Enabling DX IoT Performance and Properties Measurement - Executive Summary

Digital Transformation (DX) leverages various digital technologies to improve business processes, make industrial operations more efficient, capture new opportunities and enable new business models. This transformation process is a journey: each step has expected benefits that must be demonstrated and incurred costs that must be evaluated.

The value of each step in the DX process must be measured. The business case for transforming industrial, operational or business processes is rarely clear from the start. It begins with informed assumptions on what improvement can be made, followed by some investigation, then a pilot involving trials, errors and corrections. The benefits and costs of each move must be weighed. They all require measurements based on metrics that must be clearly defined, well understood and approved by different parties: end-users, service providers, solution developers, technology vendors and managers. Defining objectives to be reached (such as a percentage error rate in manufacturing, or reduced delays in delivery times) and defining unambiguous targets for them, keeps expectations aligned between all parties involved.

DX solutions must evolve over time. Because DX is a process, objectives and constraints change. **Improvements are incremental**, as illustrated by the continuous improvement process called Kaizen in Japan. In this process, issues or opportunities for improvement are identified, then proposed remedies are implemented, assessed and adjusted as needed. The improvement process is iterative, and proceeds by cycles. All of this relies on monitoring and measurements, where data generated by IoT plays a major role. To minimize disruption and to shorten the time to reach acceptable solutions **an improvement cycle must be evaluated quickly.** IoT technologies have been shown to shorten that cycle by automating data collection and analysis, then reducing delays and overhead in assessment and decision-making. But technology alone is not sufficient. **A culture of measurement is needed** as well as the insight to choose the appropriate metrics.

DX solutions involve **a diverse set of technologies**, whose deployment in industrial contexts is relatively recent. These include AI, digital twins, real-time analytics, time-sensitive networks, and most notably, IoT. These technologies may be well understood in theory and their tools may be mature, but best practices for industry are still in development. Thus these technologies, and expectations about them, need to be evaluated in relation to an industrial environment. **Measuring the value of these technologies for real solutions and specific contexts is critical to developing these best practices**. Because industrial IoT technologies are an important part of digital transformation, the white paper focuses on measuring the value of IIoT applications.

DX solutions involve agreements between different parties. Solution providers and their users often contract with service providers for data storage, cloud services, device management, networking and other services that are shared by different end users and their applications.

Different applications will increasingly require access to IoT data that may be brokered by a third party via data marketplaces. IIoT applications that were initially siloed are becoming more interdependent (for example, transportation logistics can get more insights into the manufacturing process across a supply chain, and vice versa.) **The quality of the service or data must be evaluated because the performance and capabilities of a DX solution depends on it**.

We identify three kinds of metrics that play a complementary role in evaluating DX systems:

- **Performance** metrics assess how the solution performs over time and whether it meets expectations. These metrics are often based on quantitative measures and automated. They measure such quantities as speed, error rates, delays, product quality and throughput.
- **Readiness** metrics assess how prepared a solution is to meet expectations prior to operations. These metrics are often qualitative and in the form of manual scorecards. They measure preparedness for exhibiting properties such as security level, reliability, scalability, financial flexibility, transparency, responsiveness to customer.
- **Profile** metrics help determine the profile of a solution defined along different parameters such as the type of data being collected and its processing, connectivity characteristics, physical assets and regulatory constraints. They express requirements of a system and characterize its capabilities. They measure characteristics such as the velocity, volume and variety of data, the quantity, cost and connectivity requirements of physical assets, or end-to-end real-time or properties network. This profiling gives insights to solution designers. One can associate known best practices, architecture design patterns and appropriate technologies to such profiles.

These types of metrics are distinguished by their usages and the role they play at different phases of a solution lifecycle, more than by what they measure. Readiness for some security level prior to operations need to be monitored by metrics about these security aspects during operations to validate the claimed security level. Similarly, some expected capacity on connectivity or data as stated using a profile metric may need to be confirmed during operations by related performance metrics to validate the assumed requirements or to detect if they are changing.

Metrics and indicators are often used to assess the non-functional properties of a system, in addition to the performance of its business operations. A well-known system property is its security. A more general property, trustworthiness, comprising safety, reliability, resilience and privacy, as well as security, was identified in the IIC Industrial Internet Security Framework. [1] Metrics for each property inform compromises that improve the trustworthiness of a system.

[1] https://www.iiconsortium.org/IISF.htm

Maturity models, such as IIC's IoT Security Maturity Model (SMM),[2] helps stakeholders determine the comprehensiveness levels for process, technology and operational practices appropriate to their business needs. Assessments of a system against a maturity target can identify gaps to be addressed using approaches from various control frameworks. Indicators of accomplishment lead to metrics that enhance the improvement process. Other models, such as the CERT® Resilience Management Model, can also improve the process for resilience, for instance.

Other metrics are specific to a particular system, such as the safety of a particular machine measured in terms of stress injuries it causes for personnel over-time. **There is often a tradeoff between the trustworthiness of a system and its cost of implementation or productivity**. Security may adversely affect the operating cost or equipment cost. A high safety level may reduce productivity in the short term, but improve it long term. **Metrics and measurements help define acceptable compromises and understand conflicts**.

The white paper **describes some cases of using metrics and of developing related technologies and standards**:

- In the mobile devices area, the QuEST Forum consortium of mobile equipment and service vendors has deployed a large-scale quality-management systems to assess aspects of mobile communication services, based on TL 9000 standards. A platform developed by University of Texas is used by every provider to log the performance of its products & services, which they can compare with the rest of the industry.
- Carnegie Mellon University has developed a set of readiness metrics for evaluating cloud service providers, and the quality of their services.
- An international standard has been developed for metrics by ISO/IEC. A major motivation has been to help services providers express more precisely how they evaluate their services (for example in an SLA) in a consistent and comparable way across an industry.

The study describes different usages of metrics and how they enable digital transformation solutions, while reflecting on existing work done with metrics in related areas, from large scale service measurement to standardization.

This is why performance and properties measurement is the *sine qua non* of effective digital transformation in your business.

Read the full white paper here.

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[2] https://www.iiconsortium.org/smm.htm