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A Generic Modeling Approach for E-Administration Based on Holonic Systems - Case Study of Collective Move Due to a Natural Disaster

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ABSTRACT

E-administration is one of the areas that continues to attract the interest of both researchers and governors. It is one of the best areas of application of Information and communication technology (ICT). The objective of e-administration is not new; it is that of constantly improving the quality of service provided to citizens through the use of ICT. The change in e-administrative services remains a capital problem because it involves a new modeling of the service as well as a new implementation of the system each time there is a change of laws, the presence of specific cases of force majeure (natural disaster). Our approach proposes a generic modeling implemented by a holonic multi agent system (HMAS) to answer the problem of change. Generic modeling and its implementation based on holonic systems make it possible to develop flexible and intelligent systems to deal with the problem of change. The paper presents a case study through which we have dealt with the problem of change in administrative services. The change occurs during a collective move following a natural disaster. The paper ends with a conclusion presenting the perspectives and future work.

1. INTRODUCTION

Increasingly involved in different public administrations, e-administration, favored by information and communication technology (ICT), is concerned with the continuous improvement of the administrative service provided to citizens in terms of time and quality, and even more for complex administrative services tasks.

Improving the quality of the administrative service remains a major concern for various reasons: the way of life of citizens is constantly changing and their needs are as demanding as on the first day, the business world marked by globalization, competition, technologies. Made that their needs are vital for administrative service.

In this paper, we are interested in new technologies widely used in the field of robotics and especially in the fields of nature complex and of a decisional character; it is indeed the holonic multi-agent systems, the study, use and train in the effective automation of e-administrative services. We therefore propose the holonisation of the administrative services to meet the requirements and the needs of effective automation (i.e. not classical or traditional), total (i.e. minimize human tasks), flexible (i.e., not fixed and static) and intelligent (i.e., that allows to make decisions).

Now imagine an administrative service such as building permits, which is widely demanded by citizens and which requires the intervention of several administrations in terms of decision-making and documents required. The citizen is obliged not only to move between all administrative services involved, but also to collect all the required documents. Thus, a solution based ICT is inevitable, especially when the number of applicants is considerable as is the case in Algerian administration.

Receiving the interest of scientists and researchers, the e-government was the subject of several methodological and technical solutions. We firstly identify the traditional solutions limited or partial, i.e., those focused at the front-office part by offering simple supply of information, simple consultations, recovery or in electronic form by means of web sites and Internet technologies. Second, the solutions which intervene in the front office and much more in the back office [1] concerned with administrative procedures that are behind the provision of e-administrative services to citizens. Found in these solutions those based web services [2, 3], and based workflow [4, 5].

The multi agent system (MAS) is located at the intersection of several areas in particular artificial intelligence, distributed systems and software engineering [6]. The holonic multi-agent systems (HMAS) is the evolution of MAS, with the introduction of the concept holon. A holonic agent differs from the agent by its lightness, ie, a holon can constitute other holons and be part, at the same time, from a group controlled by higher holon [7]. The holon can take individual decisions and can participate in the collective decision, which gave birth to the holonic multi-agent systems that are meant to be strong in their structure, composition or organization of their services or tasks as a pyramidal architecture, as is the case of e-administrative services that seen as totals service decomposed into several sub-services, which are themselves decomposed into further sub-services.

So in the event of a disturbance Low-level holons having to consult higher holarchical levels, their reactivity weakens. In

addition, overall decision-making is often based on powerless information [8].

In the literature there is some works that introduced the MAS in the field of e-government [9].

We introduce a new technique which is to explore, examine and study multi-agent holonic systems for the holonization of administrative services. The Holonisation of e-administrative services is an intelligent automation, i.e., the holonic agents cooperate, adapt and make decisions which gives transparency to the conduct of administrative services in the back office and avoid all movement between the administration and office course provides a good integration between these and make a final service to the citizen, unlike solutions based workflow (i.e. their appearance marked static and frozen) and web service [10] (i.e. marked by some problems: unavailability or overload of the service).

This paper is as follows: Subdivided into six points, the first and the second focused on the definition and description of administrative services and holonic agents respectively, while the third and the fourth present and propose a generic architecture for administrative services respectively a generic architecture for holonic multi-agents. The last two parts are involved to provide a first rapprochement between e-government and HMAS, and second, to propose an approach for holonisation of administrative services. To evaluate and to the benefits of our approach, a case study scenario of an administrative department is presented.

2. MODELLING APPROACH

Our approach consists of three phases as shown in Figure 1. The first phase is dedicated to the modeling of the administrative service. The second phase, for its part, is devoted to the generation of holonic hierarchy based on the administrative service model defined in the previous phase. The last phase therefore makes it possible to implement the holonic system by fixing the choices on the technologies to use.

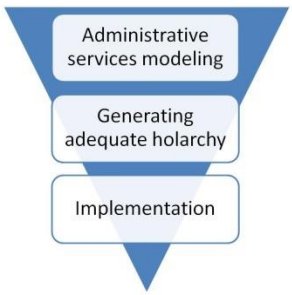

Figure 1. The modeling of the administrative service

2.1 E-administration

The e-administrative services have been defined in the literature in several ways and views. In the present work, the following definition is adopted, "e-service is defined as administrative assembly or composition of several sub-services, compounds and / or atomic performed in separate offices" [11].

E-administrative service is the prestation provided to a citizen who has filed a request in advance for e-administrative services, the provision of an e-administrative services statement from the citizen's request are made through electronic channels, and otherwise through traditional channels.

Below, we present the distinction between demand, service compound, atomic and their interrelationships.

Demand: demand corresponds to the request filed, electronically or traditionally by a citizen wishing to obtain a given service (i.e. e-administrative service) from an e-administration. Demand is the trigger for any operation providing administrative services.

Composed service: is not a simple e-administrative service, ie, it can be decomposed into other sub-services compounds and / or atomic. Decomposition is supposed to produce less complicated services.

Atomic Service: This is the basic service and not decomposable into other sub-services, it is generally simple scripts, is assigned to a single entity. This service gets composed and assembled with other atomic and / or compounds service to provide a prestation more complicated.

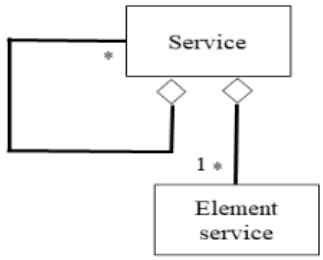

Figure 2. Definition of e-administrative service model

E-administrative services are of two types: non-compound (ie atomic) and compound services, as shown in Figure 2. Atomic services are services that are simple. They are made automatically and / or manually in a single office, for example, while services compounds are decomposed successively until all sub-services obtained are atomic they are then distributed to the entities responsible for their implementation. Composition upward atomic services and sub-services compounds leads to the composition and obtaining the final global service and provide to the citizen.

Taking into account aspect atomicity, composition and decomposition of e-administration services, they form a pyramidal architecture with in the top the final or the global service to provide the citizens and in the base atomic services and composed sub-services between the base and the top.

Below, we propose a:

2.2 Generic and common architecture for e-administrative services

In the following, as shown in Figure 3, we present the concepts and their interrelation:

Final service: is the final or global e-administrative services provided to citizens who have submitted a request to e-administration with electronic or traditional way.

Composed Sub-service: for the realization of the final service requested by the citizen, the composed sub-service is decomposed into sub-services, these can be atomic or compound, in this case, they are decomposed until the sub-services obtained are atomic.

Elementary service: the elementary service is the service atomic obtained after the decomposition of final service;

Decomposition: for their achievement, the final service and compounds sub-services are subject of decomposition until they are expressed and translated only atomic services. These

can then be produced and distributed on their appropriate executing entities. Note that an entity is an entity executor of the realization of a service; the latter can be an office, department or other.

Composition: this corresponds to the recovery of the results provided by the atomic services, their assembly between them and with composed sub-services in the order in which those services were decomposed. The composition can, in the end, to obtain the final service to provide to citizens.

Level: the architecture of e-administrative services provides a pyramid of three levels. The first level corresponds to the top of the pyramid where there is final service is the highest level where the citizen's request is submitted. The third level is the base of the pyramid combining the atomic services is the level at which they are realized. The second level is between the top and base of the pyramid, it includes only services sub-compounds.

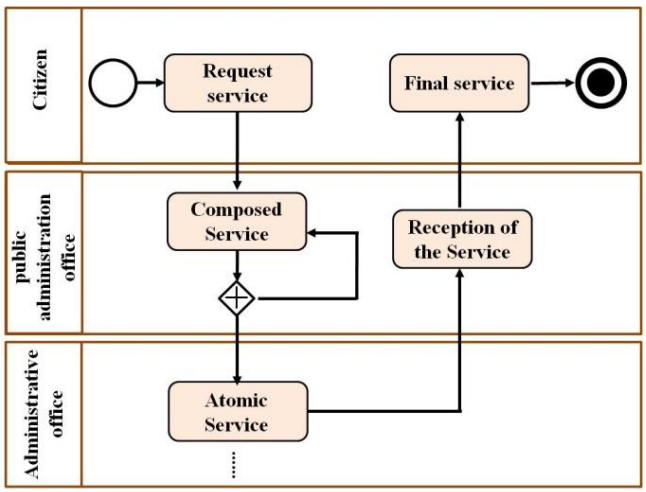

Figure 3. Generic architecture for e-administrative services

2.3 Holonic multi-agent systems (HMAS)

The holonic concept was developed by the philosopher Arthur Koestler in Angrois (1969) to explain the evolution of biological and social systems. Koestler [7] proposed the word "holon" which is a combination of the Greek word "holos" meaning whole and the suffix "on" for the meaning particle or part as in proton or neutron. Koestler also defines a holarchy as a hierarchy of self-regulating holons which function as follows: 1) As autonomous entities that have the power on their parts, 2) as dependent parts under the command of their superiors, 3) in coordination with the local environment. These systems are seen as multi-agent systems (MAS) with specific holonic systems (HMAS), which gives them the power of the holonic organization, or holarchy, which allows the construction of very complex systems.

In addition, such systems can be effective to disturbances (internal and external), and adaptable to changes in the environment in which they exist [12].

The advantage of a holonic system is that it has generic and recursive architecture. In point of view agent, a holonic agent has: 1) identity (name, type, status), 2) Knowledge (treatment, others), 3) behavior (designs, receives, sends, acts, looks), 4) Respect one set of rules.

Holons, by definition, are composed of other holons as super and sub-holons, while agents do not necessarily consist of other agents because agents are entities "atomic" in general supposition [13]. Decision-making power in the holarchy augment upward and decreases as one moves down the holachie. The HMAS are widely introduced in the manufacturing sector for the automation of complex industrial tasks [14].

Several studies have been conducted in this area to achieve an intelligent manufacturing system by reducing the complexity of industrial tasks [15].

In this paper, we would like to introduce the holonic multi-agent systems in the field of e-government and more specifically in the field of e-administration in the provision of public services to citizens on the basis of an approach we call holonisation of e-administration services. Indeed, the autonomy and cooperation of the elementary units of a holarchy, the holons, make it possible to avoid a frozen structure of hierarchical systems and therefore to respond quickly to disturbances [8].

A holon is a basic element in the HMAS, it seen as an entity composed of three main components: an interface through which the holon exchange requests and responses with other holons in the system, a resource base of information and knowledge and serving as a support memory for the holon and finally an inference engine comprising the engine itself and the other three modules used for communication. The following figure provides an illustrative view of a holon. (it should be noted that the architecture is proposed to meet the needs of the problem).

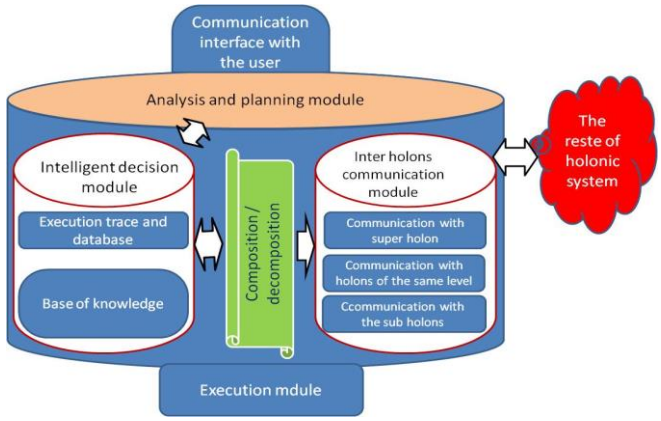

Figure 4. Model definition of holon

Thus presented, the holon (see Figure 4) is an agent that involves several elements that are described below:

2.3.1 Communication module

This module is dedicated to communication with other holons lower and upper levels and with the same level, it is composed of:

Communication module with super Holon: This module is used to exchange data between the under and upper holon when the holon will carrie tasks to his superior (results expected by the supervisor) and on the other hand, this module allows the higher holon communicate with his subordinates to convey commands or parameters necessary for the execution of a subtask.

This module will cover the entire holon system including the superior head of the holarchy to offer the possibility of integrating another system holonic wider, provides great flexibility to the approach.

Communication module with the same level of Holons: this module is for communication between holons at the same

level; if for example, holons want to cooperate between them to complete a common task requested by the superior holon, this module does not exist in the higher holon.

Communication module with sub Holons: This module contains a list of sub holons and also the services that can be provided by them. This module does not exist in the basic holons. The module occupies two missions: either directly executes the task if the task is elementary. By cons if the task is complex it divides it into sub-tasks and assigns it to its lower holons.

2.3.2 Execution module

This module dedicated to the execution, may be one of three types:

For elementary holon: this module is used to direct implementation of an elementary task and then return the result to the higher holon.

For intermediate holon: this module does the distribution of tasks in the lower holons, then proceed to the composition of results in order to transmit it to the higher holon.

For the higher holon: is the total composition of all tasks executed and returned by the lower to refine the overall service requested.

2.3.3 Interface holon

The holon has a high level communication module which is essentially its interface to receive information such as description of the tasks and requirements for planning the mission or the requested service.

Analysis and planning module: (intelligent decision module)

It is a module of main importance for the simple reason which is the definition of the holarchy of holons according to the analysis made on the state of the holons, on the changes occurred as well as the history of the decisions taken in such conditions. This module monitors the state of health of the holarchy by dealing with disruptions and breakdowns (e.g. holon does not respond or breaks down or is overloaded). This module perceives dynamic changes, disseminates information within holons and helps to make decisions.

Resource module related to composition decomposition:

This module contains an inference engine allowing generating decomposition and composition plans according to current legislation, inventory of holons (i.e. availability, surcharge, specialty) as well as specificities of the citizens. Once the hierarchy is defined, this module ensures both the assignment of tasks to holons and the recovery of sub-services accomplished. As citizens' requests are processed, it enriches its knowledge base which will be consulted and enriched over time.

When the holon needs to store the result of a specific task for future use or to keep track of execution in case of wanting more of the same task with a minor modification to avoid repeat all the steps.

2.4 Generic architecture for HMSA

The existing definitions in certain work on the HMAS are multiple, diverse and often restricted to a particular field of use. For the purposes of this work, we use the following description of a HMAS [16] (see Figure 5). The HMAS contains a super-holon, inter-holon and elementary-holons they have the ability to make queries and composition / decomposition operations. Holons are distributed over levels. In the following, we give the definitions of these concepts.

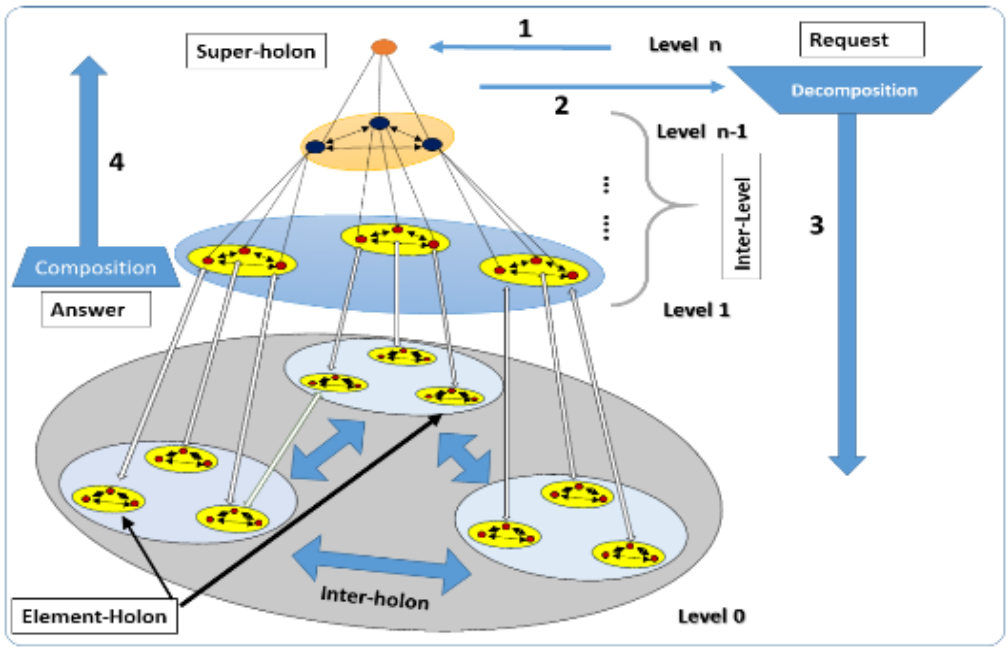

Figure 5. Generic architecture for HMAS

Super-holon: means the holon which is the highest layer that has no father holon; it belongs to receive a user request that will be subject to a decomposition into several sub-queries (i.e. tasks) distributed over the inter-holons that are directly below him they provide to the end the results of their job.

Inter-holon: is a holon that has one or more parents and several sons. It decomposes the sub-query which it receives from it super-holon to their sons and compose the sub-answers, in favor of the super-holon, that collected from its sons.

Element-holon: is the one involved in the lowest layer and which has no son. Its role is reactive, i.e., it receives a subquery, executes and renders the sub-response to its parent (i.e., the

higher holon).

Query: query corresponds to a user request deposited at the super-holon and which may be the subject of several decompositions until sub-queries non-decomposable (say atomic). These are executed by the element holons.

Answer: response corresponds to the return statement at inter-holon or to superholon the reconstruction of a response from the sub-element responses holon then up until obtaining the final answer given to the user.

Level: there are three types of levels: the first is the super-holon, the third is that of element holons and the second (intermediate) occurs between the two levels and includes only the inter-holons.

Composition: this concerns the composition of service from the bottom up, after executing tasks by atomic element-holon is the role of inter-holons combine these basic tasks to render them to their superiors and so continued until arrived at the higher holon to compose the final service.

Decomposition: it is the inverse operation of composition such that the higher holon starts the operation by subdividing the requested service to a task that will be sent to inter-holons which succeeded it directly. These divide their turn (if necessary) sub-services from other sub-services and moving towards inter-holons of lower level and so on until the tasks that will be assigned to atomic element -holons.

2.5 Holonisation of the administraf service

Conducting a comparative analysis between the HSMA on the one hand and the administration of on the other hand we can identify several points of resemblance that contribute to rapprochement, and the using of HMAS as solutions envisaged in the administration public. In the suite, there are the following:

Pyramidal architecture: an administration seen as a pyramidal hierarchy, it is a set of services grouped into offices, they are in turn aggregated into departments, which are also combined in a single unit or organization that which is the case for holonic MAS;

Decomposition principle: within the administration, a procedure is divided into several sub-tasks and procedures, which themselves are decomposed into several sub-tasks and procedures, and so on. HMAS follow the same principle, i.e., the initial mission of holon (superior) is divided into sub tasks distributed over its sub-holons, and so on up elementary holons;

Principle of composition: in an administration, the principle of composition occurs when one completes the execution of subtasks, the latter bring together to build a global task requested by the user (task = {subtasks});

Dependence Horizontal: in public administration, an administrative task may sometimes participate in two different processes, for example, the task "establish the extract act-birth" part of the process of "delivering identity cards" and "issuing the passport" Similarly, within the HMAS, a holon can provide the same role in two different holonic groups;

Principle of Communication: often, offices or branches of administration are required to communicate, collaborate and share information in order to complete each task. To fulfill their roles, holons could also require as necessary communications and exchanges between holons at the same level;

Organizational aspect predefined: HMAS as administrative procedures are characterized by structural or organizational aspect is predefined and known in advance. The dynamic emergence of new channels is little present, which means that tasks and procedures under an administrative process does not change permanently due to legal and organizational constraints that govern them, they are rather static than dynamic; that is also found in HMAS.

Decomposition algorithm:

```
Data
Let H: global service (super-holon)
Results
Adequate elementary holon holarchy (set of atomic sub-services)
Begin
Request contains the requested service
  If the service requested is atomic then
      Run the service and return the response
   Else
      While (not all sub-services are atomic) do
            Decompose what is decomposable (according to a legislative expert system, also according to history, previous knowledge, ...)
      End while.
   End if
End.
```

Composition algorithm:

```
Data
Finalized elementary services provided by offices (elementary holon)
Results
Global service finalized requested by requester
Begin
  While (the service is not final) do
     Compose the sub-services (according to the composition criteria (legislative expert system, consultation of the history, the knowledge base, ...)
  End while.
End.
```

Thus, in light of the points of similarities between the two areas, Table 1 presents and introduces the different holonic concepts which we can associate and correspond to e-administration concepts.

After introducing a generic architecture for HMAS followed by a generic architecture for administrative services, and having led a first rapprochement between these two architectures, we propose in this section an approach that aims infrastructure for the composition of administrative services through the HMAS (see Figure 6).

To progress in the field of e-government covered within sharing data in the administration, exchange of information between different administration departments and between administration and users (i.e. citizens).

All this must be implemented by our approach using a holarchical structure. This latter will be achieved on the basis of a hierarchy of services, which is itself a hierarchical sub-service, while focusing on the hierarchy of administrative services. In reality, the object of our approach holonisation uses the organizational hierarchy inherent in any administration. To describe the dynamic aspect of our system, Figure 7 shows the operating mode of the administrative holarchy. Indeed, the dynamic model shows the course of a holonised administrative service. This latter is initiated following the filing of a demand

of the service in question in the e-administration.

The model above (Figure 6) exhibits a holonised administrative service corresponds to a succession of several sub-services, single and / or compounds; these sub-services are accomplished in different levels and by different holons, generally three levels and three types of holons (i.e., super-holon, inter-holon and elementary-holon).

The first level corresponds to the super-holon, it receives the request and calls the inter-holons whose their activities corresponds to the requested service, the Inter-holons, their towers, the work divided into sub-jobs and distribute to their descendants until the sub-work obtained become atomic, they are then assigned to elementary-holons involved. This latter, return the results of their activities to their superiors till the super-holon which provides the applicant with the administrative service requested.

Table 1. E-administration vs. HMAS

Administrative concept	Holonic concept	Holonisation (comment)
Demand	Query	The application is filed at the administrative portal site
Prestation	Inswer	The answer must be returned to the applicant for an electronic or classical correspondence
Final service	Super-holon	Is the holon responsible for the service itself requested by the applicant
Sub-service composed	Inter-holon	Are all of Holons intermediate between the requested service and holons executors of the elements constituting the requested service
elementary service	Élement-holon	Holons are the direct executors of tasks constituting the global service
Decomposition	Decomposition	This is the assignment operation (down to the holarchy) of the sub services associated with concerned holons
Composition	Composition	This is the operation for returning the results of component execution of the tasks (back in the holarchy)
Level	Level	It is the administrative It is the administrative correspondence between classes and categories of holons in the holarchy

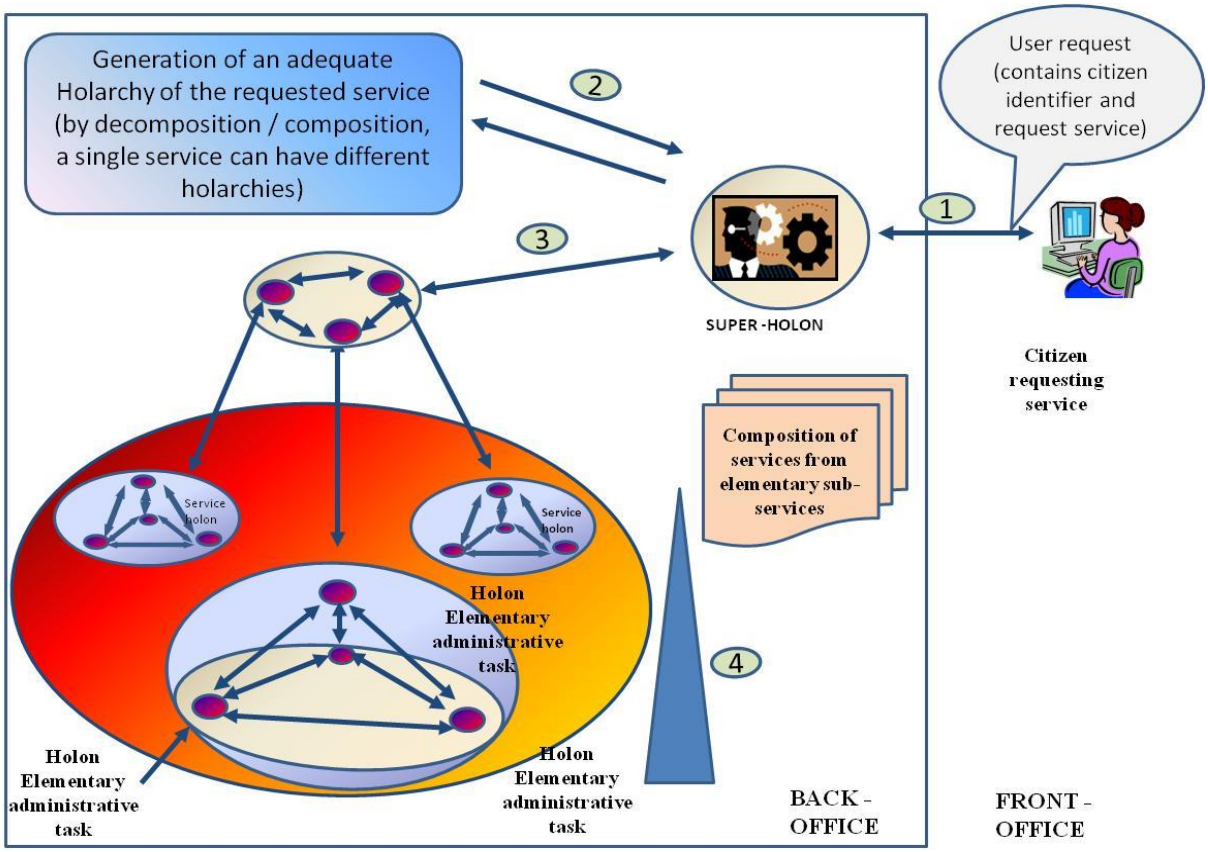

Figure 6. Holonisation process

The decomposition of services into sub-services as well as the composition of the sub-results do not occur in a purely reactive (i.e., static) and arbitrary but rather an intelligent, this means that the holon uses its base knowledge, it takes into account the workload of holons (i.e. d., he chooses the least loaded holons) and takes into account the repeated activities (ie, it does not execute several times).

Here below (Figure 8) a static model for a process holonisation of e-government. This model makes clear the way in which we use a static administrative process predetermined.

The super-holon know the decomposition of the global procedure, it will load decompose the query to sub-queries according to procedure. The inter-holons role is to decompose into simple elements and to reconstruct the results. In the end, the basic holons or the elements holons execute queries that usually include simple tasks such as preparing a document or request the response of a human decision-maker.

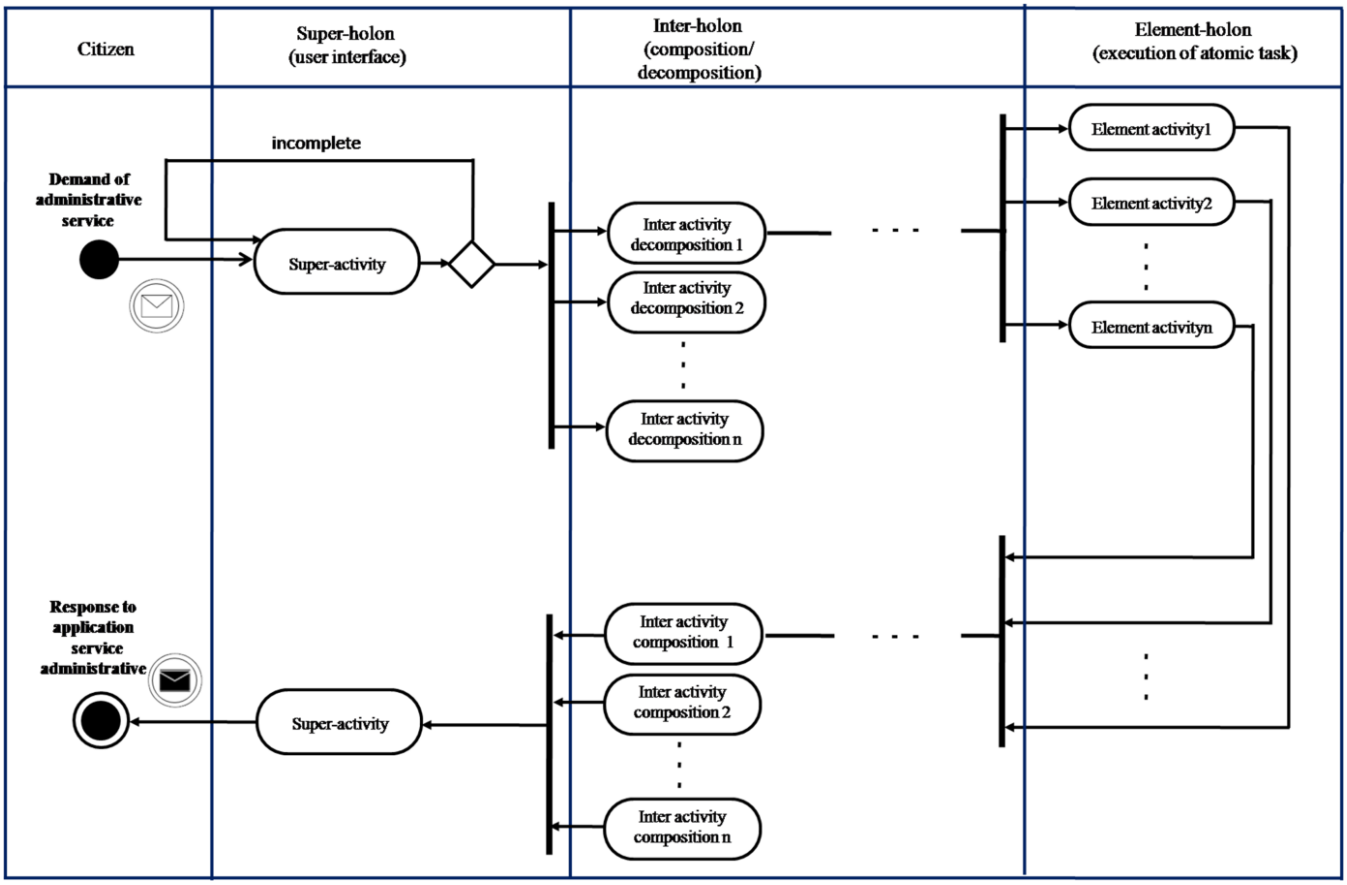

Figure 7. Dynamic model of holonisation

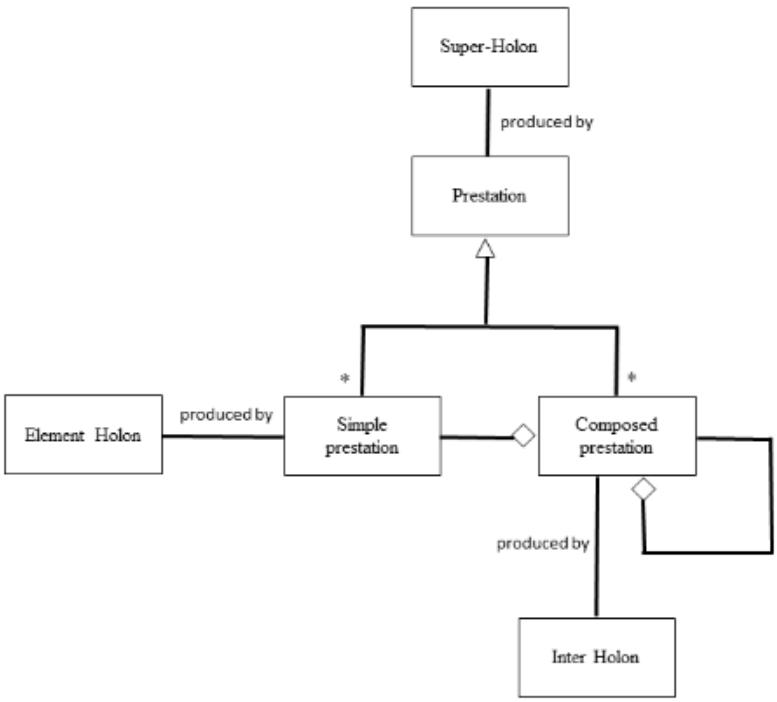

Figure 8. Static model of holonised e-administrative service

3. PRESENTATION OF A SCENARIO FOR HOLONISATION OF CHANGE OF SCHOOLS IN A COLLECTIVE MOVE FOLLOWING A NATURAL DISASTER

The holonic multi agents system have a reputation for effective emergency management, exploiting the most updated and the most important information [17].

In the following we present the "holonic" scenario associated with the procedure for change of schools in a collective move following a natural disaster.

In an ordinary case the best way to manage the transfer is to

follow the moving procedure. Plan each task of the move, by mobilizing the people and services concerned (public administration, management, department heads, etc.). This procedure takes considerable time considering the number of families to move and the cases to be treated (employment, schooling, etc.).

In the event of a natural disaster, the relocation procedure is urgent and complicated. In this paper, we limit ourselves only to the schooling service for children. The allocation of school children to new schools must respond quickly and positively to all scenarios (primary, middle and secondary cycles, special and private schools for children with special needs, etc.).

The super holon receives a request for school reassignment for the children of a family. The procedure is started (see Figure 9). The super holon dispatches the search for establishments on the sub holons that depend on it. The distribution is made according to the cycle (primary, middle and secondary). The sub holons each launch a smart search to find an establishment that meets the specific needs of each child. The search for an establishment is made according to several criteria: the overload of this one, the appropriateness of this one compared to the children, consultation of the parents, proximity to the new house.

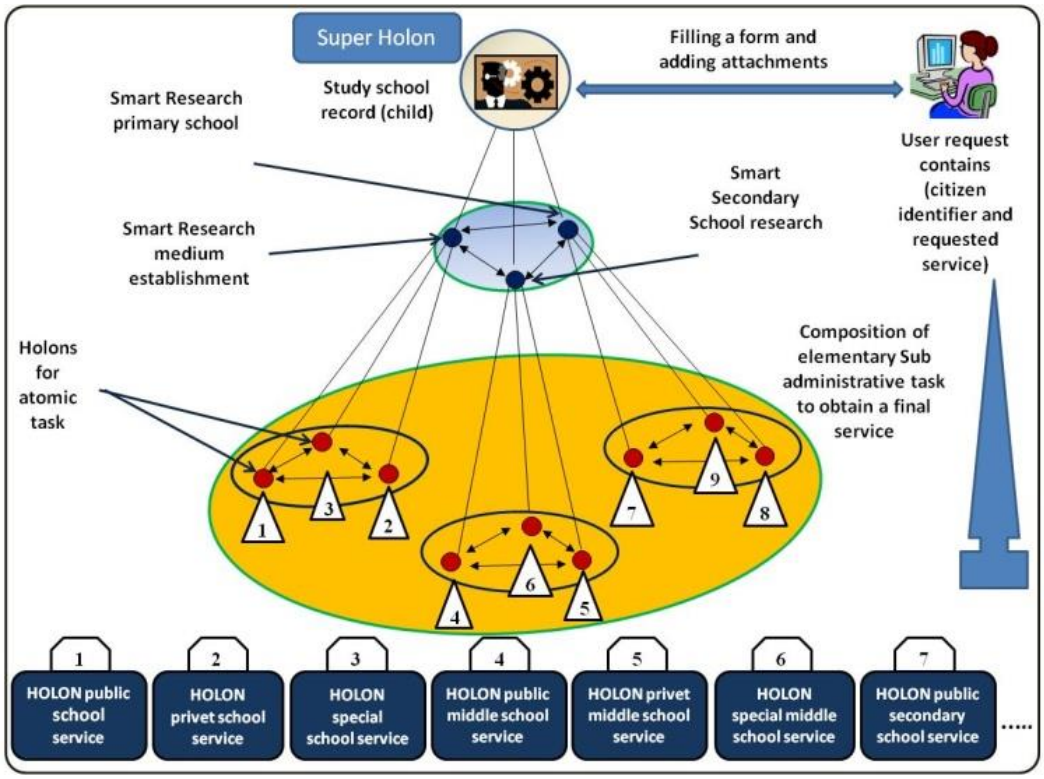

Figure 9. Holonic scenario of collective school change in an emergency such as that of a natural disaster

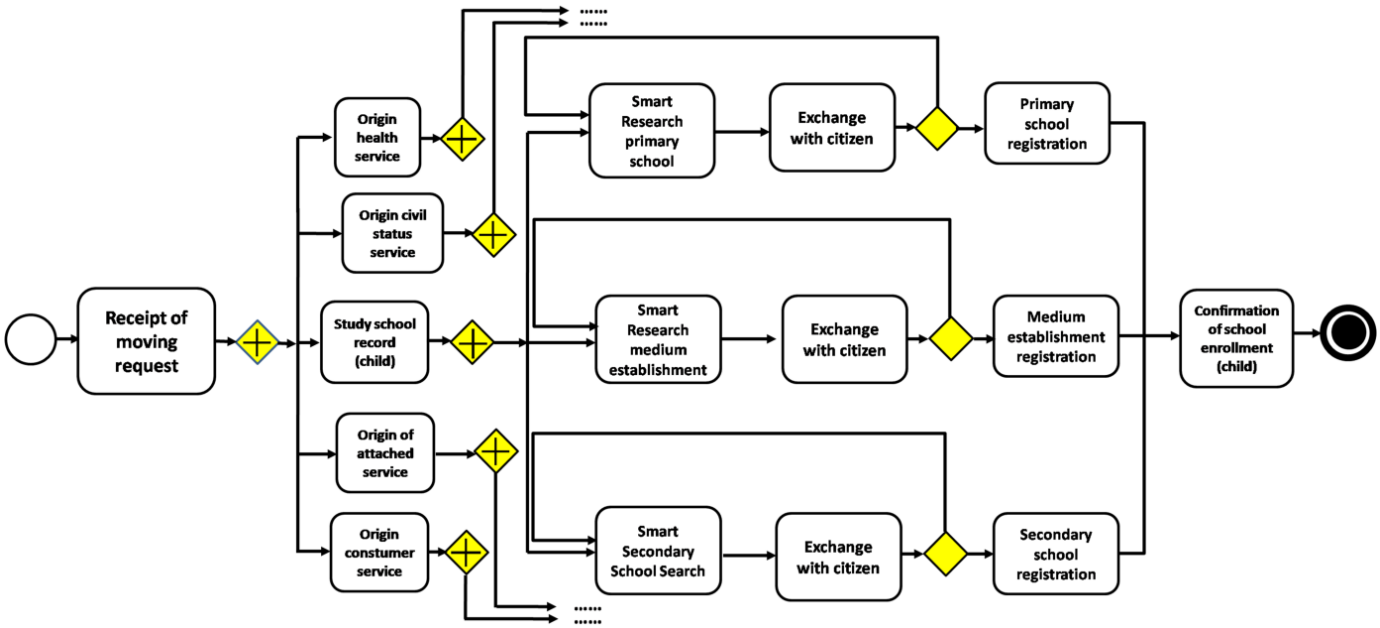

Figure 10. BPMN model for holonic scenario of collective school change in an emergency such as that of a natural disaster

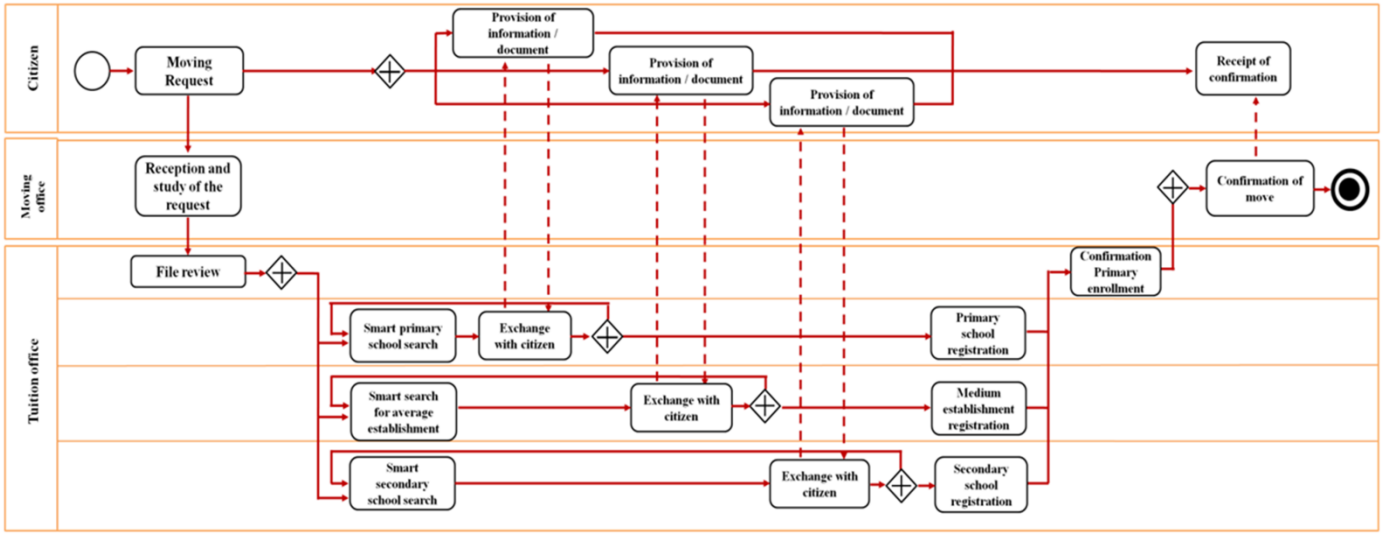

Figure 11. Business process of collective school change in emergencies such as natural disasters

The lower level sub holons initiate negotiations among themselves, exchange information and communicate the results in order of preference to the upper holons (see Figures 10 and 11). The super holon receives the results for all families and tries to satisfy everyone.

Our proposed approach is validated and implemented on a case study. A global move during a natural disaster: the case of changing schools. The tool is produced using the Java language in the NetBeans development environment while we have used the JADE platform for the multi-agent system.

The case study presents a virtual disaster case and the developed system is tested on a simulation. The system has faced the problem of moving service charge as well as the changes that result from the specific cases of citizens.

4. CONCLUSIONS

In this paper, after giving to the motivations behind the use and involvement of technology holonic multi-agent systems in electronic administration, we adopted this process involved a series of consecutive steps to cut this involvement through a methodical process. It sees as a gateway connecting two areas, the first area is the technology of holonic multi-agent systems recognized by their reputation for problems, complex, and hierarchical character, which mark the e-administration, second area; We chose HMAS as a tool to model and execute our problem in order to exploit the characteristics of holonic agents such as autonomy, communication, self-awareness, intelligence, etc. In terms of model, we intend to develop a multi-level communication protocol for the interactions of holonic agents. We also plan to improve the proposed model.

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