensures the necessary cooperation and stable networking between devices.

Real-time analytics – These applications take data or input from various devices and convert it into viable actions or clear patterns for human analysis. They analyze information based on various settings and designs, after which certain actions are taken either manually or automatically.

Application and process extension – Applications extend the reach of existing systems and software to allow a wider, more effective system. They integrate predefined devices for specific purposes such as allowing certain mobile devices or engineering instruments access. It supports improved productivity and more accurate data collection.

From the preceding discussion, it is clear that IoT is not just about devices. It is an integration between Information Technology and Operational Technology.

Definition

Shop floor *is the area of a factory, machine shop, etc. where people work on machines, or the space in a retail establishment where goods are sold to consumers.*

Operational Technology (OT) is about managing, monitoring, and controlling industrial operations with a focus on the physical devices and processes used in the shop floor where the production of goods takes place.

IT includes the use of computers, storage, networking devices, other physical devices and infrastructure, as well as processes to create, process, store, secure, and exchange all forms of electronic data.

Operational Technology – A Preview

OT is about (heavy) machineries, safety of people, and so on. There is almost zero tolerance toward downtime, errors, and safety. This is one of the core reasons why OT has always operated in a highly risk-averse manner. Another aspect of OT is that the machineries deployed at the factories cannot be upgraded or replaced at the same pace as IT systems, and these are the ones that will remain for years once purchased. This becomes a hurdle to deploy new innovative ideas on these machineries

to make them more efficient. On the other hand, most of the machineries operate 24/7 and 365 days a year, and stopping these machineries for any desired upgrades or modification is an almost impossible task.

In the consumer-facing OT world in the last few years, there have been tremendous advancements made. As an example, in the older days we were carrying analogue phones, and now almost everybody uses a smartphone. We were also previously driving manual cars although many of us have now made the switch to electric or automatic.

The nonconsumer-facing OT world however has not changed at all – in the mining industry, for example, several decades ago hammers, chisels, pickaxes, and shovels were being used, and still are to this day. Similarly, in the manufacturing industry years back, they were using conveyor belts, painting robots, welding robots, and so on. Fast forward to today, and we have the same equipment. The three key reasons why changes have not occurred is because

- Safety – Safety is to prevent or lessen the risk of workplace injury, illness, and death and therefore is of paramount importance in the OT world. Safety is keeping people away from physical harm, and there is zero tolerance toward safety compromises.
- Reliability – Reliability is defined as the probability that a component (or an entire system) will perform its function for a specified period of time, when operating in its design environment.
- Cost and risk to change or upgrades – The cost of change to machinery is quite high, and with almost zero downtime expected on machineries, upgrades are also hard to manage. Secondly, an error from upgrading can lead to reliability issues. This is one of the reasons why in the OT world there is a tendency to avoid quick patches, software updates, etc., because they may result in safety or reliability concerns.

There are several challenges in making changes to the OT systems, such as manufacturing or mining equipment. However, with more and more benefits that enterprises are gaining because of IoT, they have the desire to change, but an uncompromised requirement is safety and security. A poorly planned change (even as simple as an antivirus update) can introduce enough risk of disruption to an industrial network that OT experts are scared about as people's lives may be at risk because of a badly managed change.

IT/OT convergence or IT-OT integration is the integration of Information Technology (IT) systems with Operational Technology (OT) systems. IT systems are used for data-centric computing; OT systems monitor events, processes, and devices and make adjustments in enterprise and industrial operations.

The main difference between OT and IT devices is that OT devices control the physical world, while IT systems manage data.

The IT team is the Information Technology team and constitutes of roles such as data analysts, data scientists, developers, and testers. An OT team could be factory managers, production managers, and even agriculture farmers. These are the folks who produce food, control the oil and gas process, pump oil from the ground, or who are responsible for maintaining the fleet of company trucks.

In the long term, not making necessary changes, such as upgrading, and not adopting to IoT may lead to an increased risk of a deliberate disruption by a hacker. A well-known example of such a disruption was the Stuxnet attack in Iran. In January 2010, inspectors with the International Atomic Energy Agency visiting the Natanz uranium enrichment plant in Iran noticed that filters used to enrich uranium gas were failing at an unprecedented rate. The cause was a complete mystery, and Iranian technicians replaced the filters. Five months later, a seemingly unrelated event occurred. A computer security

firm in Belarus was called in to troubleshoot a series of computers in Iran that were crashing and rebooting repeatedly. The researchers found a handful of malicious files on one of the systems and discovered the Stuxnet virus. Another more recent event occurred last year in Germany, where hackers used malware to gain access to the control system of a steel mill, which they disrupted to such a degree that it could not be shut down. Thankfully, there was no damage to human life. These two examples highlight that OT systems are not fully secured and need to be upgraded at regular intervals. On the other side, IT-OT integration is mandatory for all enterprises that wish to be relevant in the market.

The IT-OT Integration

Until today, OT has very limited integration with the IT. The reason behind this is that OT is all about machinery, safety of people, and the creation of products. Today, more and more organizations are embracing IoT technologies such as smart meters and self-monitoring transformers. We are also seeing production lines and farm equipment outfitted with sensors.

The rise of these new technologies has created a need for organizations to optimize how machines, applications, and infrastructure collect, transmit, and process data. Done right, IT-OT convergence gives businesses the ability to fix critical issues faster, make informed business decisions, and scale processes across both physical and virtual systems. Figure 1-2 depicts a simple block diagram on how an IoT ecosystem works.