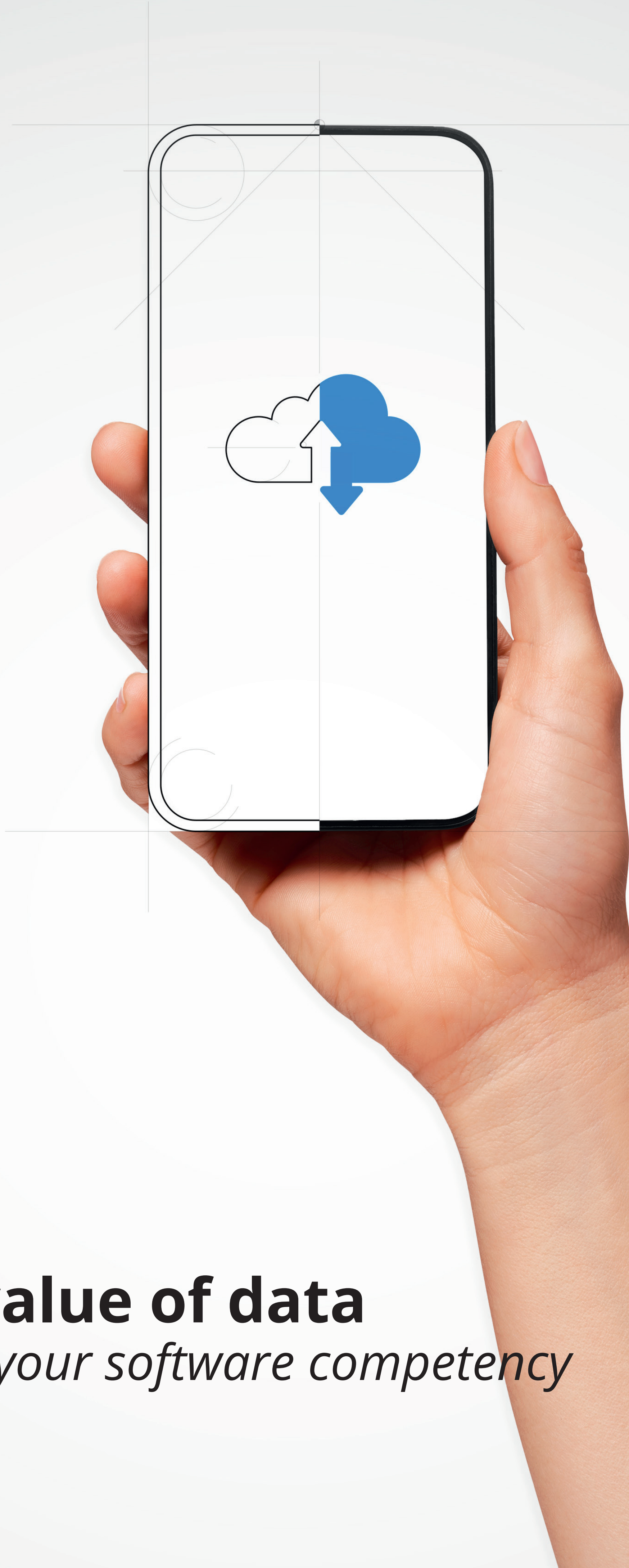


KDAB

Realizing the value of data

Making the most of your software competency

Contents

Software competence and the value of data

In our 2020 paper "Dodging disruption with software", we discussed the opportunities and potential pitfalls facing producers of physical products looking to embrace software competency as part of strategy to prevent commoditization.

In this paper, we expand on those lessons to reflect on the value of the data that can be accessed by placing software competency at the centre of your corporate strategy. Again, these lessons are applicable to almost any physical products, and they continue to embrace the whole gamut of manufacturing including the previously referenced agricultural conveyers, passenger cars, commercial airplanes, coffee machines, biomedical sorters, chemical tanks, mining equipment, diesel locomotives, and vacuum cleaners.

If software competency is your most important asset, then the data it releases for the benefit of either you or your customers is one of the key reasons for that. Just as before, this may be extremely counterintuitive - especially for companies with products that don't even contain software!

Most will be familiar with the sentiment of management guru Peter Drucker's famous observation, "[only] what gets measured, gets managed." It is this capacity of the data associated with your products to enable measurement that is key to its value.

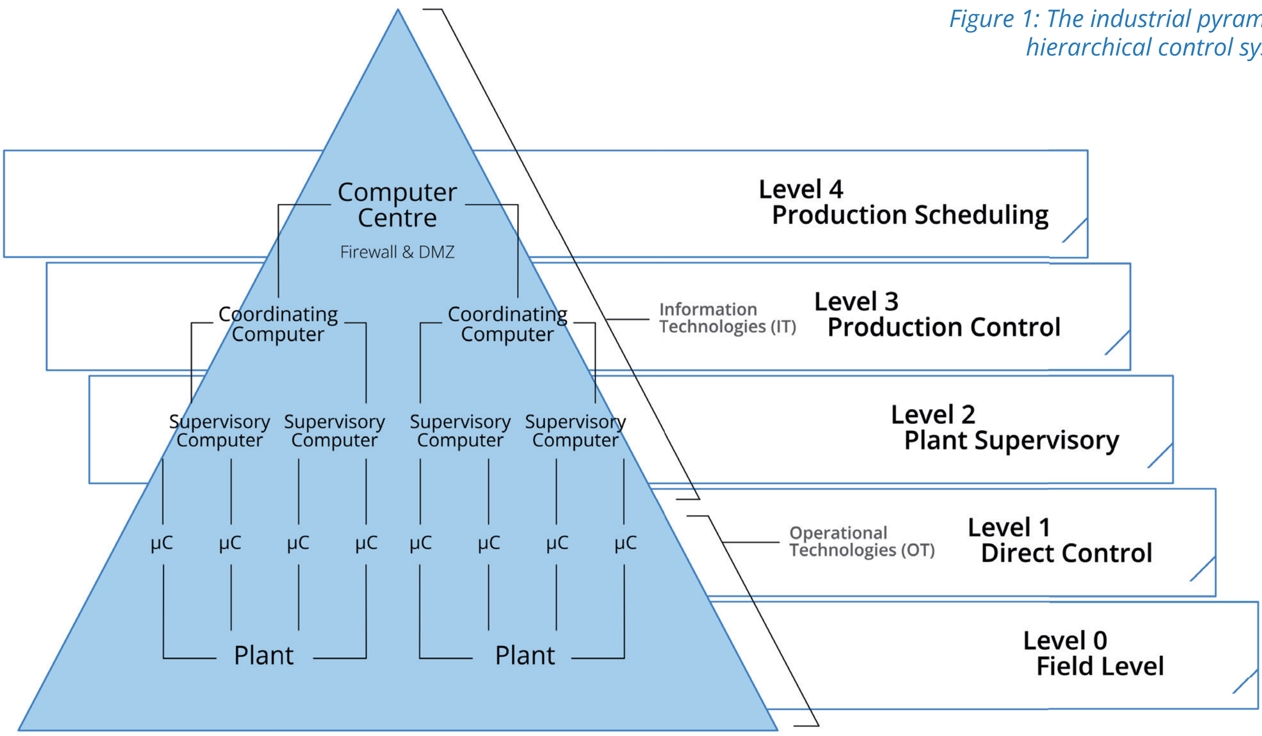
We will study a car manufacturing environment to give context to that assertion, demonstrating the lengths that others are going to in collating and leveraging data like yours. Bear with us if that seems alien to your own world. Its relevance will become clear!

Practical experiences in car manufacture

Industrial manufacturing plants – automotive plants included - have long consisted of a combination of Informational Technologies (IT) and Operational Technologies (OT). Generally, IT is focused on data and communication, whereas OT is focused on behaviours and outcomes. The industrial (or automation) pyramid classifies the different computing elements of resulting automated industrial production plants. It conceptualizes the different IT and OT levels as part of a contiguous whole, with each level having its own tasks and infrastructure.

One representation of the industrial pyramid is shown in Figure 1. Level 0 (field level) is closest to the devices and sensors, whereas Level 4 (production scheduling) is the furthest from the manufacturing floor.

Figure 1: The industrial pyramid: A hierarchical control system



"Level 4 systems, with higher computational capabilities, operate in less harsh environments and don't need real-time data source proximity"

Characteristics of devices and systems vary accordingly. For example, systems at level 0 are usually ruggedized, fanless designs with limited CPU and memory. Safety, security, and fast, dependable responses are paramount, meaning that it is appropriate to keep any processing overhead local – that is, "edge computing".

Level 4 systems, on the other hand, do not operate in harsh environments, are usually associated with a lot more computational capabilities, have less demanding real-time requirements, and hence have no need to operate near the data source.

Level 2 (plant supervisory level) represents the median of control, determinism and computation and is usually the focus of OT and IT convergence. Connecting them together exposes the security of both systems, simply because in each case it implies the provision of a potential means of access they weren't designed for.

The net result of such challenges is that system builders and administrators typically don't mix IT technologies (that work in level 3 or level 4) with OT workflows (level 0 through to level 2).

The experience of Neckarsulm

The value of breaking down that divide was demonstrated by a real-life Proof of Concept (PoC) at an Audi manufacturing plant for the Audi A3 [1]. Audi worked with Intel and Nebbiolo on a proof of concept (POC) experiment focused on improving the quality-control process for the welds on its vehicles. The POC took place at Audi's factory in Neckarsulm, Germany, the company's two principal assembly plants. The Neckarsulm plant has 2,500 autonomous robots on its production line. Each robot is equipped with a tool of some kind, from glue guns to screwdrivers, and performs a specific task required to assemble an Audi car.

Audi assembles up to approximately 1,000 vehicles every day at the Neckarsulm factory, and there are 5,000 welds in each car. To ensure the quality of its welds, Audi has traditionally performed manual quality-control inspections. It is impossible to manually inspect 1,000 cars every day, so Audi used the industry's standard sampling method, pulling one car off the line each day to test the welding spots and record the quality of every spot. Sampling is costly, labour-intensive and error prone. So, the objective of the PoC was to inspect 5,000 welds per car inline and infer the results of each weld within microseconds.

A machine-learning algorithm was created and trained for accuracy by comparing the predictions it generated to actual inspection data that Audi provided. The machine learning model used data generated by the welding controllers, which showed electric voltage and current curves during the welding operation. The data also included other parameters such as configuration of the welds, the types of metal, and the health of the electrodes.

These models were then deployed with the result that was the systems were able to predict poor welds before they were performed. This substantially raised the bar in terms of quality.

Image 1: The Audi A3 is built at the Neckarsulm plant ***Photo by: Lucho Renolfi***

Bridging IT/OT allows real-time process optimization and quality control, improving factory operations and enabling innovation.

The result is a scalable, flexible platform solution that Audi can use not only to improve quality control for spot welding, but also as the foundation for other use cases involving robots and controllers such as riveting, gluing and painting. A dashboard lets Audi employees visualize the data, and the system alerts technicians whenever it detects a faulty weld or a potential change in the configuration that could minimize or eliminate the faults altogether.

Neckarsulm and the value of data

Clearly, the data collated by the welding machines at Neckarsulm was central to this proof of concept. Without that, there would have been insufficient information for machine-learning algorithm to be able to monitor weld quality.

The current and voltage parameters are fundamental to welding machines. They would doubtless have been long known and valued by the manufacturers. But their value in the context of the plant in which they operated would perhaps have been much less apparent – and yet it is the data, not the machines themselves, that made them so valuable to Audi. It represented pivotal data in the edge computing element of the project.

Now consider that principle in the context of some of other example devices.

1. Of course, the Neckarsulm PoC is a prime example of the usefulness of data in the production of passenger cars. But the cars themselves have long been connected. This technology helps to improve road safety by enabling vehicles to communicate with each other and avoid collisions. Smart road technology enables communication between vehicles and between vehicles and traffic infrastructure, such as traffic lights, road signs, and parking meters. Each offers the opportunity for more efficient traffic management.
2. Perhaps crop yields can be compared to evaluate the effectiveness of different farming methods. Evaluating waste


Image 2: Welding in process

Photo by: Thossaphol

"The Neckarsulm PoC is a prime example of the usefulness of data in the production of passenger cars. But the cars themselves have long been connected"

percentages may yield insights into the optimal handling of produce. Looking more inwardly, monitoring the performance of individual conveyors compared to the norm flag the need for preventative maintenance and hence avoid costly failure at harvest time.

3. These examples are by no means unique to the automotive sector. For instance, the agricultural community uses belt weigh conveyors to feed processes that freeze or process fruits, vegetables, and other agricultural products for packaging for retailers or other process plants [2]. Connectivity is valued because it decreases installation time and eliminates long cable runs to a control centre. But the data that it produces is useful in other ways too, especially when it is possible to compare the data generated by different conveyors in different environments.
4. At a higher IT level, the use of intelligent transportation system (ITS) applications on roadways and transportation results in improved coverage and access to near-real-time insight into activities and events happening on roadways. They can be used to proactively address problem areas, reduce response times, and improve overall road safety. This means problem areas can be proactively addressed, response times reduced and overall road safety improved.
5. Data is also relevant at the point of sale to consumers. Coffee machine manufacturers [3] are now embracing the Internet of Things (IoT) to allow beverages to be ordered and prepared, using an easy to use, intuitive app and to remotely apply price adjustments and special offers. Incoming data from the machines analysed at an IT level permits the monitoring of beverage sales at different venues, machine health, and stock levels, and the analysis of which sites perform best – and why.

In this connected world, whatever your physical product there will likely be data that you have either always taken for granted or not even thought might be significant. That is not only valuable edge data. It is a potentially significant differentiator in your market for whoever leverages it first – whether that is you, or your competitors.

Beyond Neckarsulm

The Neckarsulm PoC was a new system in its entirety and despite all the promise of this solution and the quality control advantages it brings, it will not generally be practical to replace all existing applications in an existing production environment. Support for legacy systems by leveraging hypervisors and separation kernels [4] and supplementing them with new data harvesting technologies – or more specifically, industrial data collection - promises a pragmatic solution for many more real-life situations.

But there are issues with that approach. The devices deployed at Neckarsulm were always designed to be connected, and hence to be protected as proportionally against bad actors (hackers). Developers of traditional OT devices never had to worry about such things because security came for free by virtue of isolation. Connecting them implies the provision of a potential means of access they weren't designed for.

There are some ingenious approaches available to address this issue and to integrate legacy solutions to allow data to be collated and leveraged. To repeat; this example may not be directly relevant to you – but note the significance that is clearly being placed on data collation, even with respect to devices manufactured long ago.

Embedded hypervisors

Embedded hypervisors allow multiple computing environments to run simultaneously on a single system on a chip (SoC). System designers can consolidate diverse operating systems (OSs) and applications with different reliability, safety, and security requirements on one SoC.

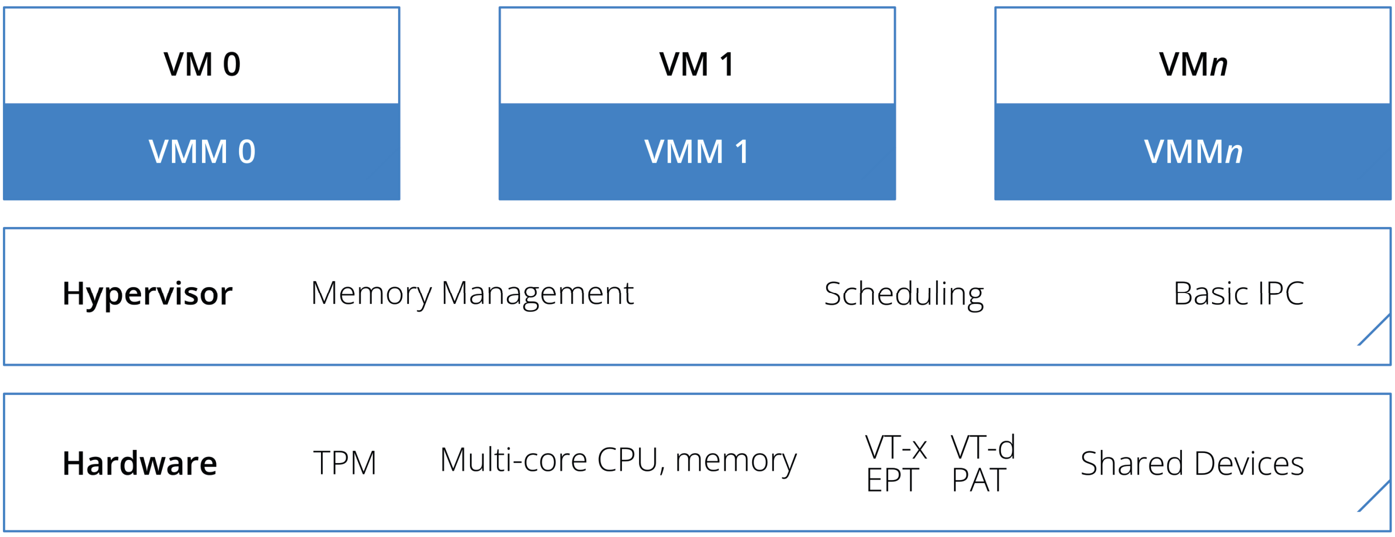


Figure 2: Schematic diagram of a typical embedded hypervisor installation

Virtual machines (VMs) in a hypervisor duplicate the underlying hardware so accurately that guest operating systems can run without modification. From the point of view of a guest OS, the VM is hardware. That allows legacy systems to run on new hardware without modification.

The net result is an opportunity for legacy code to reside and run alongside new applications that are designed to leverage modern data analytics.

Data collection from legacy applications

One of the primary purposes of all this data collection is for the measurement of Overall Equipment Effectiveness, or OEE. OEE identifies the percentage of manufacturing time that is truly productive. An OEE score of 100% means manufacturing only good parts, as fast as possible, with no stop time – or more formally, with 100% quality, 100% performance, and 100% availability [5].

Capturing the right data in a timely manner can transform manufacturing operations by short-circuiting such calculations, and the feedback responses they imply. Production plants are usually under extreme commercial pressure. The analysis of this data enables their management to ensure that they are operating optimally - and in the case of Neckarsulm PoC, to reduce overheads as part of that process.

"Capturing the right data in a timely manner can transform manufacturing operations by short-circuiting such calculations, and the feedback responses they imply"

The equipment selected for that project is obviously capable to share the pertinent data, but there is no shortage of specialists who are more than happy to help to derive data from a legacy piece of equipment. That's not a cheap or easy task, requiring an Industrial IoT (IIoT) device with the right connectors, protocols, and firmware in place on the machine connection side. The use of appropriate PLCs and controllers can gather a large amount of data to feed the analytics system, differentiating them from a parameter-specific sensor to detect (say) vibration or temperature [6].

Multiply that level of investment across a whole shop floor - and it's transparently clear that someone, somewhere values this data very much!

Data provides commercial advantage and operational efficiency, benefiting industries from lathes to coffee machines.

So what? We're not making cars!

The point is that data is valuable – and it is valuable because it yields a tangible commercial advantage. The Neckarsulm example demonstrates that quite clearly, as does the booming industry that exists in retrofitting equipment to collate data from legacy equipment, and incorporate legacy control software into hypervisors.

Why? Because it is a key factor ensuring optimal operation – and clearly, that is an objective that is shared with ANY commercial enterprise.

The data that is produced by (say) a lathe that is retrofitted with IIoT interfaces is valuable to the lathe owner because it makes their business more efficient. It is valuable to the vendors of those IIoT interfaces, whose business depends on collating data while maintaining cybersecurity. It is valuable to the system integration specialists who specify and apply those devices to collate the data. In fact, the one organisation not gaining any benefit from this scenario is the lathe manufacturer themselves. Yet they could have provided the relevant, highly valuable information more directly, and with a great deal more insight.

And if that's true of lathes then it is just as surely true of coffee machines, biomedical sorters, chemical tanks, mining equipment, diesel locomotives, vacuum cleaners...

Of course, the manufacturer of a 25 year old lathe can hardly be blamed for not having maximised and capitalised on the data

Image 3: Vending Machine ***Photo by: Stéphan Valentin***

that could be a key differentiator for their business. But there would be very little reason indeed for them not to do so now!

To put that into perspective, here are some examples of situations where accessing latent data makes offerings more valuable, and perhaps adds a unique differentiator from the perspective of their customer base.

Vending machines

Traditionally, vending machines were simply placed in situations that appeared to offer logical placement from the perspective of footfall and restocked by means of regular visits from maintenance operatives.

By accessing the latent data offered by these apparently simple electromechanical devices, operators can streamline their businesses [7] in several ways:

- Maintaining machines at optimal stock levels through route planning guided by telemetry.
- Keeping choices fresh and appealing by reviewing top-selling products, introducing new items regularly.
- Minimizing downtime by using remote fault tracking.
- Boosting sales and gathering valuable sales data:
  - Which products sell best, where?

- Which are the most optimal placements?
- Which products could be withdrawn?

In summary, connected vending machines improve operational efficiency, customer satisfaction, and sustainability while providing valuable data for business optimization and marketing.

Hand tools

Connected hand tools present the opportunity to collate usage, performance, and condition-related data. The analysis of that data presents numerous opportunities ranging from the optimisation of their use, to maintaining them in prime condition.

- Track usage patterns, identify maintenance needs, and optimize tool performance.
  - Firmware updates to improve tool functionality or address security vulnerabilities in response to this data analysis.
- Safety features such as auto shut-off, emergency notifications, and usage limits.
- Inventory management systems allow for better tracking of tool usage, reducing the likelihood of tools being lost or stolen.
- Remote diagnostics provide quicker troubleshooting and reduce downtime.
- Optimization of power usage based on real-time needs saves energy and reduces operating costs.

"Internet-connected hand tools offer convenience, safety, data-driven insights, and the potential for improved efficiency and [...]"

Internet-connected hand tools offer convenience, safety, data-driven insights, and the potential for improved efficiency and productivity, making them valuable assets for both individual users and businesses.

Medical devices

Connected medical devices and the access to the latent data they offer presents a wide range of benefits including improved patient care, streamlined processes, and enhanced research [8]. Key advantages of connected medical devices include:

- Remote monitoring of patients' vital signs and health data in real-time, enabling the early detection of health issues and allowing for timely interventions.
- Improved patient engagement by providing access to health data, educational resources, and reminders for medication or appointments.

Connected medical devices improve care, efficiency, and research.

- Enhanced data accuracy through more accurate and continuous data collection.
- Timely alerts and notifications for healthcare providers and patients when parameters fall outside acceptable ranges.
- Data collection for clinical research and trials, allowing researchers to gather large datasets efficiently.

Connected medical devices offer a wide array of benefits, ranging from improved patient care and engagement to more efficient healthcare delivery and advanced research capabilities. These devices play a crucial role in the modern healthcare ecosystem, offering the potential to transform how healthcare is delivered and experienced.

"Connectivity in food technology brings numerous benefits, ranging from food production and supply chain management to food safety and consumer experience"

Food technology

Connectivity in food technology brings numerous benefits, ranging from food production and supply chain management to food safety and consumer experience [9]. Here are some of the key advantages of accessing latent data throughout that ecosystem:

- Access to data via IoT technology enables the real-time tracking of food products and hence the identification of contamination or quality issues.
- IoT devices can continuously monitor and transmit data on temperature, humidity, and other environmental conditions during food storage and transportation.
- IoT sensors and data analytics allow for better supply chain management, leading to cost savings and reduced environmental impact.
- IoT sensors can collate data relating to quality parameters, such as freshness, ripeness, and texture, allowing for precise sorting and grading.
- IoT sensors can be used in food processing and manufacturing equipment to monitor their condition in real-time, allowing for predictive maintenance.
- IoT-generated data can provide valuable insights into consumer behaviour and preferences, helping food

companies adapt their products and marketing strategies.

- The access to latent data enabled by IoT technologies offers significant benefits in food technology by enhancing food safety, supply chain efficiency, quality control, and sustainability, while also improving the overall consumer experience and reducing waste.

Summary and conclusions

Accessing data via the Internet of Things (IoT) offers various commercial benefits to businesses and organizations. The Neckarsulm project provides an insight into how effectively these benefits can be leveraged, but the opportunities are by no means limited to automotive manufacture.

Suppliers of devices from almost any walk of life have an opportunity to provide access to previous latent data concerning when and how often their products are used, their condition, and their productivity. Those that choose to grasp that opportunity will have a significant advantage over competitors who offer no such benefits.

The analysis of the data created by the devices made by your organization will present your customers with the opportunity to improve their efficiency and productivity, reduce costs, and enhance their own customers' experiences. All of that will provide them with significant competitive advantage.

And if you don't provide them with that advantage – then who will...? ■

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