IoTNOW

ANALYST REPORT

# INDUSTRIAL IoT

## How manufacturers will optimise performance and maximise opportunities

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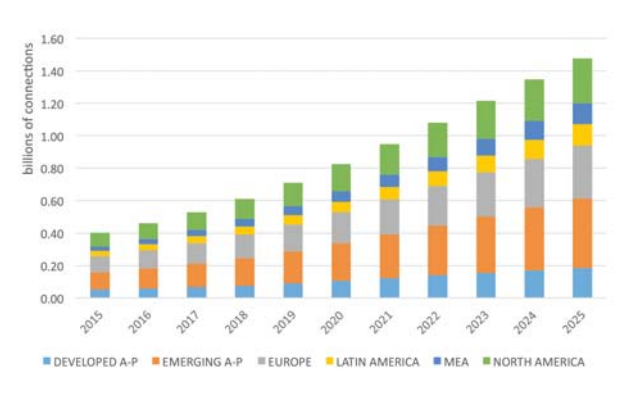
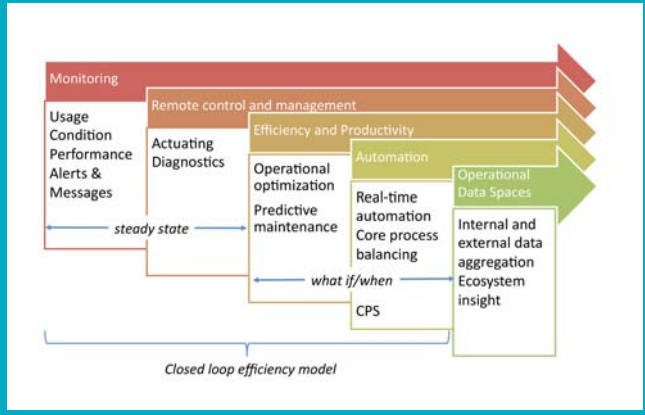
## 30

### GROWTH IN GLOBAL IoT CONNECTIONS IN CONNECTED INDUSTRIES 2015-2025




## 31

### FIVE LEVELS OF INDUSTRIAL IoT BENEFITS AND OPPORTUNITIES




# ANALYST REPORT

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# Optimise performance in manufacturing with industrial IoT

Global manufacturing faces an increasing set of challenges in growth, innovation and competition. Globally, gross domestic product (GDP) was at US$30.69 trillion in 1995. By 2014, global GDP reached a new peak at US$78 trillion. As a percentage of global GDP, manufacturing dropped its share from 21.4% in 1995 to 14.7% in 2014. In real terms, manufacturing grew, and yet the rate of growth was substantially less than that of the global economy.

Industrial IoT (IIoT) has accelerated the pace of innovation and manufacturers are pushed to explore and implement new technologies in IoT while maintaining existing systems and architectures, creating tensions between operational technologies, information technology and IoT implementations. Differences between regions and markets do exist, and globalisation has presented greater competition between markets than ever before. Common to all manufacturers are the continuous needs to reduce costs, improve performance and deliver quality to customers. Combined growth, innovation and competition have the manufacturing industry looking to industrial IoT as a way forward, and as shared in this report, exciting and innovative IoT solutions are reinventing manufacturing.

## Growth of connections in connected industry

Connected industry covers a range of industries and applications, and includes several application groups defined by Machina Research. Manufacturing and processing, supply chain, warehousing and storage, and extractive industries are some of the application groups.

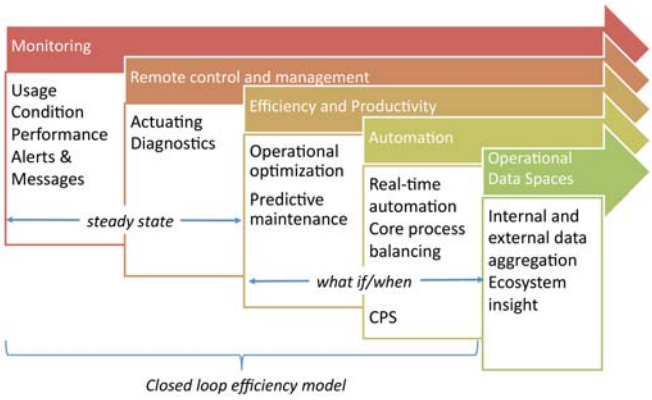
From Machina Research's global forecasts, it is noticeable that established manufacturing regions such as Europe and the US continue their innovation paths with IoT at a steady pace of 12% per year in IoT connections. In contrast, emerging Asia-Pacific with the lion's share in China, grows at 15% year-on-year, not yet eclipsing the combined number of connections for Europe and the US but reducing the gap from 43% to 29% in the ten-year period of 2015-2025, showing a real investment by emerging industries in the new technologies.

**Figure 1: Growth in global IoT connections in connected industry 2015-2025 [Source: Machina Research, 2016]**


## Benefits and opportunities from industrial IoT

Industrial IoT offers manufacturing an emerging and developing set of benefits and opportunities. Five levels are identified: monitoring, remote control and management, efficiency and productivity, automation and operational data spaces. **Figure 2** illustrates the relationship and progression between the five levels. Each level involves a complete IoT architecture and infrastructure of connected devices, networks, platforms and applications, generating real-time data from the connected devices, and enabling the processing and analysis of the data for different outcomes. ▶

**Figure 2: Five levels of Industrial IoT benefits and opportunities [Source: Machina Research. 2016]**




## Monitoring

Industrial IoT has a long history with telemetry and supervisory control and data acquisition (SCADA) solutions, delivering the earliest examples of connected devices to monitor usage, condition, and performance, and through alerts and messages, improve the overall management of different operational processes. This could range from monitoring production lines, to drilling equipment at oil and gas sites, to being embedded in defence and space vehicles, and in monitoring long stretches of pipelines, networks and remote weather stations.

Basically, telemetry and SCADA solutions have enhanced operational processes by enabling enterprises to monitor remote locations and equipment, reducing costs on 24x7 manning and/or receiving more timely information on process failures or poor performance. Being able to monitor processes in near real-time has also added to the overall operational performance of such machines as construction equipment, transportation and ships.

One fundamental development that did need to take place to enable remote monitoring to work to its full extent was wireless wide area network (WAN) communications. Without continued developments in quality and coverage of radio frequency including satellite and cellular technologies, the value of remote monitoring would not have been as great as that now enjoyed.

## Remote control and management

A next development step from being able to monitor connected devices is to enable actuation, which is remote control and management. Achieving this sounds like a strange task until you begin to explore the requirements in terms of the connected device itself – and its configuration, the type of connectivity used, and ultimately, how to manage thousands and thousands of commands to different devices at the same time.

Within the configuration of remote control and management are the steps of receiving and analysing the data off the connected devices, defining immediate actions or commands, and looping these back to the devices, or other devices in the wider solution. This could, for example, be information from a production facility measuring the level of humidity in the manufacturing process and potentially issuing a command to turn on the ventilation systems for a given amount of time to reach a defined setting level. Another example would be an office building automation system which provides temperature readings from the office building and automatically initiates the air conditioning systems and window blinds to reach a cooler temperature with less sun impacting the temperature levels.

Remote control and management has meant further developments in associated technologies. At the device level, actuation capabilities have become an important feature of M2M and IoT solutions. Previously, modules were mainly configured with a sensor, very limited processing capabilities and a wireless connectivity solution and antenna, sending alerts and messages. With the requirements of remote control and management, particularly including actuation, connected devices now require additional processing and actuation features as well as two-way communications in the connectivity technology.

Another feature of remote management that has had ▶

significant implications for industrial IoT, connected devices and their associated lifecycles are over-the-air updates. For many connected devices with lifecycles in the five to 12 year range, and more importantly, installed in remote and potentially hard to access locations, remote management including feature updates has become a very important attribute in IoT. With two-way communications, connected devices have had to become significantly more flexible and open in their structures, enabling future configuration development and as will be seen later, opening the path towards fog computing and edge analytics for automation.

Industrial IoT has moved the goalposts from passive monitoring to more of a direct interaction between the connected devices and the enabling IoT platforms.

## Efficiency and productivity

From monitoring and remote control and management, the next set of opportunities from connected devices in real-time was managed through the data. M2M applications were designed with narrow functionality objectives, and connected devices were part of the design architecture to capture and generate the data from the environment for the specific applications. In IoT, following a growing amount of data generated and transmitted by connected devices in real-time, the opportunities to analyse this data further and potentially for purposes other than the M2M or IoT applications became a recognised opportunity. Data from connected devices was used for the designed M2M/IoT application but soon became an asset which could be used for other applications, combined with other data sets, and ultimately, a monetisable asset by itself.

With multiple data sets becoming available from various connected machines, enterprises and their data scientists have been able to develop substantially more accurate pictures of the equipment including wider ranging processing and analysis of the data. As this data has increased in scale, speed and structure, and as enterprises have developed and applied advanced analytical tools and machine learning, the outcomes of data processing have become even more promising.

New insights based on for example predictive maintenance, fraud detection and condition monitoring have moved the goalposts from describing how things are to what could happen, and allow for enterprises to take preventive action. This preventive action is turn can save industries millions of dollars in terms of minimised operational disruptions, improved machine efficiency and productivity and early detection of faults and fraud. Consider the following examples which have become cornerstone applications in industrial IoT. Within most industries, maintenance routines are either based on defined schedules or some method of condition-based monitoring. Operators of, for example, wind turbines or rolling stock would carry out maintenance routines according to set schedules which in many cases were irrelevant to whether the actual equipment required the service routine or not.

While routines have helped structure unplanned disruptions into predicted activities, with connected machinery, enterprises monitor in real-time the operational performance of machines, and with the assistance of advanced analytics, predict with greater degrees of accuracy when maintenance is required. In particular, the ability to aggregate and analyse data from multiple sensors such as temperature, vibration, noise and images have enhanced the ability to detect future faults with greater accuracy. Predictive maintenance has become a significant and substantial new service available to enterprises from their connected solutions.

As an important side note, predictive maintenance services have become a crucial example of how equipment manufacturers have been able to extend their portfolio from equipment sales, to equipment plus service as devices are now connected, providing real-time data. This has unlocked substantial opportunities for equipment manufacturers to enhance their product and service portfolios, become service providers, and establish new and innovative relationships with their customers. This concept of servitisation, augmenting product sales with new services based on the data from connected equipment, is one that will be explored further in this report.

What applications such as predictive maintenance, fraud detection and condition monitoring bring to IoT and enterprises is a greater efficiency and productivity to operational performance. This development is a step further on from monitoring and remote control and management, and involves additional tools such as advanced analytics and machine learning, each in turn also improving with more and more domain expertise becoming involved in the development of these tools.

## Automation

Manufacturing industries have followed developments from early M2M to the current stages of industrial IoT ▶

including monitoring, remote control and management and efficiencies and productivity, and, as one executive expressed, the next goal is to remove "the security risks in operations by operators." In high volume, high speed production environments, real-time and near instantaneous decision-making has become a critical component in manufacturing environments. With analytical tools able to ingest, process and analyse substantial amounts of data in real-time, the goal of full automation within operations is coming closer and closer within reach. Based on operational performance data and prescriptive analytics, and driven by such significant initiatives as Industrie 4.0 in Germany, Smart Manufacturing in the US, and many innovation centres in Japan, Europe and China, the goal is to achieve operational efficiency and productivity through automation.

## Operational data spaces and closed loop efficiency models

All four levels of monitoring, remote control and management, efficiency and productivity, and automation share a common set of attributes. All these operational improvements and enhancements are based on enterprise data, generated by connected devices, and fed directly and immediately back into the operational loops in a closed loop efficiency model. It's data from enterprise equipment, used for enterprise operational improvements, and delivering operational results. Yes, in monitoring and remote control and management, the solution has moved on from what are termed steady state models such as those designed to monitor and achieve an operational steady state although time lags in decision-making may take place. In efficiency, productivity and automation the solutions have shifted towards a what-if/when anticipatory state, analysing the data, predicting future operational scenarios and either augmenting existing decision-making processes with real-time data or looping this information directly back to the operational processes, and adjusting the process. This becomes the move from descriptive to predictive and prescriptive action for manufacturers based on the data from the connected devices, and begins to show the new benefits and opportunities from internal, enterprise data.

At the next level, operational data spaces, manufacturers should begin to explore the boundaries beyond enterprise data, and understand how aggregated and augmented data, combining internal with external data delivers even further and additional value to the enterprises. Before then, it is worth identifying and sharing many of the other ways enterprise data has been exploited, particularly by other supporting processes within the business, and in the more general fields of digital twins and servitisation.

Additional opportunities enabled by enterprise data Devices producing real-time data about the status, condition and performance of connected equipment has unlocked new, innovative and additional opportunities for enterprises in other supporting manufacturing processes. Three supporting processes, core in their own rights, are supply chain, product development and management, and maintenance.

## Supply chain improvements

One of the critical and core processes to develop more efficient manufacturing processes is that of the supply chain. The close alignment and management of supply chains and the manufacturing processes enable enterprises to optimise the utilisation of machinery and plan resources in excruciating detail, including production schedules and runs. Managing supply chains has been at the centre of improvement initiatives in manufacturing for several decades – see Kanban or Just-in-Time manufacturing, and with emerging IoT technologies, the level and quality of information from the origin of raw materials to the production facilities has improved significantly.

To minimise costs, for example, raw materials held in the process, manufacturers have looked to balance the timely warehousing and stock control of raw materials with the production requirements on the manufacturing floor. Previously planned around set delivery schedules with buffer stocks, closely monitored and managed supply chains with IoT enable enterprises to improve these processes substantially, following every step of the raw materials from origin to production. Industrial IoT has enabled enterprises to understand both the location of raw materials at any given point in time but equally important for many industries such as food processing and pharmaceutical industries, the conditions under which the raw materials have been transported.

As an example, manufacturers able to monitor transportation conditions of raw materials requiring minimum and maximum temperature or humidity conditions, can detect well in advance of the production processes if anything may have gone wrong during transportation – increased humidity for example, and avoid further unnecessary production costs with quality failures later in the processes. ▶

Equally, given the accuracy of location data and calculations of arrival times, manufacturers have been able to work against more accurate production schedules and quickly align production rates where required, to keep line balancing at an optimum. For substantially larger enterprises, improved supply chain management has a significant impact on efficiencies and cost control of manufacturing processes. It delivers smoother and more efficient production runs, fewer unnecessary production disruptions due to material shortage, and avoids wasted production runs with inferior materials impacted during transportation.

Transformation of product development and management
Another significant development in industrial IoT is the impact on product development and management. Previous product development processes include customer feedback about the use and performance of products once launched in the field. These feedback processes were either at set service intervals or when issues arose with the product or sometimes never.

As products have become connected, transmitting real-time data about their status, condition and performance, product design and engineers can monitor products throughout their entire lifecycle. Through design stages to activation stages and to actual implementations or customer ownership, products are now monitored, and instantaneous feedback about product condition and performance is being captured, processed and analysed.

For example, manufacturers of tires such as Continental and Pirelli have implemented for several high-end tire ranges, the connected tire, allowing manufacturers to monitor tire condition and performance, and include any immediate findings into their production processes. Similarly, automotive manufacturers have followed suit, constantly evaluating, assessing and controlling for example engine performance, fuel mix, brakes, power, drivetrain, and a host of other activities.

Vendors have recognised this development quite early on in IoT marketplaces and offer, in addition to their traditional software based design tools, the ability for enterprises in general but more specifically for the manufacturing industry, to launch connected products and benefit immediately from the real-time data off the devices. These benefits have also been shared with customers, as this report will explore in the section on servitisation.

## Predictive maintenance, delivering the service and digital twins

Predictive maintenance has been heralded as one of the significant opportunities emerging from industrial IoT for the manufacturing industry, and it's easy to understand why given the cost of machinery and efforts to maximise utilisation without damaging the equipment.

Efficient maintenance routines have always been key to the successful management of equipment whether you are in any production industry, transport industry, or any industry where critical assets enable service delivery. For decades, maintenance solutions have taken various approaches including planned maintenance schedules, visual inspections, condition-based monitoring systems and reliability solutions. The emergence of industrial IoT has added a substantial factor in all the above approaches in terms of real-time data, and has even gone several steps further by including new analytical processes for potential fault and failure detection, or in other words, predictive maintenance.

In predictive maintenance, enterprises are accurately able to analyse the status, condition and performance of equipment through multiple sensor data sets including the traditional performance data of production speeds and output and more recently, aggregating these data sets with noise, vibration, humidity, temperature and even visual data inputs. Combined, multiple data sets are analysed and provide substantially improved insights for predictive maintenance purposes.

Predictive maintenance becomes a substantial benefit and opportunity for the running and management of machinery in the manufacturing industry. What industrial IoT in addition delivers to maintenance is the actual way of servicing machines. Previously, service engineers will have approached maintenance and repair tasks with diagnostic results and potential recommendations for problem resolution. Their expertise helped them through the task. With industrial IoT, service engineers are geared with more advanced information available, and two new gadgets, tools and applications for service engineers come into play – augmented reality and the digital twin.

## How augmented reality adds significant value to the work of service engineers

Service engineers equipped with augmented reality (AR) glasses and tablets and associated engineering ▶

applications have visual diagrams of machine equipment superimposed on actual equipment, and provide real-time guides and recommendations as to how to complete repairs and perform maintenance tasks. For service engineers, AR glasses provide additional data for greater engineering efficiency, and particularly for less experienced engineers, AR glasses and the associated application may provide invaluable service task assets. In an example shared by PTC and one of its customers, Getinge, the company showed how medical equipment could be easily serviced by on-site engineers with the new technology, and how more complex maintenance tasks can be improved with the technology.

## How digital twins will become a common design feature of the future

A digital twin is the computerised version of a physical asset, providing a detailed software-based visualisation and composition of the actual piece of equipment or product. Product designers have worked with earlier concepts of digital twins in the form of computer-aided design (CAD) and software simulations. With the emergence of industrial IoT and connected products, these digital twins have been brought to life from static computer-aided designs to visual displays sharing real-time data from the products as well as simulated effects which the data may indicate. Looped back, the digital twin becomes both the source for invaluable information and insights for product engineers as well as the tool for service engineers to work against in augmented reality.

For manufacturers, the record of product design and service management routines are becoming based more and more around digital twins, and with the concept developing together with maintenance, product engineering and customer experiences, digital twins are an unquestionable asset of the future.

## The future of servitisation

Industrial IoT has been described as a disruptive market force, and servitisation is at the roots of this thinking, making this a critical opportunity for original equipment manufacturers (OEMs), service and solution providers, and application developers. In fact, servitisation unlocks significant opportunities for the entire IoT ecosystem including the manufacturing industry. With connected products and services, manufacturers can radically transform their business models from product-oriented business models to service-oriented models with substantial impacts on the business such as financial models, customer lifecycles and skills and resources. All these changes form part of the digital transformation of enterprises, and form an integral part of the growth, innovation and competition challenges faced by the manufacturing industry. What are the changes in financial models, customer lifecycles and skills and resources for enterprises in Industrial IoT?

### Moving from capital expenditure and operating expenditure financial models

Manufacturers have traditionally focused on product-oriented business models. Here, transactions around the sale of products have been the dominant business model, and in heavy manufacturing, for example, the sale of heavy equipment has been based on capital expenditure models for the equipment and the purchasing enterprise. With industrial IoT and connected equipment, more and more manufacturers are transforming their business models to more a service-oriented model based on a service charge on equipment usage rather than asset sale. What this means for manufacturers is a realignment of financial models from capex-driven to opex-driven models, and for enterprises procuring services, the opportunity to avoid steep upfront capital expenses, and pay for the equipment as it is used. For those manufacturers who have yet to adopt the new business models, competition has begun to appear quite intense, and it is worth remembering, that all this is only enabled through industrial IoT.

## New customer lifecycles

Moving from a product-oriented business model to a service-oriented business model also means a significant change in the relations between the manufacturer and the customer. From a single, across the counter transaction, the service-based model opens an extended and important customer relationship which many manufacturers will not have dealt with before. While this unlocks opportunities for additional sales of services, it also places new responsibilities on the manufacturer in terms of customer service support and maintaining ongoing customer relations. Organisational features which many manufacturing businesses will need to develop and implement.

The new customer lifecycle challenges for manufacturers will evolve in parallel as part of the digital twin and ▶

predictive maintenance services which manufacturers will begin to offer their customers. In this emerging model of innovation, competition becomes increasingly more difficult for latecomers to the market as servitisation builds closer relations between manufacturers and their end customers.

## Skills and resources in the industry

Servitisation and industrial IoT are two disruptive forces which executives in the manufacturing industry need to prepare for and engage in. The do nothing approach is not an option. And in transforming the business, executives will need to identify and develop their skills and resources as part of the digital transformation. This includes resources in product engineering, sales and customer services as well as newer skills and resources in business and data analysis and business development.

The benefits and opportunities for manufacturers for growth and innovation are significant with servitisation and industrial IoT but as with other disruptive forces, the market does not stand still, and new competitive players and markets will emerge with the changes. This competition brings us to the next and future development of IoT data, moving from internal monetisation to external data monetisation based on operational data spaces.

## External data, data monetisation and operational data spaces

Monetisation of data for enterprises has followed a path of internal data monetisation for internal operational objectives, and with experience and the right data management tools in place, enterprises have cautiously started to explore external data monetisation, ultimately aimed at producing new revenues streams for the business. These remain early days for monetisation goals with internal and external data, and for most enterprises, especially those within the manufacturing industries, internal data monetisation remains the priority. **Figure 3** illustrates the four quadrants in which internal and external data can be monetised. The following provides a quick description of each quadrant:

**Quadrant one:** external data for internal monetisation objectives. Enterprises have a history of merging external marketing data sources with minimal customer data, building marketing strategies, defining new customer segments and create new product and service propositions.

**Quadrant two:** internal data for internal monetisation objectives. Enterprises have long tapped into historical enterprise data sources such as key performance indicators (KPIs) for operational improvement reasons, and with increasing amounts of data emerging from industrial IoT, enterprises are quick to identify operational improvement opportunities such as predictive maintenance.

**Quadrant three:** internal data for external monetisation objectives. The focus on internal monetisation remains the priority for most enterprises. The opportunities from selling internal data, anonymised and pseudonymised are tightly weighed against the potential and perceived costs of data privacy, governance and security. As technologies improve, and as more defined data communities or Subnets of Things are established with the appropriate and suitable levels of authority and security in terms of data sharing, enterprises will start to engage. Similar data sharing models have been seen in other industries such as the airline and shipping industries, the hotel industry and more openly, in many scientific fields. ▶

Machina Research

Machina Research provides market intelligence and strategic insight on the newly emerging Internet of Things (IoT), Machine-to-Machine (M2M) and big data opportunities.

The Internet of Things is the single most important technology trend today. IoT technologies are already enabling new and innovative business opportunities, proving a significant disruptor of traditional business models and processes. It is front-of-mind for many corporate management teams as well as the myriad of technology vendors that support and supply them.

Staffed by industry veterans, we provide market intelligence and strategic insight to help our clients maximise opportunities from these rapidly emerging markets. If your company is a mobile network operator, device vendor, infrastructure vendor, service provider or potential end user in the IoT, M2M, or big data space, we can help.
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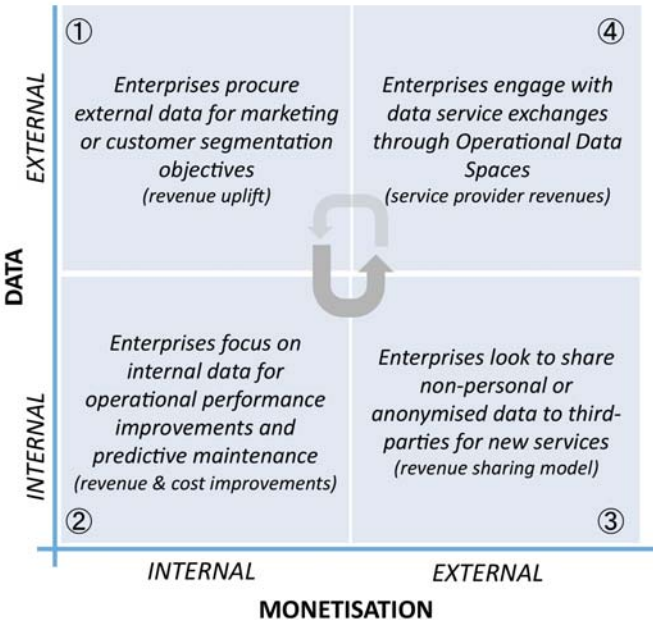
**Quadrant four:** external data for external monetisation objectives. The open data market remains a distant prospect for the time being. Enterprises remain focused on internal monetisation paths, and will continue to explore and follow developments in data privacy and security. Once markets fully accept data-sharing and the appropriate regulatory frameworks for data exchange and operational data spaces are established, this opportunity area may be explored but that remains some time away.

**Figure 3: Internal and external data monetisation paths for enterprises [Source: Machina Research, 2016]**




## The future of smart manufacturing

Growth, innovation and competition are three of the main challenges faced by industry. These have been continuous challenges for any manufacturing executive, and yet, the pace of change and scale of disruption with the Internet of Things and servitisation has led to numerous articles and presentations mentioning the impacts of the next Industrial Revolution.

Growth of connected devices and data is no longer something for the future. It is here. The behemoths of IoT such as IBM, GE, SAP, Microsoft and AWS are quoting millions of connections being enabled each year, and the same players are at the forefront of the innovation in data and analytics. Manufacturers are not immune to these developments, and will be adding to these connections and developing the tools for data and analytics.

In innovation, manufacturers are reinventing and redeveloping their businesses, and improving operational performance, customer experiences and new revenue streams. Transforming the business from a product-oriented industry to a service-oriented industry is underway.

Finally, competition. As manufacturers are reinventing themselves, they are not only unlocking new opportunities but establishing and entering new competitive markets with players extending their capabilities. This has led to the development of new ecosystems and approaches in partnerships and collaborations, and manufacturers will quickly recognise that yesterday's single enterprise empires will be made up of conglomerates and partnerships of tomorrow.