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Ontologies cooperation to model the needs of disabled persons

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Abstract. In French society, many aids are proposed for each kind of population. In the particular case of disabled persons, it is quite difficult to deal with all the different information coming from heterogeneous contexts. Such different knowledge cannot be directly integrated, so we propose to build ontologies for each aspect. Then, we manage the cooperation of these distributed ontologies through a relational structure. Finally, to ensure the representation of the guidance interactive process, we model a workflow to follow through the successive steps of an individual file. This file will go with the disabled person, first with its own information, then with some administrative information and lastly with service propositions. The process is recursive allowing a better long-term assistance monitoring.

Keywords: Distributed Ontology, Process Ontology, Knowledge Organization, Domain Ontology, Workflow.

1 Introduction

We live in a growing environment of data, but the important problem is knowledge. In order to represent knowledge issued from different sources, the ontology concept can be used. The ontologies allow to identify the concepts contained in the different sources; these concepts can be linked with synonymy, homonymy ... relations between sources.

The definition of Studer [1] based on [2] is: "An *ontology is a formal, explicit specification of a shared conceptualization*". A 'conceptualization' refers to an abstract model of some phenomenon in the world by identifying the relevant concepts of that phenomenon. 'Explicit' means that the type of concepts used and the constraints on their use are explicitly defined. 'Formal' refers to the fact that the ontology should be machine understandable and thus excludes natural language. 'Shared' reflects the notion, an ontology captures consensual knowledge, that is, it is not private to some individual, but accepted by a group.

Distributed ontology is a relevant framework for the articulation between ontology domain, knowledge management and activity. We propose first an application of this

principle in the domain of disability. In this framework, we develop the foundations of an infrastructure that connects libraries, processes and services. These document structures are associated to processes but have an internal specific logic. Our first objective is the characterization of each ontology with the objective of its articulation to the others. In France, disabled persons can be helped in many different ways, for example adapting one's home or private teacher assisted learning. Philosophically, [3] points out the necessity for human society to have a good aid for the weak or different disabled people. Every case is individual however there can be similar proposals. For the people and their family concerned, it may be baffling to know one's rights. In fact, they have to summon up a lot of heterogeneous knowledge and build a personal file to obtain help and services. At the end, we hope to propose a tool for managing these individual files. In this paper we propose to follow the construction of the file through different steps using dedicated ontologies. After a brief description of the context and some related works, we present our generic model, then the relational structure before the workflow in our system and a conclusion.

2 Context

First of all, we must have a look on the complexity for a person with a disability or his carers to find and summon up the huge amount of knowledge available. In France, many propositions are held by state-controlled structures but you have also dedicated associations linked with a particular problem like being blind or spastic.

Six public actors are listed when you simply begin with a "Wikipedia search" [4] and, reading further, more public actors appear on regional and local levels.

L'Assurance Maladie, french public health insurance, on its website recommends to apply to six different organizations public or not and point out that there can be other solutions... rather tricky for people already in a difficult situation.

[5] describes the problem with amyotrophic lateral sclerosis (ALS). To help correctly the patient, different assistances have to be proposed:

- Human assistance for the daily life, eating, washing, dressing...
- Technical assistance like identification of the best wheelchair regarding the person abilities
- Social assistance to ask for the right aids
- And medical assistance.

To our knowledge and like Cardoso and al. [5], we didn't find any ontology including simultaneously those multiple points of view. It is not only the management of multiple points of view but also the use of multiple heterogeneous knowledge sources.

How can we associate and use together scientific resources, individual information and rehabilitation service documentation in the framework of an activity? We propose

a distributed model that articulates different types of resources in the framework of an activity.

This activity is founded on personal files and its objective is the proposition of services to a person. Of course, this person can receive one service: in this case the activity evaluates the relevance of this service and if it is in keeping with their needs. This process is then recursive.

Our purpose is anchored on a specific activity: guidance of persons with a disability to relevant services. We focus on the conceptual model that allows the organization of the different information sources: bibliographic resources, personal files and service description. These sources are very distinctive both in their structure, description and organization.

We propose a distributed model that represents independently each component. Each component is structured in a way to be used by the activity.

We describe by ontology the three dimensions of this process: the knowledge organization, the service and the activity of decision and regulation. These three dimensions are about persons or individuals. But each considers the individual distinctively: for the knowledge organization, this is an instance. For the activity and the process, the individual is the object of the activity, but distinctively: for the activity, the object is the instance and for the process this is the type.

The individual is the central notion that allows the distribution of the ontology. The need is the central concept that organizes the structure of each distributed conceptual structure. The need is the issue of the deductions in the disability ontology. The activity is founded on the expression and evaluation of the needs. Lastly, the process begins with a need and is ended with its satisfaction.

The disability domain is distinctive to medical and health because it is a dynamic construction that begins with the identification of a disease or disorder and that ends with the individual rehabilitation. This process requires a succession of scientific investigations, comprising sociology, on the individual.

The organization of the scientific knowledge is only a part of the model. The process ontology represents how the individual expresses his need in the social context of an aid and the attribution of a rehabilitation service. The last ontology represents this service in relation to the need and the individual rehabilitation. It represents schematically an activity.

These three ontologies to manage heterogeneous types, instances and references are partly inspired by [6] in their methodology for coordinated evolution of scientific ontologies.

Each module has a distinctive function:

- Workflow for document elaboration and sharing.
- Knowledge organization to articulate libraries to practice, especially for individual description.
- Knowledge organization for service description in relation to individual needs.

In a more general way and including the individual, we distinguish three generic objects for the ontology:

- The characterization of a course of the action.
- An individual character, expressed by its classification.
- An action strategy, manifested by the actor's behaviors and actions.

3 Related works

We have chosen not to use an existing model, like HI-ONTO [7] for example, because these models are not founded on the association of heterogeneous entities and they postulate the unity of the domain. In our case the domain is itself distributed and oriented to an individual satisfaction of a need. The disability is described by an international classification [8]. This has been criticized because logical conceptual construction is not consistent. The second knowledge organization is the French thesaurus [9]. These tools organize the domain following a modular principle. In this way they are organized by "micro-thesaurus" or sub-domains [10]. Some efforts are engaged to build ontology on the basis of the classification [11]. We propose the elaboration of a specific ontology level that maps classes and thesaurus concepts to ontology. Our ontology integrates active and dynamic dimensions defined by a social characterization of disability. In this framework, a handicap or disability is considered as phenomena that aggregates different points of views, from medicine to social. We follow this principle, considering that these different approaches are dependent. The ordering of these dependencies allows the consistency of the ontology and the use of the BFO vocabulary [12].

As in Basic Formal Ontology (BFO) [13], the three top-level categories of independent continuant, dependent continuant and occurrent are used in our framework.

We do not create an ontology centered on the notion of service availability [14] but a part of our ontology allows to follow the evolution of a document through different activities. Therefore, some attributes characterize specific activities and agent roles.

Our ontologies do not have an upper level as DOLCE [15], but a lightweight that focus on the needs of a specific domain: disability domain.

Disability can be considered in the framework of non-formal ontology by G. Edwards & al. [16]. They propose a social and embodied ontology that "provides a theoretical framework for situating disability in the "ground of being," as an encapsulation of the limitations that are essential to the body-environment ensemble. Hence embodied ontology moves beyond both the medical and social models of disability, both these

models seek to reject limitation in different ways. Within the medical model, physical limitations are considered to be surmountable, while the social model rejects environmental limitations. From an embodied perspective, both physical and environmental limitations are essential to our humanity”.

IAO-Intel contains ontologies applied to the explication of data models and other terminology resources. The terms in these ontologies are linked together. Each ontology uses terms which are defined in terms of other ontologies [17]. In our framework, the ontologies are also linked and we have also different levels as IAO-Intel.

We have chosen to consider the individual as the foundation of the relations between the different structures. The unity is first characterized at the instance level. At the type level, the concept of the individual is a guarantee of generality. The second foundational concept is the need which can be defined at the two levels too. This realistic foundation for ontology is articulated to a dynamic representation of a domain. These positions have been defined by B. Smith [6] but have never been applied on complex domains like disability. This domain is intrinsically built by the articulation between a scientific knowledge, processes and services. These considerations are evidence for the actors but they have not been applied: knowledge organization always stays static without any connection to the other dimensions of the domain: the proposition of services and the process have never been represented. Especially, the relation between these three dimensions has never been conceptualized. This fact can be explained by the distinction between library, knowledge management and service representation.

Studying recent works on ontology management, we can also relate our proposition to modular ontologies. For Pathak and al. [18], “an ontology module is a reusable component of a larger or more complex ontology, which is self-contained but bears a definite association to other ontology modules, including the original ontology.” Although the techniques proposed in this field may be relevant to build the cooperation between our different ontologies, we are not yet in this perspective. However, even if the disability ontology seems to be a module extracted from a more general medical ontology, we argued before for its specificity.

4 Generic model

We propose a generic model to articulate three sorts of information sources:

- Scientific publications on disability. The disability ontology is essentially relational.
- (Personalized) service. This ontology characterizes the matching of a personalized service.
- Process of attribution of a service for a person. This ontology characterizes a workflow of documents implying different actors and a decision.

As opposed to a monolithic domain ontology, we have proposed a distributed ontology to capture the different dimensions of a domain. This domain is built on an activity: the rehabilitation of persons with disabilities. This activity requires different actors and firstly the person called individual and one objective: the rehabilitation of this person.

The academic knowledge organization is unsatisfying to represent a pluri-disciplinary knowledge structure that integrates both scientific knowledge, individual expression and the availability of rehabilitation services in a specific location and time. We can wonder: How can we associate and use together scientific resources, individual information and rehabilitation service documentation in the framework of an activity? We propose a distributed model that articulates different types of resources in the framework of an activity.

The distribution is foundational because an activity associates systematically embedded situations and abstract framework. The articulation of these different dimensions is founded on the individual that is the object of the activity. This individual has needs and the satisfaction of these needs is the goal of the activity.

The process is the actors and documents structure that allows the individual expression of the need and the representation of its evolution in time. We have centered this representation on the workflow: it will be extended to the document level.

The process representation is intrinsically dynamic and requires for the examination of the individual situation a similarly logically knowledge representation. We have postulated that the construction of the knowledge domain follows the progressive path from a health perspective to a particular social, individual or contextual disability. This progressive path is fundamental for the characterization of a need and identification of the tools or services that allow the satisfaction of this need.

Different users interact in our model. A disabled person creates its individual file. The information is stored in the "workflow ontology". To create and select the different information, he is guided to choose the impairments and the needs in the "disability ontology" and the services in the "service ontology". After, case workers and the medical staff will complete the individual file in coordination with the concerned person. At the end, the CDAPH assigns services linked with the needs of the disabled person and the potential places offered by the local services. The CDAPH is the committee in charge of the rights and the autonomy of disabled people in France (see Figure 1).

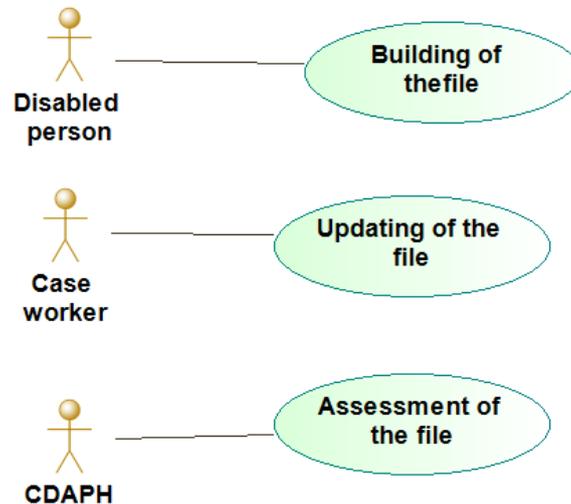


Fig. 1. Different users

We focus on the conceptual model that allows the organization of the different information sources: bibliographic resources, personal files and service description. These sources are very distinctive both in their structure, description and organization.

4.1 Methodology

Our aim and challenge are to manage two different levels of abstraction. On the one hand, we try to deal with a large amount of knowledge stored in heterogeneous documents. On the other hand, we cope with individual information about the person's impairments and life. We then propose, to connect these individual data with documented and referenced information. The PROV-Ontology is shortly described by the following: "It provides a set of classes, properties, and restrictions that can be used to represent and interchange provenance information generated in different systems and under different contexts." [19]. So, we have chosen to work with the PROV-Ontology to manage our dual issues described above.

4.2 Foundational model

Our three sorts of information sources are heterogeneous but they are in solidarity.

At a high level of generality, we clearly distinguish three sorts of entities:

- Individuals
- Tools or services
- Artifacts.

These structuring entities are always situated in context. Individual is a singular entity which participates to the different ontologies, as shown in Figure 2:

- As a categorized entity, an individual is a person with disability.
- As a person with needs, he participates to the personalized services.
- As a person that produces files and expresses his needs for the social services, he participates to the workflow.

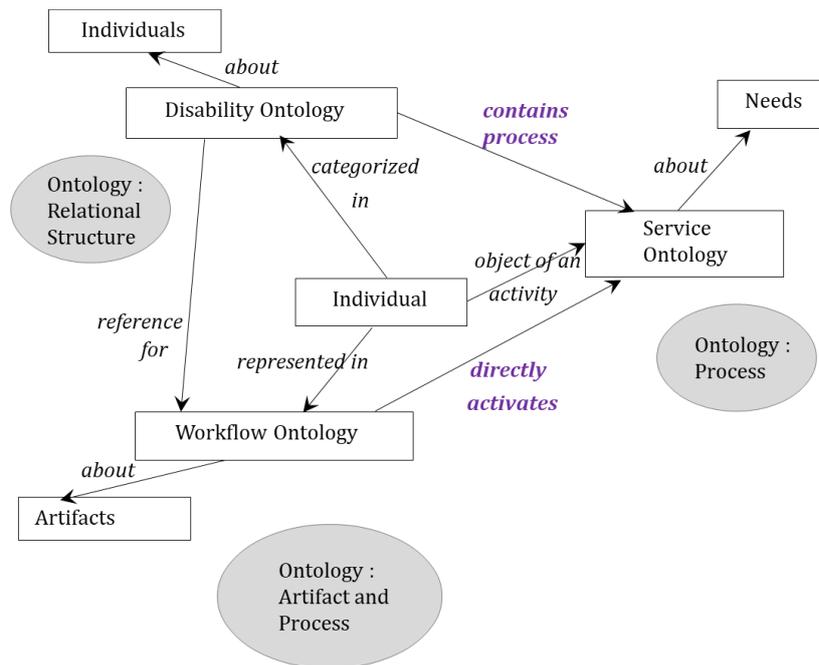


Fig. 2. Foundational distributed model.

4.3 Process

The committee of the rights and the autonomy of disabled people called CDAPH in France allocates services. But, it is in the “regional office of the disabled people” (MDPH in France) that an individual can find all the information and the help to fill in the file. The impairments and the needs expressed in the file are chosen respectively among these drawn up by the thesaurus handicap [9] and SERAFIN-PH nomenclature [20]. The individual entity contains many attributes such as the birth date, profession etc. and refers to the different caregivers who can help him in the social context. It is the role of each of them which is displayed in Figure 3. The OBO Relations Ontology [21] has been used to represent the relations between the concepts. We have chosen OBO Relations as they are meant for biological ontologies and each relation is well defined.

When he creates his file, the individual must describe his situation (medical and social). With this information, the system proposes needs according to impairments. The Disability ontology contains the description of the disabilities but also the social context in order to better choose the needs. With these needs, the service ontology selects the different services and proposes them. The individual chooses services. After the social worker studies the individual file and helps to complete it and select potential services in relation to local services. At the end, the CDAPH ‘s assessment determines personalized services. Each year, the file must be updated by the individual and the process starts again. The workflow ontology manages the process and its regular iterations to adapt the proposed services with the personal evolution of the concerned person and his circle.

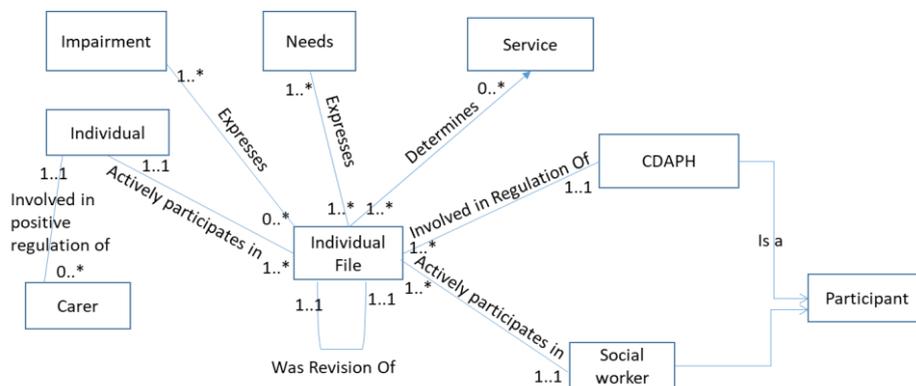


Fig. 3. General file distribution.

5 Relational structure

The individual is central in the three modules but is described by categorization in the disability ontology. Artifacts are about this individual but represent only some relevant categories for the decision. Lastly, the process associates a tool considered as a service devoted to this individual considering some of its specificities.

These three ontologies are dependent. We do not have a mapping between different ontologies but a knowledge distribution in accordance with the action relatively to persons with disability.

Disability is a complex domain that cannot be reduced to disease aspects or social action. In a way to represent the consistency of the domain, we propose phases to characterize the trajectory from a disease to a social action.

The ontology is a cognitive representation characterized by a two-level structure:

- At the high level, the characterization of the person with the potential disability. This is the global consistency of the handicap domain.
- At the low level, the context of the person where the disability is segmented into a succession of situations where the internal disease is evolved into successive frames. In this level, the accommodation and the identifiable helpers around the disabled person are described.

This representation (see Figure 4) is about individuals (or the level of reality). The publicly accessible concretizations are recorded in thesauri and classifications.

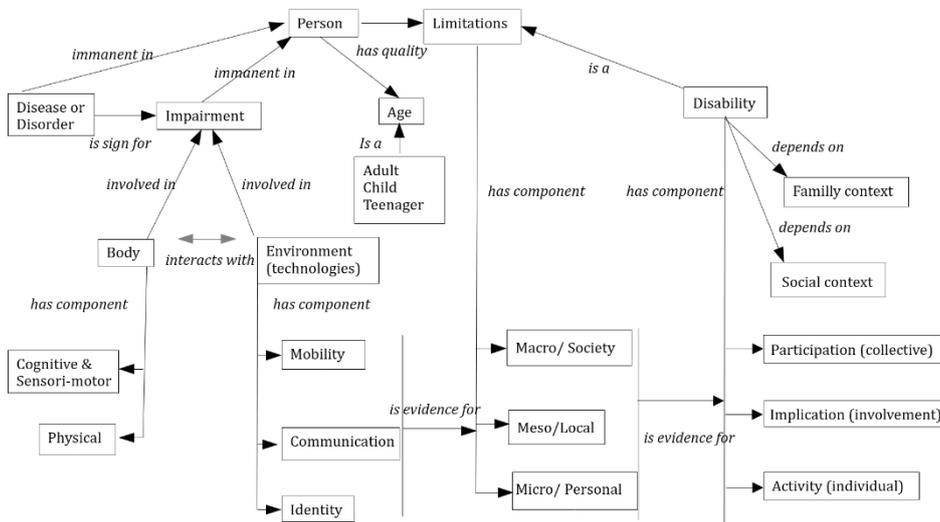


Fig. 4. Resource Disability Ontology.

We now present, in the Figure 5, the ontology of the rehabilitation process. This process allows the characterization of the satisfaction of the need. It integrates some characteristics of the service ontology such as the distinction between a service prescription and a service description. This distinction allows the articulation between the generic SERAFIN-PH [20] nomenclature and the local organizations presentation of services.

After the description of individual context, a need is identified (service prescription) and after a solution for this individual need is proposed.

We insist on the individual participation by the concept of “rehabilitation content” that describes the benefit of the service.

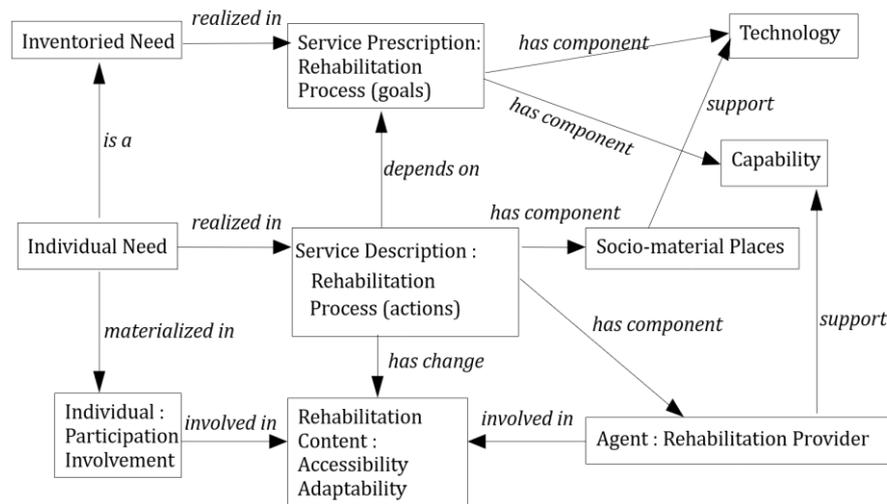


Fig. 5. Rehabilitation Process Ontology.

We describe a need as a relation between an identified disability, an individual expression and a rehabilitation process (see Figure 6). Need has a dual definition: at a type level, it is the relation between a disability, an expression and a rehabilitation service. By this information flow, we characterize how the three ontologies are connected under the question of the needs. A need is then defined both by the disability and the individual expression.

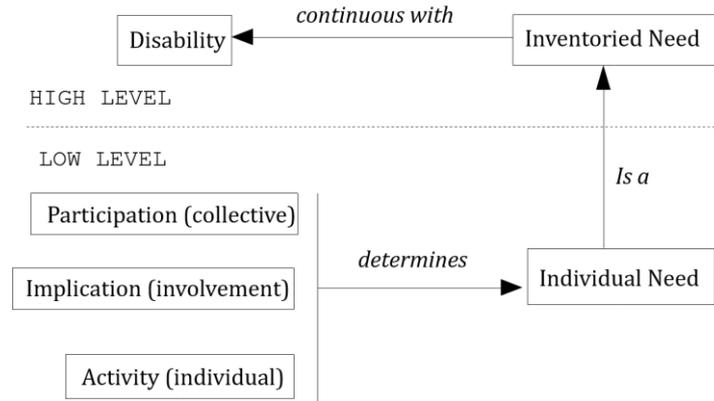


Fig. 6. Need characterization.

6 Workflow

The workflow ontology is based on the individual needs. The individual file describes the person, this one is an entity but also an actor who participates in the building of his file. The person must also list his caregivers. The individual, with the help of the case worker, expresses his impairments and his needs. Finally, services are determined. Therefore, the case worker is also an entity and an actor. The CDAPH determines the possible services linked with the request and real life (places available in special institutes, home helpers...). It is a recursive process. Each year, the individual updates his request and it is re-evaluated by the CDAPH.

Therefore, there are 3 actors interacting to build the file and the response to each need depending on the context.

The disabled person describes his diseases and his environment. He chooses the impairments and his needs thanks to the disability ontology. In fact, many propositions are made to him from his situation. After, the request is evaluated by the social worker and the medical staff and is updated in agreement with the concerned person. For example, many services are automatically selected in the service ontology by the system and are proposed. The staff helps the user to choose the right ones. Finally, the CDAPH studies the request and offers services in connection with the demand and with the local possibilities. The sequence diagram [22] depicted in the Figure 7 explains the interaction between the different actors and the ontologies in order to assign services to a disabled person.

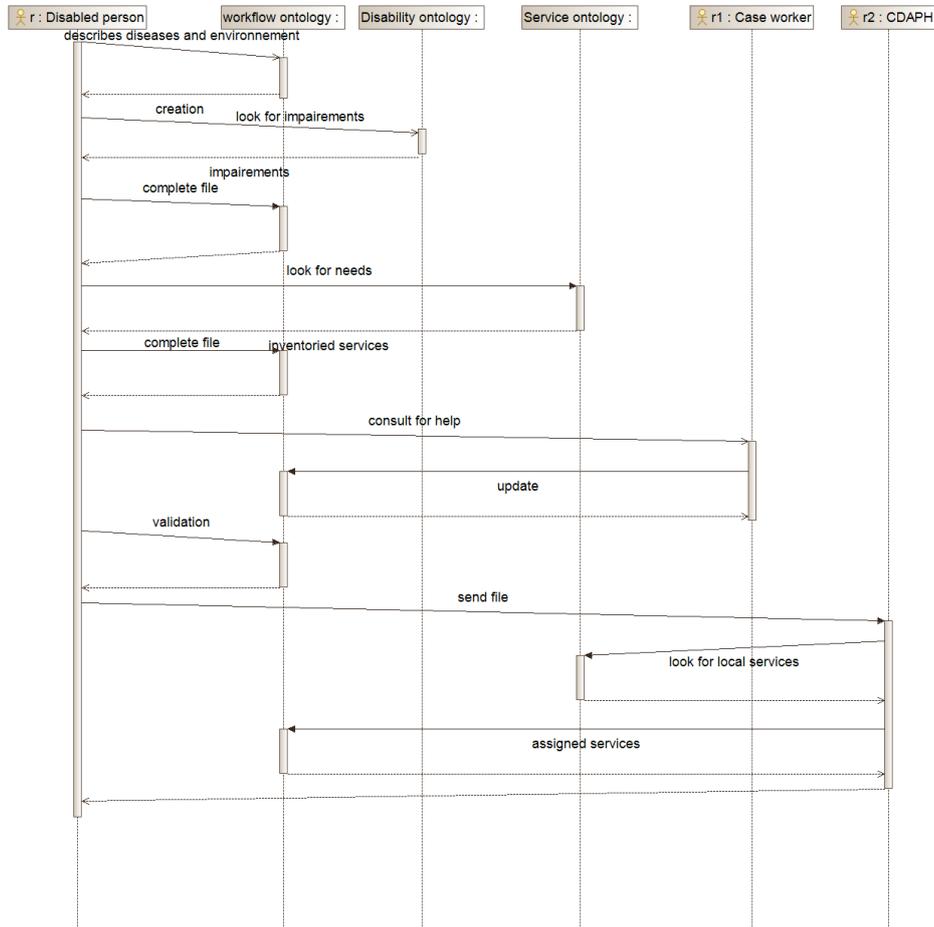


Fig. 7. Awarding of services

The PROV Ontology [19] has been used to describe the “individual file” creation and evolution. At the end, services are or are not attributed to the individual who has expressed the needs. PROV-Ontology contains three classes: prov:Agent, prov:Entity and prov:Activity (see Figure 8). The agents take act on the entities through activities. The activities can generate entities but also modify and use, the entities. The entity can be physical, conceptual or other.



Fig. 8. Classes of PROV Ontology

The scenario allows to describe the provenance of individual files. The entities are the file, the selected impairments, the needs among all the existing ones and the attributed services. Three agents take part in the activities: an individual who describes his needs corresponding to his impairments, a case worker modifies the file by adding or deleting needs relatively to the impairments and the individual situation. Finally, the concerned CDAPH studies the file and decides the services to allocate.

As you can see in Figure 9, an individual creates his “individual file” which contains, at the beginning, a descriptive analysis of his impairments and a first needs list. The composition activity (:compose1) uses the selected impairments by the individual1. The composed data are generated by this activity. After which, another composition activity generates the selected needs. Finally, the :individualFile1 is produced by individual1. He is an agent, a person described by attributes: age, name, profession and the caregivers that can help him.

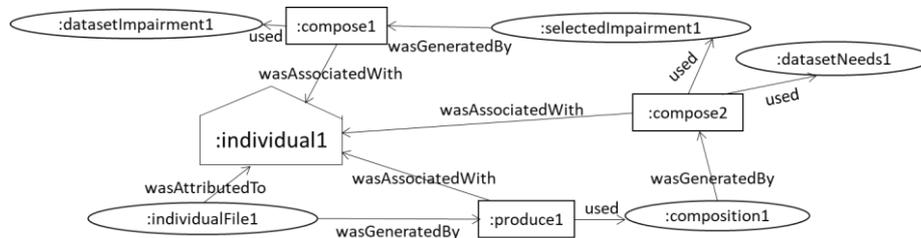


Fig. 9. file Creation.

In a second step (see Figure 10), a case worker completes the :IndividualFile1. :caseWorker1 is an agent, a person, who works in an organization which is itself an agent. The selected needs by individual1 are corrected and a new composition is created. A new individual file with better expression of needs is produced; it is a revision of the previous. Note that, in the figure, grey ellipsis are coming from the preceding step.

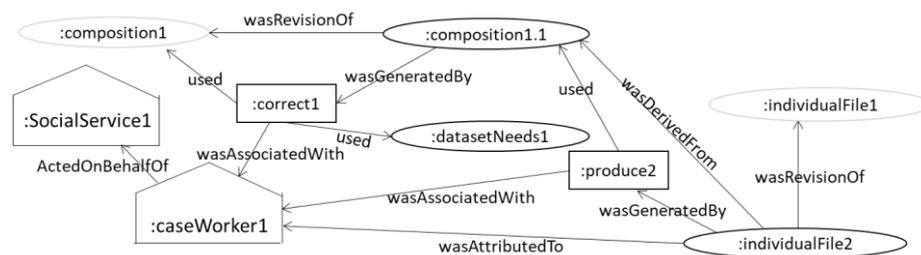


Fig. 10. File Revision.

Then, an instance of the CDAPH studies the individualFile2 with the data set of existing services (see Figure 11). With all this information, the allocated services are decided. A new “individual file” is created, it is a revision of “:individualFile2”, allocated services are added to it by the “:CDAPH1”. This “:individualFile3” is not a final one. The

individual can go to appeal and, then create an “:individualFile4” to argue for a new analysis of his case and rights. Furthermore, from time to time, at least each year, a case worker will inspect the individual and may revise his individual file. This “:individual-FileN” will, then, be studied again by the CDAPH. The process is gradual and iterative.

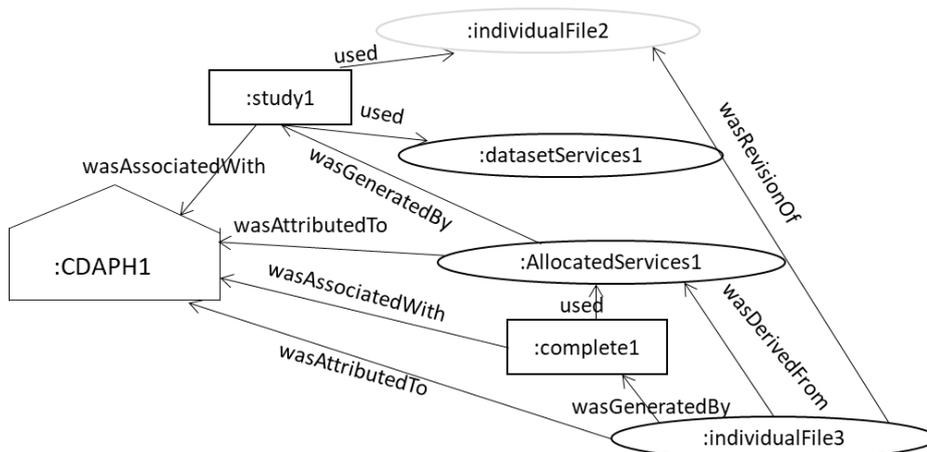


Fig. 11. File Update.

7 Conclusion

We have presented a first conceptual structure that allows the organization of a domain characterized by a process. The further step of the project will concern the connection to the thesaurus that indexes the scientific documents, the characterization of the information artifacts that compose the process and the duality composed by the nomenclature and the available services in time, location and actors.

The heterogeneity of the documents and the modalities to accede to their content (information extraction, indexation, metadata) argues to the strategy of a distributed ontology.

The building of the ontologies is beginning. The service collection is very hard because there is no national database of local services. An association helps us understand and collect data but the problem is: there are different existing associations and each one concerns a particular disability.

Our goal is to create a computer aided system which can be used by anyone, that is to say by a specialist of a particular disability but also by a final user which has a disability. We aim for this one to find all the propositions of potential services linked with his social context but also with the local services.

Another perspective to enrich our proposal will be to propose to an user the existing cases similar to his own case. Indeed, our framework will propose allocated services to a file which has a similar context and needs. The characteristics of the person do not

appear, only the caregiver's roles, the impairments, the needs and the allocated services. It is a help to better describe an individual file. The idea is to help the final user to complete the file by asking questions and suggesting proposals. This will be possible by tracing through existing cases. This search will be based on the answers and therefore gradually enriching them, the system will help the users to specify their context and needs. Kolodner [23] wrote "Case-based reasoning can mean adapting old solutions to meet new demands; using old cases to explain new situations; using old cases to critique new solutions; or reasoning from precedents to interpret a new situation (much like lawyers do) or create an equitable solution to a new problem (much like labor mediators do)". The basic idea of CBR (Case-Based Reasoning) is to solve new problems by comparing them to problems already solved [24]. The idea to associate case-based reasoning and ontology is not a new idea [25] showed a strong relationship between both approaches with respect to technological but also to methodological issues. Therefore, adding the concept of CBR to our approach seems very interesting to aid the final user to complete his file and find the most appropriate services for his needs.

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