A Tool Architecture for Diagnostic in Power Electric Network Using Method Engineering and Multi Agent Systems

Jean-Pierre LIENOU
Department of Computer Engineering
ENSPY/LIMSS, University of Yaounde I,
Yaounde, Cameroon
lienou@gmail.com

Emmanuel TANYI
Department of Electrical Engineering
Faculty of Engineering, University of Buea,
Buea, Cameroon
emmantanyi@yahoo.com

Marcellin NKENLIFACK, Thierry NOULAMO
Department of Computer Engineering
IUTFV/LAIA, University of Dschang,
Bandjoun, Cameroon
marcellin.nkenlifack@gmail.com, thierry.noulamo@gmail.com

***Abstract*—Electrical networks in developing countries suffer from several shortcomings. One can cite the scarcity of well-trained professionals to carry out maintenance operations, the ageing of equipments, the lack of spare parts and especially the deadlines for the supply in case of purchase. Diagnosis is an operation often perilous, arduous, long, semi-formal and sometimes leading to long calculations or to not satisfactory results. Activities carried out during the diagnosis are sometimes related to particular components of equipment or "modular" steps of a diagnostic algorithm. These different diagnostic modules can be formalized or not. Since recently, situational method engineering is improving its formalization and it allows designers to reuse fragments in the design process in software life cycle for example. The purpose of this paper is to present an environment based on multi agent systems which allows you to apply method engineering in other areas (here the diagnosis in the electrical networks) in order to solve problems specific to subject area. The building process is illustrated by the decomposition of certain diagnostic procedures in simpler activities achievable in parallel on the ground or in a software application and thus, reduce diagnostic time while simplifying procedures. The final goal of this on-going work is to create depending on the context, self-own diagnostic procedure and instantiate it.**

Keywords- Situational Method Engineering; FDI Diagnostic; Multi Agent System; CIM; meta diagnostic

I. INTRODUCTION

Since a decade, Situational Method Engineering (SME) has evolved and is highly appreciated by practitioners in information system to design methodologies for complex software from “chunks” of methodologies. However, outside of its use in process engineering and software engineering, SME is not visible in other areas of research. In effect, the SME is going in the opposite direction of the creation of a standard way to do things. It is focused on how to identify and document fragments from existing sources by including the practical recommendations of the industry; on how to store these fragments and ensure their quality and how to build a methodology for a specific situation from these fragments. Any constructed method thus uses fragments from a database of fragments that leads to reusability [1] which is very important. We are trying to check if we can move this experience to the field of control engineering and more precisely in diagnosis. The problem is complex and we propose to solve using agents. Agents are used in electrical networks on the theoretical level and they are applied in various features. In [2], authors use Intelligent Electronic Device (IED) as an element of measurement to propose a model for protection of equipment. In [3], authors propose Multi Agent System (MAS) for the diagnosis of faults in a distribution network of a decentralized energy production. Note that the international community is working to produce an ontology specific to power field and namely the Common Information Model (CIM) of the IEC that we recommend.

This paper is structured as follows: Section II presents the some key concepts in the diagnostic field, SME, and the MAS in power electrical networks. Section III presents the proposed approach for the construction of the method with a scenario on a hypothetical example, as well as the procedure for the selection of an elementary fragment to form a methodology for diagnostic. Section IV presents the platform model with the features of main agents.

II. BASIC CONCEPTS

A. Diagnostic

Diagnostic is a process that determines whether a device or a system is in good or bad state. There are several types of diagnostic and several communities i.e., Fault Detection Isolation (FDI), Dx, and Bridge were formed in the recent past and each develops its conceptual diagnostic tools. Bad state according to FDI community is when the residue calculation does not match with the model. For the Dx community, it is when the observations are not coherent with the description of at least one component or of the system; therefore, an R-conflict can help to diagnose a system. To support our remarks, we will use a diagnostic approach as proposed by the FDI community. By applying the diagnosis to the grid, it must be noted that the network must be modeled in the state space model. Several classes of FDI approach exist. These classes include:

- Methods based on residuals using the model to predict the values to be measured. The parity space method that eliminates the unknown variables and the estimation method by state observers is to estimate the unknown variables
- The parameter estimation methods use estimation techniques to calculate a value of a parameter of a model when its structure and design parameters are well known.

We can list some diagnostic methods of heating wire or equipment (electrical panel) in Table 1.

TABLE I. SHORT LIST OF DIAGNOSTIC METHODS TO DIAGNOSE HEATING IN EQUIPMENTS

Faults	Diagnostic principle
Diagnostic of heating	Infra-red Thermography
	Load Flow Analysis
	Radio Frequency analysis
	Dissolved Gas Analysis (DGA)

We use the term meta- diagnostic to specify the construction of a diagnostic approach by SME.

B. *Situational method Engineering*

Literature on SME shows the existence of several approaches to describe the process cycle. Researchers helped to formalize SME and tools are created to facilitate their implementation. Existing libraries appear and are enriched every day. They include OPFRO, Praxos, etc.. Several standards address issues of SME. The most common standard is the ISO/IEC 24744, OMG SPEM, OPF and many others. Most used component types in SME are "fragments", "components", "chunks", "OPF fragments" and services.

a) The Brinkkemper approach

In this approach, there are two types of method fragments. The "process fragment" which describes the steps, activities and tasks and the "product fragment" for the structure of the product at the end of the process to be put in place. A fragment can have relationships with other fragments and can be composed of several fragments; an elementary step description of the steps for successful description of the components to put in the database and extract to recompose a method.

b) The OPF approach

The approach is based on "Object oriented Process, Environment, and Notation" (OPEN), which generally produces five meta classes each producing a fragment method (process or fragment method).

c) The FIPA approach

In [1] and [2], SME is used for the construction of MAS and is now considered standard in the field of SME. It is important to define the meta-model of each fragment method to identify the architecture of the basic methods and to define how to connect these fragments of methods and techniques to describe integration method.

d) Ralyté & Rolland approach

In this approach, also called "chunks method" the process is based on the fact that any fragment of a new method to be build has an intermediate result [5]. The approach is composed of two parts: the "process aspect", which is called either map or direction of realization of intentions and the "product appearance".

e) "Method service" approach

This method based on services is according to us, the one that can be adapted to diagnostic although we have not yet investigated all others for suitability. Its meta model is shown in Fig 1.

In general, methods can be constructed in several ways: ad hoc (intuitive building from scratch) by changing (abstraction, instantiation or adaptation of an existing method, taking into account the current situation) by extension/reduction a method (by complicating or simplifying assembly) and taking into account possible overlaps between fragments. The main objective is to use a quick way for the construction of methods corresponding to the specific needs of each project by:

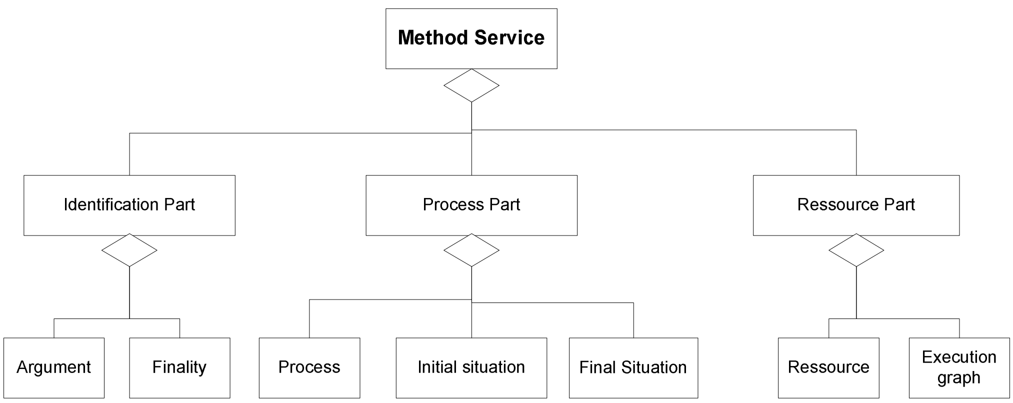

Figure 1. "Method Service" meta model in SME.

- guiding the method engineer in the requirements definition method for a specific project to develop a diagnostic system.
- helping the method engineer to select the components satisfying her method's needs.
- helping the method engineer to assemble selected fragments to build a new method or adapt an existing components method.

C. Electrical Power Network and Multi Agents System

An agent will be considered as a software component to build the system and get a multi-agent system. The choice of agent technology is due to a few of their properties: pro activity, sociality and especially the emergence from the activities of individual agents that is not provided in advance. This is actually the emerging functionality contrary to the program that is attractive to MAS because the designer does not have to consider all scenarios but the MAS can adapt functionalities: the analysis is less difficult in this point of view. But the task of distribution of subtasks on the agents remains complicated.

Equation (1) shows that emergence is due to the part of the collective function. The sum of the functions of the various agents of MAS should logically be less than the function of the MAS for collaborative agents

$$F\ (MAS) = \text{collective function} + \sum f\ (\#Agent) \qquad (1)$$

Fig 2 shows the use of a hypothetical system using a FDI diagnostic approach.

Telemetry data collection used to construct the current system state space model is compared to the nominal model stored in the physical system. A residue is calculated and if there are discrepancies, the diagnostic process is triggered and if not, the system proceeds to the next data collection.

III. PROPOSED APPROACH

The fragments of diagnostic methods depositories are stored in a database that can be queried. The granularity of selection can locate, isolate or identify the faulty component. According to written recommendations by experts, the result of diagnostic is displayed and a maintenance plan is proposed. Fig 3 shows the creation environment of the diagnostic methodology we call meta- diagnostic.

A. Environment for meta- diagnostics creation

The diagnostic engineer perceives a need to diagnose a component, equipment, network or even an embedded or not piece of software. He works in collaboration with the method engineer in diagnostic that will use (" method service" here) SME approach to populate the basic methods and simple compositions that allow not get deeper into details in the construction of the new method of diagnostic by the field engineer in diagnostic. Once the methodology is ready, the results are monitored and there is feedback to enrich the base with statistics and then the fragment method that failed to better diagnose is modified. With these statistics, future queries made by the engineer will show best diagnostic methods deemed efficient and with what tools you need to build the aggregated method.

B. Selection procedure and construction methods

In a typical case, where by example the calculation of the residue alerts, Fig 4 shows how to diagnose and if possible, calculate a new control law and control the industrial process. In case the process has a model in the state space, we can first select with a coarse granularity a method that will enable you to locate the faulty equipment and continue diagnosis with an identification method of the component in question within the equipment.

IV. MULTI-AGENT SYSTEM SUITABLE FOR PLATFORM

The platform must have a set of agents that will remove from the fragments base a set of consistent fragments that will diagnose the network an overall goal or in a goal - oriented equipment manner. We identify five agents for the realization of the system as shown in Fig 2 above.

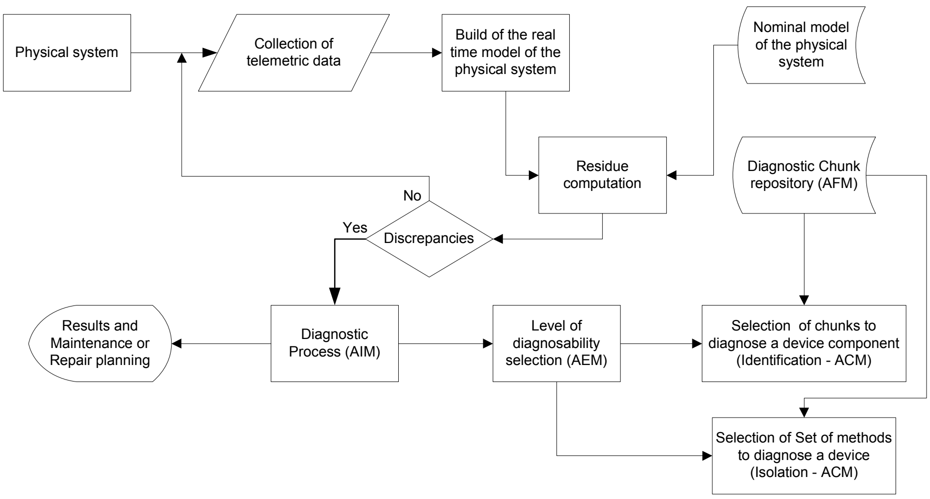

Figure 2. Main components of a hypothetical system using an FDI approach of diagnostic.

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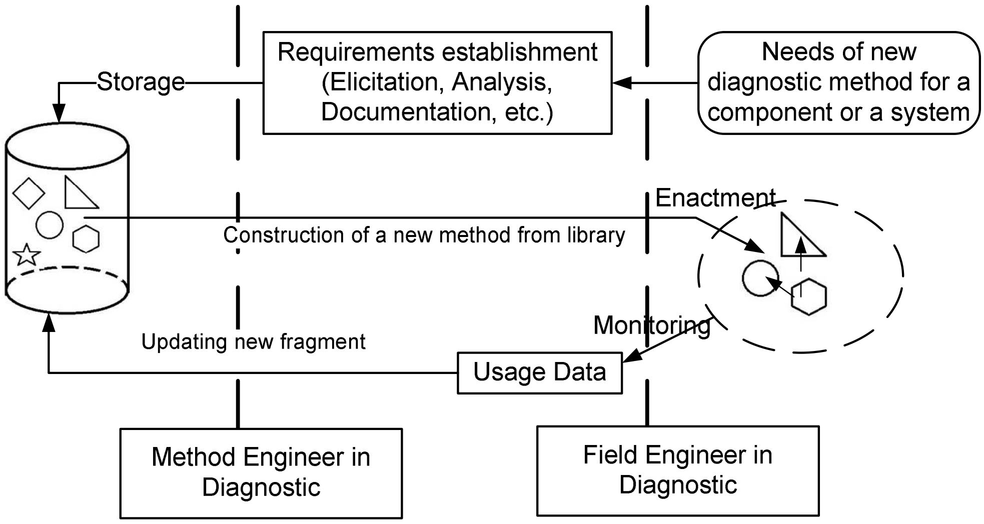

Figure 3. Actors' activities in diagnostic by method engineering

A. *Agents functionalities*

Agent Fragments Methods (AFM): This agent whose role is to interface with the basic methods used to describe a method of one of the approaches to SME and inserts it into the base methods.

Agent Construction Method (ACM): This agent from fragments and descriptions of engineering methods, selects the basic methods of the fragments that will develop new methods. It is responsible for the development, optimization, and many other features to generate the final methodology.

The Execution Methods (AEM) Agent: Under the orders of the Field Engineer Method, it monitors that developers have all the necessary need to develop their applications

The Interface Methods (AIM) Agent: Its role is to examine possible generated methods and modify the proposed agent construction choices if necessary.

B. *Plausible scenario*

Suppose part of the electrical network formed of bays, transformers, boxes and busbars. If the telemetry data create an alert, the engineer must create the diagnostic procedure based on telemetry. If he decides to go sequentially and check if the transformer is functioning and if not, he checks by Dissolved Gas Analysis (DGA), he will have the choice between the following basic methods: Duval's Triangle Roger's Ratio, CIGRE, IEEE, etc. These methods may not be feasible. He chooses a basic analysis radiofrequency method. If he suspects the box, he can think of a resistive or impedance short circuit. He moves on by studying the temperature in the cabinet or sensor noise, humidity, etc. If against the calculation of the residue shows that the voltages across the transformer is normal, it can check the safety equipment on the busbars without using selections of elementary algorithms.

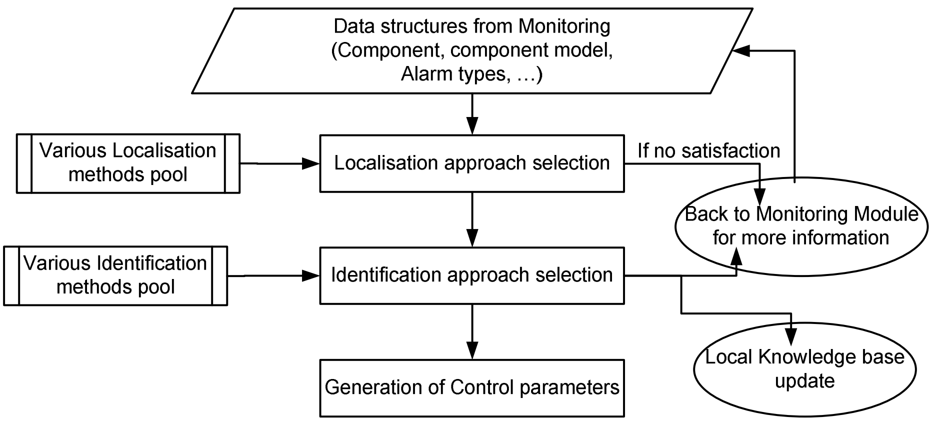

Figure 4. Fragments method selection process for diagnostic method construction.

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V. CONCLUSION

We presented in this work the possibility of using SME to create diagnostic methodologies called here meta-diagnostic. We started with a background on SME and introduced briefly five approaches. We presented the model of the power grid based on the CIM and some uses of MAS in electrical networks. Our approach has been to propose a framework for describing the basic diagnostic methods (implemented by the method engineer using CAME tool) that can be recombined to form a complete method and instantiate (by a field engineer). As perspective, we think to formalize our concepts, expand the FDI diagnostic approach to Dx approach, refine descriptors methods and tools to use and implement it using Eclipse environment.

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