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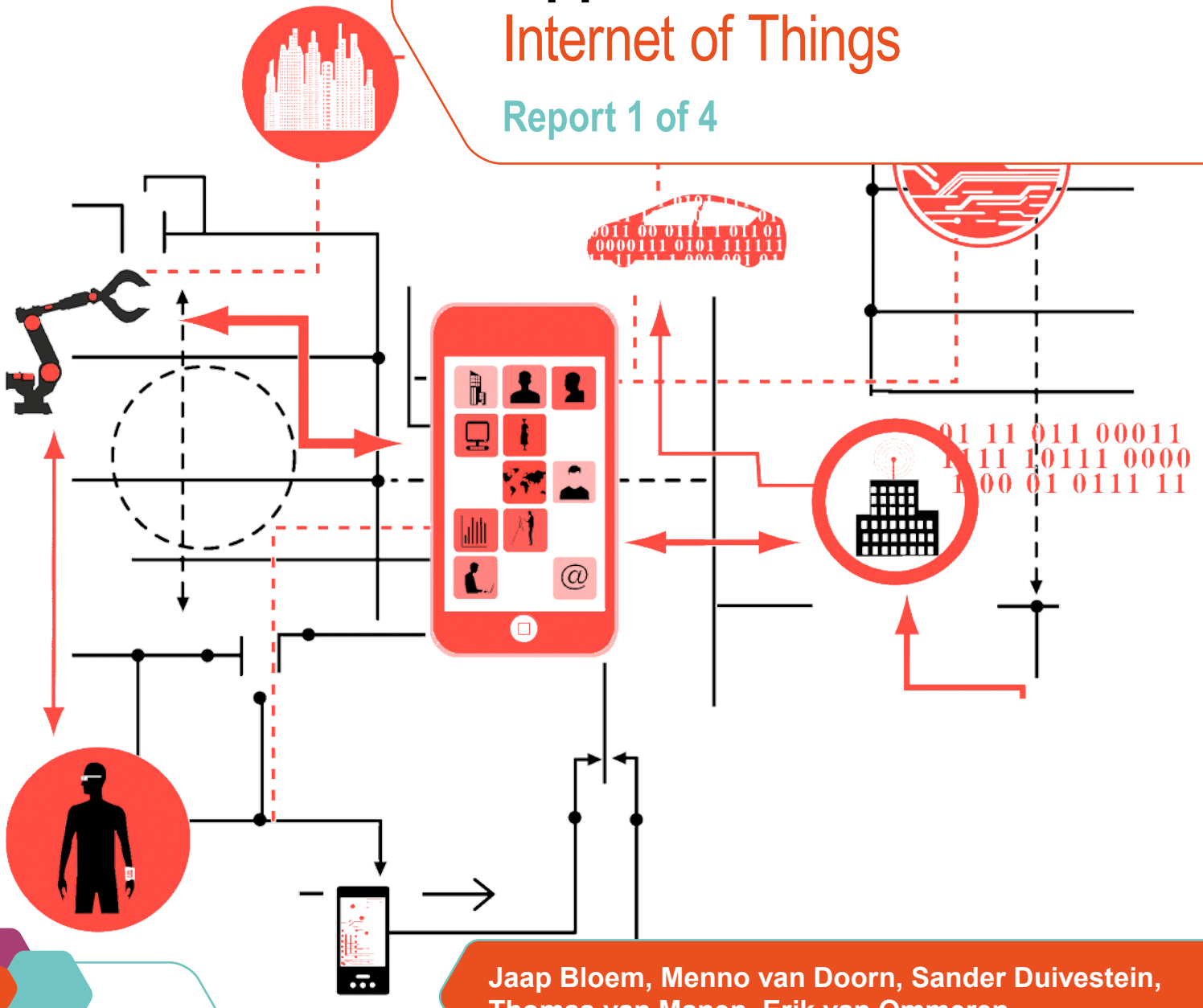
Business Opportunities

Internet of Things

Report 1 of 4



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SOGETILABS

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Book production LINE UP boek en media bv, the Netherlands

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Four new VINT reports on digital things

The rumor began at the end of the previous century: things will arrive on the Internet. Due to the long nose of innovation, as Bill Buxton of Microsoft Research articulates it, it took fifteen years to happen, but now the clamor is becoming deafening and a tipping point is near. In various sizes and shapes, all kinds of startups and established names are claiming breakthroughs, ranging from off-the-shelf sensor hardware platforms such as Arduino and Libelium to giants like IBM and McKinsey.

The relationship between humans, their artifacts and the world around them has always been a fascinating one. The difference nowadays is that we know how to program computers to store everything in cyber-physical systems. That makes it concrete: stretching from smartphones and intelligent pill jars in healthcare chains, to the lifecycles of products and services that place the customer at the center of attention. From *science fiction* to *fact of life*.

From 2000 onward, the world has changed radically in a few major steps, while developments are occurring increasingly rapidly. Social networks, Mobile platforms and apps, advanced Analytics and Big Data, the Cloud and the artificial intelligence of IBM's Watson: taken altogether these form SMAC. Now our THINGS are coming to the fore. SMACT is a decisive breakthrough. Innovation always takes a little longer than anticipated, but miniaturization, cheap sensors, smartphones in the pockets of billions of people, autonomous systems, better batteries, self-steering cars and smart software in the Cloud leave little room for doubt: SMACT is already an established fact.

After four Big Data studies, VINT now devotes four new studies to this mega theme. *THINGS, Internet of Business Opportunities* is the first foray.
The next report will deal with *Wearable Computing* in light of what Google calls *Augmented Humanity*. Everything can be reduced to the threefold chain of human-to-machine (H2M), machine-to-machine (M2M), and machine-to-human (M2H). These may occur in either simple or complex event-and-process chains. SMACT is the ongoing story of an automation that is intervening in life itself to an ever-increasing extent.

But smart cities, artificial intelligence, smartphones, digital surveillance, etc. are not risk-free. For this reason, we also pay attention to economic feasibility and social acceptability in addition to technological achievability and organizational practicability. The bottom line is that doing smart things should be our main concern, not merely making them.

1 Waste as guiding principle

Even prior to its beginning, 2013 was being celebrated as the breakthrough year of the *Internet of Things* (IoT). Toward the end of 2012, The Next Web argued, "Why 2013 will be the year of the Internet of Things," which was soon followed by an article in MIT Technology Review. *THINGS, Internet of Business Opportunities*, the first of our four new research reports, naturally following the ones on Big Data, focuses on the impetus behind this celebratory mood, on the new opportunities for organizations that are now arising, and concludes with five tips on how to accelerate your things approach. Rumors of a tipping point being reached are all around.

We simply talk about *things*: digital and intelligent, for the consumer, industry and society, because there are so many different *Internet of Things* variants. Cisco's *Internet of Everything* deviates from General Electric's *Industrial Internet*, from Bosch's *Internet of Things & Services*, from the Harbor Research's *Internet of Things & People*, and from IBM's *Connecting Everything* or *Smarter Planet*, to mention only a few.

Since 1999, the year in which Kevin Ashton, co-founder of the MIT Auto-ID Center coined the term *Internet of Things* at Procter & Gamble, our digital society has renewed itself several times: with Social (Web 2.0); with Mobile, multi-touch and apps; with Analytics and Big Data; and with Cloud computing. These are known jointly under the acronym SMAC, from Social, Mobile, Analytics and Cloud. The convergence of the four is generally acknowledged as a technology-driven impulse with a major impact on organizations, individuals and societies.

Due to SMAC, the possibilities of new, small and large cyber-physical systems – things – are greater than they were at the end of the previous century. At present, this is primarily due to the smartphone as a dashboard for smart devices and their applications. In this report, we pay particular attention to this SMAC concept and to what it means to add the T (from intelligent THINGS) to this cluster. Whatever the case, the time-to-market and its adoption have been considerably accelerated.

Waste is a core concept in the context of SMAC+THINGS — waste in the sense of the Total Care / No Waste concept, known from Toyota and from Lean. Reducing waste and thus improving efficiency and effectiveness across the board is a good starting point for learning how to recognize the possibilities provided by things and how to capitalize on these. As an appetizer, we provide three examples.

In the world we are now outlining, innovation takes on various new guises as we involve the things surrounding us in the digital game. The philosophical question concerning the things that make up our world is of practical use in stimulating our powers of imagination, as well as in helping to chart the first possibilities.

The risks are also dealt with, including the issue of social acceptability of intelligent things. We conclude with tips to accelerate your own time-to-market and the adoption of your solutions and services.

A concrete way to identify new opportunities of designing and deploying digital things is to focus on waste in its different forms: waste of time, money and productivity, and also unnecessary irritation; waste in the organization, in the chain, around certain occurrences; and waste experienced by the customer, citizen or employee. In order to enable better conceptualization of what we are referring to, we shall first examine three examples in which things play an exceptional role.

The streets of San Francisco

If we knew exactly where to find parking in a certain street, that would save lots of irritation and frustration, waste of fuel and CO_2 emissions. The number of minor accidents would also decline, for if we are only looking at possible parking places, we pay less attention to the traffic around us and to posts etc. Things are different in San Francisco. A quarter of the 28,000 parking meters are linked to sensors in the asphalt, and drivers can find a parking space with the aid of a smartphone app.

Because payment and additional payment can be arranged via the app, fewer fines need to be imposed. The parking wardens are also better off. With the information available on the app, they can go directly to an expired meter instead of randomly looking for them. The income from parking is greater because these smart parking meters adjust their prices on the basis of the number of places available. In this way, traffic on the streets has become safer, the driver's search for parking has become easier, air pollution has been reduced, and savings can be realized in parking enforcement.

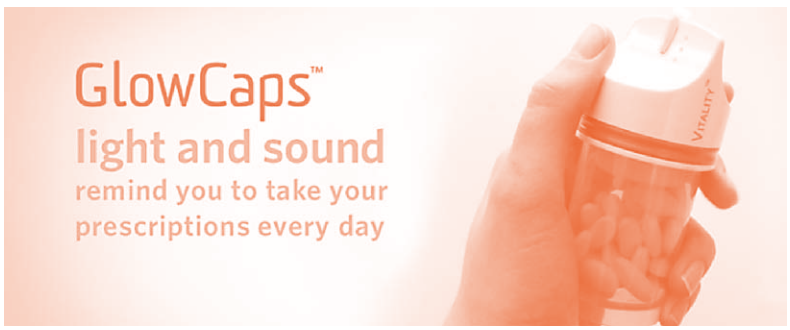
The Dutch polder

Just like factories, modern dairy farming companies are nowadays almost completely automated. The machines and the cows regulate their tasks themselves. If an animal's temperature rises, the farmer receives a signal via a smart pill that has been given to every cow. In this way, diseases can be tackled right at the outset. The temperature is also monitored to check when a cow may be ready for breeding. The modern farmer receives information by SMS.

Thanks to the ear tags, the feeding troughs know whether they are supplying Bertha 1, 2 or 3, and thus each animal profits from the ideal diet. The cows go independently to the milking machine, which automatically connects up to the cow and records the amount of milk each cow produces. If the calcium value or other values deviate from the norm, the milk can be kept apart. An advanced pedometer records the walking activity of each cow. This information is linked to its milk production and to its feeding pattern.

The smart pill jar in the bathroom

If people forget to take their medicine, healthcare costs can soon rise. In America, this rise is estimated at 100 million dollars annually for extra visits to the doctor or the hospital. The GlowCaps pill jar, which communicates within a doctor / pharmacy / family members / patient / monitor / telephone / Internet and e-mail network, helps prevent this waste.



When it is time to take the medicine, the GlowCaps lights up. If the lid is not opened, the device begins to buzz. In this way, the GlowCaps reaches into the social environment. When the jar is empty, the pharmacist receives a message to this effect. A weekly overview is produced with regard to the patient's medicine consumption, and the user can share that with the doctor and with family via e-mail.

Intelligent things in the big picture

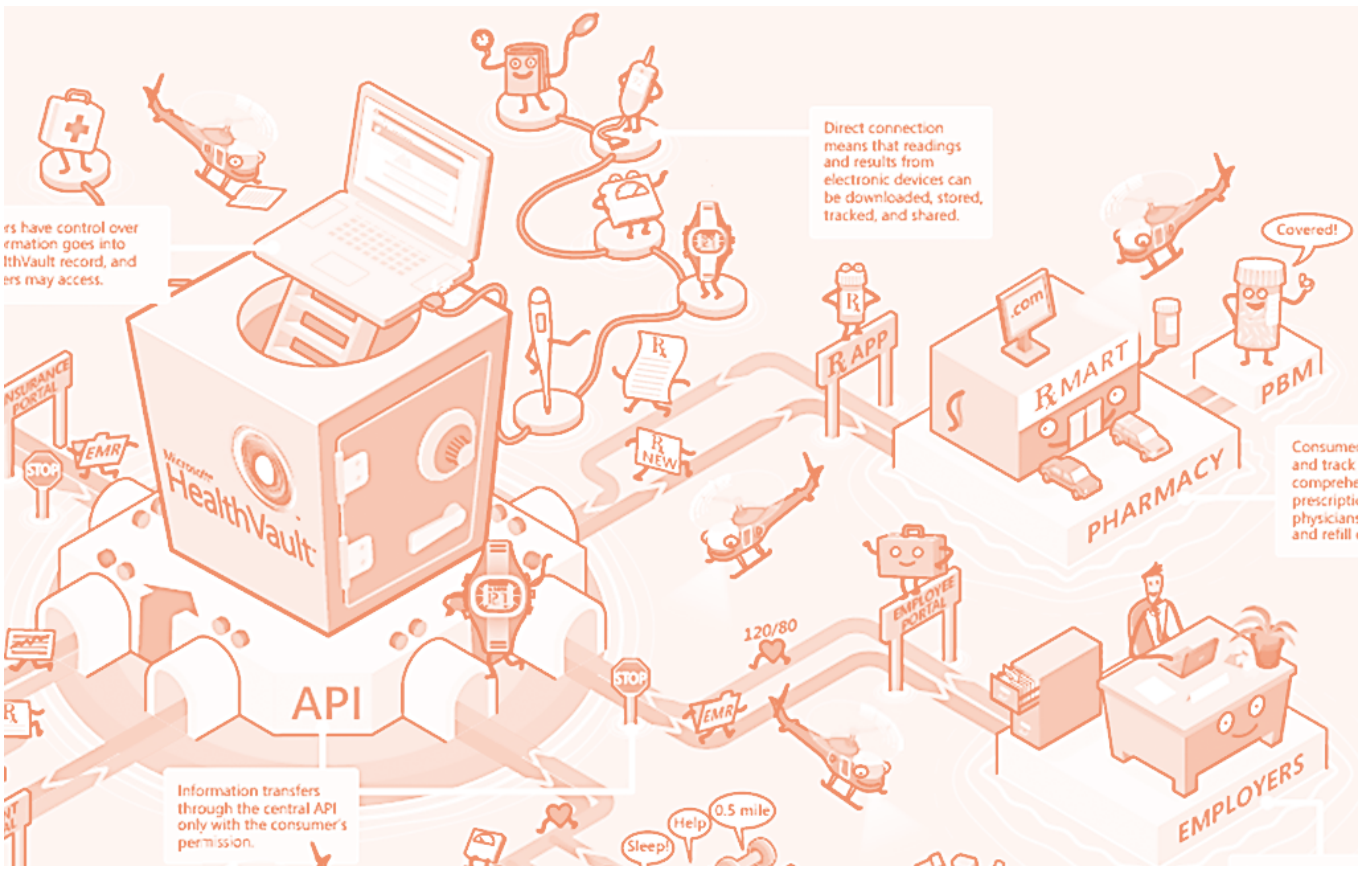
Waste can be successfully tackled by applying digital things to relatively simple activities such as parking and medicine use, or to larger process chains such as dairy farming. San Francisco now has more income from parking, fewer parking fines, fewer parking wardens, less air pollution and fewer accidents. Moreover, drivers also benefit from this system and enjoy greater convenience when parking. With the GlowCaps pill jar, the patient also wins, because he or she does not need to make extra visits to the doctor, while the stock of pills remains at a safe level. The government benefits by better managing healthcare costs, doctors and nurses have less extra work, and the family knows exactly what is going on. Digital things can take an overview on waste by supporting cyber-physical applications that genuinely work.

The term 'intelligent things' refers to:

Physical objects that gather and transmit information, and act more or less autonomously. The richer the information and the greater the use of software and often sensors, the smarter the thing and the application in question.

New insights gained from large amounts of data are currently expanding the boundaries of intelligence, as is the case with IBM's Watson computer, which won the Jeopardy television quiz, beating the two best players, and is now used commercially in more and more areas of expertise. A new generation of self-learning systems has arrived and will shortly become part of better, faster and richer Cloud services.

Tackling waste with relatively simple cyber-physical things and systems also leads to excellent new optimizations and innovations. There are many applications available nowadays, and a patented killer-app can cause a sensitive shift in the quality and speed of services in simple or more complex process chains.



In its HealthVault scenario, for example, Microsoft sketches a smart future for healthcare. On the extreme right of the illustration, behind the pharmacy, we see the smart GlowCaps pill jar. Imagine that Watson computers were to participate in this scheme …

This illustration covers only a quarter of the total wall image. The Microsoft HealthVault ecosystem gives people insight into their own health data. Information is collected, stored safely, and shared with family and healthcare organizations. Apps and all kinds of devices can be digitally connected up to chart a patient's physical condition, diet, treatment and care requirements.

2 Humans and their (sm)artifacts

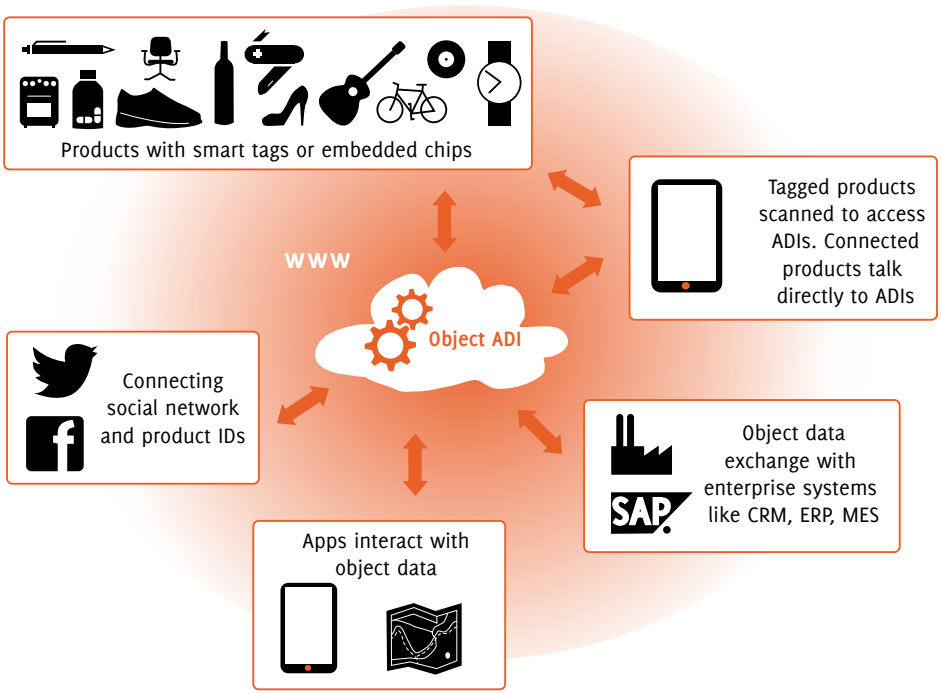
People and the things around them: do these include only their own artifacts, or does the forest that cools buildings a kilometer away or the Earth's crust that functions as a source of heat also fall into this category? In a cyber-physical world, it makes no difference at all. With micro-electronics, nano-electronics and nano-materials, we incorporate everything that is conceivable. We extend the reach of our senses by means of sensors. We no longer need to worry about such autonomous, self-regulating and self-repairing systems.

In this context it is important to pose an old question: What does our world consist of? We need to ask that because we are now going to tinker with it, build on it and program it. The answer is: It consists of the planet, the weather, wild and cultivated flora and fauna, people, our economy, our currency and organizations, our governments and politics and, not least, all the things we have made — ranging from walking sticks to smartphones, automobiles to footballs, houses and buildings to the megalopolises in which we live, all artifacts and infrastructures within and without: clothes, prosthetics, production resources and services. From recreation to healthcare to energy supplies. Viewed in this way, with digital things we truly will be building an Internet of Everything.

The Internet of Things and Auto-ID

At the end of the previous century, Procter & Gamble started equipping their products with RFID (Radio Frequency Identification) so that they could track their goods cheaply and easily via the Internet. This was the birth of the *Internet of Things*. After the Teleautomaton of Nikola Tesla (1926), the cybernetics of Norbert Wiener (1948), the first embedded Apollo Guidance System (1966), and the Ubiquitous and Pervasive Computing of Xerox PARC Chief Technologist Mark Weiser (1988), it was now possible to include not only people but also things in our cyber-physical universe.

A modern variant of Procter & Gamble's Auto-ID gadget is the *Evrythng engine: an Active Digital Identity (ADI) on the Web for every thing*. All kinds of SMACT connections are conceivable via the Object ADI Cloud, as the following illustration demonstrates. In the upper left-hand corner we have the *Things*, in the middle there is the *Cloud*, in the lower left-hand corner we have the *Social media*, the lower right-hand corner is for *Analytics* and two times the *Mobile smartphone* or other app devices.



It is interesting to see how we can control and organize our whole living environment quite simply by means of digital and networked things, services and solutions. Smart, clever or intelligent applications that monitor whether or not — and often the way in which — its own or a correlated function is performing properly. Sometimes it will automatically rectify functionally poor performances but, normally, digital things indicate that action has to be undertaken: via a signal to the supervisors or to another digital thing in a certain process system.

Toward cyber-physical systems

In 2013, the digital things evolution has been drawn into the jet stream — with our car as a *Smartphone-on-Wheels*, smart streets that know where a parking place is available, and a smart pill jar that can ultimately develop into an essential component of a much more efficient healthcare system. A healthy, clever living environment, with no wasted time and furnished with all available conveniences.

The same applies to factories, shops, cities, from which the unnecessary and the surplus have been banished. In combination with people (the customer, citizen or employee) and thanks to cyber-physical systems, everything is converging. This is the final goal of the digital connection of objects and systems: all of which are human (sm)artifacts that enable an organically functioning, well-organized world integrating everyday domains in to our complete ecosystem: including nature and climate.

In addition to technological achievability, organizational feasibility and economic viability, there is the issue of social desirability. Do we really want this form of evolution and, if so, what are the risks involved?

3 SMAC plus THINGS as a focus

It's common knowledge: *Nexus* is the name of some smartphones and tablets. We also encounter the name on the gears of bicycles. Originally the Latin word *nexus* referred to the connection of things. In everyday English it means: center, focus of attention, bicycle hub. Gartner uses *nexus* as the concentration of central digital domains in the expression "*Nexus of Forces*:" Social, Mobile, Information and Cloud clustered together. If we exchange the non-specific Information for Analytics, we get SMAC. IBM, among others, uses it in that sense: this convergence is an overwhelming breakthrough, a tipping point.

The essence is Being Digital

SMAC became popular in 2012, and is here to stay. Altogether, the SMAC domains are the fulfillment of what Nicholas Negroponte stated in his book *Being Digital*, which dates from 1995: *"Computing is not about computers anymore, it's about living."* SMAC is embedded in ordinary life, and that can easily be called a breakthrough. This will certainly be the case when billions of people on earth possess an affordable smartphone or tablet. Here is a concise list of the facts behind SMAC, as related to Being Digital:

Being Digital
1995 — *"Computing is not about computers anymore, it's about living."* (Nicholas Negroponte).

Social
2004 — Web 2.0 and Facebook (1.15 billion users in August 2013), followed by many other private and professional social media platforms, in addition to e-mail and chat. At present, many digital applications have an important social media component.

Mobile
2007, 2008, 2010 — The iPhone, the iPad, their "clones" (almost 1.5 billion users and moving rapidly toward 2 billion), plus mobile apps (more than 100 billion downloads) form the largest digital device trend ever. In the field of lifestyle, media, games, communication, and also professions, the slogan is: *Bring Your Own Device.*

Analytics
2012 — Data-intensive computing and analytics make a large-scale breakthrough with the *U.S. Big Data Research and Development Initiative*. Big Data follows the historical trend of Big Science, web analytics, new algorithms and frameworks such as MapReduce and — let's not forget — espionage programs such as Prism.

Cloud
2006 — *Amazon Elastic Compute Cloud* was the first platform that used the word "cloud" in its name. After that, cloud became a generic term.

The focus now lies on mobile and lifestyle

Until 2015, SMAC will deal with the further development of affordable mobile devices with increasingly better functionality and apps. In the meantime, the digitization of life will continue at an increasingly brisk rate. The current SMAC focus on smartphones and tablets for the next few billion people will intensify the adoption race we saw with PCs and PDAs and, separately, that of mobile telephones and game consoles.

PCs and PDAs were and are intended to be productivity tools for knowledge workers. However, with such devices, much of the stand-alone functionality, oriented toward office automation, remained unused. With apps on the always-on and always-online touch screens, times have changed. Traditional PC and PDA use is diminishing drastically. Seen from a lifestyle perspective, affordable smartphones, tablets and their apps are largely and rapidly replacing the PC, the PDA, the telephone and the game console. Sensors and GPS link them to our senses and locations.

The next step is SMAC + THINGS

Besides through the M in SMAC, the digitization of life is now rapidly expanding, largely via our artifacts. Because SMAC does not cover this aspect, we add the T of THINGS to this cluster. Now that the "nexus" of SMAC is intensifying and personalizing our experiences, the addition of the things around us is a logical next development in this process thanks to miniaturization, sensor development and affordable components.

The result of SMAC + T sounds like "smacked:" an established fact. The inevitable development of digitally connected things is already perceptible in our energy supply, in domotica, in physical infrastructures, in transport, in healthcare, in the retail trade and in our urban living environment.

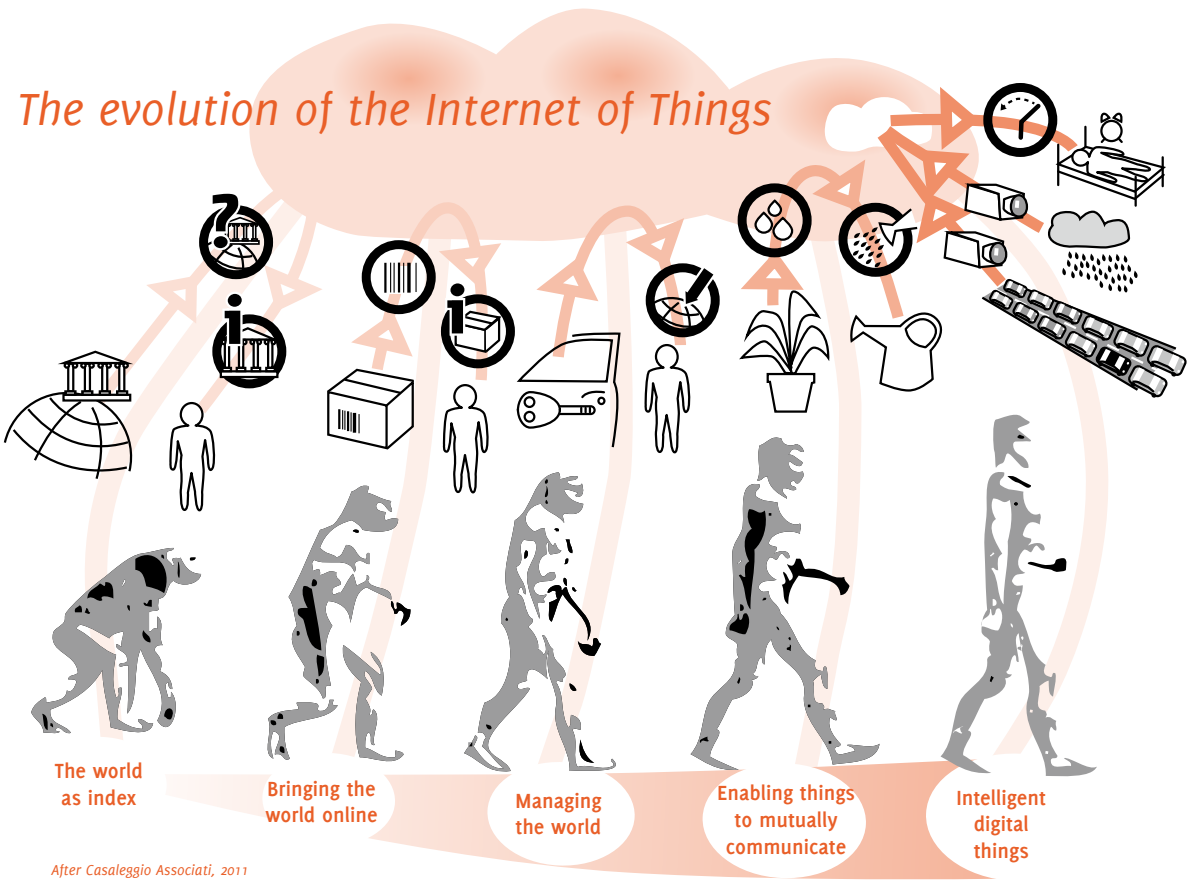
Via these domains, SMACT is extending its influence to economic sectors and the manufacturing industry, where it dovetails seamlessly with the embedded systems present there. The three communication denominators of digital things are: *human-to-machine* (H2M), *machine-to-machine* (M2M) and *machine-to-human* (M2H). All three often occur in more complex and less complex application chains. H2M, M2M and M2H simply form the core of process automation, autonomous systems and intensive interaction with humans — with the basic aim of restricting the necessity of human intervention, an inexcusable form of waste.

We must not ignore the fact that THINGS, in combination with SMAC, form a new, potentially disruptive wave of innovation. It is essential to be prepared, to recognize the opportunities provided by event and process chains, and to react to these. Waiting can be risky, because developments are happening increasingly quickly and those who take an early lead will not readily relinquish it. Capitalizing on the first-mover advantage is more important than ever, and relying upon cash cows for too long can be very risky.

4 The car and the integration of things

In 2011, advisory firm Casaleggio Associati published the following taxonomy of the development of the *Internet of Things*. It distinguishes five domains:

- The world as index
- Bringing the world online
- Managing the world
- Enabling things to mutually communicate
- Intelligent digital things



After Casaleggio Associati, 2011

In 2013, we see the five Casaleggio domains converging. Boundaries are dissolving and our life is becoming increasingly integrated through sensor systems and applications based on intelligent digital things: ranging from the manufacturing industry to the environment, our cities, healthcare, and all kinds of professional and lifestyle applications. The car is a good example in this context.

The report entitled *Connected Car Industry 2013*, to which seven major car manufacturers, a number of analyst's offices and a consortium of eight mobile operators contributed, states that we will soon experience another tipping point: twentyfold growth of the connected car market in 2022. The most important precondition is collaboration between all parties involved. Machine-to-machine communication in the chain, from the car to various other devices, is the essential factor here.

If we examine Casaleggio's figure from left to right, we see that it all begins with the identity of the car, linked to "bringing the world online." This is done by, for example, insurers along with mobile operators and a Cloud partner. *Ingenie* is an example of the type of product in question. The driver is given a black box in the car, and this is fitted to the OBD (on-board diagnostics) system that is a standard feature of the car. The insurer establishes the insurance premium on the basis of the driver's conduct on the road. The insurer not only knows whether or not the car is being driven but also where and how. Turning left without using a traffic indicator, or not wearing a safety belt — the insurer knows exactly what the driver does. The black box communicates with the car and also with the pay system for the insurance premium.

New Hyundai models, to mention a popular brand, send a monthly update to a smartphone to register "how the car feels." If something is not quite right, a message is sent to the garage for a service appointment. Honda expects to introduce its "smartphoned" models in 2015. Doors will open and close by means of an app, and the seats and mirrors will be adjusted to comply with the telephone profile. Tesla, the Californian manufacturer of electric cars, will be the first to perform service tasks at electricity supply points by installing software for better battery management, for example. Audi, BMW, Ford, General Motors — all automobile brands are on the same track.

In the near future, electric cars will be connected to the so-called Smart Grid. The car battery will communicate with the solar panels, the washing machine and the refrigerator, and with the energy supplier. Advanced analytics that determine the peak load of the electricity network will ensure that energy wastage will be tackled.

Other interesting examples are the American ZipCar and the European Greenwheels. With the concept of "wheels when you need them" they have placed a new formula on the market. In just a few second you can reserve a car at an address somewhere in the neighborhood and you can pick it up and drive off thanks to an app on your smartphone, which also opens the doors of the car. You no longer need to visit a car-hire company and even car keys are surplus to requirements. All this brings only benefit, and waste is again reduced.

If we examine Casaleggio's five domains – from left to right – we see that the foundation has been laid for this system by the fact that the cars are traceable and can thus be followed: "the world is brought online." The user experiences "the world as an index," as he can now search for cars in the vicinity and check whether or not they may be available.

The interaction runs from *human-to-machine* (H2M) via *machine-to-machine* (M2M) and *machine-to-human* (M2H) in event-triggered contextual feedback loops. The office of the lending company can remain closed and schedule planners are no longer necessary. Intelligence is added by sending handy notifications to the driver or instructions to the car. Our (sm)artifacts take superfluous hassle off our hands and thus help counteract waste.

The most advanced example of "intelligent digital things" is the self-driving car. Audi also provides this kind of automatic pilot and, just like Google, has obtained a license to take to the roads. The cars are aware of the surroundings and process 1 gigabyte of sensor data a second.

The parties that collaborated on the *Connected Car Industry 2013* report are convinced that cars will soon be driving autonomously, although no one dares to make a hard prediction yet. We will first see a semi-autonomous car, which keeps a safe distance from other vehicles, and is more aware of the surroundings thanks to *vehicle-to-vehicle* (V2V) and *vehicle-to-infrastructure* (V2I) communication.

5 Things in the fight against waste

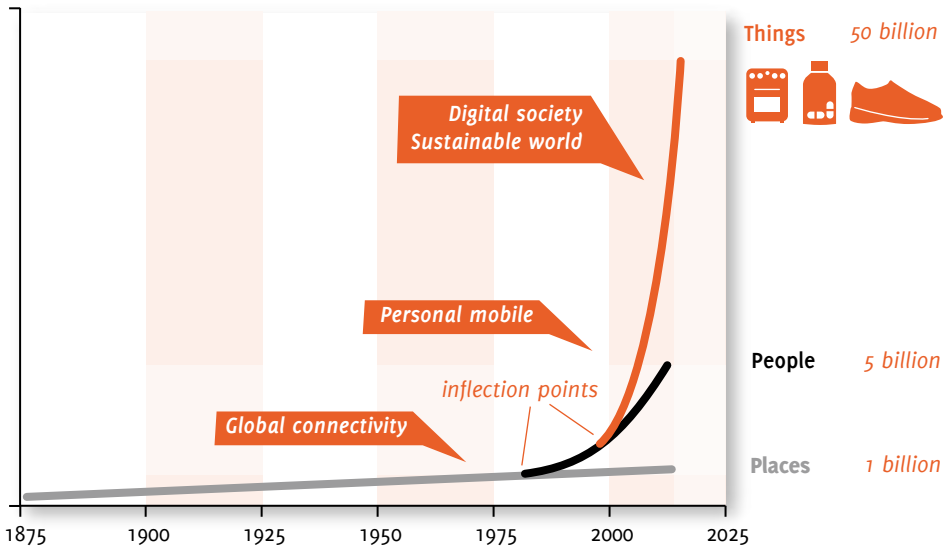
Most people refer to the "Internet of Things." We prefer "… of Things and Services," states Bosch. "Of Everything," says Cisco. "Of Things and People," according to Harbor Research. "Of Things and Sensors and Actuators," corrects Vint Cerf. "Social Web of Things," claims Ericsson. No, "I-SMAC: Internet of Everything plus Social, Mobile, Analytics & Cloud," according to Return on Intelligence.

One thing is clear: everyone recognizes the SMACT trend and its significance, tries to fit it into their own system, and gives it their own angle. We see the advent of an important new tipping point in 2015, and will give our take on the apparent rivalry between the different flavors or schools of things.

Humans, their artifacts and everything around us. The more the categories of digital and physical blend together, the more fundamental the issue becomes: linking the digital with the physical is our chance and challenge, our task and our talent, our strength and weakness — but how should we deal with this in order to reduce and prevent waste?

The usefulness of our artifacts must be evident, otherwise we do not need them, we would be just as well off without them. That applies most to *digitalia*. These things cost almost nothing and are produced in no time. And thus in abundance. Digital things at least help us to pass the time. And we have time on our hands with all those applications that perform our work. But what does that ultimately deliver? How can we separate the wheat from the chaff, to prevent waste? It is a question of usefulness and ease versus waste and laziness.

Many things are physically present and always fit into situations and processes that are continually changing. This transience is the virtual glue, as it were, that gives life its structure. Dealing with it digitally — with tangible things in rapidly changing SMAC situations and processes — offers an enormous potential as well as major risks of wastage. Therefore a well-considered approach is of paramount importance. Accordingly, it is advisable to focus on minimization and waste. We must try to realize the former and avoid the latter. A digital infrastructure for life itself can offer enormous benefit. But which solutions do we really need and which can we discard? In the complexity of SMACT, this question is more essential than ever.



Source: Ericsson (2010): Infrastructure Innovation — Can the Challenge be met?

In technological terms, we know where we are going: at least 50 billion connected devices in 2020, 5 billion people and 1 billion locations. In the meantime, Ericsson, McKinsey, Cisco, IBM, Bosch, the Fraunhofer Institute, Advanced Risk Machines, General Electric, Harbor Research and others vie enthusiastically with one another with regard to the impact of intelligent, digital things: in economic sectors, in sector-transgressing domains, and in trans-sectorial innovation.

Towards a decisive tipping point

Instead of presenting a host of diverse prognoses, extrapolations and overlapping angles of approach, we now outline what we expect to happen in terms of prime IT developments within a forseeable period of five years, on the basis of recent facts. We align ourselves with the 21 sectorial studies that *The Industrial College of the Armed Forces, National Defense University, Fort McNair, Washington D.C.* published in spring 2012. Their *Final Report: Information and Communications Industry Study* on the IT sector, which discusses the corresponding business opportunities, places the *Internet of Things* on the following timeline:

0–18 months from spring 2012 on — this period now lies behind us

The focus is on mobile computing, and we will see an explosion of smartphones and tablets. Privacy and security remain tricky issues, especially in the context of cyber security and legislation. This has proven to be correct, including all commotion around covert operations by secret services like the NSA and a true device explosion at the end of 2013.

18–36 months from spring 2012 on — that is the coming months

Internet connectivity is spreading fast across the economy. Already in 2008, there were more digital things than people connected to the Internet. Mobile devices

assume the function of intermediary between the Internet and the expanding development of things and services.

There is no reason to doubt this development, at least for the coming twelve months. In 2008, there were already more digital things than people connected to the Internet. Indeed we see mobile devices assuming the function of intermediary between the current Internet and the expanding development of things. To elaborate on this, in the following section we shall cover various enthusiastic prognoses articulated by a number of leading market parties.

3–5 years after spring 2012 — from 2015 onward

The development of the *Internet of Things* will accelerate. In particular autonomous machine-to-machine communication is assumed to evolve rapidly. The so-called Smart Grid (efficient energy supply via feedback loops) will further develop, and Internet connectivity is becoming increasingly "ubiquitous" and "pervasive" in the cyber-physical world of people, things, services, apps and websites. Plenty of examples can already be mentioned: the *Connected Car* (see section 4), *Wearable Computing* such as Google Glass and the Nike FuelBand, *Industry 4.0* or the intelligent *Internet of Things* for the German manufacturing industry, etc.

From the beginning of 2015 onward, the development of things, in combination with SMAC, will start to show a real breakthrough. It is therefore important to make preparations as soon as possible. After the smartphone and tablet explosion, intelligent things are the next post-PC stage on the consumer side. This trend has already been present in the manufacturing industry for some time, with the development of industrial automation and chain automation toward mature Product Lifecycle Management across the entire front.

A number of breakthroughs have already been identified and these make a things tipping point additionally plausible around that time: batteries have become much more efficient, the charging time of devices is gradually decreasing, Cloud environments are becoming increasingly powerful and economical, new interfaces and sensor-based forms of interaction are in the pipeline, and devices, sensors, etc. are becoming ever-cheaper. In summary:

1. A decisive tipping point is on its way: spring 2015.
2. If you do not prepare for this now, you will miss the first wave, for developments are occurring increasingly rapidly.
3. This could well be decisive, as first-mover advantage is becoming more and more important.

6 The SMACT era of business opportunities

Where will all this additional smartness become palpable? The answer is simple: in all facets of the economy. The current discourse on things makes it clear that it will be impossible to elude the impact of things. We have already acknowledged this in the rivalry between the various things schools that we mentioned above, and the answer that we gave.

We can continue our list of evaluations: Forrester Research speaks of *Internets of Things* (plural), the American National Science Foundation has a broader approach and talks about *Cyber-Physical Systems*. Marc Davis of Microsoft introduced the *Web of The World*. MIT prefers to focus on the fact that things can think: *Things that Think*. General Electric refers to the *Industrial Internet*. The Georgia Institute of Technology has published a paper on the *Internet of Nano-Things*.

Thus, the message resounding on many fronts is that a things tipping point is in the pipeline. In comparison to fifteen years ago, economic expectations have exploded. The enormous reduction in the cost of chips and sensors is contributing to this anticipated growth. In the past five years, the costs of Micro Electro-Mechanical Systems (MEMS) have decreased by 80 per cent and people are now working with chips that are just as cheap as the chips one can eat. We have seen how the RFID market is evolving: a fourfold increase in 2014 to 20 billion dollars within three years.

In terms of numbers, the loudest drumroll is currently being produced by Cisco that, in June 2013, estimated the present potential of things at 613 billion dollars, and presumes that the market will amount to no less than 14,400 billion dollars in 2023. In this context, Cisco is talking about savings — the reduction of waste — plus the direct sale of products.

General Electric, which primarily focuses on its *Industrial Internet*, beginning with sensors in turbines — *Things that Spin*, as GE puts it — gives more modest figures. Initially they speak about thousands of billions: 32,300 as the business opportunity of the total Industrial Internet, and by 2025 possibly even 82,000, but GE considers savings of 150 billion to be realistic if all machines become smarter.

McKinsey assesses the economic impact of the *Internet of Things* at somewhere between 2700 and 6200 billion dollars in 2025, with the healthcare sector, infrastructure and public-sector services as the most promising domains. McKinsey's figures have not taken wearable computers, such as Google Glass or the Fitbit, into consideration. These things are classified under Mobile Internet, whose total economic impact in 2025 is estimated to be worth 3,700 to 10,800 billion dollars.

To illustrate this point further, we provide an overview of the yields from embedded systems worldwide, taken from the EU report *Design of Future Embedded Systems toward Systems of Systems. Trends and Challenges.* Here too, we see a multi-billion dollar market. It is predicted that the largest growth will occur in the energy sector, which was actually the smallest in 2010.

Worldwide Embedded Systems Revenue, 2010–2015 (millions of euros)

Industry	2010	2012	2015	2010–2015 CAGR (%)
Automotive	58,211	78,848	103,289	12.2%
Industrial[1]	132,343	158,739	207,383	9.4%
Healthcare	43,650	54,266	75,048	11.4%
Energy[2]	41,275	64,564	180,909	34.4%
Communications	330,024	458,623	614,458	13.2%
Consumer	246,554	284,503	333,050	6.2%
Total	852,057	1,099,543	1,514,137	12.2%

Notes:
1) Includes aerospace and defence, industrial automation, services (kiosks, PoS, video surveillance, test and measurement), industrial PCs, handheld terminals.
2) Includes energy consumption points (home/building), renewable energy, electricity T&D
Source: IDC, 2011

Forrester Research avoids making hard predictions about the impact of things. Sarah Rotmann Epps, an analyst at Forrester Research, draws a comparison with plastics in the fifties. Estimating the economic impact a new basic material will actually have — plastics, IoT, etc.– is an impossible task. However, the fact that the impact will be substantial is without doubt.

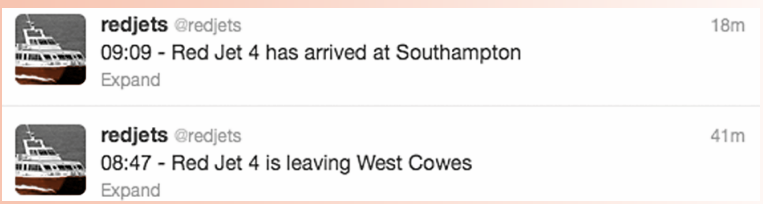
Digital things are now presented as YASNY: "You Ain't Seen Nothing Yet." By MIT for example, which proclaimed 2013 as the year of the *Internet of Things*, or by IBM, Cisco, Intel, General Electric, Philips, who have all staked their future on this development, at least partially. This enthusiasm would seem to be justified, but the justification comes primarily from the boom on the periphery of things: the role of the social media, the smartphone and the tablet, the Cloud, the new forms of data analysis. For instance, we are now working on a new ecosystem to make smarter things and do smarter things.

SMACT: social media make things more engaging

Social media are used as notification, co-operative platforms, or forms of social engagement in relation to things. This social interaction increases the chances of use and success. At the end of 2004, the year in which Facebook was introduced, the social network had 1 million users. In March 2013, this was 1.1 billion. Nowadays, it is impossible to imagine everyday information exchange without Twitter, which started

its business two years after Facebook. Every second, Twitter receives more than 9,000 new tweets and the service currently has more than 500 million users.

The ferryboats serving the Isle of Wight form a good example of useful and easily accessed information based on tweets. These "Redjets" broadcast their position via GPS. Andy Stanford-Clark, an Internet of Things expert and "master inventor" at IBM, picked up the signals and started to send them on via Twitter. By means of geo-fencing techniques he managed to mark the places of departure and arrival, and to send notifications on this basis. Every ferry now has its own Twitter account and we can follow the boats and send messages to them if required. The ferryboat service has now placed the tweets on its own website so that people can follow the times of departure and arrival.



SMACT: the mobile smartphone as a sensor-rich intermediary

Apple's introduction of the smartphone in 2007 has had various effects, as described in our book entitled *The App Effect*. The spread of built-in sensors began with the introduction of the smartphone, and being an important multifunctional Thing, certainly the smartphone in combination with all the available apps — it now functions as an intermediary between things and humans.

Sensor type	iOS 5	Android	Windows 8
Ambient light sensor	✓	✓	✓
Audio (microphones)	✓	✓	✓
Camera(s)	✓	✓	✓
Humidity sensor		✓	
Inertial motion sensors:			
• Accelerometer	✓	✓	✓
• Magnetometer	✓	✓	✓
• Gyroscope	✓	✓	✓
Pressure sensor (barometer)		✓	
Proximity sensor	✓	✓	✓
Temperature	✓	✓	✓

This was the situation in October 2012, and we can now connect all kinds of more advanced devices to our smartphones in addition to the above-mentioned sensors and the apps that make use of them.

With **Lapka**, the iPhone works as a basis station for a number of extra sensors. Humidity, temperature, electromagnetic radiation and nitrates can be displayed on the app. For example, we can for instance test whether or not an apple has been "organically" grown by examining the amount of nitrate that Lapka registers.

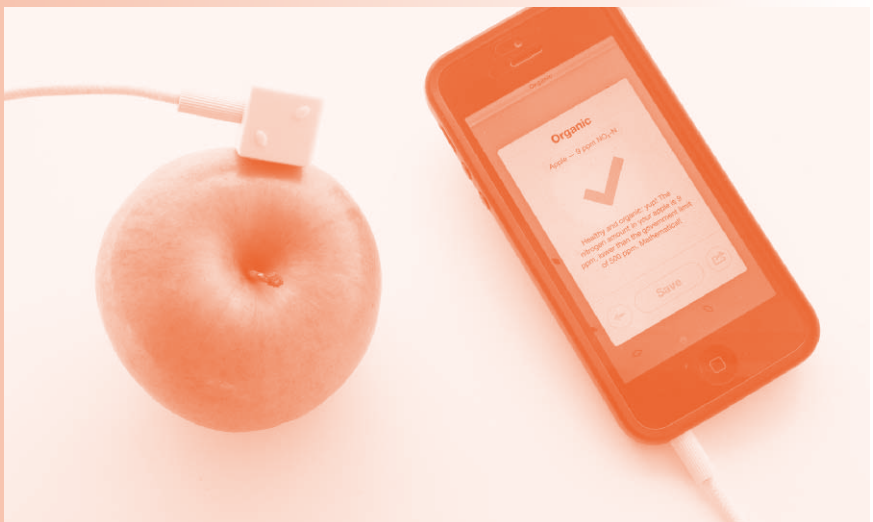


Photo by Alex Washburn/Wired

SMACT: analytics makes things smarter and clients more satisfied

APIs are the links by means of which we connect things to software functionality, services and consumers. APIs enable direct feedback. For example, the makers of the Nest thermostat use the data from hundreds of thousands of houses to optimize their energy-saving algorithms and to enable them to work as efficiently as possible in each individual situation. The manufacturer of the iRhythm medical device monitors feedback data in order to check whether or not the devices are working optimally. If not, an update is sent to the device.

APIs provide all kinds of update possibilities. The Analytics side of digital things extends the customer journey, enhances customer intimacy, and ultimately increases the satisfaction and lifecycle of the product annex service.

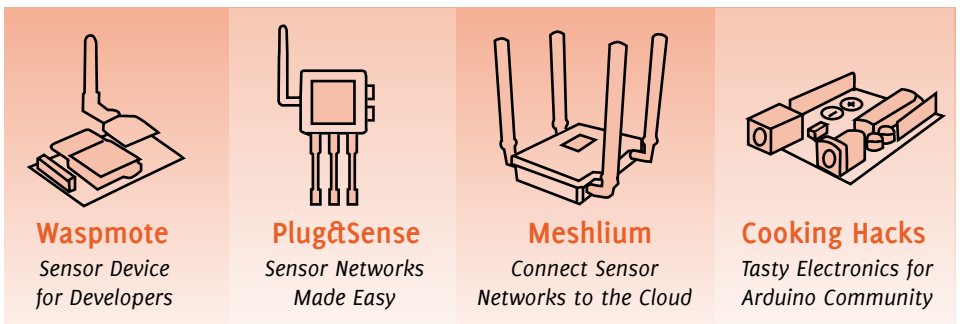
SMACT: the Cloud makes services more simple

Standard solutions, such as Amazon's Elastic Compute Cloud (2006) or Azure from Microsoft, make it easier to establish contact with things. Specific IoT platforms, such as IBM's MessageSite for example, accelerate activities even more. MessageSite processes 13 million messages a second and can process data from one million sensors. It supports new service models in the automobile industry, for instance, where the dealer receives messages from the sensors in the cars he has in service. A "check engine" message from a customer arrives via the Cloud at the garage and the garage owner subsequently makes contact with the customer for a specific service action.

SMACT: solutions on the basis of reliable things building blocks

There is an abundance of noteworthy projects, such as those created with the popular things platform Arduino. At number 10 in the top 40 is BotaniCalls, the humidity sensor that sends a tweet from the soil to our telephone when a plant needs water. Using Arduino we can also make rotating disks that work on solar energy and move with the sun so that our fuchsia develops flowers evenly all round. This may sound bizarre, but when applied in Digital Horticulture it does genuinely bring extra productivity and money.

Such innovations form the core business of the Dutch company Sense-OS (Observation Systems). And horticulture, agriculture and nutrition belong to the most important areas of concern for the present and the future, just as water management and sensors in reservoirs do.



Sensor start-up Libelium's IoT products

Another good example of low-cost SMACT innovation is the African weather station project run by students at Delft University of Technology. There are far too few weather stations in Africa, although the weather in that continent strongly determines the weather in the rest of the world. When it rains, the rain-gauge is soon broken, and humidity sensors are rather expensive. However, the standard microphones in mobile phones are not so expensive, and they are almost indestructible. So, the thing to do is to put them all into small boxes and deposit 100,000 of them at strategic spots in Africa. When it rains, you can then hear where the rain is falling, how heavy it is, and how long it lasts.

The parallel with what happened in the previous century regarding Internet and software development will be evident: again we see fertile hyper-dynamics between the major players and enthusiastic starters. The so-called "quantified selfers" fall into this category. They gather data on themselves by means of smart meters and wearables and suchlike. This kind of insight can provide suppliers with input for innovations in products and services.

7 The risks of a smart future

Everyone is anti-waste, so it is only normal to want smarter products and smart cities. But there are also risks involved. In an article in *The Guardian*, sociologist Richard Sennet stated that no one wants to live in a city where life is preprogrammed to an excessive degree, where houses all look the same, and where the citizens can no longer follow their own lifestyle. Moreover, there are all kinds of ongoing developments in the field of security and privacy. The hacking of things has become enormously popular. Finally, there is the debate about unemployment that is currently being associated with technical progress and things-related technologies. In the debate on things and the smart future, these are the principle themes with regard to risk.

Safety first always comes afterwards

Vint Cerf, one of the founding fathers of the Internet, pleads for the closure of the Internet of Things due to the risks involved. He sketches a scenario in which hackers gain access to airco systems that are subsequently activated *en masse* and thus overload the energy network.

Access to the aircos begins with tracing their positions. This can be done by means of Shodan, *The Scariest Search Engine on the Web*, as CNN described it. Shodan is a search engine for devices, such as traffic-light systems, security cameras, the control system for a waterpark, a gas station, and even control systems for a nuclear plant. In March 2013, the search term "default password" produced a frightening number of hits with regard to non-secured critical systems.

The hackers' conference DEF CON of summer 2013 opened with a number of embedded systems hacks involving the Toyota Prius and the Ford Escape. Among other things the hackers could manipulate the speedometer, turn off the brakes and sound the car's horn. Scientists at the University of Washington and the University of California had already demonstrated that they were capable of hacking connected cars. Similar apprehensions apply to smart houses.

Secret services also make use of hacks and malware to attack cyber-physical systems. The most well-known example, before Edward Snowden started to reveal covert intelligence operations, is the so-called "Stuxnet" virus. In 2010, the Iranian president admitted that the virus had damaged a nuclear installation. The spread of the virus allegedly occurred via Windows software and printers, and infected the Siemens software that operated the centrifuges of the installation.

Big Brothers strengthen their grip

The smart city embodies the ultimate tackling of waste, while at the same time it can also represent a decisive opportunity to increase the grip on citizens. Smart cities, such as New Songdo in South Korea and Masdar City in the United Arab Emirates, have been praised for their ambitions concerning CO_2 emission, energy usage, and security. The measuring and regulating systems required to realize such advances are so intrusive that some people speak of "the green police" who have the city under their control. For example, the government registers the number of kilograms of waste a household throws out. Rubbish can only be discarded by using a smart card, so all waste can be tracked down to the source.

In the light of the current commotion around NSA's Prism and Xkeyscore programs, monitoring has become a seriously delicate issue. Whereas secret services all over the world monitor the whole of digital space for suspicious patterns, Internet connected things open the door for a physical variant, such as data surveillance. Mayor Bloomberg of New York wishes to expand the network of security cameras in his city as a consequence of the terrorist attack in Boston. Smart cameras will become a part of an analytical system called "The Dashboard." In this system, emergency calls, arrests, crime patterns and video data will all be combined. Working with Microsoft, the system will be constructed over the next three years. Mayor Bloomberg comments:

> *"You're never going to know where all of our cameras are. And that's one of the ways you deter people; they just don't know whether the person sitting next to you is somebody sitting there or a detective watching."*

Privacy is a prominent issue in many fields. What do we think about the bracelets produced by IntelligentM that check whether or not doctors wash their hands sufficiently? Although the aim of this development is to prevent the spread of bacteria, it is debatable if this is the best means to do so. Isn't it a matter of over-patronizing? Nevertheless, with respect to liability regarding hospital infections, this kind of development is certainly justifiable. The evidence in legal cases could come from data from such smart products, but in general, sensor-based surveillance provokes many new privacy issues.

Even more unemployment as a result of digital things

In their book *Race against the machine*, MIT scientists Eric Brynjolfsson and Andrew McAfee calculate the extent to which technological progress leads to unemployment. They observe a deviation from the trend from 2000 onward, with productivity increasing while job growth stagnates. This exceptional situation has also been observed by Paul Krugman, economist and Nobel Prize winner. He points to disruptive technologies that ensure that this development cannot easily be halted. The Internet of Things occupies an important position on the list to which Krugman refers.

Stanford professor W. Brian Arthur speaks of an "autonomous economy," an economy based on autonomous computing:

> *"It will change every profession in ways we have barely seen yet [. . .] enabling us to do many things with fewer people and making yet other human jobs obsolete."*

The healthcare sector has witnessed the introduction of robots that help people get in and out of bed. This is a first step toward performing other tasks that can be automated in the near future. A memorable example of robot development is the Chinese Chef Robot that makes noodles better and cheaper than human noodle chefs do, with their noble handicraft. Such robots cost 2,000 dollars, require no maintenance and last for years. A real flesh-and-blood noodle-maker earns a salary of 4,700 dollars annually.

The debate on technological unemployment is not new. In 1930, Keynes spoke about it as a new disease of which we will hear a great deal in the years to come. Keynes believed that technological progress brings economic growth without creating extra jobs. But this is only a temporary situation. New jobs arise later. The idea that tech-

nology would lead structurally to unemployment was first articulated by the Luddites in the 19th century. They destroyed the machines that made laborers redundant. But up to the present, we have repeatedly seen that technological unemployment is only temporary.

The current deviation from the trend has stimulated Paul Krugman to state that he sympathises with the old Luddites. In his New York Times column *Sympathy for the Luddites,* Krugman states that this generation's chance of unemployment is considerable. Whether or not it will be structural, Krugman does not say, but for the present we must take increasing unemployment and social disparity into serious account.

Foresight is needed, now more than ever

Unsafe and also undesirable. You could describe Internet connected things in this way if we look at the possibilities from the other side. There are obvious risks to security and privacy. Devices and sensors are the eyes and ears of companies and instances, and also of hackers. If things can be operated from a distance and something in the physical world can be activated, it is certainly advisable to exercise caution. Add the scenario of technological unemployment to this situation, and you get a doom scenario for our so-called "smart future."

Whether or not a smart future is truly within arm's reach depends on one simple combination: that of technological achievability, organizational and social practicability, social desirability, and economic feasibility.

Therefore, we must remain alert and realize that there are many risks and caveats to be dealt with. For instances, there ought to be reliable institutions that monitor the government's activities. And much more attention must be given to the security of our cyber-physical systems. It may be necessary to have higher taxation and social safety nets to neutralize the risk of technological unemployment.

8 Accelerate your things approach

Applying digital things, sensors, actuators, apps and SMACT demands a certain mindset as well as concrete actions to optimize your process and event chains, and to translate surprising new opportunities into new products and services. Some organizations have been considering THINGS and SMACT for a longer period. The following ideas may not be equally relevant to everyone, but the governing target is to accelerate the time-to-market and the adoption of your things. A tipping point, as we have indicated earlier in this report, essentially means that the adoption of ideas suddenly goes into overdrive. This applies not only to you but also to the innovations of your competitors.

I Make digital things tangible

Fifteen years ago, Internet connected smart things were drawing-table fables, now working models are pouring off the conveyor belt. So, one should bring in the "concept cars" and display them. This may literally involve a concept car, such as the autonomous car developed by Audi, Google or Mercedes, or perhaps Google Glass or other wearables such as the IntelligentM bracelet. Or a model of the first Chinese *smart train*, a black-box that records driving behavior, a particulate meter for the iPhone, a toothbrush that talks back to you. Display them, make use of the fact that they are things. Let them be seen, touched and tried.

II Choose your kickstarters

There is a lively Do It Yourself (DIY) or creative culture around things. Because reliable building blocks are now ubiquitously available, everyone can initiate something, create a proof of concept, and have the project financed via crowdfunding sites such as Kickstarter. You can find DIY buffs everywhere, even among your fellow staff members and partners. You should chart what is happening in the things area that might possibly affect your sector. There are meetings for Quantified Selfers that primarily test new products on themselves, universities where experiments are carried out in labs, relevant citizen science projects that you can find on the Internet, concept products that are presented on crowdfunding sites before they come to the market. It is simple: make contact and see if and how that can help you.

III Dive into a blue ocean

The digital things theme lends itself well to a Blue Ocean strategy, a popular concept among marketers. The principle is straightforward. In a red ocean, competition is cut-throat. In the blue ocean, there are few competitors. An insurer who introduces Internet connected things on the market encounters a blue ocean. There are few rivals and there is the opportunity to formulate new rules of play in this market. Another example of the blue ocean strategy is the HUE lamp manufactured by Philips. In the red ocean, the company competes with a wide range of relatively traditional lamps.

The HUE lamp is operated with a smartphone, can take on various colors, and has a community that develops new atmospheres and colors. By creating this type of intelli-

gent SMAC THING, a part of the blue ocean is crossed. A bank that introduces a digital growth wallet when there is more money in the account will perhaps miss the boat, but the following experiment might very well succeed. Ask your marketers to come up with things that positively influence the position in the market.

IV Look from things to services and vice versa

If you wish to go from idea to realization at an increased pace, it is often advisable to seek a partner. In the special case of digital things, this is even more obvious. After all, software may well be a second-class citizen to product suppliers and, vice versa, hardware is frequently of secondary importance to service providers. In this context, we again emphasize that it is advantageous to tackle various kinds of waste in ecosystems, which is another reason to seek partners and make an ecosystem smarter. GlowCaps, which we introduced at the start of this report, is a good example of such an approach. It is a co-operative effort between pharmacists, the pharmaceutical industry and a startup. GlowCaps also is a central link in the healthcare ecosystem, like for instance Microsoft's HealthVault.

V Focus on waste of all sorts

In your own organization people are probably engaged in charting the waste production and trying to reduce it. This is certainly the case when your are involved in so-called Lean programs. You may not have taken digital things and the accompanying services into serious consideration as yet. Cyber-physical systems and larger associations are certainly worth examining if you wish to cut back on waste. Mobilizing process knowledge in a focused things Special Interest Group enables you to chart opportunities and to assess their potential impact.

Summary

Business enthusiasm for Internet connected things is related to new opportunities to combat waste in the broadest sense of the term. Lost time and attention, lost energy and money, machines that are shut down for maintenance too quickly, etc. This waste occurs among all parties: clients, suppliers, governmental bodies, service providers and the manufacturing industry. You should direct your things efforts at the triad of combating waste, building autonomous systems, and intensive client interaction: in short, SMACT.

The figures concerning the impact of such intelligent things are dazzling, amounting to many thousands of billions. McKinsey estimates the market to be worth 2,700 to 6,200 billion dollars, Cisco talks about 14,400 billion. These estimates mean that this development is related to the whole economy. This is why notions such as *Internet of Everything* are currently going around. The value behind these enormous sums is related to all kinds of waste. Whether this concerns a reduction in the cost of healthcare as a result of remote healthcare, or a reduction due to fewer car accidents, a part of the waste is consistently being eroded as intelligent digital things are arriving as a replacement.

The cards have been dealt

We still have to see whether or not they can be realized, at least on this scale. But the cards have been dealt more favorably than in 1999 when the first hype around this topic arose. In the meantime, we seem to be approaching an important tipping point, so that the application and successful market introductions of things will take place much more quickly than was the case at the end of the previous century.

The situation was quite different when we first heard of the *Internet of Things*. The basic idea was simple: wouldn't it be convenient if every product had its own digital identity so that it could tell us something about itself? The content, shelf life, price, that kind of thing. In the meantime, digital things have become smarter, cheaper, and can do much more than merely talk a little. They sense and respond, remind us of things, localize, anticipate, operate autonomously, keep whole factories running without human intervention, drive cars, etc.

SMACT as a tipping point

We would not have come this far without the boost of Social, Mobile, Analytics and Cloud. SMAC has revolutionized the information society and made many more aspects of society ready for tech-and-things. This development is now continuing in SMACT. In just a few years' time, Facebook acquired more than a billion users, and more than 100 billion apps have been downloaded worldwide onto the 1.4 billion smartphones that, thanks to the built-in accelerometer, magnetometer, gyroscope etc. have initiated the sensification of information technology. At the same time, the cost of sensors is decreasing at a startling rate, and we have computers such as Watson that can not only speak but also give smarter and quicker answers than people can.

Liberating but restricting as well

There are many opportunities to improve the world and your business, particularly because things are so close to the human senses. Sensification and reification go hand in hand and, as a result, the chance of deploying these to realize something that people will actually use becomes much greater. Simultaneously, however, we are at odds with such developments and the freedom to which we are so accustomed could be restricted by Internet connected things. The answer is that we ourselves are present and must be prepared to act if we wish to alter the situation. It is not whether something is technologically feasible that determines what is going to happen, or a business case that can't be made, but rather what we consider to be socially desirable. If the automobile sector, the healthcare sector, banks and insurers, industrial environments, the retail sector, government institutions etc. assume responsibility for the further programming of things, it is conceivable that society could follow a new course. The government may be able to gain more grip on society, technological unemployment will become reality, a risk-free life lies before us, a Valhalla for hackers could arise, and the relationship with organizations will be extended to behind the front door.

The things dialog has begun

Business opportunities — fine, but what now? The next VINT report on digital things deals with the interesting phenomenon of Wearable Computing, in the context of what Google calls Augmented Humanity. That concerns the consumer side, but the manufacturing industry and our urban living environment or *Smart Cities* also deserve full attention. By consistently shifting our things focus and by tilting the prism, in the next three THINGS reports we offer a view of the big picture from various angles.

The speed and the depth with which we will develop intelligent things is a major point of concern: for instance which trans-sectorial innovations can we expect? We wish to discuss such matters with you: online and in personal interviews. The digital things dialog has started up, and we are eager to share thoughts on the best way to capitalize on these new developments.

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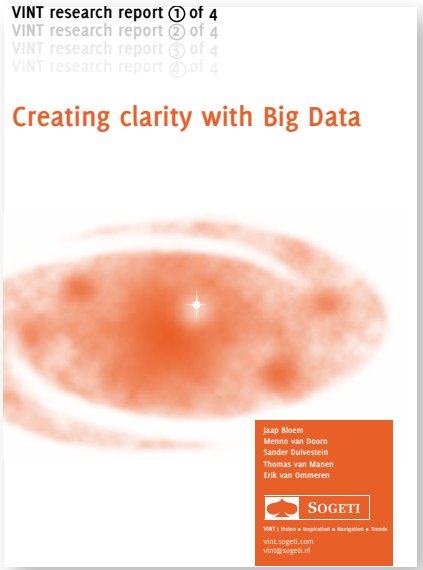

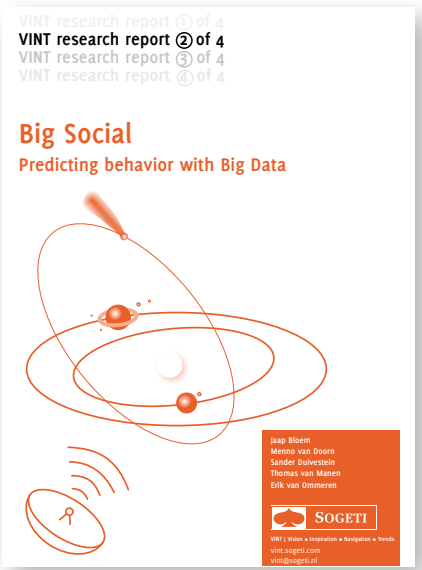

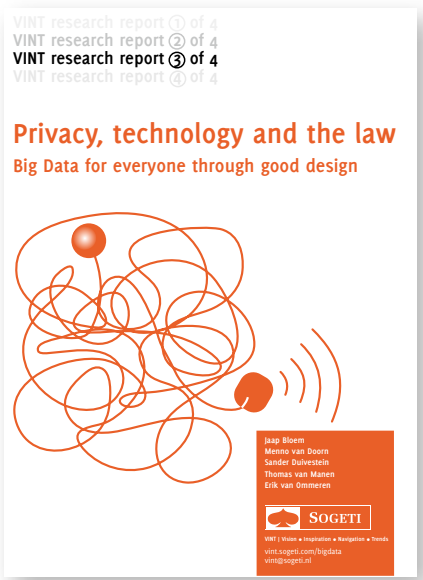

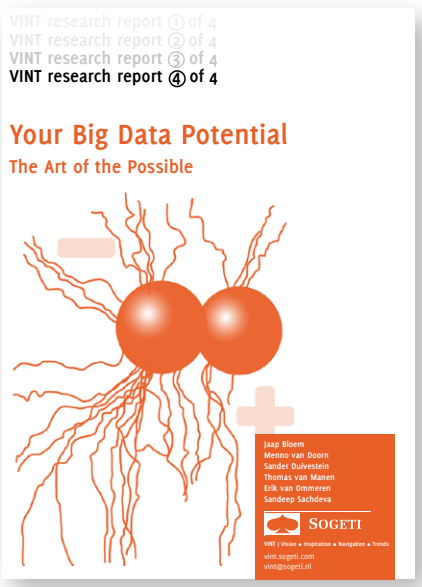

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