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IMPLEMENTATION OF A R&D&I NETWORK IN METROLOGY FOR LARGE CORPORATIONS - PETROBRAS CASE STUDY

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Abstract - Metrology demands can be found in many phases of a company manufacturing process, from product design to quality control. On the other hand, as a support technology, it is not easy to define metrology's effective value inside the complex process chain of a large corporation. Indeed, it is made noticeable only when considering the views of various stakeholders. This paper outlines a methodology and main results of a pilot application case based on network theories to increase the perception value of metrology R&D&I inside large corporations, and thus providing a way to commit the budget for R&D&I.

Keywords: metrology network, R&D&I prioritization.

1. INTRODUCTION

Large corporations face major challenges when dealing with knowledge management and dissemination, mapping their needs and searching for optimal solutions in their many operational and business units. They affect the development of competences and proper return on investment allocated for research, development and innovation (R&D&I), as well as for purchasing technological services.

Metrology plays an important role in different phases of product and production design and development: product-oriented measurements for model verification, performance and conformity testing, process-oriented measurements for analysis and qualification, measurements for production, and equipment control [1]. In fact, metrology involves, directly or indirectly, a significant part of the organization staff. In general, however, metrology is viewed as a support tool and its benefits (or its value) are not fully understood.

The prioritization of investment must take into account the technical needs, resulting impacts and associated costs. A cutting-edge metrology may be too expensive and not productive. In order to increase metrology's perceptual value a complex network could be formed, in which individuals share solutions and knowledge on different matters. Metrology increases its value when putting together distinct individuals' views. Metrology adds value when effectively contributing to production process control, quality assurance and product safety, and, definitely, when gaining valuable knowledge. In this way, metrology will be understood as a continuous improvement enabling technology.

Working with different people, locations and institutions would result in different perceptual values, thus impacting improvement and innovation opportunities. For example, the perceptual value difference between R&D&I suppliers - focused on their core competencies and technical advances - and Oil & Gas companies - mainly focused on people safety and environmental issues – constitute barriers to successful interaction between them.

This paper presents a mapping method based on network theories for collecting metrology needs in large companies. The scientific community and technical service suppliers are connected in different levels. The method has been devised by CERTI Foundation and implemented at Petrobras.

2. NETWORK CONCEPTS

According to Baran [2], despite the various possibilities of networks' formats, networks can be split into two classes: centralized (or star) and distributed. A centralized network has a central node which is connected to all nodes, resulting in a quite vulnerable arrangement. Higher maintenance and animation costs are expected. However, implementation cost and time may be reduced. A distributed network requires a great effort to its implementation and ongoing monitoring for preserving their redundancy, i.e., the correct or necessary paths for information flowing through it. A decentralized network results from the combination of centralized and distributed networks.

Regarding social network, according to Wassermann and Faust [3], one of the base characteristic is "the importance of relationships among interacting units". This means it is very important developing a community mapping in order to make use of previous relationships as a boost to the network development.

Creech and Willard [4] worked on strategic aspects of networks. Some of their concepts are focused on the leading organization, or the strongest nodes, giving them the duty to operate networks as complex organizations, thus comprising business plan, timeline, goals and deliverables. A network should consider a quality system, which means that network managers should focus on optimizing processes, monitoring results and impacts through indicators.

Performance indices should not only focus on suppliers and technical issues, but also on the network and its own goals. Some networks' desirable features can be monitored, observing the value created by strategic communications and effective engagement of decision-makers. Implementation of communication and engagement strategies are essential [4], considering transparency and knowledge dissemination on a win-win scenario.

The aforementioned concepts by them own motivate the creation of a network business plan. Community mapping, differentiation among the players, collection and selection of proposals, effective communication plan and quality system implementation are considered elements for the continuous improvement.

3. COMMUNITY MAPPING

The first effort to collect data in Petrobras was focused on building a list of people with any interest in topics related with metrology knowledge. It resulted in an overview of how the network is currently operating, under an assumption of a decentralized system. Several employees distributed over some units of the corporation were identified, such as Logistics, Production, Gas, Engineering, Construction, Exploration, Petrochemical, Environment and Safety, R&D, Supply and Refining.

The employees were extracted from four databases: (a) Users registered in intranet discussion fora at Petrobras; (b) Recommendations from the ten first contacts involved in the project; (c) Papers and publications related to metrology, written by Petrobras employees; (d) Interview with Petrobras partners in metrology solutions at Universities and Research Centers.

This survey resulted in 680 potentially interested people in metrology at Petrobras. It also includes their business information. That was the universe for the first market research.

3.1. Data collection at Petrobras

From the universe defined, 680 employees were contacted and 102 survey feedbacks were returned by the deadline. The questions were split into network connections and technical needs. The first subject intended to collect recommendations of colleagues that could be interested in metrology knowledge and in becoming a node of the R&D network under structuring.

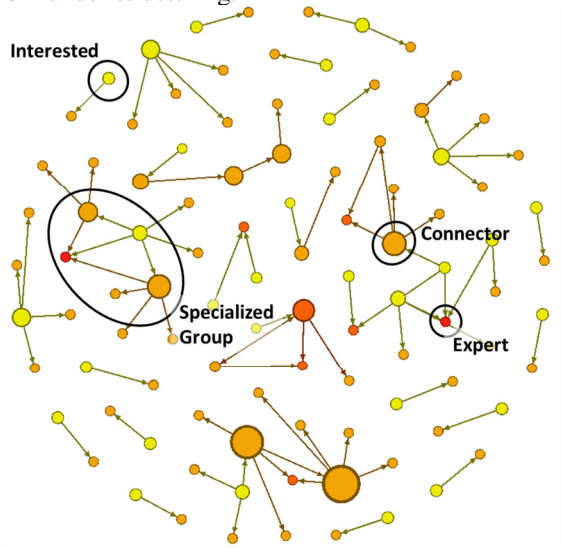

Fig. 1. Individuals' connections and their classifications according to this project (arrows represent the recommendation path).

The internal individuals' network was organized as shown in Fig. 1, characterizing a connection map in which each node represents a Petrobras employee. The connection map points out some decentralized groups not connected to the others. On the other hand, part of the groups looks like small distributed networks. This current network structure is prone to create islands of knowledge. The low interaction level will result in innovation deficits and much probably similar works running inside the company in parallel.

Rearranging the network as illustrated in Fig. 2, different roles can be clearly observed regarding communication and knowledge dissemination. Some individuals were identified by others as "experts", while others were highlighted due to their aptitude to recommend individuals, making them natural candidates to disseminate knowledge, or to become "connectors"; thus increasing redundancy in the network.

The organization of company individuals regarding their connectivity and redundancy is the main thrust of this work. In fact, networking efforts can be reduced when working in groups properly connected by their similarities. The final aim is to rearrange the actual network into a distributed and strong network. The network stakeholders are defined as follows:

- *Experts* Individuals who have had many indications from other stakeholders. They should make decisions about metrology challenges and investments. Possibly, the connection of some experts will give rise to high-level internal discussion fora, crossing the demands in the company and leading research groups and projects.
- *Connectors* Individuals who recommend many others are potential candidates for disseminating knowledge inside the company. Due to their ability to provide redundancy to the network, they shorten the node distances inside the *network and keep it alive when nodes break.*
- *Network Members* Individuals who answer surveys and queries. They are an active part in network routine. They should be prioritized in development groups, being influence points in their addresses. They must be targeted when searching for investment opportunities in R&D&I due to their proximity with the demand.
- *Interested* The universe collected in the survey with some metrology connection in the company, including network members' indications in the company. They are secondary targets on dissemination campaigns, and may become part of the network.
- *Specialized Groups* Not defined by an individual, though by an isolated group working as a decentralized network inside the company.

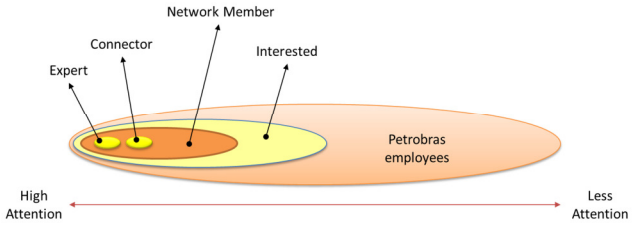

Fig. 2. Stakeholders of a metrology networking at Petrobras.

The network administrator node is in charge of inducing the main connection among the specialized groups, as shown in Fig. 1. The key factor is to keep the network dynamic (net weaving) and able to disseminate updated information. At first, the connection between the main nodes, described by experts and connectors, will set the network to a condition of

decentralized network, which represents an important leap to a distributed model in the future.

3.2. Data collection at R&D&I providers

Aiming at new connections and increasing complexity, the project team searched for lists of Petrobras employees dealing with metrology from external agents, i.e., suppliers of R&D&I solutions for O&G in Brazil, previously registered by the metrology network administrator node.

The same survey described in the former section was used for data collection of R&D&I providers, inflating the contacts classified as "interested" in metrology solutions. Fig. 3 shows the results of this data collection, from which one can notice the introduction of interlocutors as interested members. New connections were formed between Petrobras employees' specialized groups due to R&D&I suppliers. They increased network redundancy because of their similar interests and core competencies / technical references.

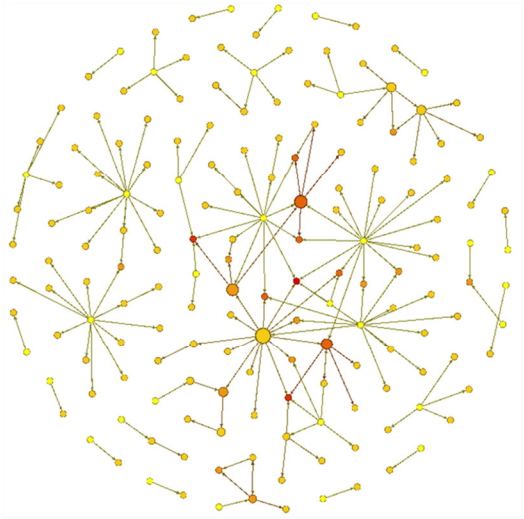

Fig. 3. Connections among Petrobras employees and R&D&I providers.

Two different types of connection are observed. The first type is based on personal and institutional core competences or on the thematic network. The second type of connection considers social interactions among people, although those interactions may not be necessarily technical.

The major challenge is the evolution of the system from a simple supply and demand arrangement to a cooperative-competition (coopetition) environment, which interconnects researchers committed with innovative solutions.

3.3. Social network mapped and its implications

The mapped social network may not include the entire Petrobras metrology network, and may not show all possible connections between people. An open research with people names should increase network redundancy, and thus create new connections on a continuous upgrading process. Using the network concepts and assuming a higher redundancy, the win-win relations will be obtainable only in a transparent environment with clear rules. Hence, Petrobras metrology network has been represented from a central node with the following network animation (net-weaving) tasks:

- Keep updated network people recordings and interaction history: demand and offer.
- Encourage continuous connection between network members (people), both for developing social relations and for co-executing projects.
- Disclose insistently the ongoing network schedules, rules and actions.
- Keep and apply transparent rules for selecting proposals and prioritizing budgets.
- Disseminate results and keep performance indices up to date.

For that purpose, an annual strategic and action plan was developed concerning tactical and operational approaches and aiming at stating and pursuing goals using indicators. Petrobras metrology network, currently called METRONET, would be operated as a business, managing the budget for strengthening the main node from a management system. METRONET must create and realize strategies to engage people, and not only the institutions, considering personal interests. It was suggested using a tool based on Customer Relationship Management (CRM) in addition to the Social Network Motivation techniques.

4. COLLECTION OF R&D&I NEEDS

From contact database, at first the collection of needs was focused on internal employees. They were questioned about immediate needs that would require R&D&I investment. This collection of needs included some features that would assist investment ranking in line with the strategic alignment of the company. The first collection of needs resulted in 87 potential demands for R&D&I projects. Fig. 4 illustrates the tag cloud that highlights the needs. As expected, flow (more than 50%), temperature, pressure, volume and density measurements dominated the survey.

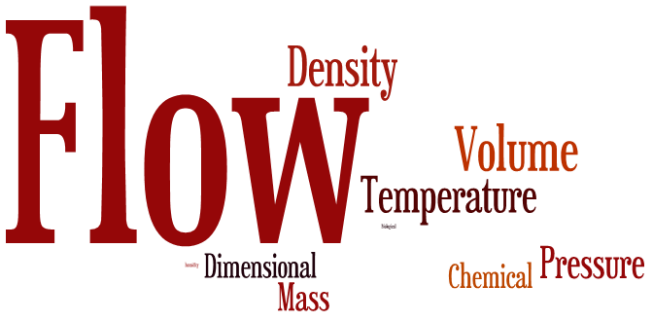

Fig. 4. Tag cloud from network members' research.

The same survey was conducted with R&D&I providers. It intended to enhance the technology roadmap. Grouping all suggestions in a ranking, considering impacts, strategies and demands (employees' needs), and future situation (R&D&I provider's needs) would guide investments in metrology. The R&D providers' collection identified 42 new opportunities of investment, which also considered its impact on the company business strategy. Fig. 5 illustrates the tag cloud obtained after R&D&I providers survey.

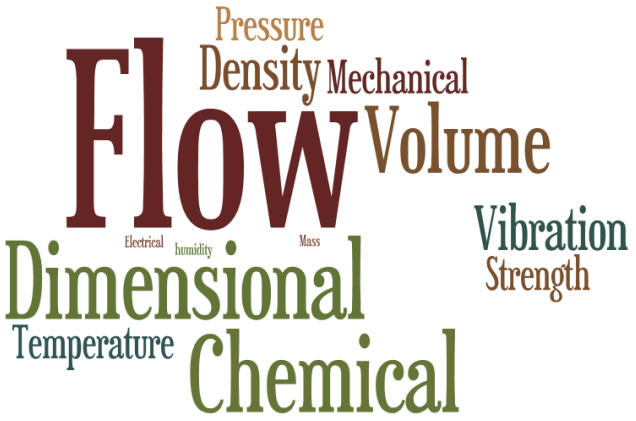

Fig. 5. Tag cloud from R&D&I providers' research.

It can be noticed that the survey with R&D&I providers increased the dispersion of metrology areas. Flow metrology maintained the first place, and new inputs were included, such as humidity, corrosion, viscosity and torque. Consequently, R&D&I providers can increase network redundancy (due to their long list of contacts and academic references). However, they can increase dispersion when R&D subject is the focus.

5. SELECTION OF PROPOSALS

As observed during the research, network members keep their informal groups through social networks. In addition, even if the relationship between providers is still incipient, many of them share the same contacts with Petrobras network members, demonstrating affinity to work together. Thus, the procedure for selecting proposals should motivate this cooperation seeking for complementarity and innovation from connection of competences.

The procedure for choosing proposals should minimize parallel negotiations between the nodes in favor of the best impact on the company's goals. Considering that, some steps were defined, starting from needs' collections, opportunities for improvement to future vision of both network members at Petrobras and providers. Network needs were collected by standard forms and made available through a collaborative database. During network meetings, the opportunities would be grouped and promising cooperation initiatives would be discussed.

The selection of proposals shall be carried out just before company budgetary planning phases, employing a Decision Matrix with well-defined criteria, such as:

a) Criteria based on Petrobras values (published in the last strategic plan of the company):
- People - Is team growth expected/allowed? Is transfer of knowledge expected?
- Sustainable Development - Will the project contribute to reduce carbon emissions?
- Results - Will the project contribute to save corporation costs? Will the project contribute to increase corporation earnings?
- Integration - How will different Petrobras' areas, sectors and employees interact in joint projects?
- Entrepreneurship, Innovation - Will the project support the creation of technology-based companies? How about the local content?

b) Network performance criteria:
- Project financial plan - Is the project budget consistent with internal rules and available funds for the theme?
- Connectivity - How many stakeholders will be within the project?

The network criteria have their own weights / scale, which would assist the evaluation of project proposals by METRONET experts.

6. PILOT PROJECT

The pilot project execution broke some paradigms spread over the team. The first one was the mass dissemination of demands and future visions, as the only submission means of a proposal. METRONET central node team had to deal with provider's resistance to spread their ideas in an environment with competitors.

Another broken paradigm was related to the assessment of the decision matrix elements, such as team growth, return on investment, and sustainable development, for a project directly concerned with metrology. In most cases, providers reported subjective answers to the decision matrix questions, and thus resulting in subjective evaluations.

The pilot action results were the following: (a) 129 needs collected (87 from Petrobras employees and 42 from R&D suppliers); (b) 28 proposals developed during the network meeting, involving more than 40 joint opportunities; (c) 11 project proposals approved and ranked by priority.

Six of the approved project proposals involved the field of flow metrology, two of them were related to dimensional metrology, and one proposal for each of the following areas: density, pressure, and chemical metrology. The assessments made by experts from subjective textual proposals using METRONET decision matrix reflect Petrobras employees' tag cloud.

7. CONCLUSIONS

The priorities of each network individual depend on the perception of value, success criteria and particular goals. The connection of these opinions in a decision matrix, supported by technical, operational and strategic criteria, is the way to find the proper answer for best use of R&D&I budgets. The network structure is to be defined with simple (but strong) roles and tools.

The project proposed a quality management system for the network, setting procedures for connecting Petrobras teams with R&D&I institutions. The pilot round for prioritization of investments in R&D&I was performed and approved on a network meeting with metrology "experts" and R&D&I providers.

The project time restriction did not allowed exploring new network members at Petrobras. Efforts in this direction should increase the number of interested individuals and network members, creating possible new "connectors" and "experts". It is recommended for a new cycle on this initiative awaiting for the natural evolution of this complex system, increased by new network strategies.

As future work, besides the increase of contact database with a complete company mapping, it is recommended a net weaving planning (as a project) and the consolidation of a management quality system based on an ISO standard. The

development of a business plan for the network is also an activity to be done. That could consider other transversal knowledge areas, such as metrology, focusing on decision support patterns and knowledge dissemination.

Mathematical models or scoring methods for estimating the impact of metrology on strategic corporation goals, such as Petrobras sustainable development, financial results, and team growth, would make possible redefining metrology to a strategic position in the company.

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