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Supporting the conception of a Knowledge Management System by the PIFA approach: case study STMicroelectronics

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Abstract— **Workflow and Knowledge Management became more and more important in the recent years. Neverless, both of the domains have still problems to resolve: Knowledge Management has to handle the problems of human resistance to capitalize knowledge. Workflow Management has to deal with changes in the process model and in process instances. Especially, in a knowledge intensive dynamic process environment, it is primordial to understand and to satisfy these two requirements to guarantee the user acceptance. In this article, we characterize and present PIFA – an analyze method to capture the requirements of both domains. We will also illustrate how PIFA can help to design a knowledge management system based on the analysis results to support workflow and information management. Our PIFA-approach is especially applicable on knowledge intensive dynamic processes. Therefore, the process level helps capturing requirements for the process flow, the information level helps capturing the information flow to improve the information sharing within a process and between processes and the functionality level guarantees that the involved actor have an immediate surplus value and will accept the changes caused to the defined process flow and the higher information capitalization. Therefore, PIFA combines the process' actions with the knowledge capitalization and the surplus value.**

Index Terms **- Knowledge Management, Dynamic Business Process Management, Information Retrieval, Ontology**

I. INTRODUCTION

Knowledge Management gained popularity in the recent years and became almost a buzzword after 1995, where a lot of works were based on the research results from Nonaka [1].
The application of knowledge management is often related to information technology (IT) as information is the basis of knowledge and information can be treated quickly by IT tools. But a lot of IT projects fail, because of different factors as lacks in identification of user needs, resource problems, acceptance problems, etc.
Enterprises tried often to build up a new knowledge management system (KMS) as a stand-alone tool, or as a separate activity. This KM activity as project end phase was often considered as an additional workload by the user with no "added value". In fact, knowledge management is not a stand-alone activity as knowledge is produced in daily work during "classic" work activities that are parts of processes to produce a good or service.
Therefore, knowledge management must be integrated in daily work by satisfying the knowledge sharing requirements as well as satisfy the requirements to improve actual work methods. This is important to guarantee the user acceptance and providing a tool being able to supporting the process execution the produced knowledge is part in.

In this article, we will explain the context of our study and characterize our **PIFA**-approach for analyzing requirements for knowledge intensive business processes that was applied in a case study at STMicroelectronics. Based on this analysis, we developed an IT-tool to support experiment processes management and integrate knowledge management activities in daily work.

II. CONTEXT

This research was accomplished in the R&D department at STMicroelectronics. The microelectronic domain is a very dynamic and agile field where new technologies or manufacturing standards become quickly obsolete and have to be replaced or redesigned:

- Products could be obsolete after 6 months,
- New technologies appear every 2 years
- Conception phases for similar products are executed in parallel.

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Therefore new technologies and production methods (called a technology platform) will be developed. Even if this platform concerns only one specific technology, new fabrication methods could also be reused for current technologies and replace old production methods as some phases of the manufacturing method could be the same or similar.
New ideas will immediately be tested by producing a prototype to verify if theoretical ideas are efficient and producible – to detect production limits that haven't been taken into account in the theoretical model as well as detect measurements that are different from the theoretic calculations.
This research work is focused on this experiment processes. It is important to mention that an experiment process is based on the "standard" fabrication route of an existing technology, divided in operations to produce certain functionalities on the microelectronic chip. Depending on the experiment to execute, the number of concerned operations is different. As one person is responsible for preparing an operation on a machine in the clean-room, the number of involved actors also changes depending on the concerned operation for an experiment process: To sum up, it impacts the number of process' actions.
We consider therefore that the experiment processes is a dynamic field.

- External conditions could cause changes as e.g. information changes
- Internal condition as e.g. the number of operation (and related number of actions and actors) could cause changes

The process execution is therefore dynamic: Actions have to be executed again, actions will be added, and actors change or wafers could be scraped during the experiment and can't be used any more. Therefore, it is necessary to mention that often not only the goal of the experiment (experiment description) change during the experiment, but the experiment information that we call the extern conditions that impact the process execution.

III. THE PIFA METHOD FOR CAPTURING REQUIREMENTS AND EXTRACT RULES

Knowledge capitalization requirements have to be integrated in daily work of process action and there is no general tool responding to most of the requirements [2]. Therefore, we think that it is primordial to understand and capture the requirements of both domains and combine them for a specific context.
Our method PIFA [3] (**P**rocess **I**nformation and **F**unctionality **A**nalysis) is inspired by the existing methods from the project management institute [4] and method "H" [5].
It helps to capture these requirements of involved actors and managers. Moreover our PIFA-approach has been developed in order to formalize a process and separate the work- from the information flow in order to understand the relation between business process and knowledge management. But information is necessary to execute an action. Therefore, the distinction allows especially formalizing which information is necessary to execute an activity. The basis of the analysis is therefore the **action** of a process.

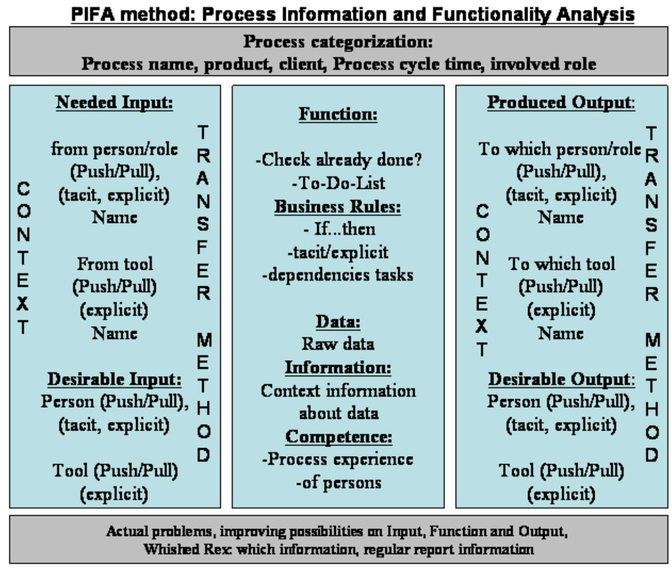

Figure 1: PIFA method – Process Information and Functionality Analysis

Each action can be composed in the five following parts:

The **Input** (opening conditions for an action): All dependencies of previous actions, as well as all needed information to start its actions are identified and also its format and its source. The source of this information can be human or an IT tool and it is transferred in an explicit or implicit way by pushing or pulling methods.

The **Functionalities**: All possible functionalities to do that are part of the action are identified based on information and on business rules. Furthermore, for each action, a group of persons is identified who have the competence to do this.
This group will be characterized by a name as well as the role that identifies the analyzed action with a person or a group of person.

The **Output** represent the produced information during the execution of an action: following actions depending on the results of the actions will be identified as well as all produced information and where they are stored or send to. Therefore, the relation between actions is formalized as well as the information flow.

These described parts are the heart of a process and each action. By applying PIFA, it is also important to keep in mind two additional aspects of a process and action analysis:

A process is unidirectional to produce a good or a service, but it might be convenient to introduce an information flow backwards the process to give a **return of experience (REX)** to all involved actors as well as to introduce a cross-over knowledge sharing between processes. Therefore, part of the analysis should be to identify all desired return of experience about a process or an action.

Additionally, the process has a certain **context** to describe itself. Each action is related to a process and has therefore a specific action and process context. A part of the context can be formalized as information – contextual information. Theses information could exist already at the initialization of the process or could be produced during the execution of the process and help to better classify the process and the action as well as support the internalization of information into knowledge.

PIFA is a help to formalize complex processes, especially organizational transversal ones. The PIFA figure (→fig. 1) can be considered as a template to do interviews with the process actors and managers to understand and formalize the process. The idea is to follow-up different process' executions to formalize them. The goal is to capture and formalize the flowchart of the different actions and the associated produced information in real executed processes. Therefore, PIFA has three different **A**nalysis levels:

- A. The **P**rocess / action level
- B. The **I**nformation level
- C. The **F**unctionality level

We detail and illustrate on examples these three perspectives in the following chapters:

A. *The process and action level*

The **P**rocess level represent the business analyze nature. The formalization of dependencies between actions of a process results in designing a process flow.
Georgakopoulos [6] defines a workflow as a collection of tasks organized to accomplish some business process. A task can be performed by one or more software systems, one or a team of humans, or a combination of these. Human tasks include interacting with computers closely. For the generation of a process model, it is important to identify if changes could be modeled in advanced or occurred during the process.
Bachimont [7] already emphasized that "models don't model the reality, but propose instruments to explore the sources that humans put in relation with its situation of use. A contextual, unpredictable interpretation of the sources can't be modeled".
Neverless, the requirement of supporting the real process can only be satisfied by having a model approaching the real process. Therefore, the process model should represent the real process and changes in the process instances should help to adapt each process to its context.
The handling of dynamics in process management is still an unsolved problem, but it exist a lot of projects dealing with these aspects as the projects ADEPTFlex, Chautauqua, WASA and WIDE [8].
Van der Aalst [9] compared different workflow tools and its functionalities. He concluded that no tool is able to satisfy all different requirements.

Therefore, an action is analyzed and put it in a certain context. Dependencies between actions will therefore be captured and formalized as well as conditions for the process flow for opening and finishing actions.
Based on this captured process, the process flow could also be optimized. Therefore, we consider that business process reengineering methods could be helpful in order to optimize the current formalized processes.
We illustrate in the following an example of a process analyze:

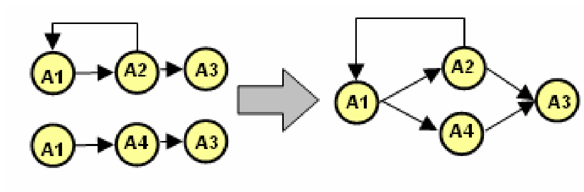

Figure 2: example of a PIFA result

In the figure above two PIFA analysis has been applied on the actions A2 and A4. The two analyses have therefore delivered a process model. Actions A1 and A3 have to be analyzed next to enlarge or validate the obtained model.
Secondly, conditions for the process flow have been captured:

- A1 has to be finished before opening A2
- The completion of A2 can re-open A1 or open A3
- A4 has to be finished before opening A4
- The completion of A4 opens A3

The **process level output** is an optimized process model containing actions and dependencies between actions as well as opening and finishing conditions, meaning to establish different rules for the action and its associated process flow.

The PIFA-process level covers the described Input and Output parts in the previous chapter in terms of process conditions for opening and finishing actions.

B. *The information level*

The **I**nformation level represents the information nature of a process. We distinguish two different natures:

- The produced information
- The contextual information

The **produced information** is the output of an action in forms of documents, presentations, etc. An action has information as input and transforms it supported by tools into new information as shown on the following figure [4]:

Figure 3: Information is transformed in output via tools

But information could also be contextual and necessary to describe the process or information of an action. The analyzed process is therefore seen as an information object that evolves during the process execution. Contextual information annotates the process.

The goal of the information level is on the one hand a formalization of used information in form of documents, presentations, etc. and to understand where it is produced, where it is stored and where it is reused in the process. Therefore, the different produced information has to be merged to the tasks where they are used to produce new information. In a knowledge intensive environment, the role of information is very important for the process, but information could be change and become obsolete. Therefore, the produced information in an action based on the obsolete information become also obsolete and the action has to be re-executed again. The dynamism source of a process can therefore be the change of information.

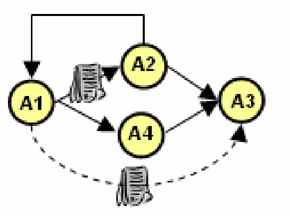

Figure 4: example of a PIFA result and the dynamisms based on information

In the example above (fig.4), the produced information (illustrated as a document) is reused in the actions A2 and A3. If the action has been completed, the workflow will continue and open A2 and then A3. In the case that the produced information in action A1 becomes obsolete, the process has to be re-executed. New information will be produced in action A1 and will impact the work in A2 and A3.

As explained, the merge of produced information to tasks improve the reuse within a process. But it is also envisaged to improve an information reuse between processes. Therefore, the process and the produced information within a process must be have enough **contextual information** in order to help the information internalization into knowledge as well as to help retrieve the necessary information within all existing processes and information.

The goal is therefore to capture all necessary contextual information to better annotate the information not only for an immediate reuse within the process, but also for a later reuse for other processes. Therefore, it is primordial to annotate the process with enough contextual information in order to introduce efficient information retrieval and information internalization into knowledge. Efficient information retrieval is today based on semantic [1] as the semantic web [10]. The description of information could also be structured and classified in an ontology. An ontology is defined as a hierarchy of concepts, relations between concepts and rules and constraints [11]. The principle of ontologies is joining contextual information (semantic) to information and relating this contextual information to a concept. As in an ontology, rules and hierarchies and well defined, these relations could also be used for a better information retrieval.

The goal of the PIFA information level is therefore to establish an ontology for the process context. Contextual Information used to classify the process has to be formalized and structured. This allows standardizing the annotations and defining a common information context for all involved actors in different processes but working on the same process domain context. However, it is difficult to define a common structure that is applicable for all involved process actors.

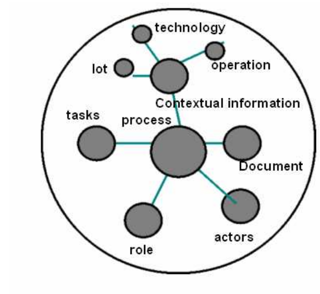

Figure 5: example of a domain ontology

On the figure above, a simple ontology is shown for the microelectronics experiment process domain. A process has different tasks and actors. Documents are produced and the contextual information could be the used experiment operations, lot or the used technology. (→ cp. Chapter II).

The **information level output** is an optimized process model merging information to the right actions. The information flow within a process is formalized separated as it allows identifying which information is produced and where and which part is reused. Additionally, an ontology is establish allowing annotate the process with symbols of concepts belonging to an ontology. We illustrate on the following figure the fact seeing a process as an information object:

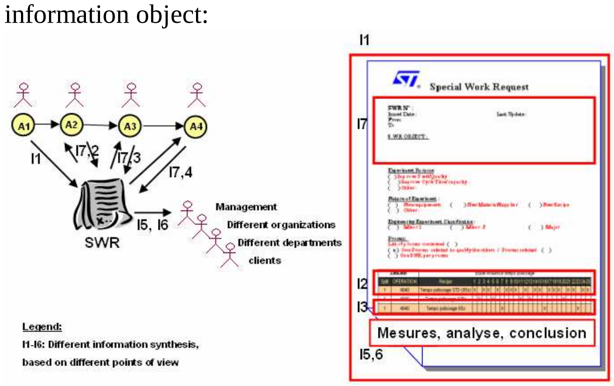

Figure 6: example for an information changes in processes

On Fig. 6, in each action, more information is produced and also more and new contextual information are produced helping to annotate the process. In each action, only a part of the whole information object is reused as for an action. For instance, for A3, only the information I3 and I7 are needed.

[1] Represent the "sens" contained in the the "sign", in an IT point of view; Information contained in Data. The first step in datamining process is to emphasize the meaning of information drowned in the fuzzy mass of data

The PIFA-information level covers the described Input and Output parts in the previous chapter in terms of information needed and produced within an action. Additionally, it represents the context and the return of experience parts as therefore the ontology can be build and additional process information flows could be introduced by responding to a return information flow backwards the process as well as between processes.

C. *The functionality level*

The **F**unctionality level of the analysis helps to identify the functionalities of an action within a process. These functionalities describe which input action information is used and how it is transformed into new information based on information (facultative) and business rules for an action. For an action in a process, Processes are often supported by IT tools. Functionalities are therefore supported and executed by IT tools. Functionalities executed by humans let a great liberty to the human as everyone can determine the order and the specific way how they are executed. Functionalities supported and executed by IT are restrictive and fixed. The way things are done is therefore always the same and have to respond and cover all humans "different" ways of execute functionalities. The process and the information level consist in improving the process and the information flow and better information capitalization and annotation for a better reuse. This impacts changes for the user:

- The process flow is better formalized and can't be changed. It is well defined which functionalities are part of an action and who has the responsibility to do it.

- More contextual information has to be filled in forms, tables, etc. in order to guarantee the contextual information capitalization for a better information retrieval

A process execution has always human interactions. We consider that every employee has its habitudes and resists to changes. It is well known that we have to pay attention on the potential high barriers of acceptance. Empirical studies have already shown that users of IT systems don't enter information even if they have a personal gain in the future [12]. Satisfying and improving current functionalities of process action will guarantee the user acceptance and secondly provide the deployment of the defined process as well introduce knowledge management functionalities in daily work and promote a knowledge sharing culture in the enterprise. Therefore the employee's behavior and functionality has to be analyzed to guarantee giving an immediate surplus value to the user. The willingness of using the tool -as well as accepting the information capitalization and a restricted process execution can only be guaranteed if a motivation is given to the potential user. It is important for a sophisticate analysis to concentrate on the process flow and the information sharing aspects in order to combine them with an identified immediate surplus value for the user:

"Getting and accepting improved functionalities by giving up flexible process execution and accepting a stronger knowledge capitalization."

We illustrate on the following list an example for functionalities (requirements) captured during a PIFA analysis. These functionalities could belong to one ore more actions on a process:

<u>*Functionalities:*</u>
- *Validate the information (A1, A3)*
- *Store a document (A1)*
- *Assign a person to a task (A1, A3)*
- *Set information to another tool (A4)*
- *etc*

Figure 4: example for a functionality requirement list a person about done work

The **functionality level output** is an optimized process model merging functionalities to each action. These functionalities could be improved and gives a surplus value to the actor. This helps to minimize the resistance of the users to accept on the one hand a new tool and on the other hand it reduces also the resistance against knowledge capitalization.

This PIFA-functionality level covers the described functionality part in the previous chapter. It analyzes which functionalities are executed based on which business rules and with which information.

D. *The goal of the differentiation of the three levels*

PIFA can be applied on all types of processes, especially on knowledge intensive ones, as it formalizes the workflow and distinguish the associated information flow of a process.
The three levels of the PIFA-analysis guarantee to track a process model representing the real process, track the information produced and identify necessary contextual information to describe the process and formalize improvement possibilities to reduce the user resistance against changes in the current process, the work methods and the knowledge capitalization, often considered as surcharge.
PIFA can therefore help to build up a knowledge management system that combines knowledge management and workflow management activities.

- The process level constructs the process model for a workflow management tool aspect.
- The information level construct a knowledge capitalization, sharing and retrieval model supported by ontologies for an information sharing via IT
- The functionality level guarantees to include all necessary functionalities and giving a surplus value to facilitate the user acceptance

Respecting these three levels improve the probability that a knowledge management system is accepted by users. Additionally, it integrates knowledge activities into daily work.

IV. CONCLUSION

Our approach is only a help and don't guarantee that all aspects could be formalized or all exceptions could be captured. Some functions keep implicit as they are also considered as implicit by the interviewer applying PIFA on a given context.

The goal is to generate a process model of work and information flows and the associated required functionalities. These two parts are essential to design an IT-Tool supporting the execution of knowledge intensive dynamic processes.

Often Processes are modeled in a fixed way and represent not the real process, or exceptions can't be handled by the defined process. The application of PIFA is completely. It could especially be used for a dynamic environment where processes change. Therefore, the formalized processes will be different as it analyzes and follows concrete processes by combining different activities by the different work and information flows.

Our approach could also be considered as a gap analysis as it discovers information flow improvement, functionalities improvements and relates information flow to functionalities improvement possibilities.

Additionally, PIFA helps to understand the dynamism of processes by producing a process model for each analyzed process. Theses models could help to generate a process model covering the different analyzed aspects.

We proposed in this article our PIFA approach that helps to analyze knowledge intensive business processes and the associated requirements to provide an IT tool. The objective is to support the management of the agile and dynamic process flow and on the other hand to capture information and facilitates its reuse.

In our context, the objective is the reuse of experimental results for similar problems of different technology generations. We tested therefore PIFA on this context in a case study at STMicroelectronics.

The results of an analysis permitted to identify

- the processes executed and built the base to generate a process model
- the knowledge that is produced and used and
- the functionalities to improve

The intensive work with the users and their reaction on the knowledge management system confirmed the utility of PIFA:

- The interest in the workflow functionalities shows that the PIFA-method has given a good process analysis of the daily work and the produced information as well captured the requirements to handle such a process.
- Secondly, the interest in the knowledge retrieval functionalities shows that users agree with the need for a better knowledge sharing

We applied our PIFA approach on the context of experiment processes (→ cp chapter II). We build up a process model, domain ontology by capturing the keywords during interview with the users and structured them based on user opinions. We also identified primordial functionalities. Based on the three facts we developed a knowledge management system that is currently used and deployed at the Front-End Technology and Manufacturing R&D Site in Crolles (France). The tool is already used for 35% of all executed experiments after a pilot phase of three weeks.

The PIFA-method has given a sufficient model of the domain to propose an IT-tool to support daily work as well as knowledge activities. As the model is always abstracted from the reality, the tool can't cover the complete needs. It is therefore important to keep in mind that the implicit knowledge sharing between users always exists and could sometimes be more efficient than a software tool.

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