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Business Models and the Internet of Things

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Business Models and the Internet of Things

Abstract

This article provides theoretically and practically grounded assistance to companies that are today engaged primarily in non-digital industries in the development and implementation of business models that use the Internet of Things. To that end, we investigate the role of the Internet in business models in general in the first section. We conclude that the significance of the Internet in business model innovation has increased steadily since the 1990s, that each new Internet wave has given rise to new digital business model patterns, and that the biggest breakthroughs to date have been made in digital industries. In the second section, we show that digital business model patterns have now become relevant in physical industries as well. The separation between physical and digital industries is now consigned to the past. The key to this transformation is the Internet of Things which makes possible hybrid solutions that merge physical products and digital services. From this, we derive very general business model logic for the Internet of Things and some specific components and patterns for business models. Finally we sketch out the central challenges faced in implementing such hybrid business models and point to possible solutions.[1]

The Influence of the Internet on Business Models to Date

Our starting point for approaching these issues is the question of how and where the Internet has impacted the development of business models to date. By answering this question, we attain a clearer picture of the role of information technology (IT) in innovating business models on the one hand, and on the other we establish an informed perspective on possible future business model innovations based on emerging information technologies, in this case the Internet of Things.

We selected the results of Gassmann et al. (2013) as the foundation for this first section. In their work, they have analyzed more than 300 case studies of companies that broke with the established logic in their industries and in the process permanently changed it. Gillette, IKEA, Nespresso and Pixar are well-known examples of such companies. Through years of painstaking work, Gassmann et al. have examined these case studies to find their commonalities, identifying a set of 55 business model patterns. They define "a business model pattern as a definite configuration of four core elements (who are the customers? What is being sold? How is it produced? How is revenue earned?) that have proven successful in different

[1] The Bosch Internet of Things and Services Lab provided major funding to HSG for this project. We thank Prof. Oliver Gassmann, Ass. Prof. Karolin Frankenberger, Kristina Flüchter and Stefanie Turber for invaluable discussions and for their support.

companies and industries."[2] The list of business model patterns determined using this empirical approach runs from *Add-on*, based primarily on case studies of Ryanair, SAP, and Sega, to *White Label*, derived from case studies of Foxconn, Richlieu-Foods and Printing-In-A-Box.

IT plays a central role in many industry-changing case studies and business model patterns

We have now investigated the influence of IT on these 55 business model patterns. In doing so, we distinguish three different roles that IT can assume in business model patterns:

- First, it can play a constitutive role, i.e. without it, the business model pattern would be impossible. Examples of this include *E-Commerce*, *Long Tail* and *Crowdsourcing*. Without IT they would be unthinkable so we identify them as digital business model patterns.
- Second, IT can increase value. Patterns such as *Self Service* or *Customer Loyalty* existed long before the Internet and as they were deployed transformed industries. But with IT, and the Internet in particular, their significance has increased dramatically in the sense of their dissemination and/or market share.
- Third, IT can be irrelevant for a business model pattern such as for *Franchising* and *Ingredient Branding*.

In Fig. 1 the industry-transforming case studies from Gassmann et al. (2013) are plotted as dots on a surface spanning a time axis and the influence of IT. The business models patterns are listed according to the role IT plays in them.

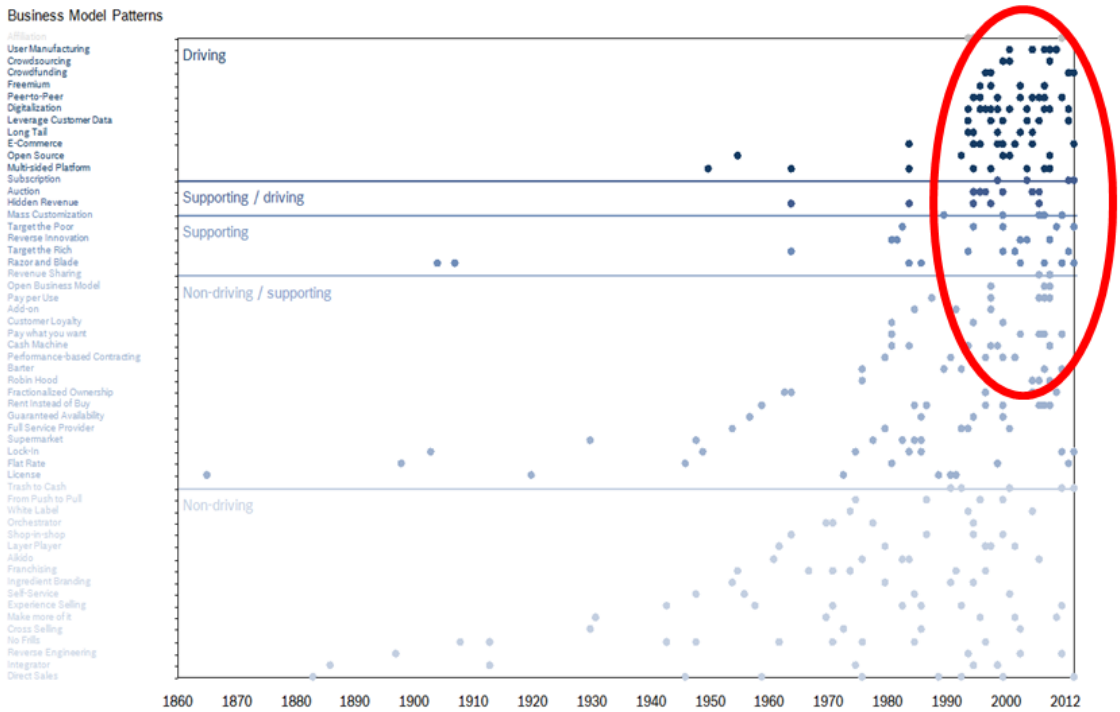

Fig. 1: Distribution of industry-transforming case studies based on the role of IT, business model pattern and time (our chart)

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[2] Gassmann, et al. (2013)

It is striking that since the 1990s, IT has been extremely significant in many case studies, even though there continue to be business model patterns that manage to transform an industry without IT. On the one hand, this is not surprising since IT first became widely used throughout the business world in the 1990s. On the other hand, the concentration of IT-driven cases is impressive. A large share of the newer case studies relies in particular on digital business model patterns.

Each new Internet wave has led to new digital business model patterns

When the new business model patterns enabled by IT and/or industry-transforming case studies associated with the new business model patterns are plotted across the time axis, the following picture emerges (see Fig. 2): A first set of new business model patterns enabled by IT appear between 1995 and 2000. These business model patterns are all based on what is known as Web 1.0, when the Internet began to be seen and used for the first time as part of business infrastructure. Using the nomenclature of Gassmann et al., these new business model patterns enabled by IT included *E-Commerce*, *Freemium*, *Leverage Customer Data*, *Open Source* (in relation to software) and *Digitalization*.

Around 2005 another set of IT-enabled business model patterns appeared. They were all based on Web 2.0, the Internet that made it possible even for ordinary users to contribute content. These included *User Designed*, *Crowdsourcing*, *Crowdfunding*, *Long Tail,* and *Open Source* (in the sense of content).

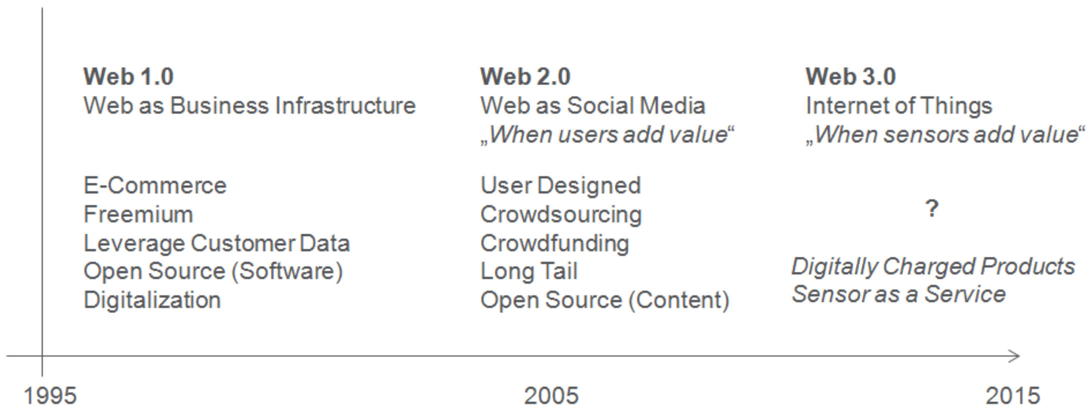

Fig. 2: Internet waves and the digital business model patterns they gave rise to (our chart)

Many Internet-driven business model patterns follow three overarching trends

Whether the Internet of Things will also generate new business model patterns and, if so, which ones, is the question driving this essay. In order to answer it, two more insights from the above analysis are helpful:

First, many of the IT-influenced business model patterns – regardless of the technology wave from which they emerged – follow three overarching trends:

- *Integration of users and customers*. IT enables companies to increasingly integrate their customers in their value-creation chain. In other words, IT allows companies to delegate some tasks to their customers. Examples can be found in the *User Designed*, *E-Commerce*, *Open Source* (content) and *Mass Customization* business model patterns.

- *Service orientation*. Run time services and/or after-sales digital contact with customers are on the rise. Using IT-based services, IT allows companies to maintain and make use of customer relationships even after the sale. Exemplary business model patterns for this include *Rent instead of Buy*, *Subscription*, *Freemium*, *Razor and Blade* and *Add on*.
- *Core competence analytics*. Precise collection and analysis of transaction and use data are increasingly valuable and represent a key skill for product design, pricing, and sales structuring. Examples can be found in the *Subscription*, *Flat Rate*, *Freemium, Pay per Use* and *Performance-based Contracting* business model patterns.

And second:

The big breakthroughs in digital business model patterns have been made in digital industries

Clearly establishing the role of IT in various business model patterns has proven to be a challenge. In some business model patterns, IT can play differing roles depending on the case study. It was only by assigning case studies to either digital or non-digital industries that the necessary clarity was established. A company is classified as part of a digital industry when it is by its very nature digital. The business model of *Hidden Revenue* provides an example of this. JCDecaux had already transformed the advertising market without IT back in 1964 with its street furniture, such as bus stops. In such non-digital industries, IT is used today to upgrade value in the business model pattern. When the *Hidden Revenue* pattern is applied by companies like Google or Facebook, however, which are part of digital industries, IT is by definition constitutive. IT not only revives old business model patterns and generates new business model patterns; it has also facilitated the emergence of an entirely new digital industry and redefined old business model patterns in that industry.

Many digital business model patterns, such as *Freemium*, have been applied exclusively in the digital world until now. In manufacturing industries, the Internet has mainly been used to simplify processes – and thus reduce costs while increasing quality and the variety offered. The Internet has been responsible for big breakthroughs in digital industries, as Google, Facebook, PayPal, eBay, YouTube, and others prove.

The Economic Power of the Internet of Things

This section outlines the formative power of the Internet of Things within the economy. A broader and more well-grounded analysis of the economic perspective on the Internet of Things can be found in Fleisch et al. (2005) and Fleisch (2010).

Digitalization leads to high resolution management control circuits

The digital world – and that includes its various industries – differs in multiple dimensions from the physical world and its industries, for instance in the areas of marginal costs in production, transport, and storage, in transport and production speeds, and in the ability to abstract and simulate.

For example, as a prominent representative of the digital world, Google has put these characteristics to good use and in the process revolutionized the advertising market. Google analyzes questions put in its search engine and clicks on web pages to measure its users' behavior. Based on this more precise – because it is high resolution – performance data, the company presents each user with an individual, profit-optimizing advertising message. Then, with the aid of user reactions, Google measures in real time the effectiveness of its banner ads, optimizes their allocation model, and uses the same data to invoice its advertising customers.

The resolution of the control circuit that Google uses to manage its digital advertising is many times higher than in the physical world, where a unidirectional medium like television or a billboard sends a static message to an unknown mass of potential customers. Finely grained control offers huge advantages that have allowed the digital advertising market to become much more dynamic than the physical one. For years now, advertising budgets have been flowing from the physical to the digital world.

Digitalization leads to high resolution management because the marginal costs of measuring (in the control process) and the actuating elements (in the controller) are almost zero, while interventions can be made with almost the speed of light.

Internet of Things now makes high resolution management possible in the physical world too

The Internet of Things is now applying this logic step by step to the physical world. It represents the vision that every object and location in the physical world can become part of the Internet. Objects and locations are generally equipped with mini-computers so they become smart objects that can take in information about their environment and communicate with the Internet and other smart objects. These minicomputers are usually barely visible or completely invisible, so the physical dimension of the object remains people's most important interface.

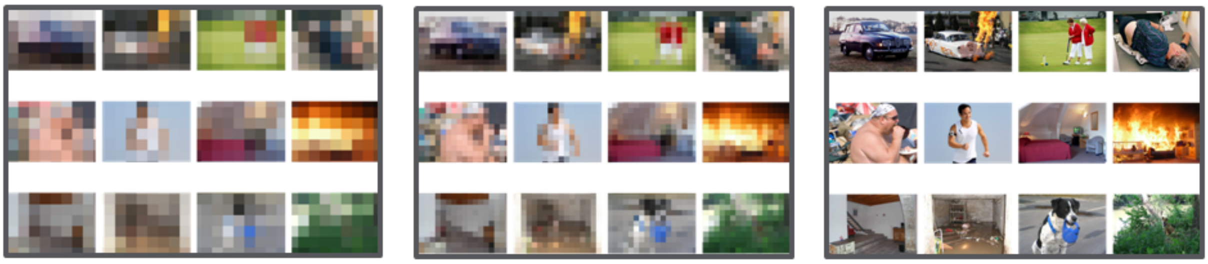

Fig 3: High Resolution Management in the Physical World (Fleisch 2009)

Smart things are hybrids, composed of elements from both the physical and digital worlds. That means that, when used, they unite the principles of both worlds and in doing so, introduce high resolution management into the physical world too.[3] The following example should illustrate what we mean. Because inventory costs in physical warehouses are high, manual counts are done as infrequently as possible; a complete inventory is taken only once a year. The relevant management control system exhibits a low frequency, as would be expected. When Internet of Things technologies are used to equip formerly "agnostic" storage containers and shelves with "smart" sensors and communication capabilities,

[3] See Fleisch (2009)

these smart containers and shelves can now transmit their specific fill level at any time at zero marginal costs. Since a company can only manage what it can measure, these new measuring capabilities result in new management capabilities. In the case study of a producer of screws, this gave rise to a new type of refill service. The Internet of Things is having an impact on business management similar to the impact of ultrasound devices on medicine or scanning electron microscopes (SEM) on physics. Things can be measured and identified using Internet of Things technologies that previously could not be (economically) identified (see diagram 3). Ultrasound and SEM spurred on their entire disciplines.

Digital business model patterns are becoming relevant to physical industries for the first time

Should the fastening equipment manufacturer provide this information to his customers free of charge or use the *freemium* model? Or service-for-pay integrated with physical delivery right from the start? And who owns the data? The customer whose warehouse is the source of the data, or the supplier; after all, he owns the smart containers that generate the data. Can and should the data – anonymized, across the entire customer base – reveal valuable, real-time developments in the industry and be capitalized as part of the *Leverage Customer Data* business model pattern? Whichever is chosen, the *Freemium* and *Leverage Customer Data* models are both examples of how business model patterns that have been confined to digital industries can suddenly become relevant for classic physical industries.

The digital and physical value-creation layers in an Internet of Things application

Even more than that, in the Internet of Things, digital business model patterns necessarily intermingle with those from the non-digital world to create a hybrid construct, which becomes particularly clear in the value-creation layers involved in an abstract Internet of Things application. The value-creation layers (see Fig. 4) are the result of an analysis of numerous applications that today are classified as the Internet of Things in academia and in practice. The following section explains what we mean, using the example of a smart LED light bulb.

Layer 1 – Physical thing: The physical element, which in this solution is the LED light bulb, forms the first layer of the value-creation model. It supplies the first direct, physical benefit to the user – in the form of comfort supplied by the light. Because the light bulb is a physical entity, it is always tethered to a location and can supply benefits at this layer only in its immediate environment, for example in a room. The business model pattern for the sale or lease of LED light bulbs is well-known to LED light bulb manufacturers.

Layer 2 - Sensor/actuator. In layer 2, the physical thing is equipped with a minicomputer with sensor technology and actuating elements. The sensor technology measures local data, while the actuating elements deliver local services and thus generate local benefits. In the example of the LED light bulb, the microwave sensor continuously measures whether people are present in the space – reliably and at a low cost. The actuator turns the light on automatically when human presence is detected and off again when not, thereby supplying local benefits – including because the smart LED light bulb functions without separate, wired motion detector to discern presence.

Layer 3 - Connectivity: In layer 3, the previous layer, in particular the sensor technology and actuator elements, is connected to the Internet so they become globally accessible. In our example, the light bulb can be addressed through an embedded radio module and transmit its status to authorized subscribers anywhere in the world at negligible marginal costs.

Layer 4 - Analytics: Connectivity per se does not deliver any added value. In layer 4, sensor data is collected, stored, checked for plausibility, and classified. Then the findings of other Web services are integrated with them to arrive at consequences for the actuator elements – typically in a Cloud-based backend system. In our LED example, in layer 4 the on-and-off times in a household are collected, motion patterns are discerned, and the operating hours of individual light bulbs are recorded as well.

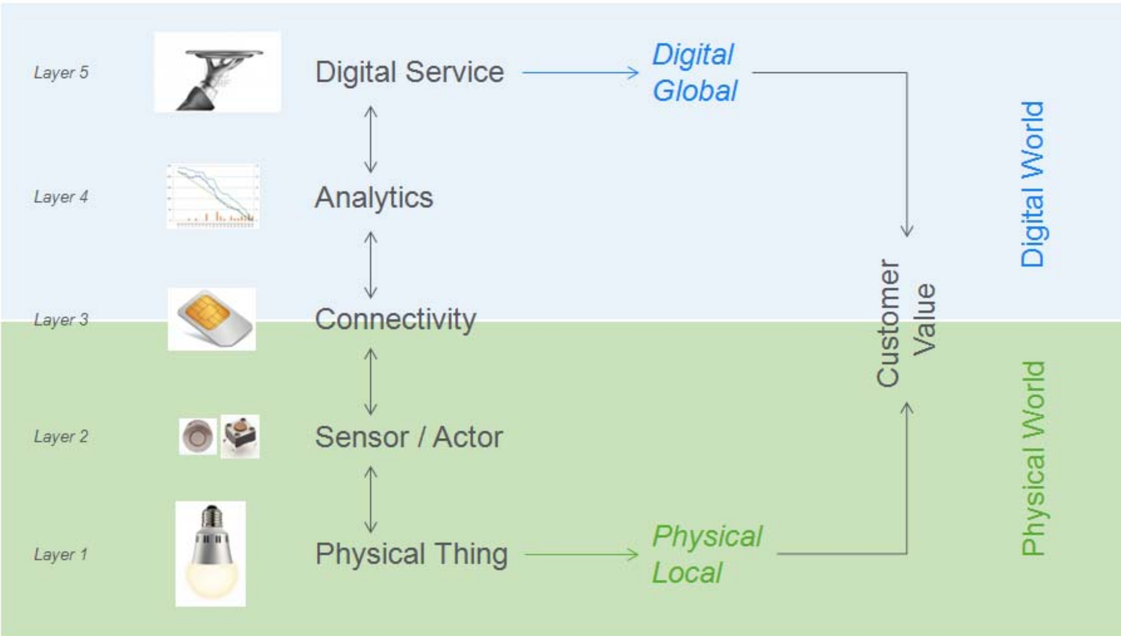

Fig. 4: Value-creation Layers in an Internet of Things Application (our chart)

Layer 5 - Digital service. At this, the final layer, the options provided by the previous layers are structured in digital services, packaged in a suitable form – for instance, as a Web service or mobile application – and made available globally. The characteristics of digital business model patterns apply to these digital services, which are inseparable from the smart things that generate the data.

With this layer, the LED light with presence sensor becomes a safety lamp that at the user's initiative and/or at the click on an app, sounds an alarm to the owner, a neighbor, or the police in the event of an unwelcome intruder, or in fight-back mode it attempts to drive the burglar out with a flashing red light – and all of that at negligible marginal costs.

One important insight is the fact that layers 1 through 5 cannot be created independently of each other. That is why the arrows connecting them are bi-directional. An IoT solution with value is usually not the mere addition of layers but rather a process of integration extending into the physical level. How the hardware is built, for instance, is increasingly influenced by the subsequent digital levels. Viewing the levels or steps in isolation will make many attractive digital services impossible. It seems more and more essential that hardware be developed in close interconnection with Internet solutions.

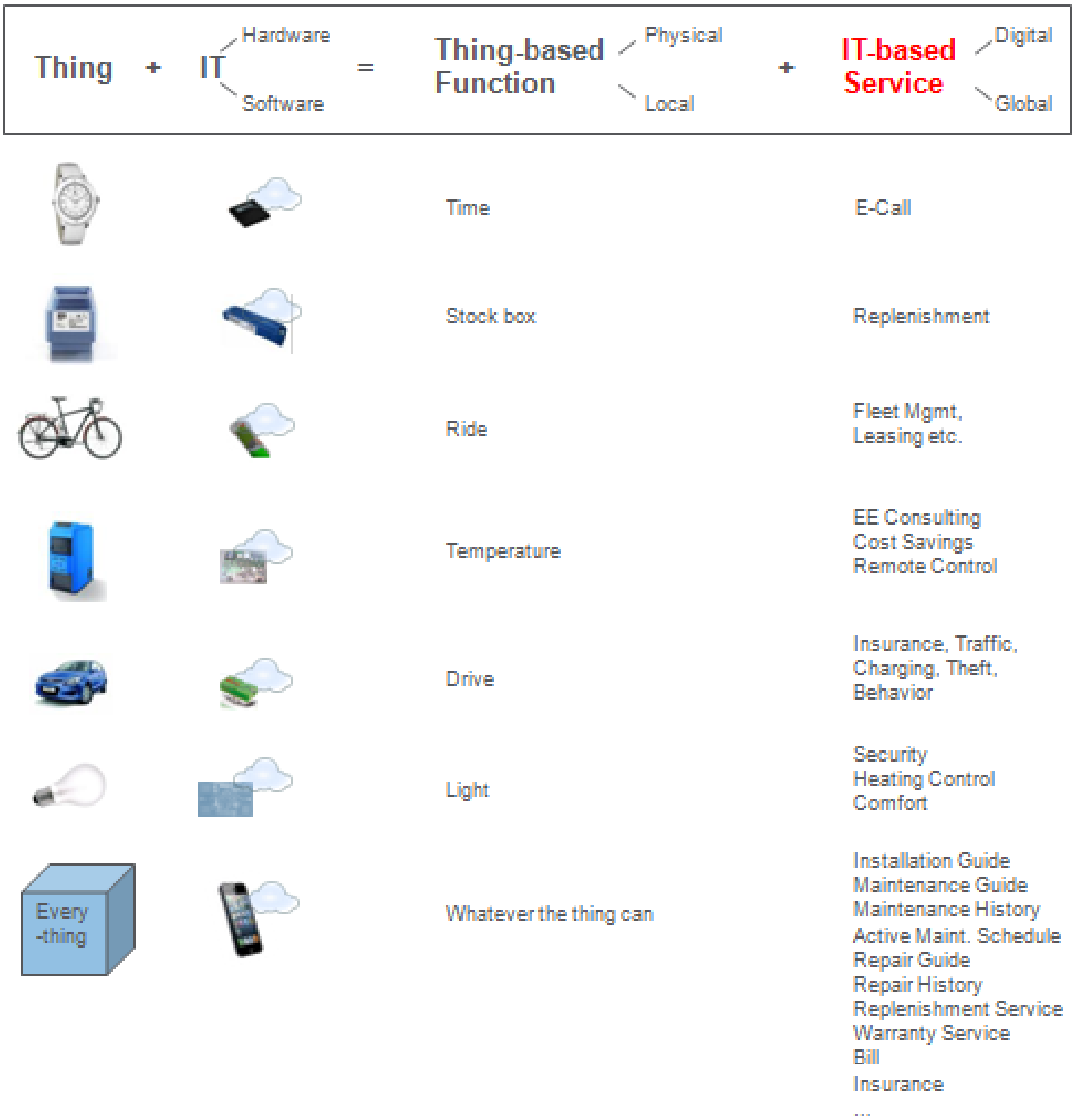

Fig. 5: The Internet of Things-Products-Services Logic (our table)

Physical products and digital services merge in hybrid solutions.

At a very abstract level, the logic of Internet of Things business models can be reduced to a simple formula (see Fig. 5). It says that the value of an IoT solution on the manufacturing side is found in the combination of a classic product that in the past was not linked to the Internet, but is now upgraded with IT, or more precisely with layers 2 through 4 in the above model. On the customer side, at layer 5, this value is experienced as benefits from the physical product and the digital services associated with it. That process results in a whole that is more than the sum of its parts, building on the original product – in particular due to the simple ability at relatively low cost to combine it with proprietary and external digital services.

A watch from Limmex (www.limmex.com) is still a watch, even if it includes a GSM module, a microphone, a loudspeaker and its own homepage. Its physical and local usefulness is still – along with telling time – to signal to others around the coffee table the owner's taste through its chic, timeless design. Beyond that, it can now also alert family members, friends or the Red Cross in an emergency, however the owner has configured it on the Internet. The "smart" in an Intellion (www.intellion.com) warehouse bin refers to a long range RFID chip embedded in it, but it's still a storage bin for screws and washers. It also makes possible a new refill service provided by the screw supplier, differentiating it from the competition. The list of such product/service hybrids offered by startups and established companies alike and ideas spawned by research grows daily. One startup, qipp (www.qipp.com), has taken this logic to an extreme, supplying an infrastructure that assists any company to very simply and economically charge its physical product with standardized, globally accessible digital services of all types.

Business Model Patterns in the Internet of Things

The application-driven goal of this article is to derive well-grounded assistance, both theoretical and practical, for developing Internet of Things business models. These models should be inspiring and provided on a level of abstraction that will facilitate their application across industries, while remaining concrete enough to be actionable for innovators in business and society at large.

To accomplish this, we analyzed 55 business model patterns from Gassmann and many Internet of Things applications with regard to their value-creating steps and high resolution management. It is the latter that embody both the opportunities and limitations of the Internet of Things' technical capacities. The results of this analysis can be represented as six components for business model patterns and two independent business model patterns for the Internet of Things. Based on their power and their kinship – all of them facilitate digital services for physical products – we merge them all together in a new business model pattern specific to the Internet of Things, *Digitally Charged Products*. On the other hand, the concept of *Sensor as a Service* is so novel and so powerful that we suggest that it is itself a new business model pattern (see Table 1).

Business model patterns	Components
Digitally Charged Products	1. Physical Freemium 2. Digital Add-on 3. Digital Lock-in 4. Product as Point of Sales 5. Object Self Service 6. Remote Usage and Condition Monitoring

Table 1: Components and Business Model Patterns in the Internet of Things

In the following, individual components and business model patterns are briefly described:

Physical Freemium

This component describes a physical asset that is sold together with a free digital service, such as digital installation, operating and maintenance instructions, which is "attached" to the product at no additional charge. Over time, some percentage of customers will select premium services that go beyond these free ones and are then invoiced, such as electronic monitoring or benchmarking across the entire customer base.

Canary, a New York startup (www.canary.is), offers a smart home alarm system that includes a variety of sensors, from temperature or movement sensors, up to a camera. The basic function of monitoring a space during the resident's absence and sending a message to a smart phone app in the event of anomalies, is included free of charge in the price of the system. Other services for an additional cost were announced during a crowdfunding campaign on Kickstarter, such as additional memory to store recorded events or use of a call center. A comparable package of services is offered by Dropcam (www.dropcam.com), a very successful company that was sold in June 2014 for USD 555 million to Google's Nest.

Digital Add-on

Digital Add-on is the term for a business model component in which a physical asset is sold very inexpensively, that is, at a small margin. Over time, the customer can purchase or activate any number of digital services with a higher margin. When an automobile's performance can be configured using software and the vehicle is a node on the Internet, then the customer can purchase an additional 50 HP for the upcoming weekend, for example. And when add-on services are offered by third parties too, the customer can easily purchase the right additional mini-insurance policy for an outing to Italy, for instance. The sales commission may be passed on to the automobile manufacturer or to a third party.

Digital Lock-in

The successful application of the *Razor and Blade* and *Lock-in* business model patterns require that only original components are compatible with the system. For instance, only original Gillette razor blades can be used with Gillette razors. In many cases, patents prevent competitors from supplying compatible components for such a system.

Digital lock-in in physical products refers to a sensor-based, digital handshake that is deployed to limit compatibility, prevent counterfeits, and ensure warranties.

Product as Point of Sales

Physical products become sites of digital sales and marketing services that the customer consumes directly at the product or indirectly via a smart phone and identification technology. A package of gum becomes an e-shop, any object can carry digital advertising, and the product itself collects and transmits loyalty points and records the world around it digitally via a smart phone.

The expansion of things into points of sale has already happened in some cases. By pointing a smart phone at a product, an Internet website opens where that same product – including replacement parts, accessories, and consumables – can be purchased. The Amazon app already offers this function for products with a barcode that are carried by Amazon.

Object Self-Service

This component refers to the ability of things to independently place orders on the Internet. For instance, a heating system could order oil refills as soon as a certain level of liquid was noted in the oil tank. The idea of *self-service* no longer refers only to the customer; now things can serve themselves too.

In this model, intermediaries are dispensed with, like in the *Direct Selling* business model pattern. *Solution Provider* business models are simplified by ordering of refills of consumables automatically.

Remote Usage and Condition Monitoring

"Smart" things can transmit data about their own status or their environment in real time. This makes it possible to detect errors preventatively and to monitor usage and the remaining inventory of consumables. Until now the technology this required was complicated and relatively expensive but as the Internet of Things continues to expand, the costs and expenditures required will diminish, making the application of this technology cost effective with less valuable products as well.

Brother, the computer accessories manufacturer, offers leases for laser printers, for example, without any base leasing rate – only the pages that are actually printed are invoiced. In this instance, the *Pay per Use* business model pattern is applied to products valued at just a few hundred dollars. Transmission of the relevant data to the supplier via the Internet provides the technical basis for efficient implementation of this business model.

Digitally Charged Products

The components described here are all variations of the idea that the Internet of Things in its applications links digital services to physical products to create a hybrid bundle that is a single whole. The services may be simpler or more complex; they may be offered by the manufacturer or a third party; they may be in the vicinity of the product, or by linkage to a fourth party acquire a completely different significance.

The term *digitally charged products* forms the brackets around these related components. Because of the power of the ideas behind the term, we proceed from the understanding that *Digitally Charged Products* is now established as a new business model pattern: classic physical products are charged with a bundle of new sensor-based digital services and positioned with new value propositions. Examples include the safety solution for an LED light described above, an electronic kanban solution on a bin, or the distress call on a wristwatch. Well-known service-oriented business model patterns acquire new relevance in physical industries.

Sensor as a Service

Another powerful idea is collecting, processing and selling for a fee the sensor data from one subsection to other subsections. That's why we suggest the term *Sensor as a Service* to describe it as an Internet of Things business model pattern. The measurement data from the physical world are no longer vertically integrated, collected, stored and processed for just one application but instead for a broad array of potential applications – for an eco-system whose emergence on the Internet of Things will certainly present one of the next big challenges.[4]

In contrast to *Digitally Charged Products,* the data-generating products or the resulting services are no longer the central focus in this pattern but rather the data itself. They are the primary currency to be earned. Streetline (www.streetline.com) is a good example of this phenomenon. This company installs sensors on municipal and private property that detect vacant parking places in order to sell the data collected to interested third parties. A car driver accesses the information free of charge through an app. For city governments, the data processed somewhat differently has tremendous value: their physical expenditure to identify parking offenders is dramatically reduced; utilization of parking places increases;

[4] See Schuermans &Vakulenko (2014)

and the quality of information available to make the best use of them rises. *Sensor as a Service* represents a business model pattern that revolves around a multi-sided market for sensor data.

The Internet of Things boosts many other "classic" business model patterns.

Up to this point, we have described components and patterns that are newly possible with the Internet of Things. These components also effectively facilitate 20 of the 55 patterns identified by Gassmann et al. (2013). Table 2 provides an overview.

Business model patterns according to Gassmann et al.	**Facilitating components and patterns of the Internet of Things**
Add-on	“Digital Add-on” – Remote sale and installation of additional options for products during the post-sale/usage period.
Affiliation	“Product as Point of Sales" – Sales commissions for Internet transactions are connected to the real world, e.g. the location of the user or an object.
Crowdsourcing	"Sensor as a Service" – A "crowd" of sensors generates data.
Customer Loyalty	"Product as Point of Sales" – Customer loyalty can be rewarded not only for the purchase of a certain product but can be measured according to use of the product, or presence at a certain location, for instance.
Direct Selling	"Object Self-Service" – Objects make purchases autonomously, directly, without an intermediary.
Flat rate	"Remote Usage and Condition Monitoring" – Use and consumption of physical goods are measured in order to reduce the risks associated with a flat-rate business model.
Fractionalized Ownership	"Remote Usage and Condition monitoring" – Use and consumption of goods of lower value can be measured too, making this business model applicable to those goods as well.
Freemium	"Digital Add-on" – This business model can be applied in the physical world as well by combining free digital services with a physical product for sale. Premium services are available for a fee.
From Push to Pull	"Object Self-Service" – Kanban systems with Internet of Things Technology
Guaranteed Availability	"Remote Usage and Condition Monitoring" – Monitoring the status of production plants or equipment via the Internet simplifies the application of the business model pattern.
Hidden Revenue	"Product as Point of Sales" – For example, flexible location-specific advertising becomes possible using the Internet of Things technology.
Leverage Customer Data	"Sensor as a Service" – Objects such as cars or razors transmit data to the manufacturer over their lifetime. The manufacturer can then use the data to improve the product.
Lock-in	"Digital Lock-in" – Compatibility with competitors’ systems is prevented by use of a digital handshake and authentication mechanism.
Pay per Use	"Remote Usage and Condition Monitoring" – Use and consumption of lower-value products can be measured too. The business model pattern is applicable to these goods as well.
Performance-based Contracting	"Remote Usage and Condition Monitoring" – Use and consumption of lower-value goods can be measured too. Technology for monitoring the status of production plants and equipment further promotes the application of this business model pattern.
Razor and Blade	"Digital Lock-in" – "Razor blades" can be authenticated online using digital mechanisms. Eliminates elaborate safeguarding of the business model, such as through patents, for instance.
Self-Service	"Object Self-Service" – Objects order consumables or services autonomously.
Solution Provider	"Object Self-Service" and "Remote Usage and Condition Monitoring" – These

Business model patterns according to Gassmann et al.	Facilitating components and patterns of the Internet of Things
	components increase the attractiveness of the business model pattern.
Subscription	"Digital Add-on" – The usability of a product or sub-functions can be restricted to the time span of a subscription.
Two-Sided Market	"Sensor as a Service" – Platforms combine data suppliers with data users.

Table 2: Business Model Patterns according to Gassmann that are facilitated by the Internet of Things (our table)

Entrepreneurial Challenges in Implementing Internet of Things Business Models

The logic described above, the components and patterns for business models that utilize the unique characteristics of the Internet of Things should inspire innovators in business and society at large to develop their own specific business models. Those characteristics can be integrated as technology-specific expansions into any method of business model development.

Working with many companies – from large corporations to startups – it became apparent that, as experienced managers know, in establishing a new business model in the Internet of Things, generating new ideas is not the biggest hurdle. While that is the focus of this essay, here we also briefly discuss the key challenges in implementation that arise in particular for companies with a history of success in classic businesses with physical products, namely manufacturing industries.

Product versus service business

A broad discussion has developed in the last ten years in business and academic circles regarding the optimal mix of product and service business. The merging of the physical and digital worlds is reigniting that discussion, since the digital part of a hybrid solution is always a service. The central questions that are addressed in the literature and by companies are: how much and which service business is appropriate? Are there developmental steps along the path from a product-dominant to a service-dominant organization? What is the best organization for the development, sale, and provision of services – on the regional and international levels? What are the various categories of services? How can I convince customers to pay for services they previously received free of charge? How is pricing determined? How do I organize and incentivize my sales organization?[5]

Services differ fundamentally from products. Services can't be stored, for instance, and as a rule they are provided at the customer's site while collaborating, and they are generally paid for in many smaller amounts, spread out over time. The heart of the matter is a comparative weighing of the strategic and operational characteristics of products and services against each other and achieving a sustained optimal balance.

[5] See Fischer, et al. (2012)

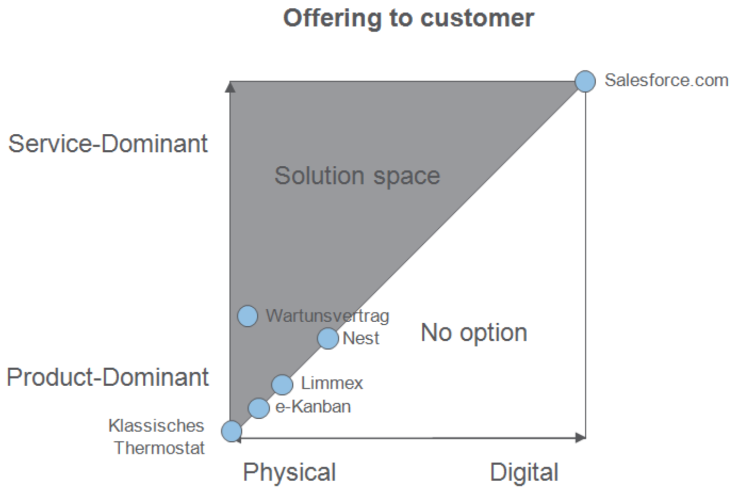

Fig. 6: Interplay of Digitalization and Service Orientation in Manufacturing (our chart)

One feature of the Internet of Things is the fact that the service portion of the business models outlined here is always digital in nature. This has two consequences: First, the theory and practice of service orientation must be critically examined and expanded as needed against the backdrop of the characteristics of digital services. Second, digitalization that extends into the product itself (in contrast to digital support in the value-creation process) must of necessity lead to an additional service orientation. Fig. 6 illustrates qualitatively how with increasing digitalization of possible products offered by producing industry the solution space opens up towards the direction of service dominance.

A clash of hardware and Internet cultures

The differing characteristics of physical and digital products are particularly noticeable in product development. When the marginal cost of a product modification is low, development is well organized when the management control circuit is appropriately short and high frequency. Consequently in the digital world, in particular the Internet, agile development processes are the norm today. Almost every successful Internet software company or project uses the SCRUM method today and tests the new visible results every evening so it can be delivered to the customer for use. In a world where a bug can be repaired with an update at almost no cost, even in an installed base running in the millions, and where right from the start high growth is required due to network effects, speed, early customer contact, and aesthetics are of utmost importance in development. The key concept here is Minimum Viable Product[6] - a product version that, with minimal expenditure, delivers maximum knowledge about the customer – and Perpetual Beta[7] – neglecting “complete” releases to promote continuous enhancement of the product.

In the hardware business, however, and in the world of embedded computing as well, other terms apply. Here, for example, an error in a product that has already been sold usually results in an extremely costly,

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[6] See Ries (2009)
[7] See O’Reilly (2005)

image-damaging recall action. These differences conditioned by technology and economics have meant that divergent cultures arose in hardware compared to those governing Internet software departments and have shaped putatively incompatible organizational units.

The technical delta cannot simply be defined away. However, knowledge of the other side – hardware or software - can be built up to the point that the two areas can be joined. This gives key employees the necessary openness for profitable exchanges and a willingness to adopt best practices from the other's discipline.

Every atom that can profitably be replaced by a bit will be replaced[8] for the reasons set forth above. Digitalization of hardware functions is advancing. This gives added significance and explosiveness to the question of who holds the controls in the development of hybrid solutions, the hardware or the software side. The correct answer relates to the solution's position in Fig. 6. Without quantitative empirical research, only one statement can be made, which relies on fragmentary anecdotal knowledge: more and more often, it is the software side that wins here.

Many of the IoT solutions we examined exhibit characteristics of disruptive innovation.[9] They use a completely new value proposition to position themselves, making them difficult to compare, and they target a new market. They are small, relatively inexpensive, of lower value and with tight margins, at least when measured by traditional metrics. Creating a business case ex ante is often fraught with major uncertainties. Given this, it stands to reason to test the development of hybrid IoT products by using the solutions suggested by Christensen (1997) for companies trying to manage disruptive innovations. The key lies in creating or taking over small independent entrepreneurial units that correspond in their dynamism and wage and reporting structures to the dimensions of their target market and that can act independently of existing customers and financiers.

The strategic value of development communities

Small units that can and must operate in the tradition of lean startups[10] are advantageous in addressing another challenge. Their leanness itself forces them to work on development together within a network of partners – which include their customers. This implies not only a lead user approach[11] but encompasses an entire ecosystem as facilitator. In the digital world, the one who brings the most developers to its platform wins. For example, today Apple and Google and yesterday Microsoft and SAP specified some of their software functions through APIs and opened them up to third parties so that tens of thousands of developers could create millions and millions of apps with relatively simple means, quickly and inexpensively, as Nest, Netatmo and Co[12] are attempting to do today.

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[8] Andreessen (2011)
[9] See Christensen (1997)
[10] See Ries (2011)
[11] See von Hipple (1986)
[12] See Schuermans &Vakulenko (2014)

Handling application data

In most instances, hybrid solutions mean that the party offering them must have access to data that is constantly generated from application of the solution. This is new for classic production companies and brings with it both many opportunities as well as risks.

The opportunities include input that is based on digital data so it is fine grained, unaltered, and complete and can be used to enhance the solution and/or develop new products, to optimize customer segmenting, responsiveness, earnings model and pricing, and for dynamic, situation-specific, and automatic configuration of offerings during runtime. Professional use of this mass data, which is discussed today under the rubrics of analytics, big data, or data science, is a new foundational capability that companies must have or develop in order to exploit these opportunities. For this reason, O'Reilly (2005) and others have famously said, "SQL is the new HTML," and "Data science is cool."

The challenges cover all the issues wrapped up in the user's informational self-determination, in particular those regarding use in compliance with regulations and data security. Who owns the data generated by the application? The user, the party supplying the solution, or both? The relatively new approach taken by Pentland (2009) among others seems promising. He views data as an asset that belongs to the parties generating the data, who are free to decide what they want to do with that asset. They can treat it like money and keep it as they wish, spend it, or trade it for another currency or quid pro quo. It is beyond debate, however, that every hybrid solution needs a clear conception, transparent for all involved and reliably implemented, of how it handles application data that is generated by the customer. That is the only way that both the customer and the supplier can derive long-term benefits from the data.

Summary and outlook

The goal of this essay is to inspire innovators from business and society at large to develop business models using the Internet of Things. It analyzes the role that the Internet has played in business models to date, documents the specific economic energy of the Internet of Things, and derives from that the general product/service logic that can serve as the foundation for specific components and patterns of Internet of Things business models. Finally, it indicates some of the key challenges involved in its implementation that will confront in particular companies with a successful history in manufacturing industries.

This article does not shed light on many aspects that are directly connected to Internet of Things business models. For example, there is no mention of the discussion that is so prominent today about technical standards at all the different levels of communication, in particular the last mile (from smart things to the first classic Internet computer), nor is there consideration of the rapid evolution of wireless protocols, the energy issue that overshadows all else, and questions of system robustness, maintainability, and security. This article also does not attempt to describe the topography and development of the suppliers' market, or the specific roles of the manufacturers along the steps in Fig. 4. This essay also cannot go into industry or process-specific applications. The central role of the mobile phone that mediates between and among people, smart things and/or a smart environment and the Internet of Things is not discussed, nor is the emotionalization of the physical world, which occurs when a thing responds in real time to its environment, awakened to what feels like life[13] and influences the behavior of its environment, including people, in a qualitatively new way.

Indeed, this essay raises more questions than it answers. Some can now be more specifically formulated. It is revealing to read today what was written ten years ago about the Internet of Things. In 10 years it will be interesting to look back and see which of the terms and developments outlined here prove to be lasting and which have receded from view. The Internet of Things remains an academically and economically fascinating and rewarding phenomenon.

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