Does Business Process Management really need IOT?

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Abstract. The paper focuses on the Internet of Things concept and tries to explore this "buzz acronym" in the context ofindustrial data acquisition for Business Process Management applications. Due to the big push of cloud and technology vendors nowadays we are facing with a race towards data acquisition from industrial machines. However, the typical workflow adopted when implementing Industrial Internet of Things to the management of business processes has several limitations. Authors introduce a user-centered paradigm that inverts the typical Industrial Internet of Things workflow by shifting from the extraction of data to the transformation of a machine into a smart appliance. The proposed paradigm starts from the typical DIKW (Data, Information, Knowledge, Wisdom) pyramid adapted to the context of Industrial Internet of Things (I-IOT) used as enabling technology for Business Process Management. The use case shows the "smartification" of a legacy drill press retrofitted with only two non invasive sensors in order to create a smart system able to provide actual information needed to optimize its use and maintenance within the business process.

Keywords: Industrial IOT · Data acquisition · Industry 4.0

1 Introduction

In the last years, technological change is so fast that many business-related aspects struggle to keep pace: job profiles, skills and competences, but also supporting IT architectures or standardization. Sometimes we face a disruption, i.e. something really new, while in other case we are in front of a new term that describes something already known that was not yet given a proper name. A third scenario is when marketing is responsible for such a change and the actually new thing is the buzzword itself. Before a buzzword comes to its natural end and new words substitute it, it is really interesting to understand how a term/buzzword evolves. The paper moves from the analysis of the Internet of Things concept

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and tries to explore the “buzz acronym” in detail. IOT is a term whose diffusion started in 2009[1] but it is still an immature concept for a non-technical audience. 2018 estimation from IOT Analytics firm affirms that in 2020 more than 9.9 billion of IOT connections will be activated with a growing rate of 10% per year bringing the number of active IOT connections to 21 billion by 2025 [4]. If we focus our analysis to Industrial IOT only, forecasts report that the Industrial IoT Platforms for manufacturing market will reach $12.4 Billion by 2024 [5] with a huge increase of connected machines and industrial apparatus.

In the IoT Domain, the term “Machine” is a generic term as well, actually it could be referred to household appliances, cars, domotic systems, robots, but others cite also production machines in factories, trains and buses, cycles and smart-watches, cameras and switches, street lamps and kiosks.

Nowadays, IOT is at the stage of a big box where people, belonging to different fields, put their products, researches, discoveries, analyses. It is a good way of being or remain visible, a good selling channel, a “good” container for very different contents: embedded electronics, big data, cloud computing, domotics, e-health, home robotics, etc.. We can state that IOT is a marketing word that makes old fashion objects “smart” and so appealing in the 2020 era[4].

We accepted that things and machines can become smart just because they are connected to the web. But, streaming giga of data into a cloud is not necessarily an added value that turns “stupid” machines into “intelligent” systems. When we talk about smartness we have to start referring to the purpose, to the applications, to the added value that makes this new smart-since-connected device better than its previous version.

1 shows the typical DIKW (Data, Information, Knowledge, Wisdom) pyramid adapted to the context of Industrial Internet of Things (I-IOT) used as enabling technology for Business Process Management (BPM). Sensors and data aren’t enough for enabling the pyramid conversion flow.

Nowadays Industrial IOT is pushed by the huge hype of Industry 4.0 fueled by cloud and technology vendors interested in selling as much as possible their cloud and data acquisition infrastructures. Looking at the offers of Industrial IOT as a service infrastructures typically the focus is directed toward data acquisition and storage and recently also to general purpose AI system aimed at interpreting acquired data [9][8].

Let us reverse the problem and start from the birth of Internet. Internet has been conceived to allow people to connect with each other, to communicate ideas, to share digital material. It is a dynamic communication channel between people for people. If this assumption and definition is correct then let’s move on extending the view to IOT. Literally, “Internet of Things” means that objects are connected to the net and are able to communicate with each other and with us as humans do. So, they are able to convey information.

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[4] https://iot-analytics.com/state-of-the-iot-update-q1-q2-2018-number-of-iot-devices-now-7b/

[5] https://iot-analytics.com/industrial-iot-platforms-for-manufacturing-2019-2024-press-release/

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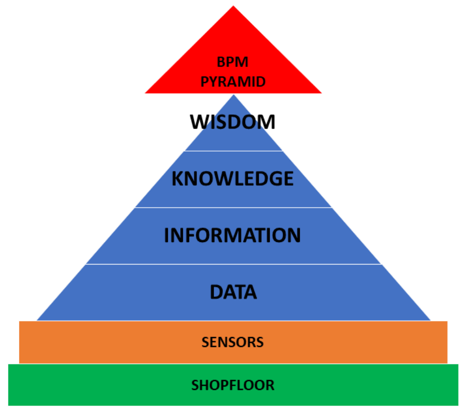

Fig. 1. The DIKW pyramid in the context of Industrial IOT for BPM applications

Some questions arise:

– Why objects should enter in one of the most used human communication channel?
– Why objects should be interested in communicating with each other and what do they want to say?
– How can object communicate each other as they speak different languages?
– How can object convey us useful and comprehensible data and so information?

The answer is simple: internet is designed for people and allows people to solve some problems and perform tasks. When a smart object or industrial machine becomes part of the internet, its capabilities need to become accessible by other machines and by people to do something for helping people in satisfying their needs.

But if the first issue is to have things connected the second is providing people with things capabilities not only data.

Actually, data and interpreted information are an important part but a small fraction of the entire picture. Many of the big players are telling us the story that the game is on big data or on cloud computing. In our opinion the challenge is on field understanding, problem setting and on the effective design of the solution, not in technology.

A similar phenomenons happened in year 1995 when accelerometers were almost "off-the-shelf components" but known only by researchers and measurements experts. Their explosion is due to the work of Benedetto Vigna that with his research activity at ST Microelectronics paved the way for over 170 patents representing MEMS technology. Vigna has been named as "The Man Behind the Chip Behind the Wii" by IEEE Spectrum in 2007[10]. Vigna's invention was not a technological upgrade, it was a solution to a more complex design/creativity problem, this it was innovation .

The same is happening in business processes analysis and understanding. Data is not enough for understanding a process. Moreover, if we look at the problem starting from the easiest source (data from I-IOT) there is a risk of having analysts pretend to extract the process model from the data. But the process is already well known in the company.

Uthayasankar et. al. analyzed 243 Scopus indexed papers classifying them into categories according to the typology study. Among a total of 11 different types of research methods identified, the majority of studies were analytical in nature (103 papers), the second category was theoretical (64 papers) and then design of research methods (12 papers). Case study (12 papers) and experiments (9 papers) where only the fourth and sixth category[12].

Pareto's law explains that few are important and many trivial, therefore the big data is the garbage, while the information you search is the diamond. But how can you find a diamond into a mountain of waste?

There is not a solution to a weakly formulated problem, but let's try to switch from Internet of Things to "Things onto the Internet", from IOT to TOI, and observe what we said before from the changed perspective. When you surf the web you try to find some information to satisfy a need and you move from a webpage to another, till you find what you were looking for. If you want to know the change for 10000yen in your currency you find a service able to get the actual change and calculate the equivalent value. Ifindustrial machines are available onto the internet, their capabilities are accessible to our requests: we can ask for data (e.g. the oil pressure detected by a sensor installed in a milling machine of our shopfloor), we can ask for an information (e.g. the level of the oil pressure with respect to its working range) or can ask for better understanding what is happening (e.g. how the oil pressure changed in the last 24h with respect to the different batches produced by the machine), all of this because you want to optimize you production being able to decide which are the less energy consuming batches to be produced with that milling machine.

It is a change of paradigm, we don't analyze data because we are able to. The TOI philosophy put at the center the human actors, their needs and confine the things where they have to stay: at the level of artifacts or tools designed by humans to help humans. In this view, the digital twin is not anymore the raw representation of a machine but needs to become the functional representation of our assets (their shadows instead of their twin). This shift of paradigm allows us to understand how central is the "design process" instead of the technology. We do not need big data, but small sets of reliable information.

In this user-centric paradigm the data we want to see are few and, if possible, we want to get access only to information instead of data. Consequently it means a new design problem in three steps:

1. understanding the machines and the business process, then
2. designing a model and then
3. acquiring only the data you need to feed the model.

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2 A new data extraction paradigm

The hype generated by the Industry 4.0[2] paradigm pushed machine producers and shopfloor managers to connect their machines for enabling continuous data extraction[3].

Nowadays, modem machines controlled by (PLC) Programmable Logic Controllers are endowed with network connection and modern data streaming protocols. These machines are typically connected to the company servers or to a dedicated cloud infrastructure where all the variables contained in the PLC memory are streamed at high speed.

In this case, it is possible to apply the typical data analysis and discovery processes and in most cases it is also possible to build machines and processes models that iffed with data provide useful information for the optimization of the industrial processes.

Unfortunately, most companies have shoplfoors mainly composed oflegacy machines that are still working in optimal conditions but are not Industry 4.0 compliant. In this case, because of the bias introduced by the previous scenario, Industrial IOT experts typically suggest to upgrade these machines with new PLCs endowed with modern networking capability thus enabling continuous data stream. This modernization process is typically expensive, invasive and most of the time require an important redesign of the machine control system and electrical apparatus. So, in most cases legacy machines are left offline waiting for their replacement.

We believe that the TOI paradigm could be a solution to this problem. If we move the focus from the data to the machines functionalities it is possible to make machines "smart" by acquiring only few data. It isn't anymore a technological problem, it is a design problem. We need to move from a machine connection challenge to an industrial machines smartfication design process .

2.1 The 4ZeroPlatform

The TOI paradigm has been applied in the last years by TOI s.r.l. [6] to various industrial scenarios using the 4ZeroPlatform [7]. 4ZeroPlatform is a plug-and-play data gathering, processing, and reporting solution that provides visibility and optimization of Industrial Processes also with legacy machines.

The platform is composed of:

- 4ZeroBox , a multi-sensor, multi-protocol data acquisition unit, with edge-computing capabilities that act as "modem" connecting the industrial machines to the cloud or company server;
- 4ZeroManager , a Cloud or "on-premise" software for device and data management that enable an easy integration with Data Analysis and BI tools.

[6] www.thingsoninternet.it
[7] www.4zeroplatform.com

The 4ZeroBox can be plugged to modern and old machines in order to easily extract processes' data and calculate KPIs. The 4zerobox has been designed in order to allow different interfacing strategy. Digital data can be acquired via RS232, RS485 (Modbus, Profibus), CAN (CANBUS, NMEA 2000), Ethernet (OPC UA, S7, Profinet) and similar digital channels. Moreover, in case ofin-terfacing with legacy machines, various analog and digital I/O channels are also available for the reading (in parallel with the machine control system) of raw sensors data. These paradigms can be also mixed by integrating the digital signal reported by the available control system with new parameters acquired thanks to the installation of new probes. Figure 2 reports a diagram with all the port and features available on the 4ZeroBox.

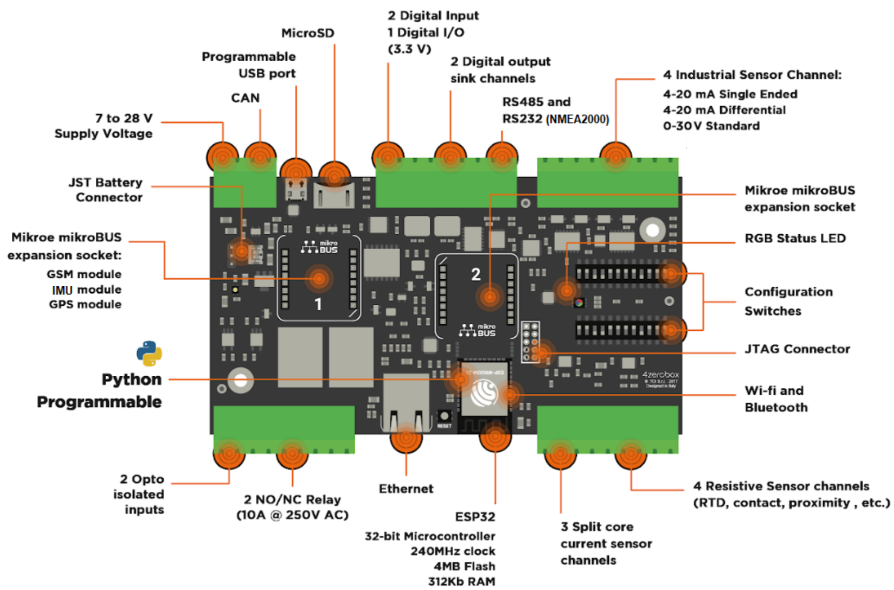

Fig. 2. The 4ZeroBox features diagram

All the acquired data can be pre-processed and filtered on the edge by customizing the firmware of the 4ZeroBox in Python language. for this purpose the system has been integrated with the Zerynth [8] developing environment that allow an easy programming of embedded devices providing an extensive set of libraries and drivers[5][7]

Data gathered from machines and/or sensors can be used to calculate locally various KPI allowing also to avoid continuous data streaming moving toward an event based data sending strategy.

[8] www.zerynth.com

The 4ZeroBox is natively configured to send data to the 4ZeroManager via a secure MQTT connection. The 4ZeroManager act as a field to cloud de-coupler. It takes care of orchestrating the connection between the server and the various 4ZeroBoxes installed on the field while also providing support for Over The Air Firmware Update (FOTA) and Remote Procedure Calling (RPC). All the data gathered by the various 4ZeroBoxes are than exposed by the 4ZeroManager via MQTT or AMQP (subscribing) or sent to a remote endpoint via REST API (pushing) [6].

Thanks to the Zerynth programmability, the 4ZeroBox can be also easily connected with all the most used cloud services (Microsoft Azure, Google IOT, Amazon Web Services and IBM Cloud) for which Zerynth libraries are freely available.

3 Use Case: Retrofitting of a legacy drill press

The case study is represented by a manual drill press for drilling wood (in Figure 3) a small device we used to pretotype[11] the solution).

The need expressed by the company was to help the operators in choosing the right cutting parameters. Actually wood is a natural material whose hardness vary from tree to tree, but also from batch to batch, and even in time (due to the aging). Therefore the standard tables with parameters for wood do not work as well as in metals where the parameters are more stable.

For such a reason, novices in the shop-floor often over-exceed the cutting parameter (speed and feed) and make the drill bits to burn, thus loosing their cutting capability. By retrofitting the drill press it is possible to alert the operator that he/she is stressing the bit so he/she can reduce the feed to stay in the power limits. However, retrofitting a manual machine can be a complex problem that often hides cases of over-engineering. Therefore a cost-benefit analysis for each sensor to introduce must be performed.

An essential set oflow cost sensors can be a current sensor to estimate the torque and an LVDT (Linear Variable Differential Transformer) to measure the displacement and so the feed. However two important parameters are not managed: the rotational speed and the bit diameter. To modify the cutting speed the operator must modify the set of pulleys and the belt on top of the drill press. Such an operation takes several minutes therefore we hypothesis that he/she could also report via a mobile app the new parameters. The Mobile app has been implemented using the Zerynth App for Android and IOS allowing also a quick access to the drill press parameters and real-time data.

For what concern the tip diameter it is calculated in reverse by asking the operator to perform an hole in a small piece of standard material before starting a new batch. The measure of the current is a good proxy of the torque, while the measured feed allow to calculate the diameter (since the material and speed are known).

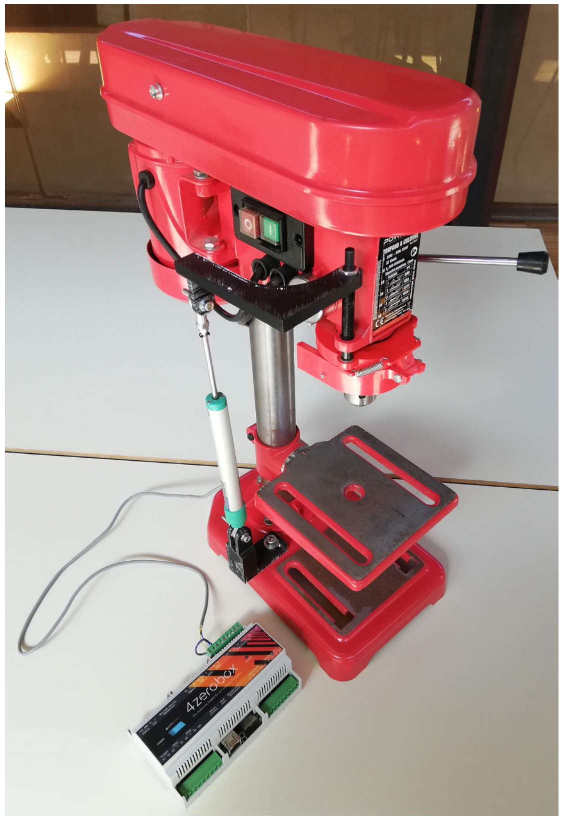

Fig. 3. The drill press retrofitted with the linear position sensors for the measurement of the chuck position. The sensor is connected to the 4ZeroBox for data acquisition and streaming.

The proposed solution is far from being automatic, but it was not the purpose (it does not make any sense to automate a manual machine) and it seems to meet the requirements given by the company.

Even if a series of other features could be introduced we decided to stick to the requirements of the company thus solving the only real pain they felt and expressed. No suggestions for tip wear detection, no suggestions about maintenance, etc. Actually to perform reliable predictions a different configuration (number and typology) of the sensors should be thought. But such a solution will solve problems that no one had in the company at a higher cost.

Figure 4 reports the DIKW pyramid applied to the drill press with detail of all the extracted Data, Information, Knowledge and Wisdom. With only 2 sensors installed in retrofitting 6 monitoring variables (information) representing the status of the monitored machine have been calculated. These variable if merged and analyzed allowed the extraction of 5 functional variables (knowledge) from which it is possible to infer the state of the drill press and its functional peculiarities driven by the operator interaction/use. Moreover, it is also possible to enable a high level layer where, in particular, the operator is "thought" in how to use the drill press by continuous alerting in case of misuses.

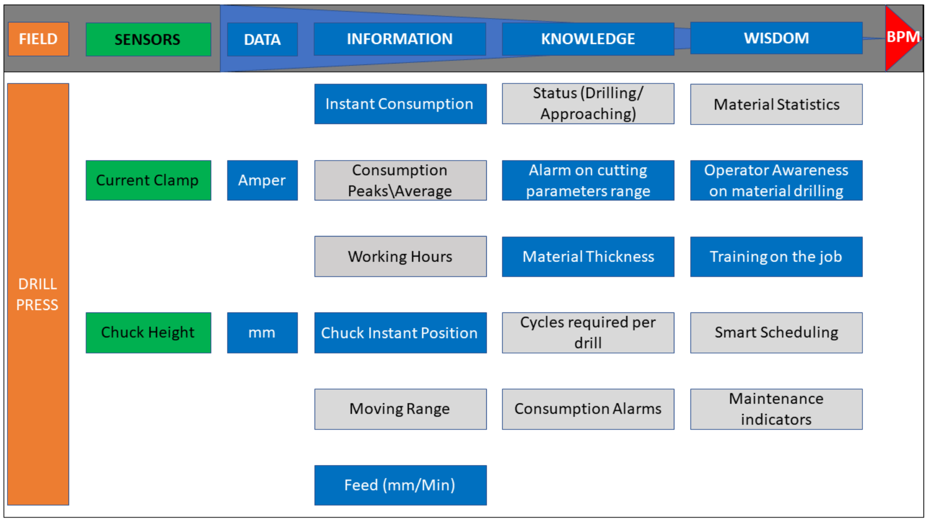

Fig. 4. The DIKW data distillation pyramid applied to the drill press thanks to the TOI retrofitting method. In gray the parameters that have been extracted thanks to the sensor installation but not used for the calculation of the outcome parameters.

4 Conclusions

Industrial processes are engineered since many years using well defined business process management and optimization methods. The limit of BPM effectiveness is related to the availability of sound and reliable data. Such data is nowadays easier to extract than in the past but typically difficult to convert into information and require complex activity and analysis to be converted in knowledge. In this work an innovative top-down approach aimed at inverting the typical data centered approach used in Industrial IOT and in BPM has been proposed. The implemented use case demonstrated how with a minimally invasive installation (only 2 sensors) it has been possible to "smartify" a legacy drill press giving to the user feedback on the correct use of the machine. This setup enabled the creation of a smart system where machine's core functions and signals are identified through the expertise of the operator and transformed into data used to optimize its use and maintenance within the related business process. In this work authors decided to provide to the final user only the information required for the solution of the felt pain (blue boxes in figure 4) while also having calculated more interesting parameters (gray boxes in figure 4). This decision has been taken following the less is more paradigm with the objective of obtaining the highest information to knowledge conversion rate in the drill press operator[13].

The proposed approach contributes to the theory that Industrial IOT has the actual potential to push the industrial process optimization towards new level of efficiency, as long as real and continuous information is available. In order to enable this scenario a shift of paradigm is mandatory. Typical industrial control design paradigms are unable to modernize the current industrial panorama. It is necessary to take inspiration from the "smart" word where simple technological elements are used in a pervasive way to gather data from everything, everyone and everywhere creating an ubiquitous network of knowledge/wisdom providers.

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