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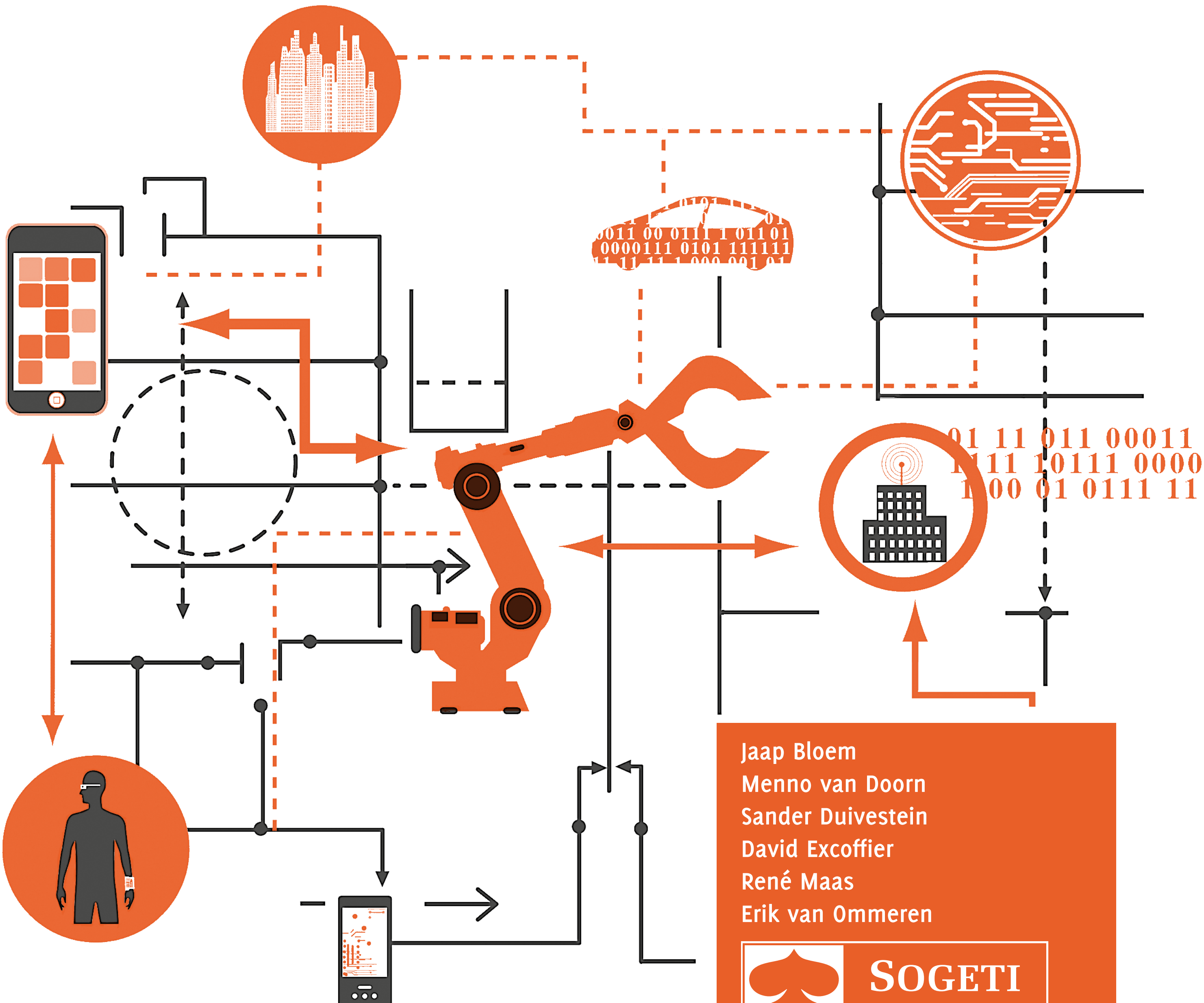
The Fourth Industrial Revolution

Things to Tighten the Link Between IT and OT



Jaap Bloem
Menno van Doorn
Sander Duivestein
David Excoffier
René Maas
Erik van Ommeren

SOGETI

VINT | Vision • Inspiration • Navigation • Trends

vint.sogeti.com
vint@sogeti.com

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Production LINE UP boek en media bv, Groningen

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Four new VINT reports on digital things

A rumor started at the end of the previous century, that "Things will be arriving on the Internet." Due to the long nose of innovation, as Bill Buxton of Microsoft Research describes it, it took fifteen years for that to happen, but now the clamor of Things is becoming deafening. In various sizes and shapes, all kinds of startups and renowned names are claiming to have made breakthroughs, ranging from off-the-shelf sensor hardware platforms such as Arduino and Libelium to business infrastructural giants such as IBM and McKinsey. The relationship between humans, their artefacts and the world around them has always been a fascinating one. The difference nowadays is that we know how to program computers and can store everything in cyber-physical systems. That makes knowledge concrete: stretching from smartphones and intelligent pill jars in healthcare chains, to the lifecycles of products and services with the customer as the focus of attention. From *science fiction* to *fact of life*.

From 2000 onward, the world has changed radically in a few major steps. Moreover, new developments are occurring increasingly rapidly. Social networks, Mobile platforms and apps, advanced Analytics and Big Data, Cloud and the artificial intelligence of IBM's Watson: taken together, these form SMAC. Now our Things are coming to the fore, forming SMACT ("smacked") in a glorious 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. VINT now devotes four new studies to this mega-theme. *Things: Internet of business opportunities* was the first reconnaissance. The next report dealt with Empathetic Computing in the light of what Google calls "Augmented Humanity." Number three, this report, examines the subject from an industrial perspective.

Everything can be reduced to the human-to-machine chain (H2M), machine-to-machine (M2M), and machine-to-human (M2H). These may occur in either simple or complex event and process chains. SMACT is naturally the ongoing story of the automation that is intervening to an ever-increasing extent in life itself. But Empathetic Computing, smart factories and cities, artificial intelligence, smartphones, digital surveillance, etc., are not without risk. For this reason, we also pay attention to economic feasibility and social desirability in addition to technological malleability and organizational practicability. Essentially, it's all about doing smart things instead of only crafting them.

1 Digital technology links blue and white collar

Wherever we get down to work – on the factory floor, on the railway, or even if the work only involves doing the laundry or brushing our teeth – there is a silent revolution taking place. Thanks to the Internet, sensors and embedded systems, completely new opportunities are opening up for new combinations of mental, physical and mechanical work. The latest phase of what we call "Pervasive Computing" is currently underlying the far-reaching integration of Information Technology (IT) and Operational Technology (OT). This integration, which knows many forms, produces profit in three ways that this report explores: by reducing costs as a consequence of predictive maintenance, and in greater speed and intelligence thanks to Machine-to-Machine communication and improved Human-Machine Interaction (HMI).

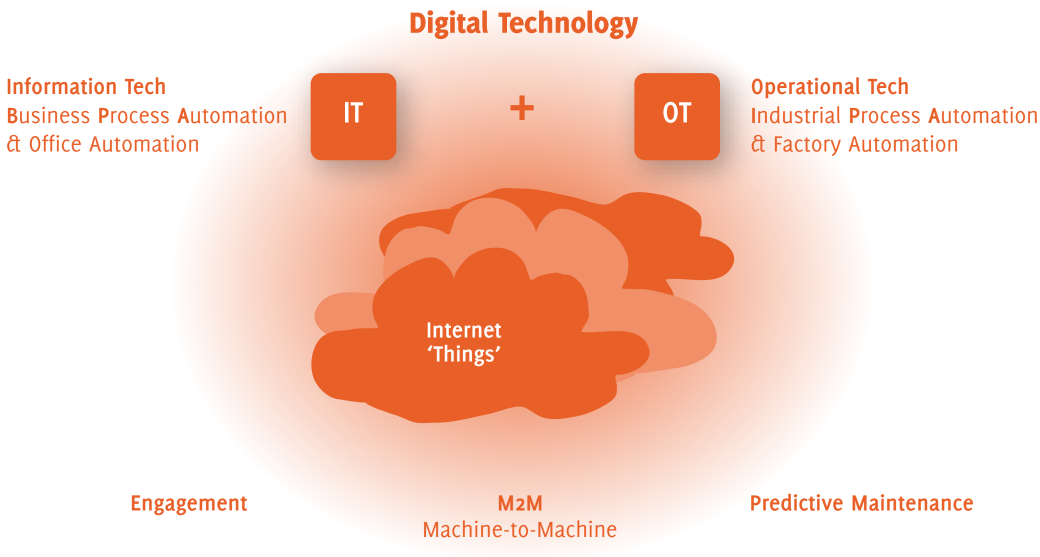
Industry is at the forefront of this development, which is generally regarded as the fourth stage of the Industrial Revolution. To exemplify the range of applications, *Computerworld* compared Boeing's extensive use of sensor data in factory operations when building the Dreamliner to the American National Football League's early stages of sensor use on players, the ball and helmets. Evidently there are differences in the integration – let's call it maturity – between IT and OT.

As an industrial colossus, Germany is running a strategic program directed toward the year 2020, under the name *Industry 4.0*. In America, too, consortiums are investigating the possibility of further industrial development on the basis of end-to-end automation, with the Internet as the pivot (such as the *Smart Manufacturing Leadership Coalition*, for example). Last year, in an article entitled "The Internet of Things and the Future of Manufacturing" in the *McKinsey Quarterly*, Bosch top man Siegfried Dasch made the prediction that, in industry, everything will eventually be connected to everything else. Helmuth Ludwig, CEO of the North American industrial branch of Siemens, foresees the same breakthrough: from design to maintenance, upgrade and reuse, between producers, service providers and clients. Virtu-real processes will enhance efficiency and effectiveness in all areas:

> *"This is nothing less than a paradigm shift in industry: the real manufacturing world is converging with the digital manufacturing world to enable organizations to digitally plan and project the entire lifecycle of products and production facilities."*

IT and OT converge

This is the new tendency: Business Process Automation and office automation converge with Industrial Process Automation and factory automation. This integration has been taking place for some time now. And because it is becoming increasingly apparent, we currently speak, with Gartner, in terms of IT and OT: *Information Technology* and *Operational Technology*, with the Internet providing the core structure.



This is the amalgamation of two independent, historical, economical developments – that of advanced information technology, with predictive data analytics, smartphones and traditional administrative automation, among other things – and that of the impressive machinery and automation that have been designed and developed since the start of the industrial revolution. In Gartner's definition, OT stands for the following:

> *"**Operational Technology (OT)** is hardware and software that detects or causes a change through the direct monitoring and/or control of physical devices, processes and events in the enterprise."*

According to the roadmap report of the European Union on the future of the industry, a new production paradigm is arising with the advent of cyber-physical Internet-based systems to offer innovative capacities that can benefit industry and other economic sectors. The leading paradigm is M2M: machine-to-machine communication, not only between machines in factories but also between all conceivable devices and systems. In this context, one can think of fleet management on the basis of SIM cards, sensors and GPS.

The original idea behind the *Industrial Internet*, a term first coined by General Electric, is that digital technology will ultimately be added to all machines and all devices. With more sensors in the engines of planes, trains and MRE scanners, GE wishes to make aviation, railway services and healthcare more efficient and effective. It will thus cross the boundaries of sectors and domains, and evoke the prospect of new revenue models. GE has calculated that such developments could save the aviation sector 2 billion dollars a year, and the energy sector twice as much. And by equipping the 1,100 beds of New York City's Mount Sinai Medical Center with sensors, 10,000 extra patients could be given care.

This pioneering Industrial Internet embraces machines, appliances, devices and other artefacts, including the systems and processes in which they play a role. Nowadays, all these things can communicate with one another, thanks to digital technology. In this way, the production machines can tell one another (and us) the following:

- I would be able to work 15% faster if my inbox were always full.
- I have produced 25 components in the last hour, of which five have been rejected.
- I would be able to reduce my energy use by 5% if my equipment were in sleep mode while I wait.
- I have already been waiting for production for 30 minutes.
- It took 2 minutes longer for me to reach the right temperature. Could you check that?

Rockwell Automation, a member of the Smart Manufacturing Leadership Coalition, speaks of *IT-ready machines*: machines equipped with sensors that measure their functioning then communicate this in normal human language to ERP systems and to technical and administrative personnel. This kind of M2M communication and the corresponding HMIs (Human-Machine Interfaces) form the basis of how the so-called "Smart Factory" can work in heavy industry, but it can also work in the food industry, consumer goods and the high-tech sector.

Not only production machines and airplane engines, but also all domestic appliances – ranging from washing machines to televisions to toothbrushes, the thermostat and the car – will be able to talk and tell us things such as:

- I have not been used this morning: that means someone has forgotten to brush his teeth (connected toothbrush).
- This espresso machine has made 500 cups of coffee, but has never been decalcified (wifi coffee machine).
- With 10% more pressure in the tires, this car could save 5% on fuel costs (connected tires).

2 Triple profit

Industry has three main reasons to add networked software to machines and products in the classical industry division of design, production, and product support and services (particularly Maintenance, Repair and Overhaul, MRO). Networked software, added to products and machines, makes it possible to gain important benefit in the fields of:

1. *Machine-to-Machine* communication, so that human work can be reduced and important contributions to efficiency and security can be made.
2. Maintenance, preferably *Predictive Maintenance* of machines and appliances on the basis of direct status reports and possibly also remote repairs.
3. *Engagement* or client interaction via the use of products by consumers or professionals.

1. Machine-to-Machine communication can bring much extra efficiency and extra security in production units ranging from factory halls to cattle stalls. In our previous report, we gave a sketch of the "farmerless" farm where, through the use of sensors, cows can be recognized by feeding machines, and where digital sensor capsules inside the cow send tweets to report that the cow is fertile. This is one of many examples. Taken literally, Machine-to-Machine is a synonym for technology that communicates without human intervention. Modern M2M applications use microelectronics and wireless technology, by means of which embedded appliances gather and distribute realtime data. In this way, tens of billions of connections soon can be accessed at will.

An M2M system makes use of sensors and meters to communicate "events" – ranging from temperature, via a communications network (fixed, wireless or hybrid), to application software that converts the raw data into meaningful information. Telecom companies in particular recognize the opportunity to expand their services and to gain access to their clients' operational aspects.

One example of this at macro-level is a project run by the Parker Water & Sanitation District in Colorado. This is a rather dry area that the Parker Water Company has optimized by offering rain sensors and services to their end users. The Company thus works on so-called "end-to-end solutions." All wells, pumps and pipes in the systems are linked via a software-controlled water system. In this way, matters such as mechanical, human and natural sources can be optimized centrally, in detail. The pumps also mutually communicate in order to regulate the pressure on the system.

By means of a network of thousands of sensors, the district monitors the water flows, water pressure, chemical parameters and leaks in the system, which serves more than 55,000 customers. And the customers can allow their irrigation activities to be automatically managed by sensors, which also record the amount of rainfall, etc. In addition to the optimization of the pumps, this automated operation means a much more sustainable use of water.

2. Maintenance and upgrades, preferably in the ultimate form of **Predictive Maintenance**, bring extra reliability and speed to numerous appliances: from networked espresso machines to sensors in engines and turbines. IBM is one of the firms now capitalizing on this development, through advanced analytics that enable them to take the proper decisions. This development is currently being applied to enhance excavation machinery in the mining industry, for example, which represents an annual market of 5 trillion dollars.

The condition of various things and components can be measured by equipping machines with sensors. A component may be new, but intensive use may wear it out prematurely. Knowing which activities have been executed, or knowing that some machines have been deployed for heavy work for days on end, enables the (routine) maintenance schedules to be adjusted in response.

To companies such as Thiess, which manages and hires out 700 models of mining equipment, a day's outage means a loss of 1.8 million dollars. Nowadays, sensors send all kinds of user data via the Internet to central systems. This data sharing provides around 10% productivity profit, according to calculations by IBM, because timely interventions can be made. The aim is to realize zero unplanned downtime and peak productivity, by progressing from Corrective Maintenance (repairs) to Predictive Maintenance, so that significantly less downtime is necessary and no bottlenecks or defects, resulting in irreparable damage to the systems, can occur.

3. With **engagement**, or customer interaction, we can share, via all kinds of domestic appliances – refrigerators, toothbrushes, televisions, vacuum cleaners – user data in order to create new value and to shape service provisioning. The client can be the professional worker who always has to be completely up to date in his operations, and prefers to be supported by modern screen devices or Google Glass-like portable aids. But this applies equally to the end user who would much appreciate improved service in the facilities he wishes to use, such as a combination of data from the traveler's digital train ticket (IT) and rail traffic (OT).

Traffic For London (TFL) operates the Oyster Card in the UK. Via digital card readers, this pass gives travelers pay-as-you-go access to trains, subway lines and buses. Thanks to operational systems that report train malfunctions, TFL knows whether or not people have had to wait too long. By coupling such data to administrative IT systems that record the personal data of the card users, TFL can automatically credit the card user's account if the time limit has been exceeded, without recourse to application forms and the corresponding time and cost required to deal with the compensation – an advantage to both the traveler and the TFL organization.

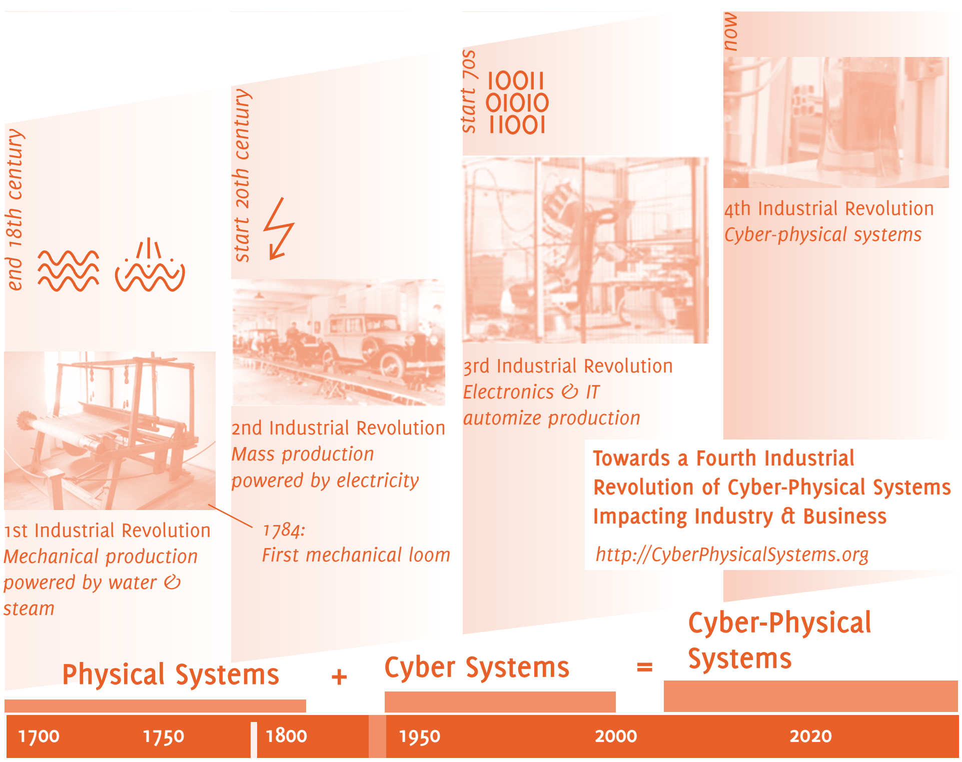
In addition, in the London Underground, Microsoft and partners have integrated an existing network of sensors into the Azure Intelligent Systems Service (AISS), producing a tool that offers the chance to view a map of the Tube system complete with flags for equipment that needs attention. These examples demonstrate that we can expect much creativity in the future.

M2M, maintenance, upgrades and customer interaction: altogether we are talking about the Fourth Industrial Revolution, which will nurture further growth of already extensive industrial, process and factory automation. The total volume of this automation market is currently more than 300 billion dollars. The most optimistic view of the value that the industrial Internet of Things (IoT) can deliver to the manufacturing industry comes from Cisco. This is not a completely unbiased view, due to Cisco's own interests in the market, but it may very well be accurate in terms of where value can be realized. Cisco estimates that the total IoT market will be worth 14 trillion dollars in 2022. Manufacturing will account for 27% of this: 3.88 trillion dollars. Of this, people expect to be able to realize 1.674 trillion dollars' benefit through the engagement of staff and customers. A sum of 675 billion dollars should result from the improvement of asset management, in which smarter maintenance plays an important role. And a gain of 1.539 trillion dollars is expected through the reduction of all forms of waste, such as wastage of time, by embedding M2M communication.

3 The Fourth Industrial Revolution

The Industrial Revolution is a concept and a development that has fundamentally changed our society and economy. The term "development" may seem to indicate some tardiness in the context of a "revolution," which really signifies a rapid and fundamental change, but there is no doubt that major alterations occurred within a relatively short period. Industries arose and replaced small-scale workshops and craft studios. Textile and pottery factories were the first to recognize the new dawn, and a new infrastructure of canals and railway lines enabled efficient distribution. It was the transition from *industrious* to *industrial*, and the start of a boom for both.

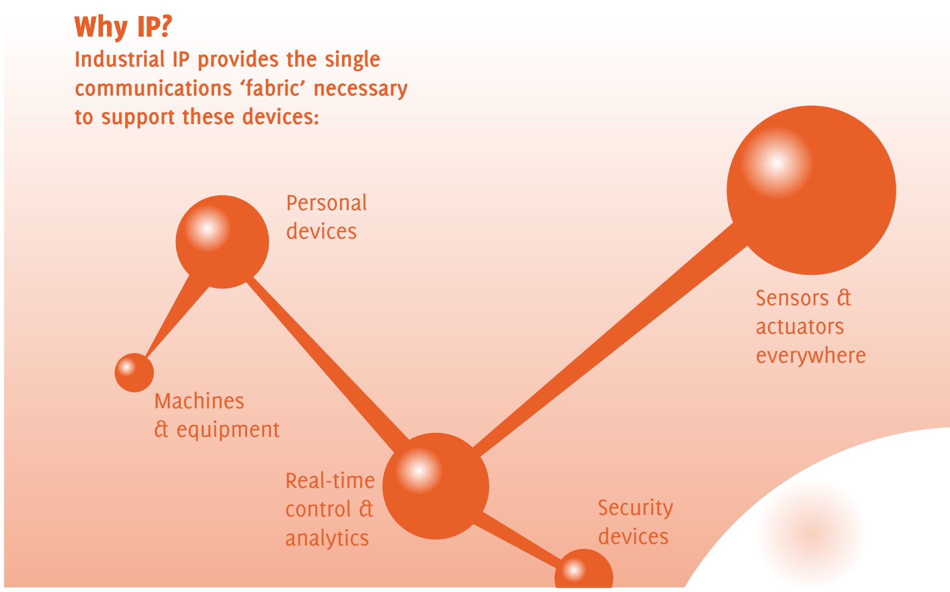
From the first mechanical loom, dating from 1784, exactly 230 years ago, we can distinguish four stages in the ongoing process called the Industrial Revolution. That is the way we currently look at it. The first "acceleration" occurred toward the end of the 18^{th} century: mechanical production on the basis of water and steam. We place the Second Industrial Revolution at the beginning of the 20^{th} century: the introduction of the conveyor belt and mass production, to which the names of icons such as Henry Ford and Frederick Taylor are linked. Number three is the digital automation of production by means of electronics and IT.



At present, we find ourselves at the beginning of this fourth stage, which is characterized by so-called "Cyber-Physical Systems" (CPS). These systems are a consequence of the far-reaching integration of production, sustainability and customer-satisfaction forming the basis of intelligent network systems and processes.

Factory floors are already teeming with Internet "things." In this context, one can think of microprocessors, which are the brains of digital devices and systems. They dovetail smoothly with conventional components, such as I/O modules. But the enormous Internet acceleration of industry comes from the explosive growth of digital devices from other disciplines. Video cameras, RFID readers, tablets, entrance tickets, etc. – all these kinds of Internet devices improve the quality, efficiency and security of production and process operations.

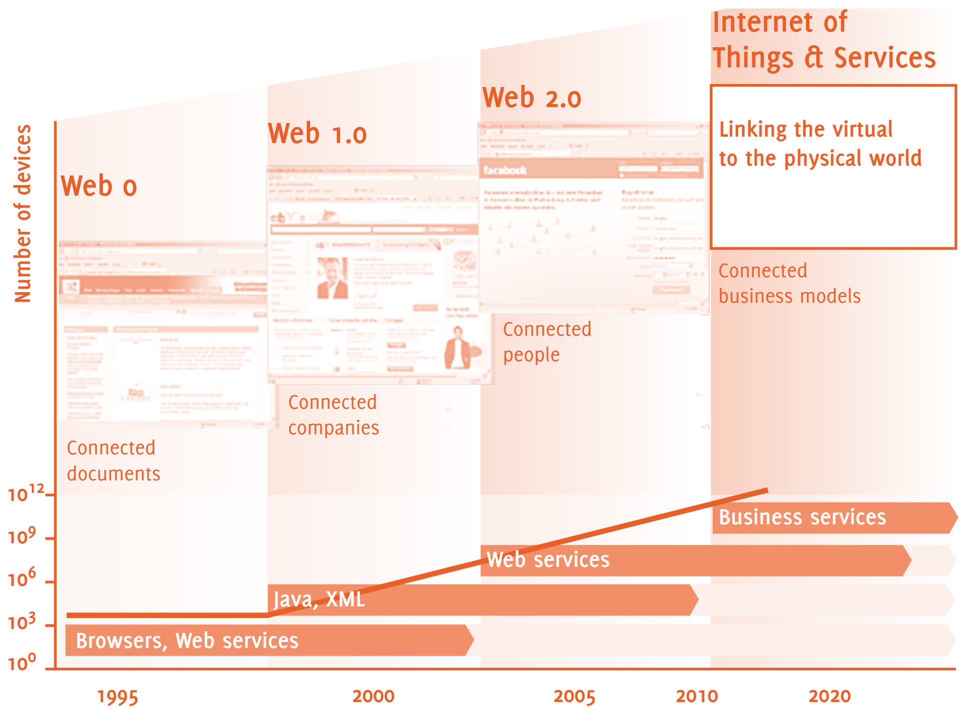
It is becoming easier to connect appliances, machines, things, complete factories and other industrial environments and processes to the Internet. The Industrial IP Advantage consortium (http://www.industrial-ip.org), established in 2013, is seriously engaged in this domain of expertise. Industrial IP aims to enable all industrial network infrastructures and applications to benefit from end-to-end Internet connectivity. In addition to ethernet connected to Industrial IP, there is also the Common Industrial Protocol (CIP), which is geared to unified communications.



The greatest value of Industrial IP is the possibility it provides to process and analyze significantly larger information flows from production and auxiliary processes, so that companies can operate in a more flexible and innovative way.

Despite all the benefits of the Internet, there are still plenty of separate application networks active in the world of Industrial Automation. Keeping special networks up, including the hardware needed to enable them to communicate with Internet, costs much time, money and manpower. And these three costs increase – along with the complexity of the complete network – as more Internet devices enter the industrial arena. A single system – the Internet – seems to be preferable in this context, certainly from a viewpoint of scalability and flexibility.

If we look at the ongoing Industrial Revolution from the cyber-physical Internet perspective, these four steps come into view:



The Internet of Things & Services is responsible for stage 4, which is currently beginning to take shape. New business services are now being developed on the basis of their capacity to link the physical and virtual worlds. A marriage is a more romantic depiction, and particularly between Operational Technology – ranging from engines roaring, to people being transported to bread being baked – and Information Technology that supports our business processes.

A new phase of robots and robothings

Today, robots are present in large numbers only in industry. But industry without robots is now almost inconceivable. They do everything covered by the three Ds: *dirty*, *dangerous* and *dull* work. Robots do it tirelessly, and function with unprecedented precision and often power, which is of major importance to the durability and quality of products: ranging from baby nutrition to cars. In that respect, robots are better than humans, just as all the other non-automated tools that we have invented: from the saw to the electric screwdriver and the pneumatic hammer.

This is where we observe a crucial difference from normal tools: production robots are a part of industrial automation. Mostly they can be found in cages or behind a fence on the workfloor. This has to change, is the idea. Intelligent machines that can learn independently, that are flexible and take their environment into account, must be able to collaborate organically with their human colleagues.

At present, traditional industrial robots are evolving into assistants to humans. In accordance with the vision of the Fourth Industrial Revolution, humans and intelligent machines will jointly perform production tasks in the future. Sensors, cameras and self-learning software will be indispensible to this process. The leitmotiv is that robots will have to adapt to humans, and not vice versa. In fact, this principle must be implemented to the extent that the new generation of intelligent industrial robots will learn from their human colleagues who simply demonstrate the necessary actions.

In 1961, General Motors deployed the very first industrial robot. The first Unimate model weighed 1.8 tons. More than 50 years later, in 2013, almost 162,000 robots were sold worldwide, and in 2015 more than 1.5 million robots will be in use. After 50 years of classical industrial robotization, we are now on the brink of 50 years of collaboration with service robots. It is expected that, between 2013 and 2016, around 95,000 new-generation robots will be sold, with a total value of some 14 billion dollars.

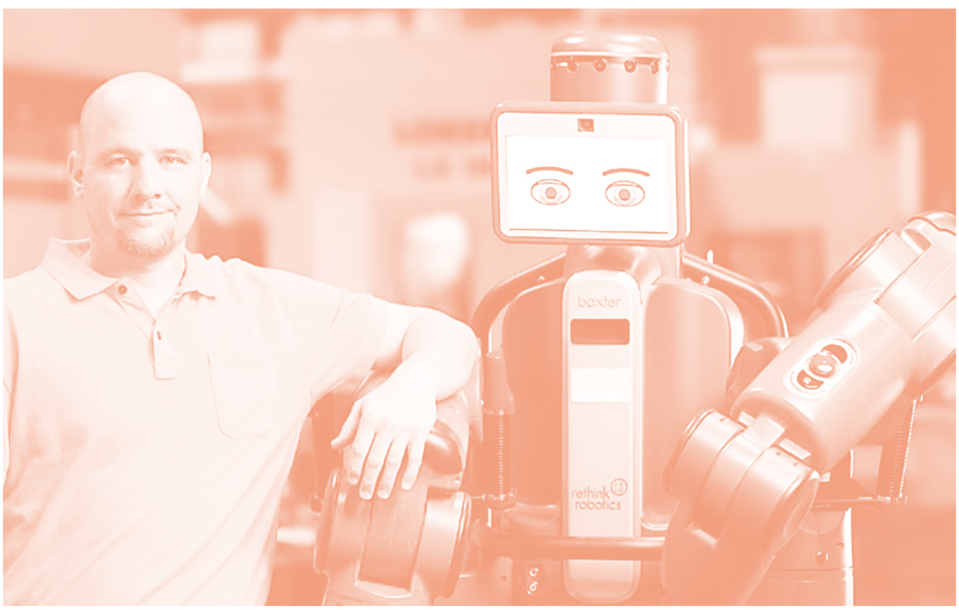
The word *robot* has Czech origins: it was used in a science-fiction play in 1920, where it referred to human clones that were raised to work. In May 2014, Marieke Blom, chief economist of the ING Bank, stated that the term "robot" refers to every reduction of human labor, with all the corresponding digital technology. This harmonizes with other common use of the word, as in *bots* and *robocop*. Bots are pieces of software with a certain goal, disseminated through digital networks. A robocop is a humanoid or android police super robot. In the latter case, the boundary between human and machine blurs, and it is unclear as to which side possesses more intelligence.

Robots, intelligence, automatons, reduction of human labor and mediation via tools, appliances, machines, industrial automation and office automation are widespread themes. In the MIT standard work *Introduction to AI Robotics*, an intelligent robot is defined as a *mechanical creature that can function autonomously.* "Mechanical" refers to the fact that a robot is built, constructed; "creature" signifies that it seems as if a robot has its own motivation and decision-making processes; and "functioning autonomously" means that an intelligent robot – in line with the Industry 4.0 vision – can perceive and act, and perhaps even reason, in the foreseeable future. Altogether, this goes further than traditional automation, which is directed toward the predictable repetition of actions, even if they are now becoming increasingly complex.

Adding this all up, it is apparent that the term "robot" is rather vague. It is definitely the case that, in robotic applications of varying natures, humans delegate certain sensory, mobile and intelligent qualities to machines. This is what the development of robotics is all about – regardless of whether or not they are humanoid or android. Delivering packages by means of drones, as Amazon has envisaged, is an example of an everyday service application.

Introduction to AI Robotics emphasizes the following five qualities of intelligent robots: mobility (legs, arms, neck, wrists), perception (sight, hearing, smell and touch), control via a digital central nervous system and a digital brain function, energy supply, and finally, communication via voice, gestures and hearing function. Unmanned vehicles on land, in the air and under water are important service applications outside the domain of industrial robots. But there are also modular robots under development, which can operate collectively, in swarms.

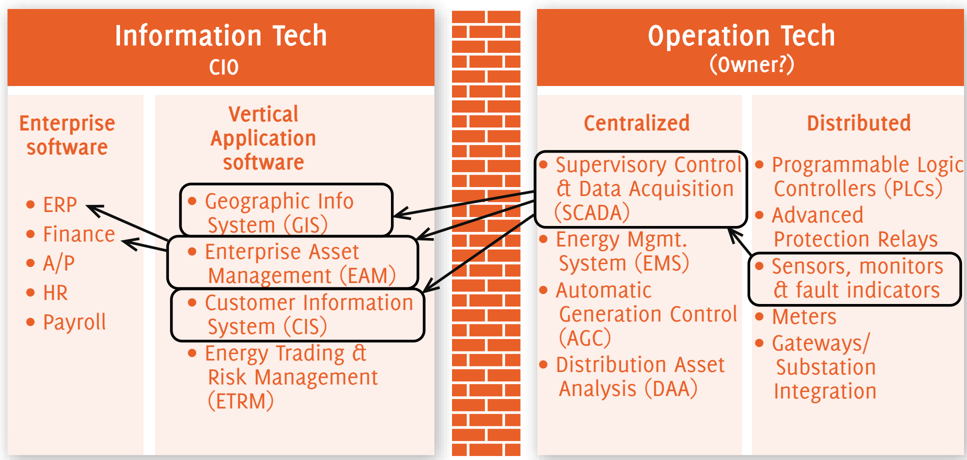
Currently, RoboEarth is building an Internet for robots and, via Industrial IP Advantage, the Internet of Things will enter the realm of industry. This justifies the conclusion that intelligent robots and robothings will soon become a genuine force in society and will cooperate with humans – in whichever form they might manifest themselves in the future: as self-driving cars, as SwarmBots or as Baxter from the Rethink Robotics company.



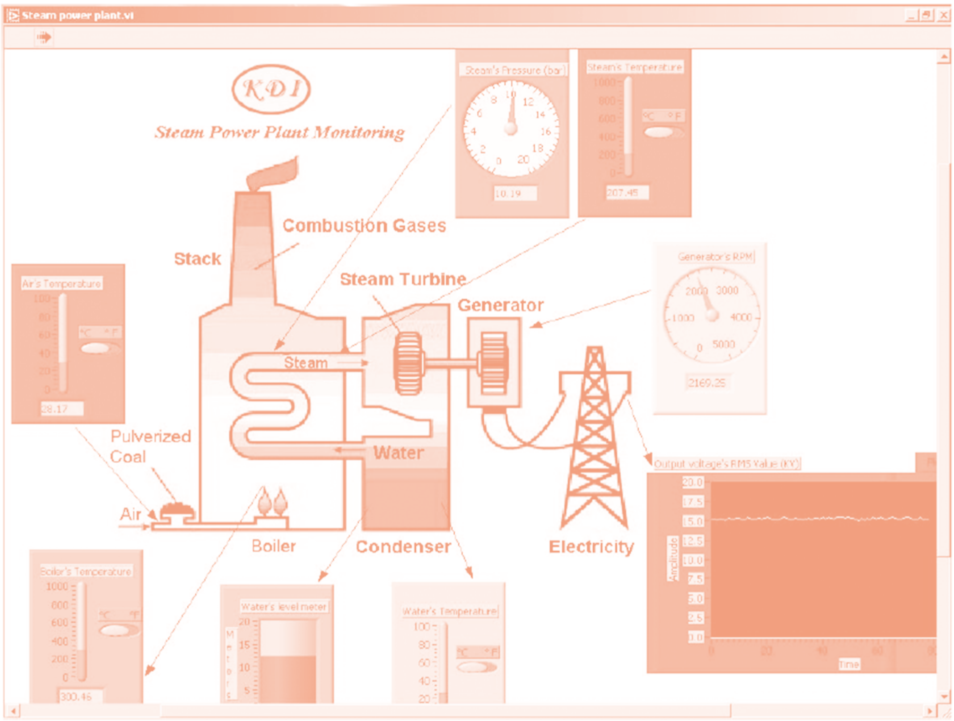
Source: http://www.hizook.com/files/users/3/Baxter_Robot_from_RethinkRobotics_6.jpg

4 Marrying IT, OT, the Internet and things

Traditionally, the systems, processes and people within IT and OT have been managed, controlled and governed independently of one another. The Internet of Things has brought greater interdependence. It has accelerated the development in which operational systems are becoming direct extensions of information systems, and vice versa. In most organizations, there is still too much of a barrier between the two envisaged partners, so relationship therapy is required. We see a recurrence of the problems in the following diagram of IT and OT operation in the energy market. The question as to who is actually responsible for OT is highly revealing.

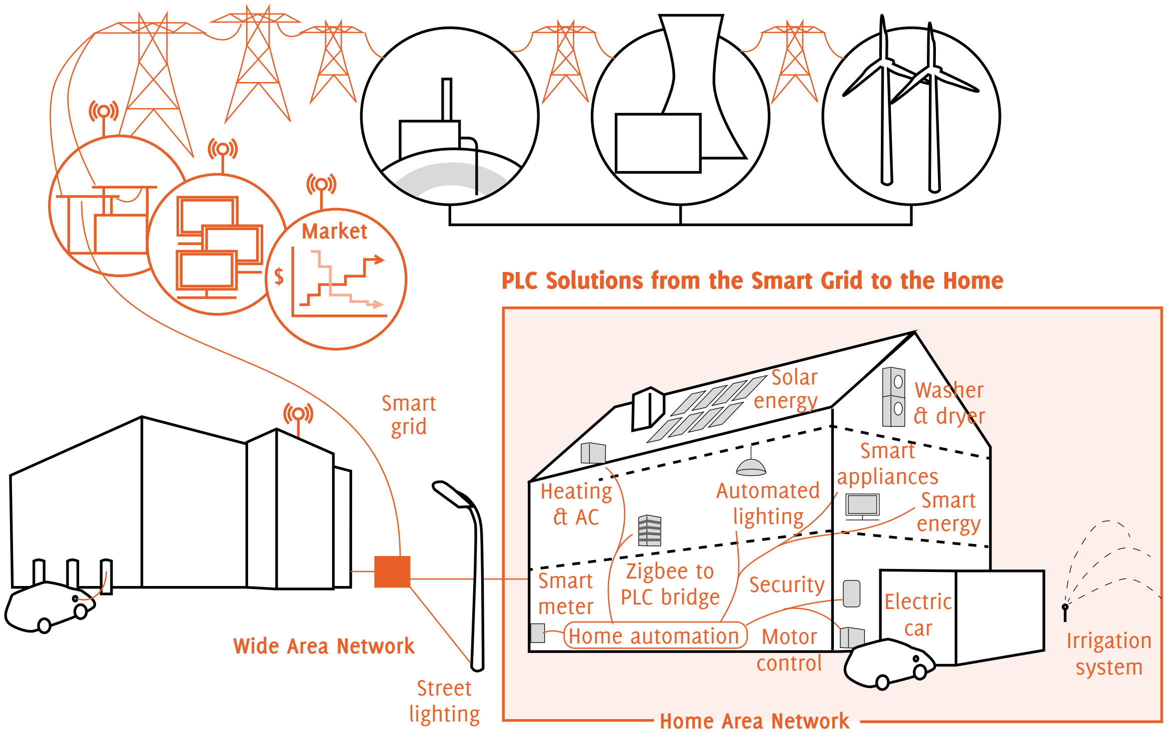


If we examine the OT side of this energy supplier, we see a central control section where the Supervisory Control and Data Acquisition (SCADA) takes place, relying on the sensors that measure pressure and temperature, among other things. SCADA concerns the measurement and regulation of Industrial Automation and presents insightful analysis. It focuses on the collection, transmission, processing and visualization of metrics and monitors, data from machines in an industrial environment. This is all necessary to enable the network of people, processes and machines to function well. The following figure visualizes the process for a steam turbine.



This image demonstrates that SCADA is already a few decades old. To the visionaries who can already picture the Fourth Industrial Revolution, in around 2020 or so, SCADA and the addition of the Internet mark the transition from stage three to stage four on the production side of the energy branch. On the distribution side, we see energy suppliers developing their own smart thermostats and rolling out their own smart meters.

If we examine the figure in terms of end-to-end, the huge difference between these two worlds becomes very clear. At the forefront of the market, people are engaged in cutthroat competition with IT, and new market players such as Google (Nest) are making their entrance. The app on the iPhone that receives data from the smart thermostat does not resemble the SCADA system of factory operation in any way whatsoever. On the production side, people are mainly looking for new possibilities to deploy sensors to protect assets and to implement better maintenance, or to communicate more quickly with people on the workfloor or in the field via M2M. The ultimate aim is enhancing safety and security, among other things. Finally, the smart grid will close the circle. Then realtime data from the consumption and domestic production of energy (by solar panels for example), in combination with data on energy in the battery of the electric car, can be coupled to this production side.



End-to-end ecosystems are under development – from design and production to client interaction and advanced Maintenance, Repair & Overhaul (MRO). They will enable a future in which appliances, devices, things and machines for professionals and private people will communicate with central systems, with one another, and with users for the purpose of providing the best possible facilities to makers, service providers, legislators and customers. They will have optimum functionality and lifespan.

Wedding plans

The University of South Australia performed research on the convergence, alignment and integration of IT and OT. An important conclusion was that the integration of IT and OT must never be the sole responsibility of the engineers. Either IT is solely responsible or there is joint governance. With regard to the integration process, the study explicitly recommended focusing primarily on the entire end-to-end operation. Higher business objectives, regardless of how important they may be – such as security or legal issues – should not steer the integration process. The researchers proposed these four steps:

Satisfy the basic conditions first of all

Organizations can plan convergence ("**pre-convergence**") when a number of basic conditions have been met: universally accepted industrial standards are the norm, and there must be a corporate vision to analyze the business requirements and aims; several scenarios must be examined, and a convergence strategy must be developed.

Reaching consensus between business and IT

Organizations must switch to **convergence** when there is consensus between the business and IT. Convergence has been reached when all hardware is accessible via an IP address. Engineering and IT will supply input for application development.

Designing an architecture

The next step after convergence is **alignment**. When all hardware can be accessed via the Internet, information and applications must be aligned to one another. It is critical to design an architecture that charts the application and information landscape. Engineering and IT collaborate here, with the assistance of external suppliers.

Action, as soon as cost-savings and competitive advantage become an issue

The final step is moving from alignment to **integration**. To gain competitive advantage and to save on costs, the planned architecture must be realized. This is done by integrating the various applications and information structures according to the plan.

This final point, about cost-savings and competitive advantage, is self-evident. We assume that researchers primarily wish to emphasize that good preparation is essential before undertaking action. This is something that people in the OT world are more accustomed to than people who are employed in the more opportunistic domain of IT.

The smart grid, as we have already seen, covers an enormous program for which good collaboration, vision and alignment between IT and OT are crucial. Not every initiative is of such magnitude. The telecom industry today provides many specific M2M solutions on a smaller scale. M2M is also a precondition for a smart-grid approach. But because all components of the grid must be able to communicate with one another, extra capability is required: a so-called “translation machine” that connects all M2M lines.

5 The benefits of M2M: machine interaction as the basis of speed and intelligence

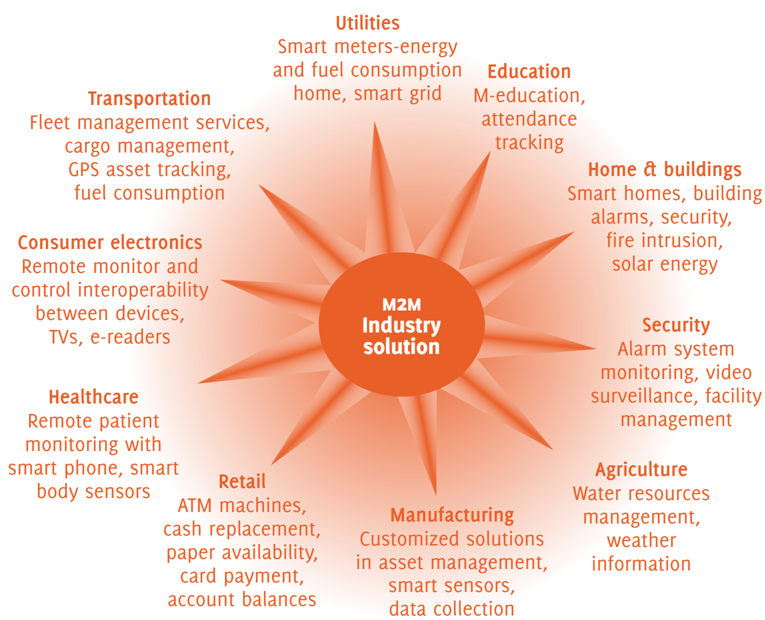
The leading paradigm in every automation is limiting human intervention as tasks are assigned to machines, appliances and systems. In our era of microelectronics, sensors and actuators, and fixed and wireless networks, M2M is the apt term: Machine-to-Machine communication. This digital interaction between and within machines and systems is the cyber-physical heart of the Fourth Industrial Revolution.

The *European Roadmap for Industrial Process Automation*, which dates from 2013, defines M2M in the context of Human-Machine Interfacing. This is logical, as automation is always in the context of Human-Machine Interaction.

Human-Machine Interface (HMI) and Machine-to-Machine Communication

[...] Internet compatibility and open standards are expected to be key elements in the expansion of large-scale automation systems. Machine-to-machine communications (M2M) using Internet of Things (IoT) principles will form the Cyber-Physical Systems (CPS) of tomorrow; these systems are predicted to enable new automation paradigms and improve plant operations in terms of increased Overall Equipment Effectiveness (OEE).

M2M applications can be directed toward individuals, companies, communities and organizations in public and private sectors. The following diagram shows ten common areas in various sectors, ranging from monitoring the money supply in cash dispensers to checking whether or not pupils are attending school.



In addition to industrial processes, M2M thus applies to business processes and, in fact, to all types of process where digitally networked, functional "things" play a role. Examples other than machines and devices in factories include smartphones and tablets for business and personal use, toothbrushes and lamps, cars and energy networks, building management tools, healthcare networks and insurances, solar panels and climate control, waste processing and heating, horticultural glasshouses and livestock breeding, and so on. The process chains in question may be large or small, simple or complex, and may function in traditional or innovative associations or within industrial production lines. Telecom companies envisage a key position for themselves as a result of the networks they manage that make M2M solutions possible. Machina Research predicts that 12.5 billion SIM cards will be operational in 2020. In that year, M2M will generate more turnover than the whole mobile telephone industry collectively, which now represents 1.5% of GDP.

Via maintenance and software upgrades, these M2M applications are directly involved in interaction between professional and private customers and end users, covering, for example, fleet management, vending machines, smart meters, medical equipment and solar panels.

M2M communication in cars and other devices thanks to the SIM card

It is not surprising, therefore, that M2M is currently attracting interest from companies worldwide. Commissioned by Vodaphone, Analysys Mason developed an M2M barometer. Of all the participants in the M2M Adoption Barometer 2013, 78% stated that M2M would be a central factor in their business success. Worldwide, the auto industry, the energy sector, the transport and logistics sector, consumer electronics and, finally, the retail sector are in the vanguard of new M2M application. The growth prospects for 2014-2017 are very promising, as the ambitions of the above-mentioned sectors demonstrate in the following illustration. More than 80% are currently engaged in developing or implementing an M2M strategy.

Percentage of organizations:	Automotive	Energy & utilities	Transport & logistics	Manufacturing & consumer electronics	Consumer goods & retail
• currently developing/ implementing M2M-strategy	88%	85%	85%	75%	78%
• thinking M2M is very relevant to their business now	37%	30%	32%	28%	23%
• thinking M2M will be very relevant to their business in 3 years	39%	32%	48%	57%	40%

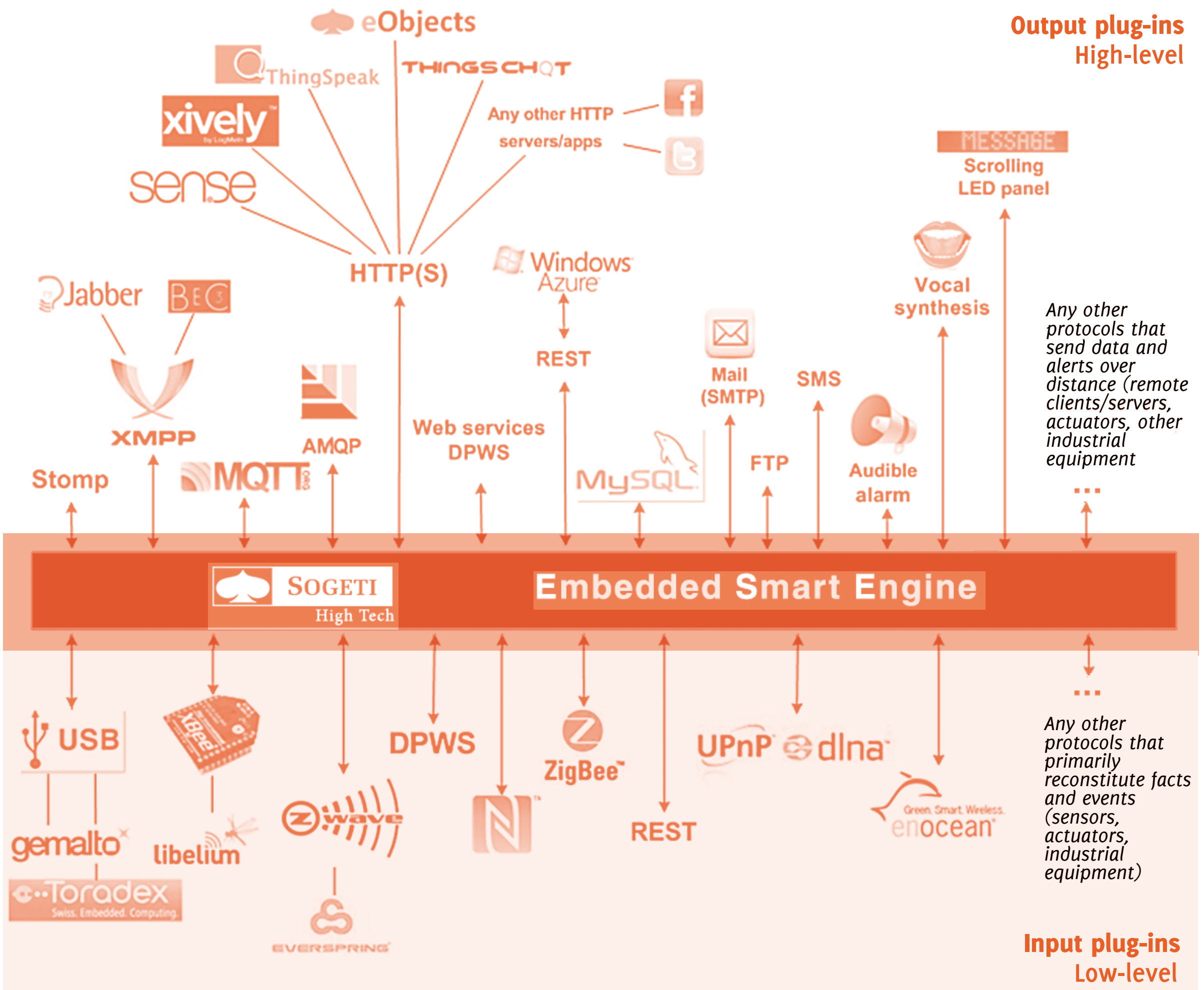
M2M Barometer 2013
Source: http://www.m2m-alliance.com/fileadmin/user_upload/pdf/2013/ Whitepaper/A412-M2M_Circle_Research-130524-28-web.pdf

Large and smaller telecom providers such as Vodafone and Aeris have taken the initiative to roll out M2M networks. This is quite a new business and, in addition to telcos, there are also other players in mutually overlapping roles, such as:

- *suppliers of hardware and semi-conductors:* they supply the material that collects the data, such as sensors, GPS units, smart meters, RFID tags, video cameras and smartcards
- *communication service providers:* they take care of the transmission of data
- *M2M service providers:* vertical niche players that provide specific M2M analysis solutions to support decision-making
- *system integrators:* they deliver the expertise to integrate systems and can add value by means of advanced analytics.

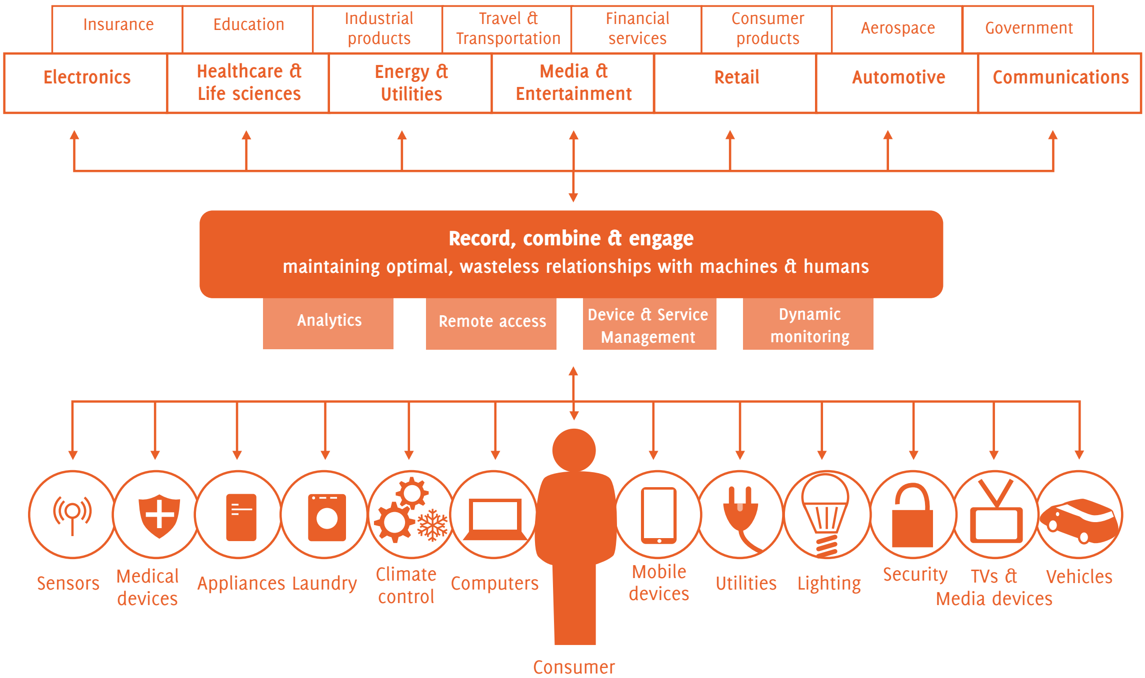
To realize the potential of the Internet of Everything, anything must be able to communicate with anything. In striving to reach that potential, we struggle with the current reality that there are more than a hundred communication protocols, so how this universal communication will happen is unclear.

Solutions are being built to tackle this problem, such as the “smart engine” in the following illustration.



In the bottom layer we see the input plug-ins and, in the top layer the output plug-ins. The *Smart Engine* is the intermediate unit that mutually connects all communication protocols. The machines to which this input is sent may be the *actuators*, to get matters going: a light that goes on or off, an e-mail that is sent, a bridge that opens and closes, a Twitter or Facebook update, a voice response, an alarm that goes off – the entire spectrum of possible output can be organized through an integration tool like this.

Packed in a cloud solution, this kind of product makes it possible to realize a "lean hospital," for example. If sensors in the beds, medical equipment and the wearables of the doctors and nursing staff can work together in a single system, "as-a-service" can ultimately become reality. The following triple-layered architecture illustrates that principle for numerous different sectors.

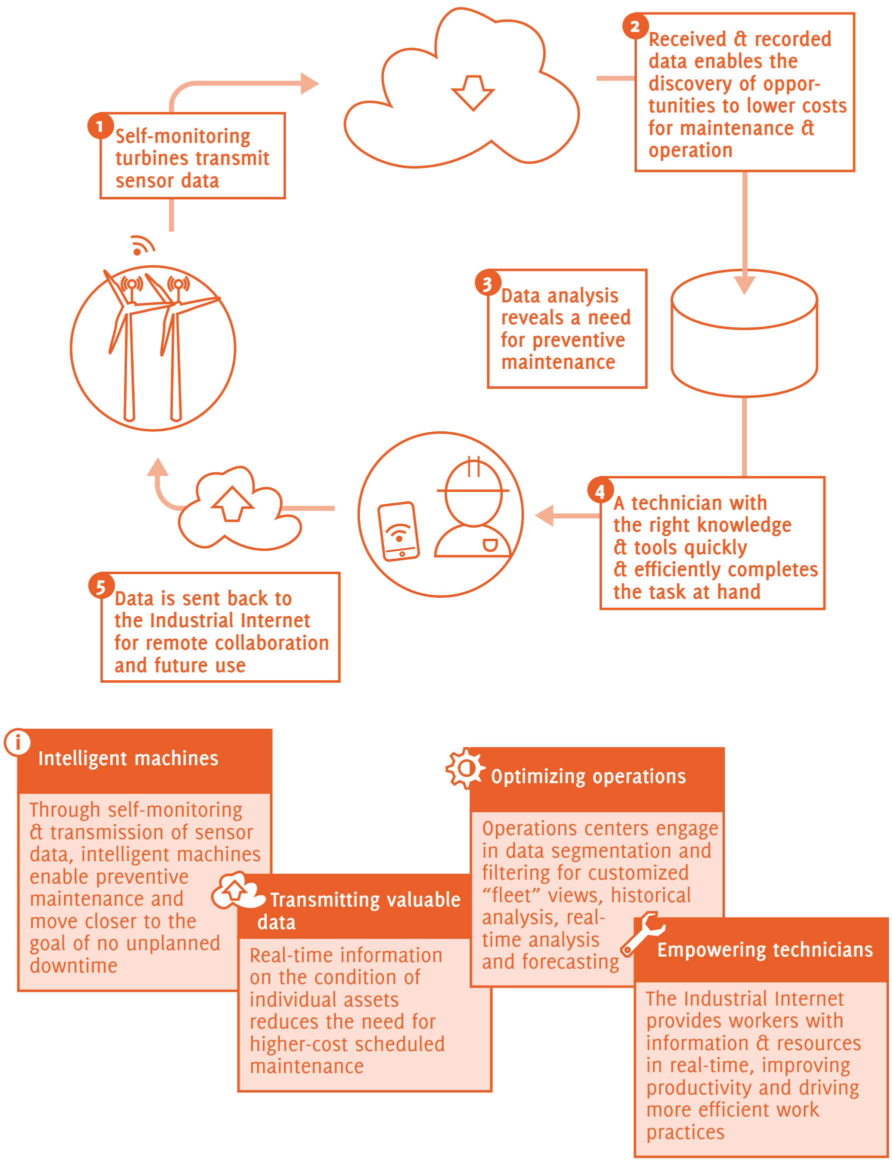


Source: Martin Kienzle, IBM Research, 2013

Even better, lower maintenance costs can result from using specific M2M services. Predictive Maintenance, in particular, can deliver many savings. In all fields where costly assets are managed, it is important to have as little downtime and production loss from power outage as possible. In addition to M2M communication and the Things that supply sensor data, this requires analytical capacity. It therefore demands more intelligence, and that harmonizes well with the IBM pitch: the world of the Internet of Things is *Instrumented, Interconnected & Intelligent*. This describes exactly the catalyst function of Things as a link between IT and OT: the basis of a Fourth Industrial Revolution.

6 The benefit of better maintenance: preferably Predictive Maintenance

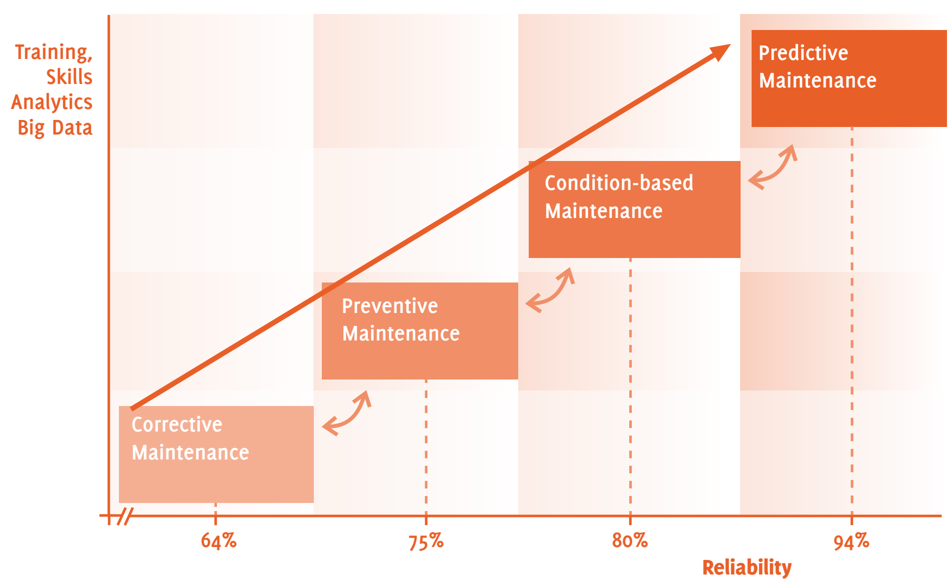
The new way of working must alter the interaction with industrial tools, medical appliances and other machines. In this context, one can think of wind turbines equipped with sensors that send data on their operations to the controlling engineers via M2M communication. Data analysis leads to preventative maintenance measures, with particular emphasis being placed on preventing expensive unplanned outages.



Source: https://www.ge.com/sites/default/files/GE_IndustrialInternetatWork_WhitePaper_20131028.pdf

The Industrial Internet sends data back to the turbines, in order to enable remote collaboration. In this example, the advanced analytics that are needed to generate the right predictions about outage is a black box. In our book *No More Secrets with Big Data Analytics*, we have previously discussed the need to develop new competencies in this field.

Various forms of maintenance offer different potential gains. They range from Corrective Maintenance (which is, of course, less reliable because it only happens when something has gone wrong with the operation), to Predictive Maintenance (which offers the greatest advantage). Predictive Maintenance improves reliability and availability by no less than 30%: from 64% to 94%.



"Lean" benefit can also arise in a broader context, through maintenance, monitoring and optimization, as the following examples from IBM indicate.

- The Srinagarind Hospital in Thailand realized an uptime of medical equipment of almost 100%. The maintenance costs decreased by almost 50% by preventing expensive errors in the operation. Proactive M2M alerts from medical equipment facilitated reporting within five minutes instead of the average 2 weeks as used to be the case, which was a decisive factor in this development.
- Volkswagen realized an improvement of 15% in machine downtime in factories. Predictive analytics foresaw the failure of certain components that caused outages.
- The Tarkreer oil refinery in Abu Dhabi was able to improve its preventative maintenance. Unplanned downtime decreased by 3-5%. With predictive asset management, inventory could be reduced by 10-20%.

7 The benefit of engagement, or client interaction: the human being and the machine in Smart Factories and beyond

There are now countless applications providing convenience to consumers and business professionals. Many focus on health, healthcare and energy, but there are others. Connected car systems offers information on maintenance and drivers. And, of course, there are feather-light digital glasses: with these, we can easily read the newspapers, but they can also give us directions on assembly and maintenance work. They can also allow other specialists to watch during delicate interventions, such as surgical operations, for example. Such combinations belong to the *Internet of Things & Services*, as Bosch calls it, and are closely linked to industry.

The best examples of engagement are applications that are directly related to interaction with blue-collar members of staff or end users, through measuring and regulating, maintenance and software upgrades. The subway in London realized a cost reduction of 300 million dollars and claims it will realize another 700 million dollars by means of better access to OT data. The most important contribution came from a new IBM system that gave the engineers realtime access to information, so that they could plan and implement their tasks much more efficiently. We encounter a completely different category of customer engagement in the domain of consumer electronics. The success that Philips enjoyed with its Internet-of-Things lamp, the Philips HUE, is indicative of this development. Thanks to the release of the Application Programming Interface (API), consumers can operate the lamps as they wish. External developers are also involved in the further development of Philips products. In this niche, the business case does not embrace cost-savings but rather an increase of turnover, primarily due to more sales but also due to a new product: Philips and other companies have brought "Things and Services" to market. What these two examples – which seem to be so totally different at first glance – have in common is that a new human-machine interface has created these possibilities.

Demolishing the barrier between IT and OT is again front and center here. In this context, we have already mentioned the *European Roadmap for Industrial Process Automation*, in which Human-Machine Interaction (HMI) is regarded as an indispensible step for efficiency breakthroughs. We now present three interesting HMI highlights – with respect to engagement and collaboration – from the Fraunhofer study *Produktionsarbeit der Zukunft – Industrie 4.0* (2013):

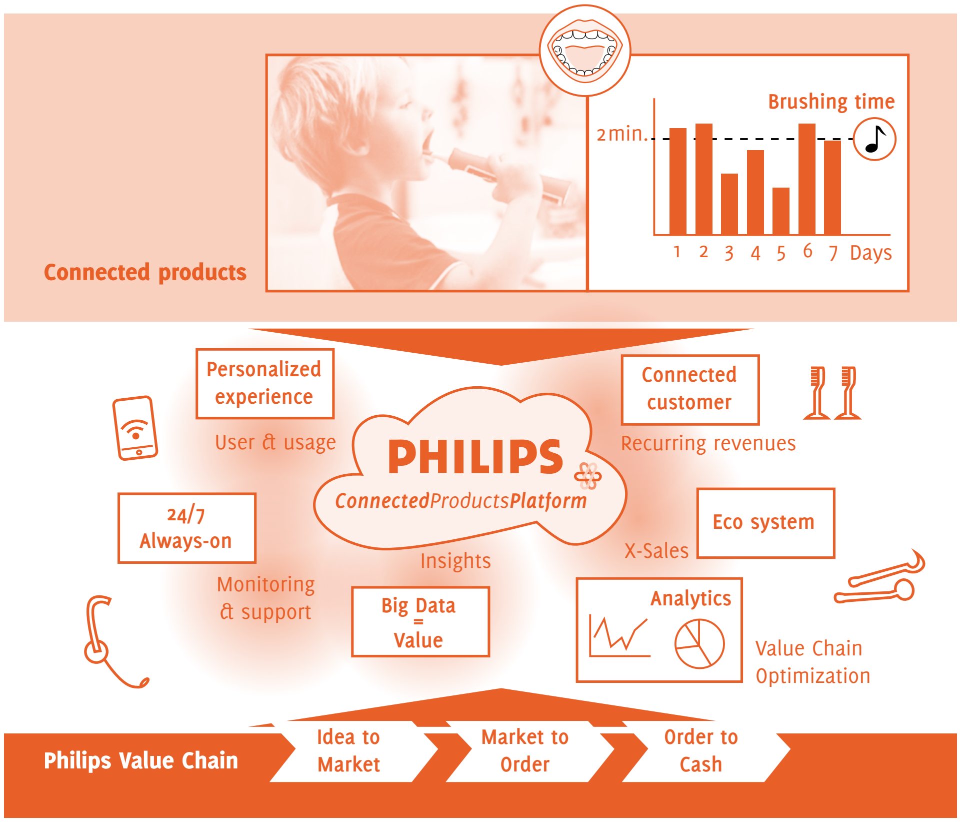
1. The Fourth Industrial Revolution covers more than cyber-physical systems. Intelligent data gathering, data storage and data distribution via artefacts and humans are essential elements here.

2. Production and knowledge workers will collaborate increasingly closely via their IT and OT systems.
3. Production personnel will be increasingly concerned with elements of product development.

If we replace the words "production personnel" by "consumers," this describes exactly what is happening with regard to the HUE lamp. And the interaction that Philips built up with the consumer can again herald new interactions between the blue-collar workers of the London Subway and their IT department. At Philips, this process occurred as follows:

Normally, a company does not know how its products are being used. But now, thanks to the Internet connection, Philips knows exactly where the HUE lamps are being used and which color is the consumers' favorite. Just a week after its introduction it was evident how the lamp could be improved and which colors were favored. For instance, the consumers wanted an API that could be operated by means of vocal instructions. The purchasers of the lamps now have their own app store for sharing new app functionality. This platform is the beginning of collaboration between IT and OT, which can lead to contributions to the design of new lamps. There are opportunities for closer cooperation not only on the software side (the app) but also on the hardware side. Philips has taken the first steps in setting up this kind of connected customer platform, in which we find many items from this current report:

- the Internet element that enables industry to be connected to its customers 24/7
- the possibility to expand user experience through improved human-machine interaction
- an M2M connection from the user to the platform
- products that are a part of an end-to-end ecosystem between the maker and the user of the products (the consumer) and the maker and the user of the data (the consumer and the dentist, for example)
- Big Data Analytics that adds value to the data that are generated on the platform.



Philips Customer Health Platform

EXAMPLE: Thanks to M2M, you will never again lose your luggage. Smoother luggage process and less passenger stress

Thanks to harmonious M2M cooperation between KPN, Fast Track Company and Air France/KLM/Delta Airlines, luggage processing is now taking place much more smoothly, resulting in much less passenger stress. Two innovations have made this possible: eTrack and eTag, which can be deployed either independently or in combination. Suitcase manufacturer Samsonite is planning to integrate both in a suitcase, which will be issued in a limited edition.

eTrack: you always know where your luggage is

eTrack is a compact device that the traveler places in his or her travelling case. The luggage can be located anywhere in the world by means of GPS and GSM. eTrack makes use of a patented Auto Flight Mode, which satisfies all the criteria governing GSM and radio signals aboard airplanes. eTrack also helps prevent theft, since it can link the luggage to the traveler's smartphone via Bluetooth. As soon as the owner and the luggage are separated, an alarm goes off on the smartphone. It is also easy to check whether or not the luggage has been opened at any point between the check-in and the baggage carousel.

eTag: a faster luggage process

eTag is an electronic luggage label with two e-ink displays that can be assigned an appropriate barcode with flight information during online check-in. In this way, the passenger can arrange both the baggage tag and boarding card in advance. This enhances the speed and efficiency of luggage processing and shortens waiting times at the baggage drop-off. The traveler writes the eTag via his eTrack, or directly via the eTrack app. The passenger and flight information are stored on a built-in RFID chip.

See also: https://www.youtube.com/watch?v=XFUHACwp8VA

8 Beware of security loss

Looking at the converging worlds of IT and OT, we see not only an increase in opportunities but also an increase in risks. Security expert Bruce Schneier expressed his concern in *Wired*, where he pointed out that the chips now entering the market have outdated hardware and software. The makers of these chips have little interest in keeping the chips up to date because they are concentrating on developing and producing newer versions. The network that makes use of these chips takes on a greater risk when this kind of chip or sensor is added to the network. With each sensor, with each (mini-)computer that is added to the network, the security of the network diminishes. Robert Metcalfe, the founder of 3Com Corporation and deviser of the ethernet protocol, observed that networks – of telephones, computers or people – increase in value exponentially with every new hub or with every new user added to the network. The fax is a good example of the workings of this so-called "Metcalfe's Law." This kind of communications device has little use when few people use it. The American National Cybersecurity Center built upon this Metcalfe's Law and published a new model in 2008 ("The Economics of Networks and Cybersecurity"), which took into account not only the benefits but also the costs of cyber security and "hacker economics."

How big is the risk of being hacked in IT/OT systems? Consider the harm done by Stuxnet, a computer program that managed to infiltrate the computer networks of various uranium enrichment plants in Iran. More recently, Heartbleed, a leak in SSL security protocol, caused alarm bells to go off all around the world. This bug makes it possible to read out the memory of computers and to steal security keys.

However, problems do not always arise on the side of the things connected to the Internet. Human beings, too, make errors. The retailer Target is an interesting example. It failed to protect the personal data associated with millions of credit cards because hackers cracked the account of an air-conditioning installation firm. This account allowed access to the Target network, through which the installation firm managed the air-conditioning appliances. The eventual damage amounted to hundreds of millions of dollars: 200 million for the banks who had to produce 21.8 million new credit cards, 100 million dollars for the accelerated upgrade of the Target systems, and a profit decline of 46% in the last quarter of 2013 because customers had less confidence in the company.

9 Summary and conclusion

The transition from our previous Things report on "wearables" to this report would seem, at first glance, to be a great leap. The Fitbits, smartwatches and smart pills appear to occupy a world that is completely different from the one based on factory work, the process industry and the monitoring of gas pipes. But both worlds keep a close eye on the condition of their assets: ranging from the human body and machines to infrastructure. However, the contexts within which these possibilities can develop do indeed differ enormously. Accordingly, hospitals, producers of agricultural machines and owners of trains and rails all have to formulate their own plans. Embedded systems have already been common on factory floors for many years and people are now orienting their ideas toward further integration with higher-level IT systems or toward processes aimed at making robots smarter. Hospitals are preparing for total connectivity and are investing in infrastructure and standardization to be ready for the true advent of "Things." The integration of IT and OT means something slightly different to all these users, and people are concentrating on different competencies to realize their goals.

The Industrial Revolution 4.0

If we take the industrial considerations of the German government, General Electric, IBM and McKinsey seriously, we can only conclude that we are on the eve of a major turnaround. The world of machines and appliances, artefacts and the corresponding processes is about to receive an enormous Internet impulse that will have great impact on human-machine interaction. Reviewing the Industrial Revolution process, we have already seen that these relations have undergone radical changes in the past. Whether this will be quite as big a step as that from steam engines to Henry Ford's mass production can only be determined in retrospect. But there is reason to regard this development as an extension of our ongoing revolutionary industrial past.

The use of the word "revolution" in combination with "industry" has now become a part of our cultural heritage and requires little explanation. Our industrial achievements are so monumental and numerous that their impact can hardly be overrated. Think of the appliances we have in our homes, such as the washing machine and vacuum cleaner, the trains and cars to transport us wherever we wish, the advanced food industry, and the pharmaceutical industry. New opportunities are becoming increasingly dependent on the further "Internetification" of the physical world: airplane engines, locomotives, buses, building, toothbrushes, lighting, post-sorting machines, solar panels, and suchlike. Not only are they assigned an Internet connection with the digital world, they are also equipped with better capacities to distinguish and register situations and events.

The Internet of Things plays a crucial role in this development. As a matchmaker between information technology (IT) and operational technology (OT), the IoT has capacities at its disposal that appeal to both partners. The operational machine world is becoming more human due to "things." Moreover, sensors are more entrenched in that field. But, thanks to these "things," the IT world is becoming more integrated in the domain of operations, and the opportunities to add value "where the action is" are simply there for the taking: in everyday interaction with appliances and physical products. In this report, we examine the three main reasons for the manufacturing and process industry to embark upon the IoT adventure:

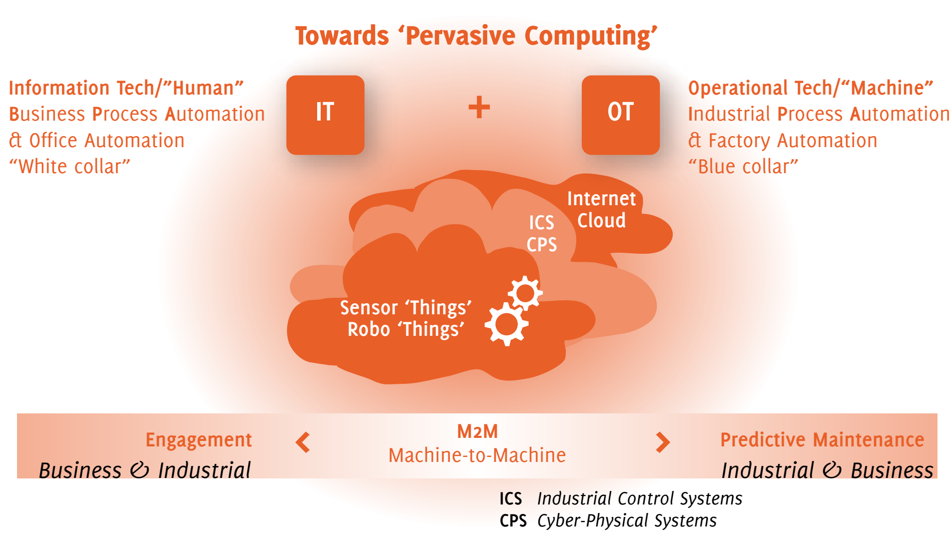
1. the benefits of machine interaction (M2M) start with improved speed and intelligence
2. the benefits of better maintenance: preferably Predictive Maintenance
3. the benefits of engagement or customer interaction: humans and machines in smart factories and beyond.

Equipping everything on the factory floor and everything that leaves the factory with sensors and Internet connections brings benefits to the user and, of course, to the underlying industry. And when Internet connection is lacking, the telecom providers, in particular, dive directly into the market of M2M services with their SIM cards: covering everything from postal packages to hospital beds.

Expressed in numbers, the impact is enormous. McKinsey has charted a route stretching to the year 2025 in which thousands of billions can be acquired and saved. The industry sector is likely to see a third of the total impact, with improvements in maintenance that should considerably reduce the cost of operations. In the examples of Predictive Maintenance that we have given, we have seen enormous savings in maintenance and the application of valuable assets. M2M provides the necessary new link to new services. And customer engagement can lead to further cost reductions in industrial processes and to turnover enhancements via consumer electronics.

The marriage between IT and OT must be more than just a marriage of convenience

Thanks to office automation, the automation of operational processes, the apps and the smartphones and the wearable computers, it is much easier to make a connection with industrial process automation and the automation of manufacturing processes. This marriage offers numerous new opportunities and the Internet of Things, as the central pivot, brings everything in our world closer together.



The marriage between these two provides numerous new opportunities, but they are not all self-evident. Engineering and IT speak different languages and there is as yet no mention whatsoever of a happy marriage. In terms of character, IT and OT are totally different. IT generally has a functional basis, the CIO, and is engaged with the market side rather than with machines. This is the world of office automation, mainframes, business processes, keyboards and desktops, but it is also – to an increasing degree – the world of iPads and smartphones, the cloud and wearables. In contrast to IT, OT is much more incident-driven, its technology is embedded, it is run by engineers and it is engaged in the control of machines.

The University of South Australia has devoted an extensive study to the topic of IT and OT integration. One of the recommendations from this research is that engineers should not bear final responsibility for the integration process. Moreover, this route should be systematically followed in four stages. This phased plan proposes a logical order of sequence and emphasizes the choice of the right standards, which is a complex matter in the OT world. The requirement that everything should be able to speak to everything else – one of the components of the necessary standardization – can be resolved by the enterprise service bus that we introduced as the “Smart Engine.” This intelligent device can cope with the many communication protocols that all conceivable sensor-things make use of. The translation to the IT side can be made via this kind of engine, which subsequently delivers the desired output: an e-mail, an alarm that goes off, a twitter message or a database entry.

Out of the comfort zones

To enable the IT-OT fusion to succeed, a change of mindset is the first requirement: the information orientation of the two professional areas. The engineers could experience any plans to do other things with their technology as being detrimental to their aim to realize 100% uptime. The IT staff, too, will have to exit their comfort zone. They will have to move away from their business dashboards with the quarterly figures and out onto the factory floor, into the outdoor workplace or the living room of the consumer: to the places where the action takes place and a difference can be made in perception, registration and speed, and the quality of the decision-making.

10 Three recommendations

In this blue-and-white-collar collaboration, Internet-things have a connecting function. Besides being a technical operation, the necessary amalgamation of various company departments and cultures is primarily an activity on the "soft side" of the organization. A precondition of success in IT/OT is the ability to bring people together, both physically and mentally. This means that all barriers will have to be flattened. Three recommendations are made to speed up this integration.

A Place IT-OT integration on your digital transformation agenda

Given the fact that almost every organization is implementing a digital transformation project, it appears obvious that the envisaged IT-OT fusion should be given a place within this project. Realizing this total connectivity demands attention and knowledge from various disciplines, ranging from connectivity, infrastructure, standardization, work processes and risk management to human resources and marketing. The body of strategists, planners and portfolio managers has the ability to allocate the resources required to realize the specified aims. A new vocabulary should be employed here. Besides B2B and B2C we are now also talking about M2M, and about bridging distances over and through complete chains. A so-called end-to-end (E2E) link is necessary for this digital acceleration. Of course, your own IT-OT activities will have a different content depending on the nature of your organization. They will involve:

- linking the data from the work processes via wearable technology to production systems, such as those of wholesalers, hospitals and energy suppliers
- standardizing data and communication protocols for "things-readiness" and the realization of total connectivity
- monitoring the use of appliances and machines in order to be able to provide better maintenance, as in the process industry, the machine industry and consumer electronics
- deploying new Human-Machine Interfaces and Interaction that make data from the operation more accessible to the users: blue collar and white collar workers and consumers.

The greatest common denominator for these digital transformations is the connection of hardware, software and services to data and digital content. Meaningful smart solutions can then be built with the use of advanced analytics. This means that hard work must be done on new digital capabilities, such as:

- governance: steering the digital transformation is the responsibility of the business operation and not the CFO
- the integration of people and cultures, which used to be called "alignment" in the IT business but now also concerns other disciplines such as R&D and design, for example – the soft side of the integration: bringing people together both physically and mentally
- alignment with stakeholders in the various channels, such as service providers in the field of customer interaction or new groups of data users in larger ecosystems

- new architectures that can convert cyber-physical components into services more simply, perhaps in collaboration with partners.

B Look at the operation through telecom eyes

An inspiring point of departure to bring together IT and OT is to view your organization through the eyes of the telecom sector. The telecom sector actively promotes bridging time and distance by means of machine protocols (M2M). Companies such as AT&T foresee a larger market than the one that currently exists for mobile telephony. The distances that must be bridged may be related to the distance between the factory and the products at home, for example, or between the professionals in the field and the assets with which they are involved: railway tracks, train, water and gas pipes, etc. In this framework, the leading questions are:

- Which opportunities do you see arising when the distance between humans and machines, other artefacts and processes is bridged?
- For which activities in your organization do you have no operational data (as yet), and how could sensors that deliver data be integrated into IT systems?
- How could modern IT devices such as iPads, smartphones and wearables add value for the consumer and/or the professional when coupled to these operational systems?

Of course, the examples from this and our first two Things reports could serve as inspiration to kick-start the creative process: ranging from office chairs with sensors that monitor the degree of occupation of offices and floors, to the Nissan that connects the heartbeat of the car driver to his or her driving style, and the many other possibilities that we sketch in our reports.

C Configure a new IT-OT sector

The barrier between IT and OT meanders not only through the organization but also through the educational programs and training courses. It is essential to add IT-OT knowledge to the curriculum in order to realize acceleration in the new area of application but, as is known, every introduction of education or training occurs subsequent to actual real-life practice. Initiatives such as “Towards 21st-Century Cyber-Physical Systems Education,” which is sponsored by the American National Science Foundation, are already being undertaken. Their aim is to develop a multidisciplinary training program, cross-domain, which should lead to nothing less than CPS fluency among the entire American working population. On the IT side, too, requests are currently being made for new professional sectors. In *Harvard Business Review*, an appeal was recently made for a new “physiolitics” approach: a combination of motion studies from wearable computers and analytics. Of course, we already know masters in human-machine communication, telematics, mechatronics and embedded systems engineering, among other things. A genuine cross-over of domains, with specific IoT knowledge as a bridge between these worlds would be a valuable and extremely welcome addition: a digital machine and human behavioral science in which themes such as design thinking, cyber security, privacy, consumer psychology and labor all converge, taking in the energy efficiency of embedded systems and, of course, lean production and processes.

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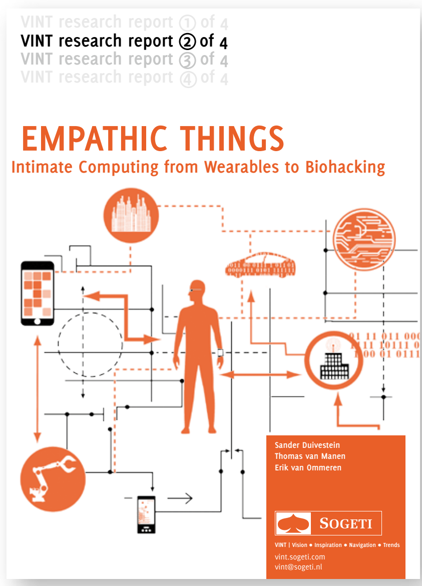

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