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(Article begins on next page)

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Abstract − Performance Indicators (PIs) are designed to help organizations and decision makers to better understand how well they are performing in relation to their strategic and tactical goals; nowadays, numerous methods and tools have been developed to facilitate the generation and selection of the most suitable PIs. Especially in the service sectors, service performance assessment methods should be used to develop a coherent and comprehensive set of service driven performance indicators. The basic idea behind a performance assessment method in the service system is to generate and select the performance indicators to be used by the members of the service delivery eco-system, which represent the actors for the delivery of services. In this respect, the purpose of this paper is to lay out a method for generating and selecting the performance indicators related to particular service system requirements. To accomplish this, the proposed method will be defined to optimize monitoring and controlling activities within a service system. In order to be able to produce meaningful results a case study is presented, where the method has been adopted by a company producing domestic appliances.

Keywords − performance indicators, monitoring & controlling methods, service ecosystem, service assessment

I. INTRODUCTION

Several tools (recommendations, models, methods, systems and frameworks) proposed by various researchers and business managers have been developed since 1950s with the aim of helping organizations to measure and manage their performances. The '80s were especially known for their recommendations concerning the choice of performance indicators (PIs), in particular, highlighting the ineffectiveness of exclusively financial indicators used in the previous years. From the '90s, other models have aimed to obtain an efficient Performance Measurement System (PMS) or effective PIs based on the following concepts: well-balanced (several dimensions), integrated (centered on external and other dimensions), determinants and results concept (causes and effects relationship), and still other recommendations relating to their elaboration (definition, implementation, revision).

Various authors have expressed either positive or negative criticisms on the models. Their criticisms included: the nature of PIs used, dimensions retained, well-balanced and/or integrated character, procedure for the PIs selection and their connections, etc. Even the Balanced Score Cards (BSC), perhaps the most popular and used method, was deeply criticized with regard to the reduced stakeholders, the lack of procedures for the choice of PIs, etc. [1], [2]. In spite of these criticisms, it turns out that these tools present a lot of both similarities and differences, advantages and inconveniences. Several methods have been developed around the world by academics or practitioners for the definition and implementation of PIs, such as: ECOGRAI, IPMS and DPMS [2], [3], [4], [5] and [6].

It should be emphasized at this point that several kinds of PIs can be found in literature. The first kind of PIs aims at measuring results in terms of performance evaluation in achieving specified objectives. Let us consider for instance total amount of turnover raised by service against overall organization revenue. The second kind of PIs is related to progress performance. For example: total number of service occurrences per month and average service value vs. the organization's monthly objectives.

Regardless of the types of the PIs, attention must be drawn to the definition and selection PIs. A special approach has been determined based on sequential addressing of objectives, relevant decisions and finally PI definition. Let's assume that an enterprise needs to implement a maintenance service in a foreign country and needs to measure it; the objective is represented by implementing a new service abroad, decisions affect different functions of the organization and for each function proper PIs should be sorted out, so that they are consistent with the enterprise policy.

Therefore, PIs must be coherent and integrated at a different level of the organization and decision centers. Indeed, to control the system an enterprise needs PIs at strategic level for long term performance monitoring. Then, tactical PIs are required to control middle term performances. Finally operational PIs are required to measure the performance at the daily routine level, and are always short term. . Let's consider for instance, total increase of turn over related to the maintenance service in a foreign country (Strategy level), overall increase of saturation of maintenance department (Tactical level), daily productivity increase within the enterprise (Operational level).

It is interesting at this stage to consider the role of a PI, which is allowing the decision makers to know the status of the service system, to measure the efficiency of their actions and to react/be proactive in the appropriate response time, in accordance with the global objectives of the system. Meanwhile, service managers need to be able

to measure and monitor the service performance in order to ensure maximum productivity [7]. Furthermore, the results which can appear by using the appropriate performance indicators will allow for regular observation and recording of activities, controlling and measuring actual performances and presenting a visualization system which can guide the service system, on taking corrective actions/proactive action [7].

At the end it should be emphasized that among the available methods, which can be used to define and to implement PIs, GRAI method has been adopted because it represents a good integration between the focus on results and the consistency with strategic, tactical and operational decision process. Indeed, this is the method based on decision modeling, thus focusing everyone's attention on why we need PIs (to make decisions and which decisions), instead of sorting out the best indicators directly [8].

In order to illustrate the PI method proposed for manufacturing service system, the paper is structured in different sections. GRAI GRID method, used as a modeling tool is explaining in the next section. Then VRM, a classical reference model, providing a catalogue of building blocks for the definition of processes and PIs, will be emphasized in Section 3. In section 4 MSEE PI actions will be specified in terms of PI generation and selection. Then in the final section, MSEE PI method will be exemplified and explained according to its application to one of the MSEE use cases involving an industrial partner (Indesit Company).

II. GRAI GRID TOOL

This section provides a short description of the GRAI model, GRAI (Graph with Results and Activities Interrelated) model and also tools (GRAI GRID), which are used in the MSEE PI method to define decision framework. The GRAI conceptual reference model has a recursive structure, which allows all concepts of a manufacturing system (such as the global and the detailed models) to be represented within an enterprise. In fact, the GRAI model defines the various concepts that will be represented in GRAI graphical formulations [8].

The GRAI GRID is a modeling tool, which modeled the decisional systems in various concepts. These concepts are proposed within and are presented consistently by the GRAI Model. The GRAI Model is a generic reference model while the GRAI GRID enables its user to instantiate the generic concepts on real individual cases (Figure 1). The GRAI GRID takes up a hierarchical and functional approach: concepts presented by the GRAI model are implemented by the GRAI GRID in order to get a specific model. As a consequence, the GRAI GRID does not aim at the detailed modeling of information processes, but the identification of those points where decisions are made in order to manage a

system to provide a real case model to be used for the specific company's purpose [9].
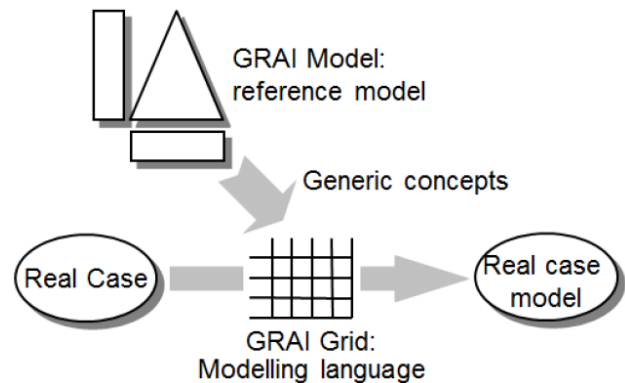
Fig. 1. GRAI Model and GRAI GRID [9]

The GRAI GRID is presented in the form of a matrix with two axes:

- The managerial axis or control axis, which represents the various levels of decision in an organization. Traditionally, this axis is decomposed hierarchically in several levels, according to the nature of the decisions: strategic, tactical, and operational levels.

- The functional axis, which describes the various activities required to the product life cycle. However, in a manufacturing service ecosystem this axis is adapted to service life cycle. It is decomposed into several functions which group a set of activities having a same identified finality (Engineering, Manufacturing, Quality, Maintenance, and Delivery and Recycling).

Each function is decomposed into three management levels: manage the products and services (internal or external; that is, both supplying and purchasing), manage the resources (human or technical) and plan (to synchronize at each level product and resource management).

Two columns are added to the functions, one on each extremity of the grid. They concern the external information (i.e. exchanges with the environment of the production system, primarily commercial information), and the internal information (i.e. exchanges with the physical system, primarily information of follow up). A decision center is defined crossing a function with a decision level [9].

The GRAI nets are aiming at describing in details all the activities identified inside each of the decision centers in the GRAI grid. It should be emphasized at this point that they are two types of relationships between decision centers in the GRAI grid:

- Decision frameworks, symbolized by a block arrow;

- Information flow, represented by a simple line arrow.

Finally, the GRAI GRID defines the points where decisions are made (decision centers) and the information relationships among these.

Fig. 2. Decision framework and information flow [9]

III. VRM (Value Reference Model)

VRM is the method which will be used to design, select and implement specific PIs according to the precise objectives identified by the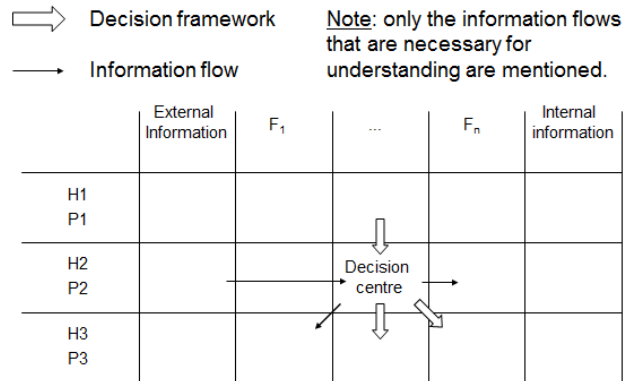 reference governance framework [10]. VRM has been chosen for the selection and measurement of metrics for the MSEE project end-users, which provides pre-defined measurable indicators for value chain goals in several dimensions. It can also be successfully adopted for the manufacturing service ecosystem in general.

The VRM method provides descriptions of standard processes, their inputs and outputs, metrics and best practices. Input and output templates and guidelines for tactical and operational level processes are also provided. The VRM does not only focus on managing the supply chain processes for a given product, but also incorporates the preceding and successive activities of product development and customer relations in the sense of a value chain. The VRM model is structured to support the integration of the three domains within an integrated value chain: product development, supply chain management and customer relation. The top level of the model encompasses all the high level processes in value chains, which are represented through the process categories *Plan – Govern – Execute* (figure 3). "Plan" is used to align strategic objectives with tactical and execution abilities. "Govern" supports the strategic objectives by rules, policies and procedures for the Value Chain. "Execute" encompasses all execution processes in a strategic context within the management criteria from Govern and the parameters defined by Plan [11].

Furthermore, it should be emphasized that VRM provides a catalogue of building blocks for the definition of processes and PIs. However, VRM has no explicit methodology for selecting a consistent set of PIs that is aligned to the required decisions. In the MSEE project VRM is used as a framework that provides pre-defined business processes to be identified and then used as input for the GRAI method. In this way, VRM supports the end user in selecting the main processes to take into consideration and structuring their service system governance.

Fig. 3. VRM Strategic and Tactical Level Processes [10]

IV. MSEE PI METHOD

Within the MSEE project, the MSEE PI method represents the supporting tools for defining and assessing the efficiency of performance indicators. The following section describes the MSEE PI method in detail. It aims to become a new method for service performance management from an innovation point of view and provision of product-service system. The MSEE PI method has been developed within the Manufacturing Service Ecosystem (MSEE) project in 2012 [12]. The MSEE PI method was established to create and select PIs according to specific use case decisions.

In the MSEE PI method, VRM has a main role, because it will be used as a method that provides pre-defined business processes to be identified and then used as input for the GRAI method. In this way VRM can offer support to the MSEE end-users on selecting the main processes to take into consideration while structuring their service system governance. As such, VRM provides pre-defined PIs, which are used by MSEE PI method to create a consistent set of PIs that are aligned to the required decisions.

Therefore, the proposed method integrates VRM method and GRAI approach to provide a more coherent and useful set of PIs. The governance reference model is needed to support the definition of service and use cases' objectives so to govern the selection of processes from the blocks provided by VRM. A list of actions is presented in order to specify and clarify how the MSEE PI method

works and can be used to generate and select PIs by a company:

1. GRAI GRID is used to define the governance framework, which is then used as a reference to govern the process selection through VRM according to the precise service and use case's objectives;
2. VRM framework is used to identify the affected business processes for each use case according to three levels (plan-govern-execute), which are used to define the processes and functions in GRAI GRIDS;
3. A priority dimension is identified for each process through VRM.

When the roadmap is accomplished, use cases will be involved again in order to test all the defined PIs so to maximize their efficiency according to select more matching indicators from the list of PIs suggested by VRM framework for the process steps/activities. MSEE PI method process is shown in figure 4.

Fig. 4. MSEE PI Method

V. CASE STUDY

The proposed MSEE PI method has been developed and refined through an industrial case study proposing a real service use case in collaboration with one of the MSEE project end-users, Indesit Company.

The company is one of the leading European manufacturing and distributors of domestic appliances (e.g. washing machines, dryers, dishwashers, fridges, freezers, cookers, hoods, ovens and hobs). It has a traditional product-oriented organization and processes are usually evaluated according to product indicators. In reality the Indesit level of servitization is rather low, as it is limited to selling the physical product and only few basic services are offered in a traditional way (e.g. warranty, technical support, service call center etc.).

The Indesit use case for the MSEE project is focused on washing machine usage. In particular, the company aims at realizing a new service focused on supporting the customers' usage by personalized services (i.e. personalized best practices, machine monitoring, tailored commercial offers).

First of all, the specific use case requirements have been investigated and elicited according to a proper methodology [13]. After that, the servitization process and activities have been investigated and structured in order to achieve the objectives and satisfy the use case requirements. In the following tables the Indesit servitization activities has been organized according to use case main objectives.

As it is possible to notice, first of all a set of functions has been defined and classified inside the framework of servitization: customer decision; service ideation; service-product design; service-product (implementation, planning and delivery) have been detected as the main functions. Secondly the main objectives have been identified inside each function, specifying the internal objectives at strategic, tactical and operational level in order to detail the decomposition of level of decision.

Table I
Use Case GRAI GRID map

	External Information	CUSTOMER decisions	SERVICE IDEATION	service-product DESIGN	service-product IMPLEME...	service-product PLANNING	service-product DELIVERY	Internal Information
	EI	<F>	<F>	<F>	<F>	<F>	<F>	II
H: 2 Year / P: 6 Month	Existing services on WM; Company image	Customer expectation in terms of services	BUSINESS PLAN for service proposition	Selection of design methodologies and partners	Selection of targeted WM and technologies	Annual service planning	Partner relationship organization	Business strategy; WM master planning
H: 1 Year / P: 1 Month	Existing HW and SW implementation technologies	feedback on customer satisfaction on the	Assessment of existing services	Definition of PSS functions and design specifications	Action plan to modify WM production process	Planning of the specific service actions	General planning of service delivery	Available in-house technologies
H: 1 Month / P: 1 Week	Advertising	Customers orders; Customers claims	BRAINSTORMING meeting; Validation of service orders	Detailed design planning	Implementation of modifications	Service scheduling; feedback measurement	Short term delivery planning	Status of production and service system
	EI	<F>	<F>	<F>	<F>	<F>	<F>	II

Table II
Use Case PI list

	External Information Sour...	Customer relationship	SERVICE IDEATION	service-product DESIGN	service-product IMPLEME...	service-product PLANNING	service-product DELIVERY	Internal Information Source
	EI	<F>	<F>	<F>				II
H: 2 Year P: 6 Month	-	ROI for each service; Service performance and capabilities	Capability to implement cross-selling	Total cost of PSS design	Global implementation costs	Amount of PSS sales for the next 2 years	Cost of delivery channels	-
H: 1 Year P: 1 Month	-	Service exploitation and easiness	Amount of sales per month (existing services)	Average of new functions for each WM	Time to market	Capacity of each production workshop	Number of contracts with carriers	-
H: 1 Month P: 1 Week	-	Time to start up service and to manage claims	Increase of the new ideas	Delay in design; Cost of each design activities	Delay and costs in SW and HW development	% of WMs with CarefreeWashinsService produced in time	Number of new customers; PSS frequency	-
	EI	<F>	<F>	<F>				II

VI. CONCLUSION

Finally a proposition is suggested according to the data given by the PIs. Although the use case provided has already a list of PIs used for its internal report and monitoring activities, these indicators have been purified and classified according to the new servitization modeling process. It is important to highlight this is the first feedback on the path of precise definition of PIs; therefore further research is needed in order to support the use case with final and exploitable results.

This paper defines a PI method for the manufacturing service ecosystem to generate and classify specific PIs according to use case requirements. Therefore MSEE PIs method has been created in order to design, implement and select specific performance indicators. Indeed, MSEE PI method has been designed to be aligned with use case objectives in order to provide a more coherent and useful set of PIs.

Finally this paper proposes to start a validation phase of the MSEE PI's methodology through other use case objectives. A definition of objectives and functions needs to be provided by the use cases in order to help defining their governance rules with which processes and PIs can be selected from VRM.

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