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HOSHIN KANRI visualization with Neo4j. Empowering Leaders to operationalize Lean Structural Networks.

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Abstract

Organizational leaders´ decision-making is being constrained by the limitations of Value Stream Map tool to show real time exchange information processes within their organizations. Therefore, the risk of making bad strategic value stream-related decisions based on misconceptions of the environment is high. In this research, an intuitive and self-configurable tool for HK visualization that is developed as a Neo4j graph database is presented. Based on the paradigm of (CPD)nA, this technology will help leaders to keep track of information exchange within Lean Structural Networks and, therefore, will pave the road for Lean Leaders to better make decisions on such complex networks.

Keywords: *HOSHIN KANRI; (CPD)nA; Lean Structural Network; Network Visualization*

Nomenclature

KPI	Key Performance Indicator
LSN	Lean Structural Network
PO	Process Owner
VS	Value Stream
VSM	Value Stream Map
(CPD)nA	Check-Plan-Do-…-Act
HK	HOSHIN KANRI

1. Introduction

Organizational structure complexity, which is understood in terms of [1] as "*the level of interdependence between organizational units,*" is increasing. Therefore, Leaders may fail when making decisions regarding the VS within the company, due to a lack of information. Thus, we seek a map that represents the organizational information exchange structure and its complexity, allowing Leaders to follow information exchange processes within the organization in real time and. therefore. to better operationalize HK´s processes within it. The technology presented in this paper will minimize the risk that the Leaders will miss information regarding the VSs and, hence, will improve their efficiency in making decisions.

In [2], the authors provide an approach to deal with organization complexity by introducing organizations as networks where interdependencies between units are described. LSN can be defined as a set of nodes that represent the different units that PO connected to each other by edges. These units are (CPD)nA processes that were developed as an improvement of Deming´s concept of PDCA. In keeping with the strategic goal of Lean Management, through LSNs, Leaders take advantage of HK´s principles application and its basic unit, (CPD)nA, which standardizes information exchange processes.

The extent to which they have an updated state of the information´s flow implies a level of understanding of the situation that can make the difference between success or failure when making decisions regarding VSs.

Therefore, by having an updated map of the information exchange with which one can easily visualize the complexity of the organization, connections within the organization

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(internal connections) and its environment (external connections) in real time results from (CPD)nA processes, Leaders would be able to make more stable and efficient strategic decisions as the map will provide a holistic view of the organization at the time of decision.

As stated by [3], VSM is one of the tools that are most preferred for keeping track of manufacturing processes. It allows one to easily identify wastes, as excess of inventories or material flow bottlenecks, etc., within the process production. However, VSM, in its focus on manufacturing processes, fails to show the information exchange dynamically in real time.

As stated above, HK and its concept of (CPD)nA provide a useful tool with which to approach this issue. By continuously checking the state of manufacturing and information exchange processes, leaders can have a more current view of the process and, therefore, reduce the risk of taking decisions that are based on misunderstandings of the environment. Senders and receivers in the information exchange process within LSN are better connected than those in traditional organizations with rigid structures and high levels of hierarchy where personal goals tend to receive higher priority than the organizational goals, thanks to (CPD)nA.

In this paper, we focused our research on the next research question:

RQ1.Would it be possible to have an information exchange visualization tool that not only could enable one to follow (CPD)nA processes in real time, but also represent the network's structural complexity and its dependencies at the same time?" Also, "Would it be possible to also visualize the temporal evolution of the network and its performance as process Key Performance Indicators (KPI) are depending on the time?"

In this paper, we present a new HK visualization technology that has been developed as a graph database that will help Leaders to visualize, in a more operative and on real time way, information exchange processes based on HK´s basic unit (CPD)nA. The environment that has been chosen for the development of the graph database is Neo4j, one of the most commonly used graph database management systems today. The main reasons for choosing Neo4j were (a) its intuitive and easy query language (Cypher) and (b) the fast response in transversal navigation through the connected data. The tool presented in this paper will provide a general process overview within LSN and will open the boundaries of intercommunication process visualization and. Therefore. improve Leaders decision-making.

Hereinafter, we will first provide a literature review in which we will present different approaches to the information exchange process and its representations. Second we will introduce our new visualization tool that has been developed in Neo4j and explain some of its features and how it can represent information exchange processes. Connections within different POs, process states searched by different filters and temporal evolutions of the process are easily visualized in a graph database. In the last section, we will summarize the result of this research and discuss the extent to which the previously-stated research question has been answered. Also, limitations of the model and future lines of research will be presented.

2. Background

In this section, the framework for this research and main concepts that led to research arises will be introduced.

Within organizations, decision-making could be examined from different angles. Decisions could be focused on problem solving [4] or process management [5], or based on KPI´s [6]. By our research, we aim to improve process management decisions by helping Leaders to keep track of their processes.

In [7], the Hoshin Kanri Tree model is presented by the authors as a model for successful HK implementation within networks to address strategic goals between different hierarchy levels. This model provides direction in Lean Management and develops the previous concepts. As described in [7], HK is a "system approach to improvement of a company´s management process." Moreover, it appeared as a strategy for continuous improvement within the entire organization, aligning all the hierarchy levels to the same strategic objectives. Also called Policy Deployment, it aims to breakdown the strategic goals within the different levels in the organization and defines l achievable goals for each level according to their positions and to cause the whole organization to focus on the same direction.

As HK involves the whole organization, it can be difficult for the Leader to follow the different dependencies within the network and keep track of the performance of each of the processes. Therefore, being able to visualize HK, in terms of (CPD)nA processes within the organization will enable the Leader to state more precisely and clearly intermediate level goals. They will have a clear picture of their situation within the organization and make more accurate decisions regarding the VS that consider how their decision may affect to the processes in which they are involved and the rest of the organization.

With a starting point in those research studies, the need for a visualization tool that permits the information exchange processes to be followed was identified. It became the starting point for this research.

Previous research on VSM had shown its effectiveness for identifying wastes in manufacturing processes [3] and potential improvements. In addition, VSM's models have been proved to be very useful in non-manufacturing processes' improvement, They it easily represent workflows and identify value adding steps in the process [8]. However, the lack of dynamic representation of the real information exchange within networks assumes a constraint for Leaders. This gap night be closed with our model that has been developed as a graph database that considers the dynamic flow of information exchange processes that vary with time.

3. HK visualization method with Neo4j. Operationalization of Lean Structural Networks

Graph databases provide high data scalability and performance within interconnected data. They enable one to store huge amount of data and their connections, representing them as nodes (data) and edges (connections). Because of their easy query language, they permit one to navigate through the data more easily and quickly than possible with relational databases, which require several joins to represent and store highly connected data [9].

Within the framework that has been presented in the previous sections of this paper, we have designed and developed a new LSN visualization method that will provide Leaders with a useful tool for improving decision making. The model that is proposed in this paper has been developed as a graph database and will allow Leaders to have a more accurate view of the organization when making a decision.

3.1. Neo4j

Neo4j [10] was chosen from all of the graph databases environments that are available for development of our tool. Neo4j is an open-source graph database that has been developed for making maximum use of nodes and their relationships [9], and permitting one to add as many properties to nodes and relationships as needed.

To show some of our technology´s features we will use an example that is based on one department within a small factory that may serve as an easily expandable LSN fractal unit. This department has three POs. They are the Factory Manager, Production Leader and Supervisor and are first, second and third, respectively, in the department´s hierarchy. POs within the factory are interconnected by (CPD)nA processes that represent information exchanges between them. The Factory Manager owns the (CPD)nA.1, process received by the Production Leader who also owns the (CPD)nA.2 process that the Supervisor received. The production line is involved in this case in two different (CPD)nA processes and acts as a sender in the one with the Supervisor and as a receiver in the one with the Factory Manager. Those dependencies between levels can be easily identified and represented with our technology as shown in Figure 1.

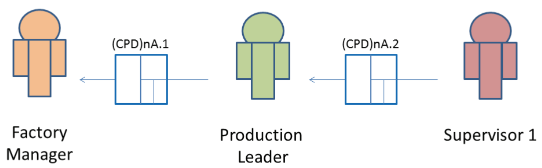

Fig. 1. Small Factory´s Department representation

Moreover, the dynamic character of this technology allows visualization of the network´s variation with time, by saving different states of the network that are related to the day in which it varied. Therefore, Leaders will be provided with a set of chronological states of the network and will be able to follow its variation with time. Figure 2 and Figure 3 represent the state of this department at two different times on the same day in consecutive years. One can see that a new PO has been introduced in the network.

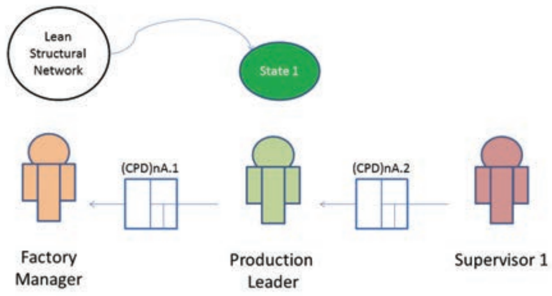

Fig. 2. State 1 of the network showing the actual state of the network formed by three different PO.

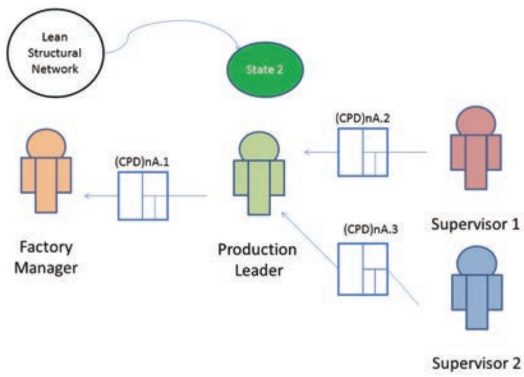

Fig. 3. State 2 of the network, showing that the network has increased as a new supervisor has been added.

This model has been developed in order that Leaders can keep track of the (CPD)nA processes in which they are involved. Therefore, it permits the storage of all of the data that these processes generate. It permits the storage of both the planned and actual values for defined KPI´s each day. It also calculates daily, weekly and monthly cumulative values, which can help in the analysis of the performance of that specific process within a specified period. Following with our example, we can see in Figure 4 one of the possible representations of the (CPD)nA data for one specific PO and month.

Although (CPD)nA represents the link between different POs, all the generated data from (CPD)nA processes has been stored in a node called "(CPD)nA" for ease of data storage and its representation. This can be seen visually in Figure 5. This form of also enables one to see at the same time the PO involved in the considered (CPD)nA process. The data is represented numerically in Table 1.

In this table, relevant data from (CPD)nA processes for a period of one month is shown. The first two columns represent the PO involved in the process, the next four identify the day when the information was collected and the last three columns show the KPI´s that were expected and values that were obtained for that day. The difference between the expected values and the actual values is expressed in hours.

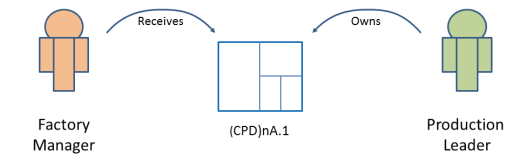

Fig. 4. PO´s (CPD)nA representation of KPI

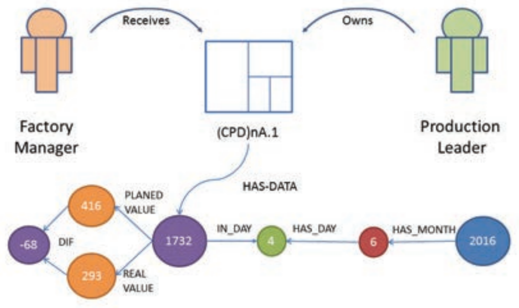

Fig. 5. Data Storage

Table 1. (CPD)nA numeric data representation.

Source	Sink	Day	Month	Year	CW	Dif	Cum_ Plan (t)	Cum_ Real (t)
Prod. Leader	Fac. Mgr.							
		2	6	16	22	-55	208	153
		3	6	16	23	-68	416	293
		4	6	16	23	-65	624	436
		5	6	16	23	-67	832	577
		6	6	16	23	-70	1040	715
		9	6	16	24	0	1040	715
		10	6	16	24	-69	1248	854
		11	6	16	24	-20	1456	1042
		12	6	16	24	2	1664	1252
		13	6	16	24	-43	1872	1417
		16	6	16	25	-51	2080	1574
		17	6	16	25	-50	2288	1732
		18	6	16	25	45	2496	1985
		19	6	16	25	0	2496	1985
		20	6	16	25	-10	2704	2183
		23	6	16	26	-24	2912	2367
		24	6	16	26	-4	3120	2571
		25	6	16	26	16	3328	2795
		26	6	16	26	-38	3536	2965
		27	6	16	26	48	3744	3221
		30	6	16	26	-42	3952	3387

3.2. Model design requirements.

In order to design the model and to store the data derivate from LSN and (CPD)nA processes, several aspects needed to be considered.

First, the model allows one to easily identify the LSN topology node dependencies and connections and represent relationships between different POs. Moreover, the model helps to represent the performance of the network and its variations over time so that Leaders can know how their connections have changed over time. An overview of the network will help Leaders to focus their decisions on the specific process and consider how the decision may affect other processes.

Second, the model allow one PO to visualize the state of the (CPD)nA processes in which it is involved, check the state of KPI´s in real time and interact with the process information.

Third and one of the most challenging steps in the design of the model is the need to ensure that the latter is time-dependent, in order that Leaders can keep track of their processes. Neo4j, does not allow one to define time variables, as it doesn´t contain time type in its libraries. However, Neo4j permits one to avoid this issue with its "Path Tree" [11] model. This model allows one to represent different events related to the date on which they occurred. By representing year, months, days, etc. as nodes that are linked with arrows to h help to keep the chronology, this model provides a good time representation, which is very useful for the purpose of our research.

In order that Leaders interact with this new HK visualization method, the model has been designed to minimize the amount of inputs needed for it to generate and provide all of the information that is needed. As given by HK Tree methodology, Leaders will have to define different KPI´s according to their processes in order to operationalize LSN with this model. Being able to visualize the performance of the processes according to previously defined KPIs will help Leader to define, if needed, new KPIs and, therefore, to better operationalize the network. Once the KPIs have been defined, to interact with the model, Leaders will only need to identify the process in which they are involved and introduce the date and the expected and obtained values of the pointed KPI. Then, the model will generate a data node with all the information from that day, calculating cumulative values and storing the processes to which it belongs. It will also connect the node in the model so that its dependencies in date and (CPD)nA will be defined.

By querying the database, Leaders will have all the information that they may need.

4. Management implications

With the model that is presented in this paper, we hope to improve processes within LSN from a managerial point of view. More specifically, we have concentrated our efforts on information exchange processes within the organization.

Dynamic Topology Analysis. One of the first managerial implications concerns processes dependencies and influences. Thanks to our model, connections between different PO´s will be easily identified and, hence, their dependencies and relationships. This feature is a great advantage for a Leader at moments of decision within LSN. It is not only important for Leaders to consider their processes, but also to be aware of how their decisions may affect the network and to understand which processes those decisions may affect. By having a network map when making decisions, Leaders will have an overview of the organization and their position, and, therefore, make better decisions as network dependencies may influence Leader decision making.

Visualization of HOSHIN KANRI. Thanks to our model, Leaders will better operationalize HK as they will be able to follow the performance of the processes in which they are involved. The model, allows Leaders to show on screen previously obtained values for a specific process. Therefore, they will be able to analyze the effectiveness of previously defined KPI´s, allowing them to decide if they are good indicators for the process or if new ones must be defined. Moreover, Leader will be able to study and improve the effectiveness of their decision making criterion.

Visualization of the Lean Structural Network´s Evolution. Another important aspect for Leaders to consider is how the network has been changing with time. An overview of the evolution of the network will help Leaders to better position themselves within the company and to see how their dependencies with other POs have changed. This feature might be even more interesting for top management levels that are responsible for the establishment of the strategic goals on which the company will focus its efforts and pursue due to HK implementation. This method may enrich other more static management tools, such as a balance score card.

Leading complex Value Stream Networks. This tool can represent highly complex networks with a great number of interdependencies between POs who are involved in the process. This model has been designed to enable Leaders to deal with the organization´s complexity and the increasing number of relationships within networks. It can easily represent highly complex networks. By simply extending the size of the network and representing the different information exchanges between the different POs, Leader will be able to visualize the needed information when making decisions, thanks to Neo4j´s query language. When leading highly complex networks, being able to visualize the dependencies within the network will help Leaders in their decision-making.

Strategic Organizational Design. Processes and dependencies are constantly being modified within LSN. This means that there is uncertainty the network´s future size and layout is uncertain. As shown by [12], LSN develop under certain conditions towards scale-free organizational design configurations. This desirable state is only possible with a preferential attachment that is more effective if the LSN is holistically understood. Hence, taking advantage of Neo4j´s features, we have designed our tool in such a way that dealing with high variability within the networks is not a problem. It will help Leaders to easily represent the network or parts of it with the desired level of detail. Therefore, Leaders will have an overview of the processes for which they are responsible and, therefore, will be able to make more accurate decisions regarding those processes. Due to its high scalability, our tool will make it easy for Leaders to deal with network complexity. It has been designed to easily modify the network state and to keep a record of modifications made that help the Leader to analyze the efficiency of previous decisions made within the LSN.

In summary, the main strength of our model is that it enables Leaders to visualize the network and to represent its complexity on a map that will help Leaders to make decisions with an understanding of how their decision may affect the entire network.

5. Conclusions, Further steps and Limitations

The implementation of HK principles is crucial for organizations to increase productivity and efficiency, as it provides alignment through the same strategic goals among all of the organization´s levels. By applying (CPD)nA, Leaders will be able to improve their decisions making concerning VS to address those strategic goals. However, as organizational complexity is increasing, Leader´s decision making efficiency can be compromised by a lack of understanding of the network's situation.

Therefore, as an outcome of our research, one can conclude that Leader´s decision-making has room for improvement in regard to control of the information exchange processes. Within LSN, where (CPD)nA processes are defined between different POs, Leaders may have an inadequate overview of the situation when making decisions due to the large amount of information that they must consider.

Thus, we have developed a visualization tool that will make it easier for Leader to make strategic decisions within organizations. The model presented in this paper enables Leaders to have a better view of the network´s situation and its evolution with time. It helps Leaders to visualize and keep track of the information exchange processes in which they are involved. Leaders will have now a better vision of the situation of the organizational KPIs and their relationships when making decisions. Moreover, its capacity to represent the LSN´s topological state will help Leaders to understand its topology and the connections within the company that will help them to make decisions from a broader perspective as they will be aware of the possible consequences within the organization.

However, as the tool is still in the design phase, there is the possibility of further improvements.

First, one of the main shortcomings of our model concerns the interaction user-tool. As developed in a specific graph database environment, users need to have basic knowledge in its querying language to interact with the tool. Therefore, a learning process may be necessary for the user when beginning to interact with the tool. However, this can be time-consuming

Second, for this model to be successful within LSN and become really beneficial for PO´s, there must be a real commitment by Leaders to perform HK. The transparency related to the (CPD)nA process management is not always wanted by all POs. For this reason, leadership is necessary to explain and accompany the growth of the LSN to ensure that the KPIs represent real and unbiased process performance.

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