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The Internet of Things and new business opportunities

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Abstract Since the Internet of Things (IoT) is an emerging phenomenon, there is a lack of holistic understanding of what IoT is and what business opportunities it can offer for entrepreneurs and existing companies. This article has three main parts. First, it introduces IoT as a broad, socio-technical phenomenon. As a part of this goal, the article covers various elements within the technological, physical, and socioeconomic environments that comprise IoT. Second, this article proposes two approaches for creating new business models using IoT: a sustaining approach and a disruptive approach. The article concludes with a brief reflection on the extent to which the future of IoT can be predicted. This discussion brings up the limitations of the approach for creating new business models outlined in this article and provides guidelines on how this approach should be used. The ultimate goal of this article is to stimulate thinking, creativity, and entrepreneurship in relation to the IoT.

1. The Internet of things: Opportunities and threats

In March 1875, then-obscure inventor Alexander Graham Bell offered Western Union Telegraph Company President William Orton a patent for Bell's telephone invention at the price of $100,000, roughly $2 million today (Carlson, 1994). William Orton turned down the offer. What happened next is history. At the time of Bell's offer, Western Union was the most dominant telecommunications company in the U.S. Within a few years, smaller companies started to use Bell's telephone invention to cut into Western Union's market share. In an attempt to catch up, Orton attempted to develop Western Union's own version of the telephone. However, this was too little, too late. Western Union was never able to return to the level of prominence it had achieved thanks to its successful business model based on telegraph technology. Today, not too many people remember what Western Union once was. Some think Western Union has always been a service for sending money abroad. The story of Western Union is often used in business texts as an anecdotal proof of how blind business leaders can be in relation to the future potential of a technology (Christensen, Anthony, & Roth, 2004).

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The Internet of Things (IoT)—also called the Internet of Everything or the Industrial Internet—is a new and a potentially disruptive computing paradigm that is likely to change business processes, strategies, and competencies across many industries (Lee & Lee, 2015). IoT has the potential to become a powerful threat even in low-tech industries. For example, who would have thought that wireless sensors for measuring air and soil parameters would be used in farming—a millennia old and previously very low-tech industry? While being a potential threat, IoT can also present entrepreneurs and business leaders of established companies with new opportunities for innovation (Krotov, 2008). Market research companies estimate that the number of devices connected to the IoTwill grow from 16 billion in 2014 to 50 billion in 2020, creating a global market for IoT products and services measured in trillions of dollars (Weinberg, Milne, Andonova, & Hajjat, 2015). Given this potential, the main purpose of this article is to educate readers about IoT as a socio-technical phenomenon and discuss possible approaches for creating new value propositions within the IoT paradigm.

2. The lessons from Western Union's story

So why did William Orton turn down what many people believe was the most valuable patent of the 20th century? Did he lack the technical knowledge or business insight to understand how this technology could impact the telegraph business of Western Union? A technology whiz himself and a successful business visionary, Orton understood what the telephone (or acoustic telegraph, as the technology was known at that time) was and how it could potentially impact the telecommunications industry. In a detailed historical account of the story of William Orton and the telephone provided by business historian W. Bernard Carlson (1994), one can clearly see that the story is more complicated than some business writers paint it.

At the time when Alexander Bell made his pitch to Orton, Western Union was facing enormous competitive and legal pressures. Numerous private companies tried to build their own telegraph networks and lure away Western Union's customers via lower prices. The competition was about to become even more intense due to the growing concern of political leaders that Western Union was a monopoly. To make the telecommunications market more competitive, some politicians were proposing to underwrite the creation of companies that could compete with Western Union. Western Union was even viewed as a threat to national security. At that time, 90% of telegraph messages were transmitted using the company's network (Carlson, 1994). The government was increasingly concerned with Western Union's hypothetical ability to access and even alter the nation's latest information related to business and politics. Bell's father-in-law Gardiner Habbard, a lawyer and a prominent political activist from Massachusetts, was one of the most vocal critics of Western Union.

Faced with immense competitive and legal pressures, Orton worked diligently to entrench the Western Union's position in the telegraph market. The growing competition created a market for new message transmission inventions. Market participants increasingly believed that a new technology could change the landscape of the emerging telecommunications industry, creating opportunities for smaller players. Because of this, telecommunications executives like Orton were bombarded with new ideas and inventions.

Telephone was one of these promising new technologies. Yet, acoustic telegraph was not the main focus of Western Union at that time. Instead, Orton commissioned Thomas Edison to work on the so-called quadruplex technology—a data transmission mode that would allow Western Union to send four messages simultaneously over a single physical line. Although the quadruplex transmission was the main interest of Western Union at that time, William Orton was quite open to other inventions related to message transmission. In fact, by the time Bell pitched his telephone invention to Orton in March 1875, Orton had already commissioned another employee, Elisha Gray, to develop an acoustic telegraph system (a transmission technology similar the one used by Bell's telephone). By no means was William Orton blind to the emerging telephone technology.

Despite this, Orton was not particularly impressed with Bell's invention. Bell's telephone was not reliable enough for transmitting messages over long distances. Moreover, Orton thought that voice transmission would overload Western Union's existing telegraph lines and distract the company from its core business: sending and receiving short messages for business customers. Once Orton learned that that Bell was associated with his nemesis, Gardiner Habbard: "Bell was promptly (but politely) escorted out of Orton's office" (Carlson, 1994, p. 170).

Why do business students smile when they hear the story of Orton's failure to embrace the telephone invention? One reason is that they are often not aware of the full account of the events that led to Orton's decision to reject the telephone. This can also be explained by a bias that many individuals have. Carlson (1994, p. 161) explained this bias in that:

> Both historians and the public often assume that the "end use" of a new technology is embedded in the technology itself. It is assumed that once a device is invented, it is clear how it will be used and by whom . . . Instead . . . the "end use" of technology is created or constructed by a variety of participants in a technological enterprise . . .

These participants or factors may include the features of the technology itself, the actions of the original inventor, the engineers of technicians who actually built a particular artifact, the first customers of this new technology, organizations adopting this new technology, or even numerous non-technical and non-business opinion leaders (Carlson, 1994). For example, the financial support and extensive political connections of Hubbard helped Bell secure contracts with companies that would later compete with Western Union. Moreover, there was a market niche in which the telephone could entrench itself before it threatened the telegraph's market share. Western Union's main business was transmitting telegraph messages over long distances. In its early days, the telephone was not suitable for long-distance transmission due to reliability issues. Yet, there was demand among businesses and wealthy individuals to create telephone networks within small geographical areas. For example, the first private telephone line was ordered by Charles Williams, a telegraph instrument maker, to connect his store in downtown Boston to his home in the suburbs in 1877 (Carlson, 1994). All of this shows that understanding future business potential of a technology requires a broad, socio-technical perspective that connects together all of these dots.

3. The Internet of Things: A socio-technical perspective

To equip the reader with a holistic understanding of what Internet of Things (IoT) is and what trajectories this new trend in computing can take, this article presents IoT as a complex, socio-technical system (Alter, 2013). Consistent with this perspective, IoT is defined here as a network comprised of various nodes belonging to the technological, physical, and broad socioeconomic environments. The physical environment consists of human and nonhuman objects linked together with the help of a ubiquitous wireless network that enables automatic communication and interaction among the objects and the physical environment. The technological environment is comprised of hardware, software, networking technologies, data, integrated platforms, and technical standards that enable interactions of the objects in the physical environment.

The broad socioeconomic environment is comprised of several stakeholders. First, it consists of entrepreneurs and business leaders engaging in entre- and intrapreneurship within the IoT domain. They connect the dots in the IoT landscape, address technical and legal problems in relation to the IoT, and set the overall direction for the development of this new computing paradigm. Second, numerous industry associations, government bodies, and consumer advocacy groups set technical and legal requirements for the IoT in order to ensure smooth interoperability of its components and protect consumers from harm. Finally, customers targeted by entrepreneurs with their IoT inventions are probably the most important element of the socioeconomic environment, since customers ultimately determine the success or failure of any business venture. Each of the elements of the IoT as a socio-technical phenomenon is briefly summarized in Table 1 and then discussed in more detail in this section and visualized in Figure 1.

3.1. Technological environment

3.1.1. Hardware

The hardware components used to connect IoT objects include wireless devices such as portable computers (e.g., laptops or tablet PCs), smartphones, wearable devices (e.g., Apple Watch), Radio Frequency Identification (RFID) tags (small electronic devices that can wirelessly transmit and receive information about an object to which they are attached), RFID readers, wireless sensors, etc. Humans can participate in the IoT network with the help of laptops with wireless connectivity, smartphones, wearable devices, or even injectable RFID transponders. Wearable or injectable RFID transponders can be used to tag not only humans but also animals. RFID tags are quite suitable for tagging physical objects such as cars or consumer goods. These tags can come in a variety of shapes and forms suitable for different types of applications and environmental conditions. RFID tags can be passive (drawing energy from the electromagnetic field generated by an RFID reader) or active (containing an internal energy source that can power tag operations and, thus, enable more advanced features, such as encryption/decryption or GPS functionality) (Krotov & Adams, 2006). An

Table 1. Elements of the IoT landscape

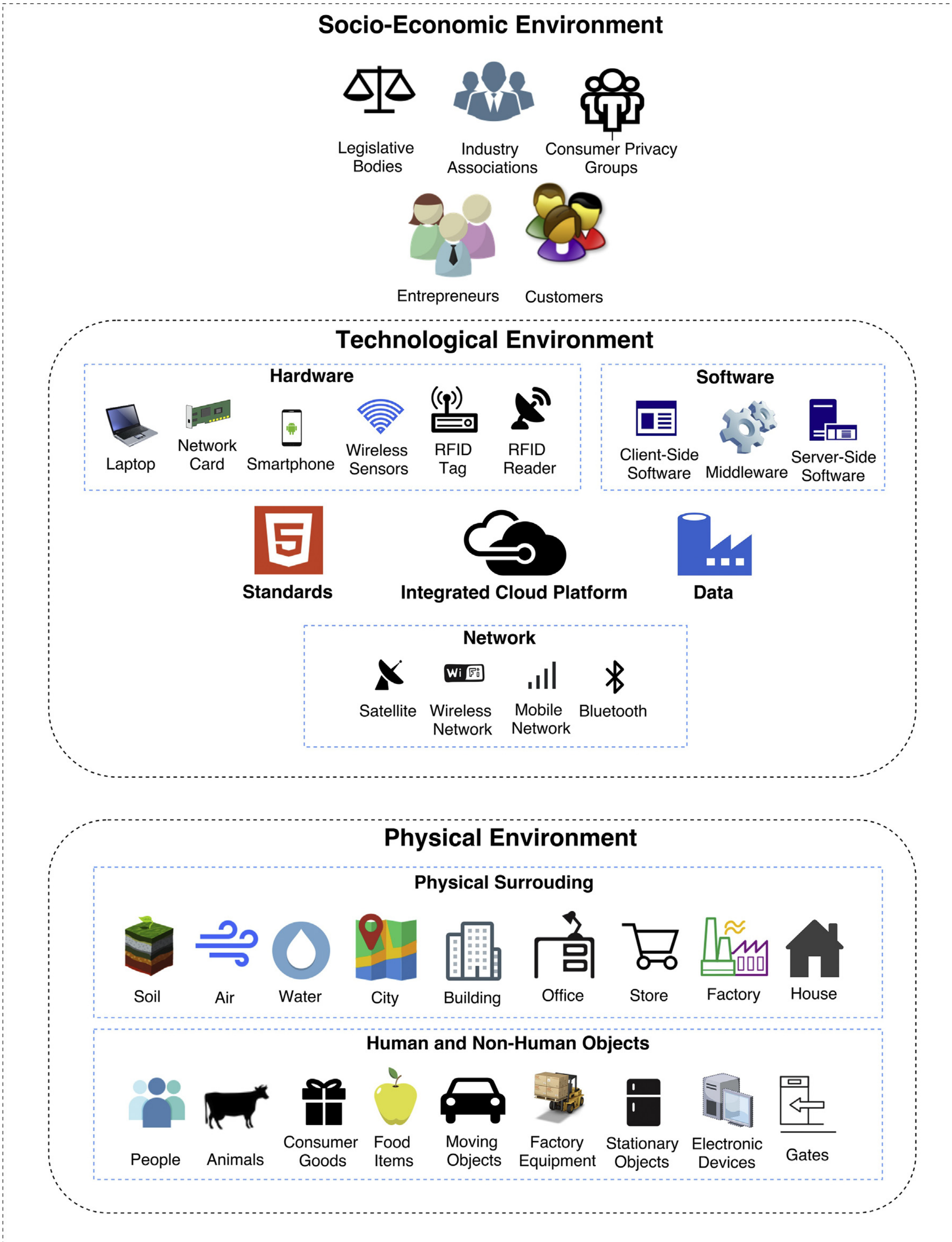
Technological Environment	Hardware	Various wireless devices (e.g., wireless laptop computers, smart phones, RFID tags, wireless censors, RFID readers) used to connect human and non-human objects to the IoT and enable communication and interaction among these objects via a ubiquitous wireless network.
	Software	Front-end software applications developed to create value for a particular group of customers and various utility applications (e.g., middleware or server-side software) supporting execution of end-user IoT apps.
	Networking	Various networking technologies and hardware enabling wireless communication among IoT nodes and connecting these nodes to the internet.
	Integrated platforms	An integrated, cloud-based platform (e.g., Microsoft Azure) that enables integration and seamless interoperability of various hardware, software, and networking elements of the IoT.
	Standards	Various technical and operational standards outlining the design of various IoT elements and ensuring their interoperability. Standards are developed by industry associations.
	Data	Massive volume of data generated by IoT nodes constantly broadcasting their properties via the network (e.g., a temperature sensor broadcasting room temperature every 2 minutes) or by engaging in transaction with other IoT nodes.
Physical Environment	Human objects	People directly interacting with the IoT with the help of various wireless devices (e.g., laptop computers, smartphones, RFID tags, health sensors).
	Non-human objects	Physical objects (e.g., cars, fruits, packages) and animals that can connect and communicate via a network.
	Physical surrounding	The physical space (e.g., room, building, park, city) or a physical substance (e.g., air, water, soil) that human and non-human objects are embedded in or interact with.
Socio-Economic Environment	Consumers	Individual consumers or organizations targeted by specific IoT applications.
	Legislative bodies	Organizations responsible for formulating, disseminating, and enforcing various laws and regulations related to IoT.
	Industry associations	Various organizations comprising for-profit companies and non-profit institutions responsible for setting standards and guidelines that facilitate IoT adoption and ensure interoperability of IoT technological elements and security of the overall IoT infrastructure.
	Consumer privacy groups	Formal and information organizations advocating for consumer rights and protecting consumers of IoT applications and related technology from security and privacy violations.
	Entrepreneurs	Entrepreneurs and leaders of existing businesses or non-profit organizations engaging in entrepreneurship and intrapreneurship using IoT.

RFID tag can contain a unique identifier for an object (e.g., Electronic Product Code or EPC) that can be used to retrieve information about this object from a centralized database. Some types of active tags can store and transmit substantial chunks of data locally, using their own internal storage memory. Some bulky, stationary physical objects can contain embedded communication hardware that would allow them to connect to the internet. For example, a refrigerator can be equipped with a wireless networking card that would allow the object to communicate over the internet with other IoT nodes.

3.1.2. Software

IoT software can be one of two main types: application software and middleware. Application software includes client-side applications (or apps) as

Figure 1. IoT as a socio-technical phenomenon



well as server-side software supporting the use of these apps by consumers. For example, Uber's app allows smartphone users to access the service by submitting trip requests (consisting, among other things, of their geographical location and the place where they are going) to Uber drivers, which drivers can then respond to. Thus, this application connects together passengers, drivers, and the physical environment in which both passengers and drivers move around. The Uber app also has an extensive server-side component that facilitates these trip requests and processes payments made by passengers to drivers.

Some IoT applications may also rely on middleware—software that facilitates communication between various software components used together to support a particular IoT application. These software components are usually from different vendors and, thus, do not rely on the same technologies and communication protocols. For example, CATAMARAN® middleware, from software company Shipcom Wireless, allows clients to integrate together various devices used in logistics (e.g., RFID or barcode readers) with a company's existing databases or ERP systems. Thus, this middleware can support various IoT applications in the supply chain context (e.g., an automated baggage tracking and locator system at an airport).

3.1.3. Networking

Various types of networks are used to support interactions of human and nonhuman objects. Bulky stationary objects (e.g., a refrigerator or an industry-grade stationary RFID reader) can be hardwired to the internet via networking cards connected to a local area network using physical ethernet cables. But since many IoT applications require unrestricted movement of objects within a physical space, wireless networks are more common in IoT applications. A wireless network can be a Bluetooth Personal Area Network (PAN) that allows electronic devices located in close proximity to each other to connect and share data. Alternatively, objects can be connected to the internet using a wifi network covering a specific physical area (e.g., a college campus or a corporate office). IoT applications connecting objects moving over vast geographical areas (e.g., the Uber app) may require connectivity to a mobile network or even a satellite link if used in remote areas.

3.1.4. Integrated platforms

Today, there is an increasing vision that IoT applications should be built on the top of an integrated cloud (meaning internet-based) platform (Gubbi, Buyya, Marusic, & Palaniswami, 2013). A cloud platform can potentially provide a seamless integration of hardware devices, data storage, and data analytics in relation to various IoT applications. Consistent with the cloud computing paradigm, these integrated IoT platforms can allow for such capabilities as virtualization (also called platform as a service or PaaS) of computing resources and delivering end-user IoT applications in software as a service (SaaS) manner. For example, the Microsoft Azure offering is comprised of a global network of data centers. This platform can be accessed over the internet for building, deploying, and managing various IoT applications.

3.1.5. Data

IoT is increasingly becoming a source of a vast volume of data characterized by velocity (data is continuously created in real time and is characterized by exponential growth) and variety (data is of a different nature and is available in different format). Data characterized by these three V's (volume, variety, and velocity) is increasingly referred to as big data. For example, IoT objects can continuously broadcast such properties as location (in the case of moving objects), temperature or other environmental characteristics (when physical environment is connected to the internet via a Wireless Sensor Network [WSN]), or resource consumption (in the case of water or gas meters). Alternatively, IoT objects can generate data via transactions that they enter when they come in proximity of each other. For example, a car passing a toll payment gate on a freeway will generate a transaction containing data about the vehicle, vehicle's owner, vehicle speed as well as the time when the car passed this tollgate. All these interactions by billions of objects worldwide can result in truly big data.

Big data can be mined for discovering new knowledge about customers, existing business processes, and various macroeconomic or social trends. Some experts posit that these vast data repositories will become the most strategic asset of the 21st century (Davenport & Harris, 2007), similar to fossil fuels in the 20th century. Alternatively, these digital streams of data generated by IoT objects can be captured and analyzed in real time, improving organizational decision-making speed and responsiveness to events inside and outside of the organization (Pigni, Piccoli, & Watson, 2016).

3.1.6. Standards

Technology standards are an important determinant of technology development and adoption. Until a dominant standard is established, the technology can still be viewed as being in an emerging stage and, thus, likely to take various alternative vectors in its development and diffusion. Creating a de facto standard with proprietary technology is a lucrative proposition for technology companies. For example, Microsoft Windows OS's rise to become the de facto standard for desktop operating systems enabled Microsoft to secure a dominant position not only in the operating systems market, but also in various office and personal productivity applications. All this translated into above-average profitability for Microsoft for many years.

Sometimes technology standards are established in a collaborative fashion when industry associations comprised of private companies and academic institutions are formed to establish technology standards within a particular industry. This is often done to facilitate development and adoption of the technology within the industry by removing some of the associated risks of investing in one version of the technology. In the presence of a dominant industry standard, clients do not have to place bets on which particular technology vendor will emerge as a winner—or even simply on which ones will be around in the next few years to provide technology support. Similarly, technology vendors can invest funds in developing hardware and software with some assurance that the standards that these technology products are based upon will not become obsolete by the time the development is completed.

One notable attempt to establish an IoT industry standard is the development of the GS1 EPC Global Architecture Framework (GS1, 2015). The standards outlined in this framework relate mostly to the supply chain management (SCM) context. At the heart of this framework is the so-called Electronic Product Code (EPC)—a unique identifier for physical goods moving through a supply chain that can be written to an RFID tag. The standard also provides detailed specifications for the RFID hardware (e.g., tags and RFID readers), middleware (software connecting RFID networks with organizational information systems), as well as numerous protocols for information retrieval and exchange (called EPC Network Services). The standard envisions that EPC Network Services will be used by companies collaborating with each other by sharing information about products moving through a supply chain via EPC Global Network. The standards comprising the GS1 EPC Global Architecture Framework are meant to guide hardware and software developers on the creation of new technology products and services that would support supply chains utilizing RFID and other forms of automatic product identification technologies.

With RFID still as an emerging technology, it is hard to say whether GS1 Architecture has or will become a dominant IoT standard. A number of other organizations have published standards in relation to various fundamental IoT technologies. These organizations include the International Telecommunication Union (ITU) agency of the United Nations (UN), International Electro-technical Commission (IEC), International Organization for Standardization (ISO), and the Institute of Electrical and Electronic Engineers (IEEE) (Li, Xu, & Zhao, 2015). Yet, standards in general—once they are widely accepted—become an important force in shaping development and adoption of IoT applications and related technologies. Thus, entrepreneurs need to pay attention to existing and emerging standards when developing new IoT applications and services.

3.2. Physical environment

3.2.1. Human and non-human objects

At the heart of the IoT are human and non-human objects linked together with the help of wireless devices and networks that enable automatic communication and interaction of these objects with each other and the physical surrounding in which they are embedded. Human objects are people from different walks of life directly interacting with the IoT with the help of various wireless devices (e.g., laptop computers, smartphones, RFID tags, health sensors). Physical objects (e.g., cars, fruits, boxes) and animals can also be connected to the network via RFID tags and other wireless devices. Both human and non-human objects can send their data via the network to centralized data stores or share their data with each other or their physical environment directly.

3.2.2. Physical surrounding

Human and non-human objects are embedded within a particular physical surrounding. A physical surrounding can be a physical space: a room, a house, an office building, a park, a city, etc. Physical surrounding can also be a substance such as air, water, soil, or sand. In any case, this physical environment can be viewed as another object connected to the IoT. For example, a substance can have wireless sensors embedded into it. These sensors can measure certain properties of this substance (e.g., water temperature or soil acidity) and then transmit this information via the network to other objects. Alternatively, a physical space can have certain elements (e.g., doors, signs, or buildings) tagged with wireless devices so that the interaction with other objects can occur via those specific elements of the physical environment.

For example, an office building can have doors equipped with RFID readers. The doors will sense other objects (e.g., humans equipped with badge transmitting an encrypted signal) and automatically open when the object is in the vicinity.

3.3. Socioeconomic environment

3.3.1. Customers

Any business model should create a solid value proposition to a specific group of customers. Similarly, any solid technology that is here to stay should address an important problem of a specific group of customers. Although some entrepreneurs may argue that customers often do not know what they need until one shows it to them, most business models start with an end-consumer in mind. Regardless of which philosophy in relation to new product creation an entrepreneur is subscribing to, it is customers who pay money for a new product and service and, thus, determine success or failure of a new venture. Thus, customers are an important (if not central) element of any business model, including business models relying on the IoT.

3.3.2. Legislative bodies

IoT applications often enter realms governed by specific regulatory bodies and legislature. For example, RFID hardware needs to be compliant with Federal Communications Commission (FCC) regulations for near-field communication. Any IoT applications in healthcare involving gathering patient health data need to be compliant with the Health Insurance Portability and Accountability Act (HIPAA) passed in 1996. Failure to comply with existing legislation can seriously undermine trust from potential consumers of IoT technologies or lead to a situation where IoT products and services are simply banned. For example, Uber is infamous for allegedly violating licensing and trade regulations in several countries where the service was introduced. This led to strong protests from taxi drivers and even legal action from the governments banning or restricting Uber use in these countries. Thus, existing and future regulatory frameworks need to be taken into account when introducing new business models related to the IoT.

3.3.3. Industry associations

Various industry associations can potentially shape the way IoT technologies and applications are developed and used. For example, GSI is one well-known industry group comprised mostly of retailers (e.g., Johnson & Johnson, Procter & Gamble, TESCO, CVS) and with participation from university researchers. One of the main goals of this group is to outline various standards for software, hardware, and communication protocols in relation to RFID and other auto-identification technologies (e.g., barcodes). As it was discussed previously, one of the most important contributions of this industry group is the creation of the EPC Global Architecture Framework—a potential de facto standard for RFID-based IoT applications in the supply chain management context.

3.3.4. Consumer privacy groups

Growth of the IoT is likely to create unique and severe challenges in relation to privacy and security (Weinberg et al., 2015). First, IoT can produce vast repositories of data about individuals. For example, the whereabouts of a person driving a car with an RFID tag used for toll payments (something that is quite common in big cities around the globe) can be obtained in real time or analyzed later to see whether a particular person was in an area where a crime was committed. Similarly, if all physical goods have an RFID tag, then one can quickly and remotely scan the contents of someone's home. Second, IoT is susceptible to serious security threats by allowing intruders to control remotely physical objects. Imagine someone hacking into a car's central computer and changing its breaking or steering parameters while the car is moving on a highway at 70 miles per hour. What if someone remotely accesses a patient's life support system and switches it off? Or, what will happen if terrorists start developing roadside bombs equipped with RFID readers that trigger an explosion once they sense several RFID tags embedded into credit cards or passports in the vicinity?

For decades, these hypothetical scenarios have been breeding privacy and security fears among the public in relation to IoT. As a result of the growing public concern, numerous privacy groups have been established. For example, Metro Group, one of the world's largest retailers based in Germany, experimented with RFID in the retailing environment as a part of its Future Store initiative in the beginning of 2000s. The privacy group Stop RFID was formed in Germany specifically to stop Metro Group's experimentations with this new technology. Metro Group partially addressed the concerns of this group by promising that all RFID tags would be physically destroyed once a shopper left the store. The German Stop RFID privacy group now seems to be defunct, but a myriad of other official and semi-official privacy groups (e.g., Spychips.com, RFID1984) have sprung up to monitor the IoT landscape for potential violations of consumer privacy and security. If privacy and security issues are not properly addressed by the developers of new IoT applications, these privacy groups can become a serious and vocal obstacle to IoT growth and development.

3.3.5. Technology entrepreneurs and their strategies

This article uses the term entrepreneur in a broad sense. First, this term includes private entrepreneurs establishing new ventures related to the IoT. Second, the term includes business leaders of existing private and public organizations engaging in innovation and experimentation with various elements of the IoT for the purpose of improving existing business processes or offering new value propositions to clients.

Entrepreneurs play an important role in the development of the IoT (or any other technology). Driven by their desire for self-gain, self-actualization, or contribution to their communities, these entrepreneurs use their technical knowledge, business experience, and intuition to create new business models in the realm of the IoT. Bringing these business ideas to fruition often requires addressing existing technical, managerial, and legal issues by developing new technologies, new business processes, and connecting the dots in relation to IoT in numerous other ways. Entrepreneurs collectively set various vectors for further development of the IoT.

While numerous IoT innovations are possible, I argue that most of the IoT applications fall into two categories: sustaining innovations and disruptive innovations (Christensen et al., 2004). Sustaining innovations attempt to improve an existing product or service along the dimensions traditionally valued by customers. For example, adding an additional blade to a shaving razor with the promise of a quicker and gentler shave is an example of a sustaining innovation. In contrast, disruptive innovations aim to create brand new products and services. For example, the creation of an ultrasound device that makes hair fall off with the press of a button would be a disruptive innovation to the shaving market.

Disruptive innovations often start out weak and unstable. It is not clear from their inception whether these technologies will ever become reliable enough to be commercialized and what their main applications will be. For example, when Bell presented his telephone invention to Orton, Orton had serious doubts about this technology (Carlson, 1994). First, the technology was not reliable enough. Signal could be transmitted reliably only over the distance of 20 miles or so. Western Union's main business was transmission of short business messages over long distances. Because of that, Orton was not sure whether the telephone aligned with Western Union's existing business model. In fact, at least during the first few years after Bell established a telephone manufacturing company with his father-in-law, Western Union did not view telephone technology as a direct substitute for what they were offering. Indeed, the telephone was used primarily to connect offices of business within the same geographical area.

But disruptive innovations have one notable property. Once such technology matures, it can take unforeseen trajectories. These trajectories, once they intersect in a particular industry, can completely change the competitive landscape, rendering existing investments and competencies of market leaders obsolete and creating opportunities for smaller startups. This is exactly what the telephone, once viewed by Orton as technology of little relevance to his telegraph business, did to Western Union. Of course, the problem facing entrepreneurs and business leaders is the difficulty of seeing this future trajectory. Yet those who are insightful or lucky enough to foresee how a particular technology will evolve can quickly emerge as market leaders and leave existing, well-established industry players far behind. Thus, disruptive innovations or disruptive uses of a technology present entrepreneurs with high risk, high reward opportunities.

4. Creating new value propositions

This article proposes two approaches for creating new value propositions or business models using the IoT: (1) the bottom-up or sustaining approach and (2) the visionary or disruptive approach (Krotov & Junglas, 2008). Consistent with the IoT definition used in this article, both methods view IoT predominantly as a collection of human and nonhuman objects embedded within a physical environment and connected via a ubiquitous, wireless network. Each of these objects comprising the IoT has certain properties and methods. Properties are characteristics or attributes of a particular human or nonhuman object or a physical surrounding. Methods refer to what these objects can do or the transactions with other objects or the physical environment that these objects can participate in. These transactions are triggered automatically without any human involvement. Since objects together with the physical environment are connected to a ubiquitous network, these objects can exchange or communicate their properties during these transactions. These automatic exchanges or modifications of properties via these transactions can enhance existing processes or transactions that objects participate in or create new ones.

4.1. Creating sustaining value propositions

Sustaining entrepreneurship strategies use IoT to enhance existing products or services. This approach requires analyzing properties of existing objects and devising new ways for improving existing processes or transactions involving these objects. For example, a frozen dinner has the property of required cooking time. This property can be recorded on an RFID tag attached to the frozen dinner or stored in a central database so that this property can be retrieved over the internet using the identifier assigned to this specific box with a frozen dinner. A microwave also has a property of cooking time and power output. When the frozen dinner is placed within the microwave, the microwave can read this property of the frozen dinner (either directly from the box or by accessing an online database) and adjust its cooking time and cooking power accordingly. Thus, the transaction between a frozen dinner and the microwave can be enhanced by eliminating the extra efforts on the customer side when it comes to warming up a frozen dinner using a microwave.

4.2. Creating disruptive value propositions

Disruptive strategies for creating new business models with the help of the IoT require a visionary approach. One should imagine a world in which every object is a part of a global, ubiquitous network. If this vision becomes a reality, what kind of new transactions or business models will be possible?

For example, if every clothing item has an RFID tag attached to it, then someone can remotely scan the code of a stylish jacket that his or her coworker wears using a smartphone with an RFID reader. Having obtained this code, this person can quickly view the price and other information about this jacket online and even order the jacket right on the spot from Amazon. The coworker whose jacket code was scanned and who, perhaps unknowingly, initiated this transaction, can get a sales commission from Amazon.

4.3. Connecting the remaining dots

Of course, once one comes up with a value proposition using one of the two approaches discussed above, it becomes time to reflect on how other elements of the IoT landscape will impact this business model. Each of the elements discussed earlier can be an opportunity, a threat, or both. For example, the previous example involving a jacket requires decisions about what hardware, software, and networking technologies can support this application. Most importantly, one needs to reflect on the legal and privacy issues that may come into play. For example, some individuals may view the ability of others to retrieve information about their clothing as an invasion of their privacy. For example, a person may not be comfortable letting others know that his or her suit was purchased at Walmart. In that case, the person needs to enter an explicit agreement with the manufacturer concerning whether or not information about the suit can be shared with others. To overcome these privacy concerns, the manufacturer or the vendor selling these suits can offer a commission discount to consumers who wish to share information about their clothing with others.

4.3.1. Second-order business opportunities

A number of second-order value propositions can be created to support the current IoT infrastructure. The reason these business models are of second order is that they are not immediately related to what seems to be the essence of the IoT—the interaction of human and nonhuman objects with themselves and their surroundings. Instead, these business models of value propositions support other elements of the IoT. For example, there may be a market for security solutions that would ensure consumer privacy and security of transactions executed with the help of the IoT. Another promising area for creating new business propositions is the big data generated as a result of the continuous data streams generated by the devices and sensors comprising the IoT (Pigni et al., 2016).

Although these models are called second order, this does not imply that somehow these value propositions are less valuable. As it was discussed previously, an infrastructure technology that supports a valuable activity and becomes a de facto standard can become a source of sustainable competitive advantage. That is why technology companies often rush to be the first to introduce a particular technological platform and then devote significant resources to warding off alternatives to their technology. Examples of such tactics include Microsoft's decision to bundle the Internet Explorer browser with its Windows operating system for free in an attempt to destroy Netscape Navigator (a browser that had the potential to be a dominant platform for web-based computing).

5. The daunting task of predicting the future

Arguably any entrepreneurial endeavor requires betting on the future. An entrepreneur may invest his or her time and money developing a new business model based on the belief that in the future, this new product or service will become popular among the customers and generate a steady flow of revenues for the new venture. For example, an entrepreneur opening a new hamburger joint is placing a bet that in the future people will still eat hamburgers (as opposed to salads).

Unfortunately, predicting the future can be a daunting task, especially if these predictions are related to the rapidly evolving technological landscape. It is easy to explain why a particular technology succeeded or failed in retrospect. As Warren Buffet put it: “In the business world, the rearview mirror is always clearer than the windshield.” What is often problematic is predicting the future of a particular technology.

Just like any other management framework, the IoT framework presented in this article does not answer any questions in relation to the future of IoT on its own. Instead, this framework helps entrepreneurs and business leaders to brainstorm various opportunities and threats in relation to the IoT. At a minimum, this line of thinking can prepare a firm for various opportunities and threats in relation to IoT that might emerge in the future. It is also possible that one of the scenarios envisioned with the help of this framework will be one of those future successes and the entrepreneur who places that bet will have drawn the winning number.

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