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Shaping a quality framework for IIoT companies

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Abstract. The technological progress of the past century has led to the emergence of integrated technologies such as those encompassed by the Internet of Things (IoT). Recently, IIoT (Industrial Internet of Things) emerged as a first step to revolutionize the industrial sector, by taking advantage of modern technologies and capabilities such as: the interconnectivity of industrial devices, the usage of machine-to-machine communication (M2M), big data and machine learning in order to improve a company's efficiency and operations reliability. At the same time, the concerns for quality management within these companies continues to remain a constant concern and while quality has also evolved in the past couple of years to match the requirements of Industry 4.0 enterprises, an unexplored direction is that of the relevance of quality frameworks in manufacturing and industrial enterprises. The present paper explores this research direction in order to help provide the guidelines for developing a quality framework for IIoT companies.

1 Introduction

The concern for quality and everything that it encompasses – from the way the processes inside a company take place to the way the deliverables are perceived by the customers has become more significant with each year and socio-economic trend. One of the most recent trends concerning quality has been the evolution of quality to "Quality 4.0" in an attempt to match the requirements of "Industry 4.0". It is still within this trend that the Industrial Internet of Things (IIoT) emerged to revolutionize the industrial sector and help make use of available technologies in order to optimize production processes.

It is in this context that more and more companies have looked at how the activities and resources involved in the IIoT can bring benefits and also minimize losses and waste. A clear concern regarded the quality of the products created by IIoT companies and the ways in which this quality can be achieved, maintained, controlled and improved. An approach to all of these aspects has been the development of quality frameworks such as Six Sigma, ISO 9000, Baldridge and many other – some of which adapted for the particularities of a sector or industry. The author of the paper, in the current research looked at the ways in which a quality framework could be developed for IIoT companies in order to help meet and maintain quality targets, based on the already available frameworks but also taking into account the goals and core values of IIoT companies.

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2 Current trends in quality and IIoT companies

Quality, encompasses almost everything that's happening within an organization and its deliverables [1]. In order to meet the requirements of the companies in the market, quality has evolved in recent years, one of these development directions being the birth of "Quality 4.0" [2]. The link between Quality 4.0 and Industry 4.0 can be observed in multiple ways, among which: the way that the companies look to digitalize quality management systems [3] and the mass adoption of digital tools for increasing the efficiency and quality of their products [4-5].

The term Industrial Internet of Things (IIoT) has first been used within General Electric [6], which in their description defined two key components: the connection to local processing and the Internet for industrial machine sensors and the onward connection to other industrial networks, with the role of independently generating value. A comprehensive definition for the IIoT is that of Boyes et al who in their paper described it as being "A system comprising networked smart objects, cyber-physical assets, associated generic information technologies and optional cloud or edge computing platforms, which enable real-time, intelligent, and autonomous access, collection, analysis, communications, and exchange of process, product and/or service information, within the industrial environment, so as to optimise overall production value" [7]. Among the benefits brought by IIoT, presented in Figure 1, we can notice: improved quality control and reduction of error rate, more accurate prediction of machine condition and more efficient maintenance among others, greater flexibility of production processes and more [8]. These aspects can be categorized based on three aspects: the degree of flexibility of IIoT companies, the degree of automation and the degree of control.

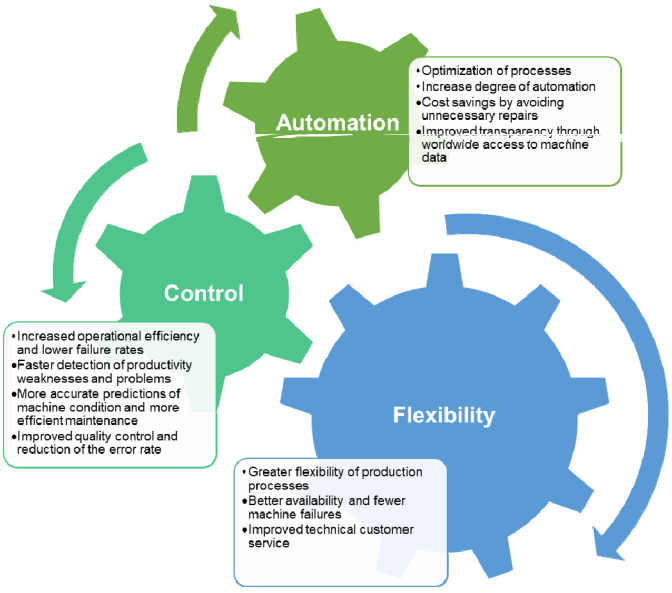

Fig. 1. Possible benefits of IIoT companies (adapted from: [8]).

This could explain the reason behind the adoption of IIoT across several industry verticals, including manufacturing, logistics, oil and gas, transportation, energy, mining, aviation, among other industrial sectors [9]. The concern and adoption of IIoT has become

even more prevalent in the context of the COVID19 pandemic, with global industries taking steps to develop international standards in the field [10].

Quality frameworks have been used in order to mandate a consistent and integrated approach to delivering quality services and to provide a form of support to a company's departments to encourage these to have a proactive approach to addressing gaps, identifying systemic issues, best practice and continuous improvement opportunities [11]. Adoption of quality frameworks such as Six Sigma, ISO 9000 and Baldridge has been noted to help companies ensure a source of competitive advantage by producing superior products with minimal loss of quality [12].

Some examples of quality frameworks include: that developed by Healthcare Improvement Scotland which is based on the structure of the European Foundation for Quality Management (EFQM) model and focuses on nine areas/domains [13], as shown in Figure 2.

Fig. 2. EFQM based Quality Framework (adapted from: [13]).

Others choose to focus on the top down and bottom-up aspect of quality and therefore when designing a Quality Framework choose to focus on three main components: Foresight, Facts and Foundation, with six key aspects: Management strategy, Reporting, Root cause, Process monitoring, Repository and Operations [14], as shown in Figure 3.

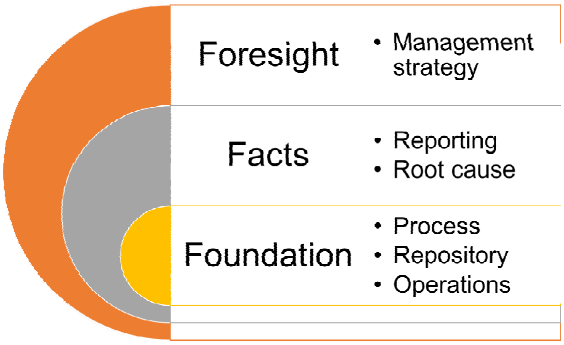

Fig. 3. Top down and bottom-up Quality Framework (adapted from: [14]).

A different approach to designing and implementing a Quality Framework focuses on six essential steps to undertake in order to better understand the requirements of the organization and make sure that the Quality Framework meets these requirements, as shown in Figure 4. The six steps start with understanding the purpose of the quality framework, what the company is looking to measure and why. The second step aims to understand and direct how the customers are currently interacting and how they'll interact with the company, in order to adjust the channels that the company uses in its relations to the customers. Step three focuses on identifying the values of the brand that should be incorporated into the design of a scorecard. All of the information gathered in the previous three steps will then be used during the fourth step in order to build a map of the specific measurements and metrics that the organization needs to asses. The fifth step is concerned with identifying the most relevant scoring options by taking into account both their objective and subjective nature. During the last stage of implementation, the new quality framework is introduced and assessments are made. In some cases, it might be necessary to also include a calibration process during this step [15].

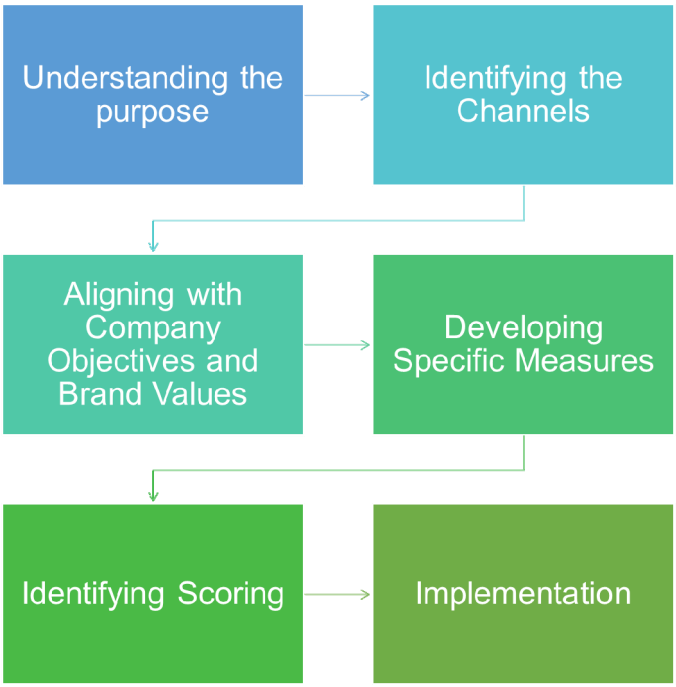

Fig. 4. Six step Quality Framework (adapted from: [15])

Of course, more examples of quality frameworks exist and at the end of the day, it is the company's interest to choose the quality framework that best suits its needs and particularities.

In the context of the emerging IIoT companies and organizations, it is interesting to look at how quality frameworks could complement and support these companies in their business activities. Thus far, the author was unable to identify literature regarding the possible applications of quality frameworks for IIoT companies, and this research gap will try to be addressed in the next section of the paper.

3 Towards a quality framework for IIoT companies

In order to be able to design a quality framework for IIoT companies, we must first understand the implications of operating within such an organization and use quality tools, principles and applications in order to complement the base activities and drive the core values of the organization.

An essential aspect of IIoT is the usage of information technology and operational technology such as: networking of operational processes and industrial control systems, including human machine interfaces, supervisory control and data acquisition systems, distributed control systems and programmable logic controllers [16]. Basic activities in IIoT companies include: sensing, data collection, data processing and communicating real-time occurrence of events. It is in this context that the influence of Big Data in IIoT has been evaluated in research [17].

A common key point among quality frameworks is the foundation for operations, driven by the company's leadership along with the impact and importance of the customer and integration of customer requirements in the company's set of objectives.

The basic requirements of a proposed Quality Framework for IIoT companies can be seen in Figure 5.

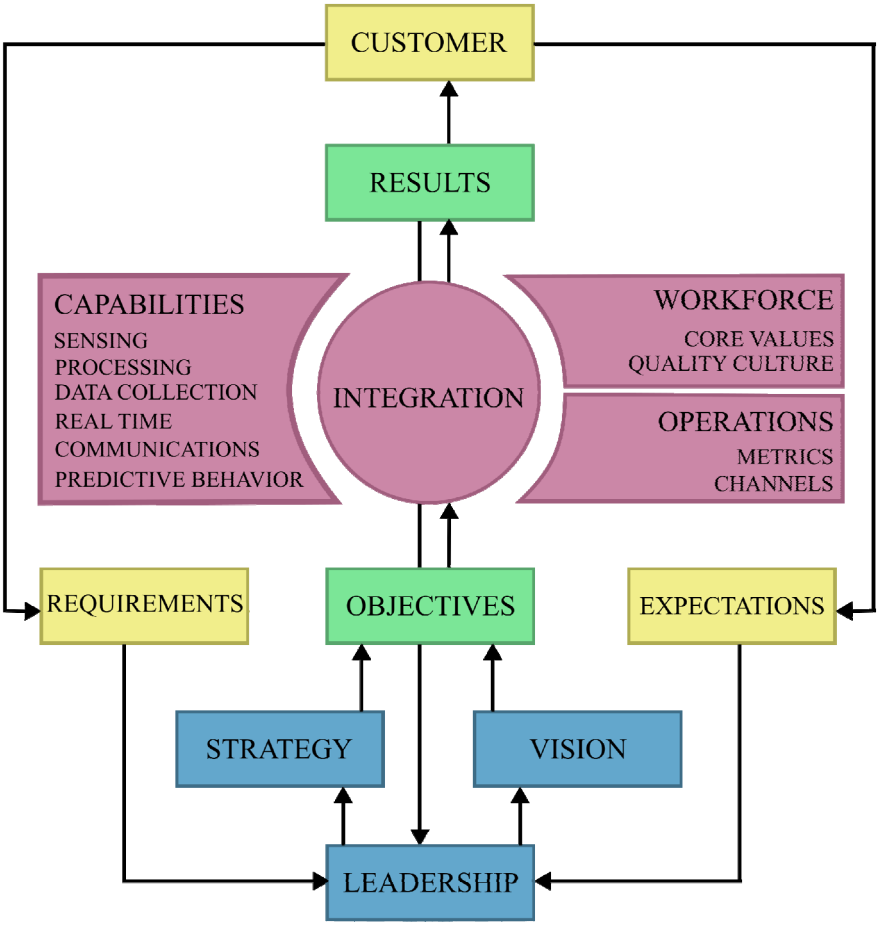

Fig. 5. Proposed Quality Framework for IIoT companies.

As it can be observed, the main driver of the framework is the customer who, though his requirements and unstated expectations contributes to the establishment of objectives along with the vision and strategy planned by the leadership. It can also be noted that the strategy and vision stem from the leadership but are also based on the customer requirements and expectations as well as previous results obtained by the company.

Once the objectives have been established, the integration of three key aspects: capabilities, workforce and operations lead to the results which are tested against customer expectations and requirements in order to obtain customer feedback and ensure that the main objectives have been reached.

In terms of capabilities, the IIoT company will be concerned with one or more of the following: sensing, processing, data collection, establishing predictive behaviour patterns for tools, processes, machinery or even people, being a driver for real time communication and analysis of data. The workforce component refers to the core values that drive the behaviour of all of the actors involved in the company along with the company culture and more importantly, the quality culture within the company, while the operations segment refers to the set of metrics that the company plans on implementing and using and the channels that the company will use to interact with the customers and outside markets.

This can be of course seen as an iterative approach to achieving the expected results while making the best use of all of the available resources and minimizing waste. Furthermore, the proposed framework can and should be adapted according to the particularities of the IIoT company in order to ensure maximum efficiency and yield most benefits.

4 Conclusions

In the current research, the author proposes a basic template for designing a quality framework for IIoT companies. The framework is based on the already available frameworks but also takes into account the goals and core values of IIoT companies.

The core drivers of the framework are the customers and the capabilities of the company, which together, along with the workforce and the operations lead to the integration of all of the key activities in order to achieve the established results. Another important aspect is the role that the company's leadership plays and furthermore, the fact that the leadership should take into account the customer's explicit requirements as well as any unstated (where possible) expectations when establishing the set of objectives to be met and the metrics that the company will use for measuring various aspects of the business activities.

Of course, the framework is not a complete solution and should be adapted to fit the requirements and particularities of the company that is looking to implement it in order to ensure maximum efficiency.

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