Mathematical Modeling and Proposal of an Architecture for the Surveillance in the Distance of Similarly Installations

Bala Moussa Biaye[1(✉)], Khalifa Gaye[1,2], Cherif Ahmed Tidiane Aidara[1], and Serigne Diagne[1,2]

[1] Laboratory of Computer Science and Engineering for Innovation (LI3), Assane Seck University of Ziguinchor, BP 523, Diabir, Senegal
{b.biaye3299,c.aidara3345}@zig.univ.sn, {kgaye, sdiagne}@univ-zig.sn

[2] Laboratory of Sciences of the Engineer, Computer Science and Imaging (Icube – UMR 7357), National Institute of Applied Sciences of Strasbourg, University of Strasbourg, CNRS, Strasbourg, France

Abstract. In our works, we present a remote monitoring system to handle distributed installations. This system makes it possible to solve the analysis part of the problem of remote monitoring of distributed installations. Remote monitoring of distributed installations requires the use of heterogeneous and sometimes complex tools. A mathematical model allows an analysis the structure of distributed installations. This modeling allows us to categorize the installations in order to facilitate the remote monitoring of similar equipments. The purpose of categorization is to know, for each type of equipment, the necessary tools to monitor them. In addition, from an installation, we can deduce the tools needed to monitor equipments same category. Then, we propose an architecture that will be implemented for the remote monitoring of installations distributed on the territory. This architecture highlights many sensors installed in the equipments for the acquisition of measurements datas. The choice to use many sensors is justified by the fact that installation is consist of many equipments of a different nature.

Keywords: Remote monitoring · Mathematical modeling · Sensor · GIS · Distributed installations

1 Introduction

The control of the proper functioning of the installations spread over the territory must be based on a continuous control of their quality in order to quickly find non-compliant situations. This monitoring is provided by a remote monitoring technique. Implementation remote surveillance system requires taking into account many factors (what type of sensors, protocol, database etc., to use). To manage each of the elements of the architectural proposal in Fig. 4, it is necessary take into account the natural state, the heterogeneity of

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the distributed installations and their rapid evolution. We want to suggest a mathematical model to analyze the structure of distributed installations. The mathematical modeling of installations is to classify installations by category. This allows us for each type of installation to identify these equipments. Moreover, for each type of equipment, what tools are needed for remote monitoring. Remote monitoring applications have been proposed in the literature without use mathematical modeling [1–3]. Biaye et al. [1] works propose an smart method for real time surveillance of reparted infrastructures and equipments in rural zones. Lei Y. et al. works [2], concern on carry to search on information acquisition and broadcasting based on remote surveillance method of a new motor to energy.

A mathematical model allows us to categorize the installations in order to facilitate the remote monitoring of similar equipments.

In Sect. 2, we present a mathematical modeling of distributed installations. In Sect. 3, we present the similarity classification of the equipments to be monitored. In Sect. 4 of this paper, we present the architecture for remote monitoring of distributed installations. And finally, the paper presents the conclusion and offers some development perspectives of the remote monitoring system.

2 Mathematical Modeling of Installations

Installations networks analysis can be defined as the study of a relational phenomenon. In other terms, it is about manipulating installations and making connections between those installations. For this, we can deduct from an installation tools necessary to monitor equipments same category. The modeling of an installation network is part of this logic in our works. This is one or more methods of describing relationships between installations and equipments. In our works, we use the approach based on the characteristics (model, power, capacity, etc.) of the equipments. This approach is a comparison of two installations (Fig. 1). The part common to these two installations contains equipments with the same characteristics in common. And the disjointed part, contains equipments with different characteristics.

Fig. 1. Relationship between two distributed installations

Two installations of same type located in differents localities or in same locality may not have same equipments in common. In this context, the need to know the number of equipment in each installation and their characteristics is important to determine the needs in terms of material to monitor them. Each piece of equipment to be monitored must be instrumented with a measurement acquisition system (sensor) for the collection of measurement data. An installation (I) can have one or more equipments (E) (Fig. 2). We identify relations existing between an installation and these equipments. The objective is to group the distributed installations to be monitored by category. In order to deduce from an installation materials necessary for remote monitoring same category installations, we verify similarity of their equipments.

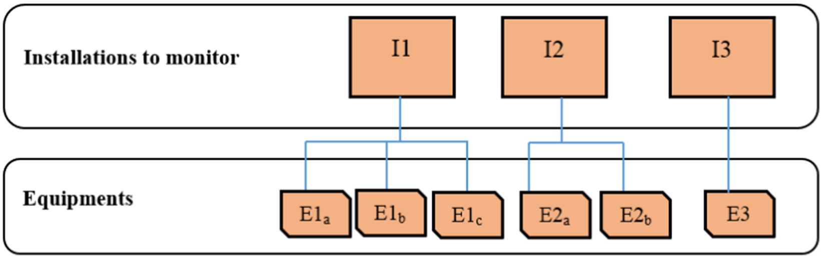

Fig. 2. Tree structure of distributed installations.

In our work, we use the contrast model. In this model, resemblance between entities are determined by a linear combination of measures of the common and distinct attributes for each entity:

E_1 and E_2 are two equipments. $E_1 \cap E_2$ represents characteristics (model, power, capacity, etc.) that E_1 and E_2 have in common, E_1 - E_2 represents characteristics that E_1 has but not E_2, in the same way E_2 - E_1 represents characteristics that E_2 possess but not E_1. Similarity between E_1 and E_2 is given by formula (1):

$$S(E_1, E_2) = \theta k(E_1 \cap E_2) - \alpha k(E_1 - E_2) - \beta k(E_1 - E_2) \tag{1}$$

Where k is an additive function. θ, α and β are coefficients attributed to the joint and disjoint parts. From this formula, we can identify similarity of two equipments. This allows us to also calculate the total number of similar equipment by the following formula (2):

$$T_E = \sum_{i,j=1}^{N} S(E_i, E_j) \tag{2}$$

Calculating the total number of similar equipment allows us to determine the number of sensors using for categories of installations.

3 Classification by Similarity of the Equipments to Be Remote Monitored

Classification by similarity is a study that is most often used in text mining [4–6]. Kotte, V.K. et al. [4] have proposed a similarity function for feature pattern clustering and high dimensional text document classification. Abualigah, L. M et al. [5] propose three feature selection algorithms with feature weight scheme, dynamic dimension reduction for text document clustering problem. Informative features in each document are selected using feature selection methods.

Ma, A. et al. works [6] propose a new strategy for constructing sequential features from single image in long short-term memory (LSTM) is proposed. Two pixel-wise-based similarity measurements, including pixel-matching (PM) and block-matching (BM), are employed for the selection of sequence candidates from the whole image.

In our works, we apply it to the management of distributed installations. The equipments similarity study consists of grouping together those having the same characteristics for a given category of installation. Similarity allows us to identify identical equipments in two or more installations of the same type. To group the equipments into identical groups, we will rely on the similarity classification algorithm presented in Fig. 3.

Algorithm : Classification by similarity ;
Input :
N ← Total number of equipments to monitoring ;
Sortie : Similar equipments ;
Begin
For i := 1 to N **do**

$$S(E_1, E_2) = \theta k(E_1 \cap E_2) - \alpha k(E_1 - E_2) - \beta k(E_1 - E_2)$$

If $S(E_1, E_2)$>0 then
E_1 et E_2 are similar ;
End if
End for
End.

Fig. 3. Equipments similarity calculation algorithm

In order to facilitate the implementation of the remote monitoring application of distributed installations, we have proposed an architecture.

4 Remote Monitoring Architecture of Distributed Installations

The software architecture describes in a symbolic and schematic way differents elements of one or more computer systems, their interrelation and interactions. We propose here an information system architecture for the capitalization of knowledge, the sharing of data for remote monitoring of distributed installations. The functionalities of the application will be implemented according to the architecture shown in Fig. 4. The equipments according to its category is instrumented with acquisition systems capable of acquiring measurement data. The proposed network architecture allows collection of information on the operating state of installations distributed on many remote sites, storage, analysis and real-time treatment of this information with a view to making maintenance decisions of equipments. Moreover, on the other part, to connect the storage database with Arc Gis to allow geolocation of the position of failures equipments.

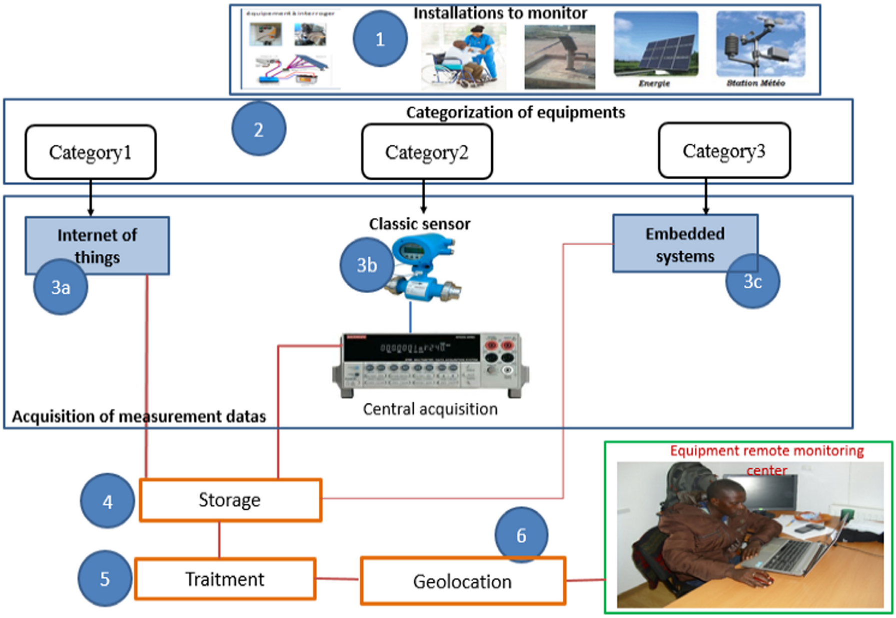

Fig. 4. Simplified architecture of the remote monitoring chain

The architecture proposed in Fig. 4 integrates in a hybrid way the technology of real-time systems, embedded system, connected objects to internet and GIS, for implementation of remote monitoring system. The diversified use of measurement acquisition systems is justified by the fact that we have many equipments of a different nature to remote monitoring. In each equipment must be installed a measurement acquisition system capable of sending data of measurements taken. The real-time system is applied to the treatment of the acquired data. In this system, the respect of the time constraints in the execution of the treatments is as important as the result of the treatment. In fact, after detection of the failure, an alert message is automatically sent to the remote monitoring center. GIS allows us, after detection of the failure, to geolocate installation in order to facilitate rapid access to maintenance teams.

5 Conclusions and Perspectives

This work allowed us to categorize distributed installations and to quantify similarities equipments. This allowed us to identify from one installation the materials necessary for remote monitoring of pairs installations. This identification of materials led to establishment of an architecture. Architecture symbolically and schematically describes different elements of remote monitoring system, their interrelationships and interactions. The architecture proposed in this work integrates in a hybrid way the technology of real-time systems, embedded system, internet of connected objects and GIS, for implementation of the remote monitoring system. Functionalities of the application will be implemented according to this architecture. We envisage as perspectives for this work to finalize application of the remote monitoring system.

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