Identification number: DOI: 10.1016/j.irbm.2014.09.002
Official URL: http://dx.doi.org/10.1016/j.irbm.2014.09.002

A framework for decision making on teleexpertise with traceability of the reasoning

M.B. Doumbouya [a,b], B. Kamsu-Foguem [b,*], H. Kenfack [a], C. Foguem [c]

[a] *University of Toulouse, Faculty of Law, 2 rue du Doyen Gabriel Marty, 31042 Toulouse Cedex 9, France*
[b] *Laboratory of Production Engineering (LGP), EA 1905, ENIT-INPT University of Toulouse, 47 Avenue d'Azereix, BP 1629, 65016, Tarbes Cedex, France*
[c] *Centre for Food and Taste Sciences (CSGA), UMR 6265 CNRS, UMR 1324 INRA, University of Bourgogne, 9 E Boulevard Jeanne d'Arc, 21000 Dijon, France*

Abstract

This paper provides a methodological framework for decision making process to ensure its traceability generally in the context of telemedicine and particularly in the act of teleexpertise. This act permits to medical professionals and/or health professionals to collaborate in order to take suitable decisions for a patient diagnosis or treatment. The main problem dealing with teleexpertise is the following: *How to ensure the traceability of the decisions making process*? This problem is solved in this paper through a conceptualisation of a rigorous framework coupling semantic modelling and explicit reasoning which permits to fully support the analysis and rationale for decisions made. The logical semantic underlying this framework is the *argumentative logic* to provide adequate management of information with traceability of the reasoning including options and constraints. Thus our proposal will permit to formally ensure the traceability of reasoning in telemedicine and particularly in teleexpertise in order to favour the quality of telemedicine's procedure checking. This traceability is to guarantee equitable access to the benefits of the collective knowledge and experience and to provide remote collaborative practices with a sufficient safety margin to guard against the legal requirements. An illustrative case study is provided by the modelling of a decision making process applied to teleexpertise for chronic diseases such as diabetes mellitus type 2.

1. Introduction

Telemedicine is a kind of remote medical practice, in which there is the possibility of making multiple actors working together and allowing their collaborations in the diagnosis or treatment of a disease, by the means of telecommunication and information technologies. The telemedicine involves either patient with one or several health professionals (HP) and among them a medical professional, or a collaboration between a group of health professionals (HP) and among them at least one medical professional (MP). Telemedicine permits to [1]:

- establish a diagnosis,
- provide for a risky patient a medical monitoring in the context of prevention or a therapeutic monitoring,
- require expert advice,
- prepare a therapeutic decision,
- prescribe products, prescribe or perform acts or services,
- monitor a patient.

This practice is very useful in several domains of application where medical expertises are needed, for example:

- **Rural area** [2], where there is difficulty in health care for remote rural areas because they are unable to attract, afford or retain speciality providers. So telemedicine can help solving these issues by allowing access to specialists regardless of location.

* Corresponding author.
E-mail addresses: mdoumbou@enit.fr (M.B. Doumbouya), bernard.kamsu-foguem@enit.fr (B. Kamsu-Foguem).

http://dx.doi.org/10.1016/j.irbm.2014.09.002

- **Corrections** [3], in this area telemedicine allows prison facilities to deliver high medical quality without the cost and dangers of inmate transportation and the need for clinical specialist to enter the facility.

There are also many fields of telemedicine application such as schools, mobile health, disaster relief, industrial health, ...

The practice of telemedicine is divided into these five acts listed below [1]:

1. **teleconsultation**: a doctor gives a remote consultation to a patient, the latter can be assisted by a health professional. The patient and/or the health professional gives information for their side, the remote doctor then performs the diagnosis.
2. **teleexpertise**: a doctor seeks remotely the opinion of one or more of his colleagues on the basis of the diagnostic and therapeutic needs to foster concrete discussions aimed at solving the medical problems related to a patient's care.
3. **telemonitoring**: a doctor monitors and interprets remotely a patient's medical parameters. The recording and the data transmission can be automated or performed by the patient himself or by a health care professional.
4. **teleassistance**: a doctor attends remotely other health professional performing a medical act.
5. **medical regulation**: this is specific to the French telemedicine specification where doctors of centre 15 establish by phone first diagnosis to determine and trigger the best answer suitable to the nature of the call.

In this paper we are interested in the **teleexpertise** act which is used by health care provider to make and take decisions concerning a patient's treatment. Because important decisions are made in this act, then the responsibility of each participant is engaged. Currently, due to the lack of interoperability of Hospital Information System (HIS) or absence of computerised patient records in facilities, the traceability of decisions and information that are used for decisions is ensured by a telemedicine information system. Within this telemedicine information system, it is some forms to be completed that can be specific to certain specialities. The content is structured according to the process in the medical procedure. This helps assisting the applicant in making its request for an opinion to the expert, and to facilitate the processing of the application by the expert. Some forms can sometimes perform by calculations for knowledge discovery in databases. Unfortunately, some health providers not always take the time to complete these forms. But whatever the means of communication used, the most important point is the traceability of decisions. This is our problem, in other words, how to ensure the traceability of the decisions taken by health providers?

To achieve this goal, we propose in this paper two main contributions. First, the paper presents the architecture that we propose to show the interaction between participants and some ontological concepts. This architecture includes an important component called *argumentative logic*. This component is used in our architecture to ensure the traceability of the decisions in teleexpertise to favour the checking of the telemedicine's procedures quality. Second, the paper will focus on the component where we detailed by a use case its purpose.

This integrated approach includes a semantic formalisation of collaborative information models that assists medical actors at all levels to share knowledge and integrate ethical needs in their telemedicine services: this shows the novelty and originality of our work i.e. integrating semantic modelling and laws concepts for aiding in decision making.

2. Objective

The main purpose of this paper is to propose a methodological framework coupling semantic modelling and argumentation for aiding medical professional in their decision making process. In fact, the proposed framework will permit to medical professionals to manage medical information concerning their patients. So by our proposal we want to give innovative solutions in the practice of telemedicine which will lead to increase telemedicine programs' effectiveness. In fact our proposal combines conceptual graphs and Dung's argumentation system (argumentative logic). With this approach, we aim to propose a rigorous modelling framework since it includes argumentative reasoning which have a mathematical foundation and conceptual graphs based on ontological mechanisms. This argumentative logic will permit to ensure reasoning traceability in a structured manner while the ontological models (conceptual graphs) will permit reasoning visualisation (by the use of CoGui software) and see more ensuring semantic interoperability. By making this tool easy to use we can encourage medical professionals to change their habits by using these new technologies in the practice of medical acts. We aim also to provide a tool which will permit a strong communication among medical professionals and in the same occasion to share knowledge and experiences. For example, when a medical professional cannot take decisions in front of specific diagnosis, by using the system he can make some queries in order to know if there has been a similar case in the past. If yes, then he can know what decisions have been taken for this diagnosis, if no, he can then contact other medical professionals who are specialised in a particular domain and have a thorough understanding to remotely share experienced knowledge during the teleexpertise activity.

3. State of the art

In this section, we start with a state of the art to show what has been already done for the argumentation and the traceability of the decisions in the literature.

3.1. Related work

In our team many works dealing with conceptual graphs for visual knowledge representation have been achieved. However, the global research approaches are not the same and each is useful for different purposes. The work of Potes Ruiz et al.

[4] proposes a methodological framework for experience feedback processes and in their approach they combine conceptual graphs with association rules mining. The main objective is to analyse the knowledge extracted from industrial information systems in order to improve the management of the maintenance activity. This approach is quite similar to ours since, the proposed framework permits to manage and generate knowledge from information based on past experiences, in order to make suitable decisions in a particular context. However, the work of Potes Ruiz et al. [4] did not intend to address general aspects of the quality of collaborative decision making. The work of Kamsu-Foguem et al. [5] proposes a methodological framework for a formal verification approach of medical protocols and in their approach they combine conceptual graphs with computational tree logic. The aim is to formalise medical protocol defining temporal reasoning paths for the monitoring and prevention of specific diseases (e.g. nosocomial infections). It does not cover aspects related to the remote collaboration, but we share the goal of developing the means to facilitate the understanding of reasoning steps. In those terms, our approach combines conceptual graphs with argumentative reasoning in the medical collaboration setting. So this must make it possible clearly and noticeably to identify the argumentations drawn up or received by the collaborative medical team. The exchange of expertise under this new framework will therefore help to sustain traceable reasoning instruments and improve work quality in the collaborative situations, such as in the teleexpertise between medical professionals located at remote sites.

Some works have been done by the authors of [6] to help health care providers to take decision for a patient's treatment. In their work they presented a tool called *Virtual Staff* which permits to have cooperative diagnosis in order to make decisions. The *Virtual Staff* permits decisions traceability by keeping track of the history of their characteristic elements based on patients *life line* [6]. This *Virtual Staff* is based on a SOAP (Subjective, Objective, Assessment, Plan) model [6,7] which permits to the doctors to structure their reasoning and also on a QOC (Question–Options–Criteria) model [6,8] for support to decision-making. Globally in their approach they have a database called Nautilus DB, from this basis they build ontologies that are transformed into RDF[1] format. Then they use a search engine called CORESE [9] to navigate into this ontology. CORESE interface allows physicians to visualise the ontology and validate it by errors detection and also by the correction suggestion. CORESE also provides an environment for responses to queries on the ontology. Even if their proposal offers argumentation on decisions and traceability, but it is too heavy to build in the way that there are different forms of graphs namely SOAP, QOC using the ontology generated from a medical database. The common points with our proposal is that their architecture is composed by ontologies, conceptual graphs handled by CORESE and a willingness to explain the reasoning in an argumentative manner. Unfortunately with CORESE only conceptual graphs modelling facts are visualised and there is no way to visualise the reasoning process. In our approach we propose a way to visualise the reasoning by the use of COGUI [10] software including purposes to edit constraints, rules which aid in reasoning. We propose to use the argumentative logic to reinforce their formal semantics on explicit elements for decision-making, whilst investigating real impact of possible options. Finally in our proposition we introduce a legal point of view in the defined ontologies which will allow to identify the responsibility of each participant in the act of teleexpertise.

K.-L. Skillen et al. proposed in [11] an approach based on semantic technologies for user modelling and personalisation techniques. Their proposal is adapted for pervasive environment in which they create ontological user models and developed a semantic rule-based mechanism for the personalisation of context-aware service. These rules are created with *SWRL*[2] in *Protégé* [12]. This approach is somewhat similar to ours in the sense that they use semantic modelling and reasoning options. But to create the rules they need additional plugin in *Protégé*, this means that they need more than one language (SWRL for the rules and OWL[3] for the ontological models) whereas in CoGui the rules creator are natively included, thus only one language to handle both rules and ontological models. As their approach is based on Help-On-Demand services, it can be used for decision aiding in the telemedicine services.

3.2. Telemedicine overview

Telemedicine is the fact to use information systems and telecommunication in order to deliver medical care remotely. Nowadays with the rising of new technologies, telemedicine is becoming a real centre of interest with regard to the research domain. As said in the introduction, telemedicine is built around five main acts. In these five acts, four of them are more important namely: teleconsultation, teleexpertise, telemonitoring and teleassistance. These four acts are illustrated in Fig. 1 below.

An important work has been done by the authors of [13] in which they give a systematic review of reviews of telemedicine. In their work, they show that telemedicine has positive effects. And these positive effects concern therapeutic effect, health service improvement, and the use of technical services such as ICTs[4] [13]. We talk about only the health and the technical outcomes.

Even if the effectiveness of telemedicine is demonstrated it seems that it still limited and inconsistent in many domains [13]. For example in therapeutic actions, the telemonitoring for heart failure has its limits in terms of improving effectiveness and influencing healings [13,14]. The elements describing that evidence on the limits and the inconsistencies of telemedicine concern decision support tools, chronic diseases, computer-based cognitive behavioural therapy and so on. For the teleexpertise point of view many efforts are currently being made concerning tools used in its practice.

[1] Resource Description Framework.

[2] Semantic Web Rule Language.

[3] Web Ontology Language.

[4] Information and Communication Technologies.

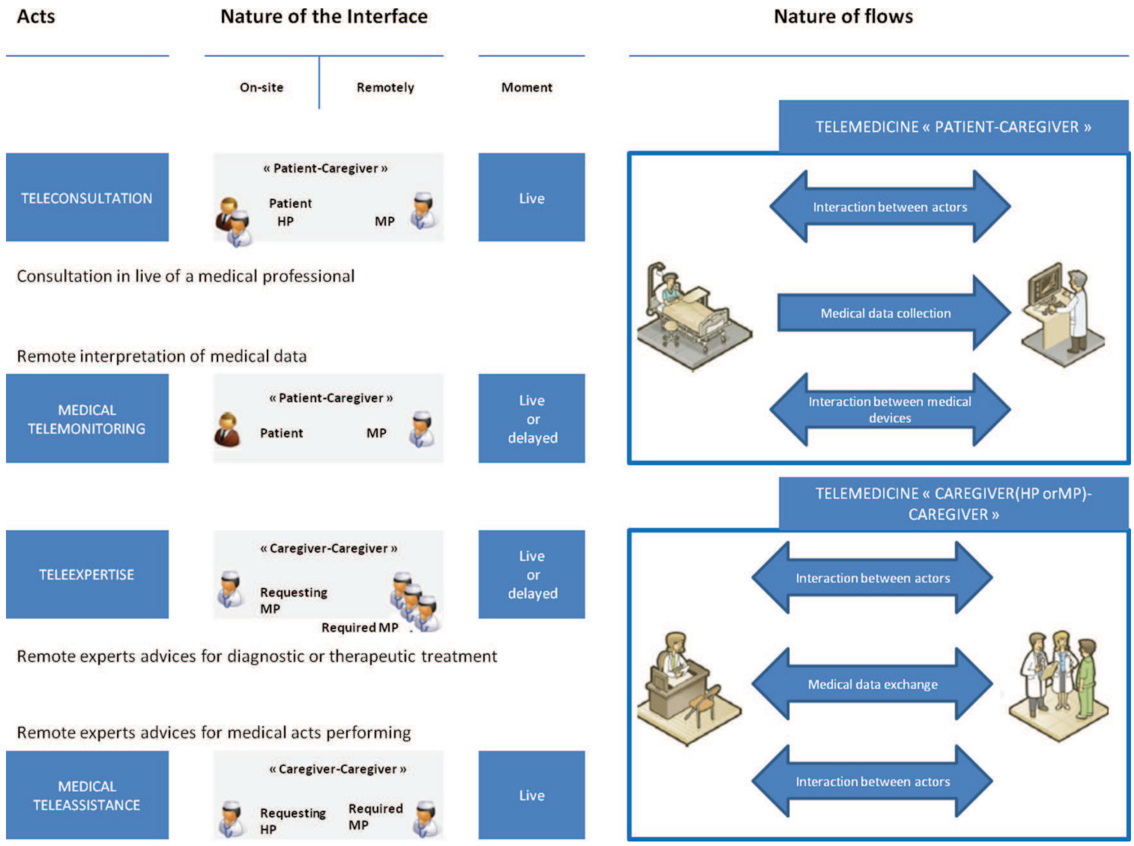

Fig. 1. Main acts of telemedicine.

4. Materials and methods

In this section we show the different steps followed to achieve our goal, namely the proposed communication architecture and the explanation of the abstract argument-based framework for decision making called *argumentative logic*. We introduce this abstract framework in our work because, it will permit us to achieve our goal, namely: ensuring formally the traceability of the reasoning for checking the quality of telemedicine's procedures. In addition by the use of Cogui software, the reasoning could be visualised easily which is a value-added contrary to the previous works.

4.1. Proposed architecture

E. Nageba et al. [15] proposed a methodology for knowledge-based framework construction in pervasive computing. This methodology contains a knowledge meta-model description and formalisation that can be instantiated in different scenarios and contextual situations. The described knowledge-based design methodology provides a framework for problem solving and decision making in a given domain. In particular the authors showed a technical and empirical result in telemedicine domain for the purpose of organisational assessment and development. But in their work they do not show that their proposal guarantees the traceability of decisions. Thus the proposed work in this paper will permit to overcome this failure and to visualise easily the reasoning. We add in our architecture an additional component called *argumentative logic* in order to guarantee the traceability of decisions for ensuring formally the decision process traceability in favouring the checking of telemedicine's procedures quality.

In this architecture we propose a methodological framework coupling:

- semantic modelling
- explicit reasoning
- ontology (including medical and legal concepts) modelled by conceptual graphs.

The proposed architecture is depicted in Fig. 2 below. It represents our proposed architecture in which the component developing and implementing argumentative logic is a kind of middleware between the GUI and the knowledge base. This component is built from the definition and properties related to Dung's argumentation system (Section 4.2.2). It retrieves data from the knowledge base according the medical professionals' queries and computes accepted or rejected advices in the act of teleexpertise. The argumentative logic component likewise allows the generation of a framework for sharing of experiences, analyses and proposals between remote medical professionals.

Our architecture is composed of eleven main components listed below:

- **GUI**: a user friendly interface which permits the user to access the system functionalities.

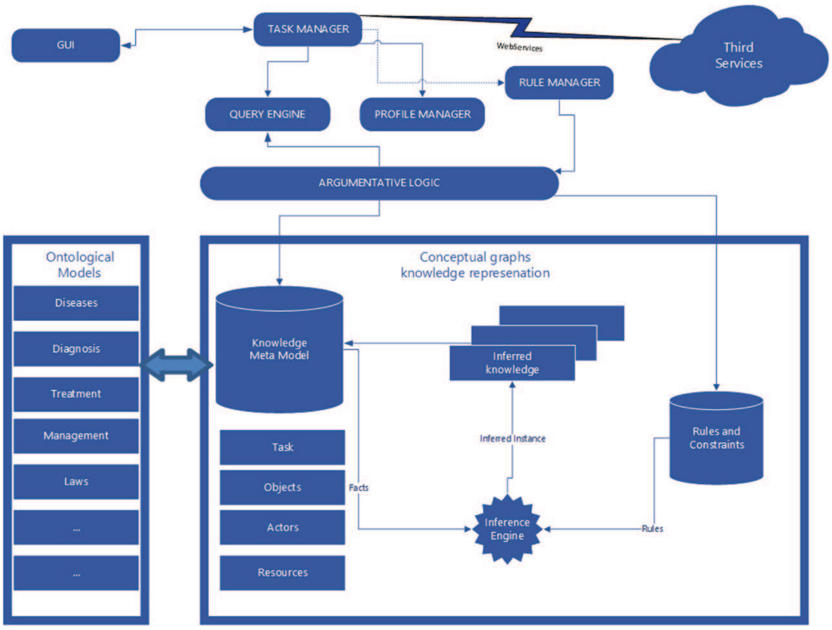

Fig. 2. System architecture.

- **Third services**: it includes several services such as hospitals, clinic, medical centre, PMR[5] host where patient data are stored and organisation such as social security.
- **Query engine**: it is already included in CoGui software. It permits to query and get response from the knowledge base for aiding medical experts in the decision taking.
- **Profile manager**: it handles user profile. It permits to inform the task manager which user is connected in order to load information concerning this user.
- **Rule manager**: it is contacted by the task manager to apply rules on a specific query.
- **Argumentative logic**: it is the component which ensures the traceability of the decisions in a structured manner. And as previously said, it retrieves data from the knowledge base according the medical professionals' queries and computes accepted or rejected advices in the act of teleexpertise. This component will be detailed more precisely in the next section.
- **Ontological models**: the ontological models are used in eHealth to make medical decision support systems [15]. Ontologies are instruments used in the knowledge engineering community for concepts and interrelations specification [16,17]. Ontologies are also used for context modelling, management in pervasive environment and they permit to solve semantic interoperability [18,19]. Ontologies are still an emerging research and development area for telemedicine task support [20]. In our architecture, ontological models are defined by diagnosis, management, laws, diseases, etc. The diseases ontology was constructed by information collected in ICD[6]-10 [21]. The authors of [22] designed an ontology incorporating core legal concepts that we integrated into our architecture.
- **Knowledge meta model**: it is a set of generic and domain-independent ontological models and the associations which connect these models [15]. In our architecture the knowledge meta-model includes Task, Objects, Actors, Resources.
- **Inference engine**: it permits to perform rule-based reasoning. The inference engine is included natively in CoGui.
- **Rules and constraints**: it is a kind of database where the rules and constraints are defined. In CoGui this is defined by Rules, Negative constraints and Positive constraints.
- **Task manager**: all the tasks via the GUI are done by the task manager. Indeed it permits to access the query engine in order to query and get response from the knowledge base. And also when querying the knowledge base, the task manager can contact the rule manager for applying some rules and the specified request. It can connect to the Internet via webservices over secure HTTPS[7] connections to get patient medical record and some additional information if needed. The return format of the webservices is in XML[8] [23] for ensuring the syntactical interoperability.

4.2. Abstract argument-based framework for decision making: Argumentative logic

The argumentative logic as said previously is a rigorous framework which permits decisions justification with traceability of reasoning including options and constraints.

[5] Personal Medical Record.
[6] International Classification of Diseases.
[7] HyperText Transfer Protocol Secure.
[8] Extensible Markup Language.

4.2.1. Different types of arguments

According to Amgoud and Prade [24], there are two types of arguments, namely:

- **epistemic arguments**: based on believes and themselves grounded only on believes.
- **practical arguments**: based on options and are made by both believes and preferences or goals.

Generally we can have these two types of arguments and it is the context that will determine which one to implement.

4.2.2. Acceptability semantics

Above all, we define what is a decision framework (system) [25] also called argumentation-based framework AF [24].

Definition 1. An (argumentation-based) decision framework AF is a couple (A, D) where:

- A is a set of arguments,
- D is a set of actions, supposed to be mutually exclusive,
- *action*: $A \to D$ is a function returning the action supported by an argument.

Definition 2. From an argumentation-based decision framework (A, D), an equivalent argumentation framework $AF = (A, Def)$ is built where:

- A is the same set of arguments,
- $Def \subseteq A \times A$ is a defeat relation such that $(\alpha, \beta) \in Def$ if $action(\alpha) \neq action(\beta)$.

Definition 3. Let $AF = (A, Def)$ be an argumentation framework, and let $B \subseteq A$

- B is conflict-free if there are no $\alpha, \beta \in B$ such that $(\alpha, \beta) \in Def$.
- B defends an argument α iff $\forall \beta \in A$, if $(\beta, \alpha) \in Def$, then $\exists \gamma \in B$ such that $(\gamma, \beta) \in Def$.

Definition 4 *(Acceptability semantics).* Let $AF = (D, A, Def)$ be a decision system, and B be a conflict-free set of arguments.

- B is admissible extension iff it defends any element in B.
- B is a preferred extension iff B is a maximal (w.r.t. set $\subseteq$) admissible set.
- B is a stable extension iff it is a preferred extension that defeats any argument in $A \setminus B$.

By these acceptability semantics the authors of [24] identify several arguments' status which are depicted below:

Definition 5 *(Argument status).* Let $AF = (D, A, Def)$ be a decision system, and $\varepsilon_1, \dots, \varepsilon_x$ its extensions under a given semantics. Let $a \in A$.

- a is skeptically accepted iff $a \in \varepsilon_i$, $\forall \varepsilon_i$ with $i = 1, \dots, x$.
- a is credulously accepted iff $\exists \varepsilon_i$ such that $a \in \varepsilon_i$.
- a is rejected iff $\nexists \varepsilon_i$ such that $a \in \varepsilon_i$.

The consequence which follows immediately from the above definition is as follows:

Property 1. *Let $AF = (D, A, Def)$ be a decision system, and $\varepsilon_1, \dots, \varepsilon_x$ its extensions under a given semantics. Let $a \in A$.*

- *a is skeptically accepted iff $a \in \bigcap_{i=1}^{x} \varepsilon_i$*
- *a is rejected iff $a \notin \bigcup_{i=1}^{x} \varepsilon_i$*

The component of the proposed architecture called argumentative logic is built from these definitions and property. In this component the definitions and properties are transformed into algorithms. So when medical professionals enter some queries, they are relayed to the argumentative logic which extracts the answers from the knowledge base to show the accepted arguments in a specific act of teleexpertise based on the underlying algorithms. By applying the established definitions we build algorithms for extracting conflict-free sets, admissible extensions and preferred extensions and with the properties we build an algorithm for knowing the accepted and the rejected arguments in the decision making process. These algorithms are part of the argumentative logic component.

5. Analysis of results with case study findings

In this section we will show an applicability of the argumentative logic thanks to a case study in the context of teleexpertise.

5.1. Case study

Application case. The attending physician (or family doctor) of Mrs C., a 80 years old female with a 10 years history of high blood pressure, requested a medical opinion of the geriatrician because his patient presented a sub-acute confusion symptoms. Physical examination was normal apart of blurred and/or diminished vision's complaints. The geriatrician disclosed a chronic hyperglycemia [fasting blood glucose value at 20 mmol/L and hemoglobin A1c (glycosylated hemoglobin) higher than 14%] yielding diagnostic of unrecognized diabetes mellitus type 2. Laboratory analysis displayed a renal impairment (clearance of creatinine at 24 ml/min/1.73 m^2) with proteinuria (2 g/24 H). Firstly by the provided system the geriatrician makes some queries to know if there has been a similar case in the past. If yes, he could then have the answers on how to treat such patient; if no, he uses the same system to ask for expertise to the Internist (for the renal complication of diabetes mellitus), the Ophthalmologist (for the ocular complication of diabetes mellitus) and the Diabetologist (for the management of hyperglycemia). The experts' advices are collected as shown in Table 1 (Stakeholders' argumentation). From the elements of this table there is built the graph of attacks according the option parameter in the table (the arguments with the same option do not attack each other). On this graph of attacks there will

Table 1
Stakeholders argumentation.

	Stakeholders	Reasons	Options	Concerns	Goals
1	Internist	He does not want to make invasive investigation, he prefers medication approaches in this context with less of side effects and the prevention of further micro-vascular (eye and kidney) and macro-vascular complications of Diabetes Mellitus	↘ *Proc*	Ensuring a good quality of life for this elderly patient	Risk reduction such as side effects and prevention of further micro-vascular and macro-vascular complications related to the Diabetes Mellitus
2	Ophthalmologist	He wants to perform invasive investigations on the eye to appreciate the extent of retinal vein thrombosis and the importance of the associated oedema. He advocates then an intra-ocular injection of an anti-oedematous treatment	↗ *Proc*	Ensuring a good quality of life for this elderly patient	Appreciation of the extent of retinal vein thrombosis, the importance of associated oedema and curing patient visual disorders
3	Geriatrician	He would administer treatment to the patient to prevent cognitive impairment such as Alzheimer disease common in the elderly	↗ *Proc*	Ensuring a good quality of life for this elderly patient	Prevention of conditions which lead to cognitive impairment
4	Diabetologist	He would prescribe as soon as possible treatments to the patient in order to prevent his loss of sight, knowing he already has visual disorders and type 2 diabetes which can lead to the blindness of the patient.	↗ *Proc*	Ensuring a good quality of life for this elderly patient	Avoiding patient's loss of sight

be applied the argumentative logic to compute the accepted and rejected arguments. Finally the Geriatrician compares the accepted arguments and then by some parameters takes the final decisions and these decisions will be stored for future expertise.

The sequence and collaboration diagrams (Figs. 3 and 4) illustrate our case study. These diagrams are based on UML[9] [26].

In the sequence diagram above the "Experts" represents the group composed of the Ophthalmologist, Diabetologist and Internist whom are contacted for expertise. In the following we describe some methods to foster more understanding:

- *AskForExpertise*: in this method the geriatrician provides all information concerning the patient (with his consent of course), and the needed remote experts. By the same occasion he sends to the server his advices if only he can take a decision according his skills and his experiences.
- *ProcessExpertiseRequest*: when the server receives the expertise request it computes it to know the available physicians and then transmits by the method *TransmitInformation* (which is a kind of multicast) them the medical information concerning the patient if they accept to participate in this act of teleexpertise [27].
- *GiveAdvices*: the remote physicians give their advices according to the parameters described in Table 1. This method should include some parameters to know which physician's answer has been received.
- *BuildAttackGraphsAndExecuteArgumentativeLogic*: this method creates the graph of attacks on which will be applied the argumentative logic to identify the arguments that should be accepted or not.

Fig. 4 represents the collaboration diagram that shows the interaction between the different entities of our proposal. Unlike to the previous diagram, it shows explicitly the messages exchanged between the different entities. When the geriatrician asks for finding similar cases, one of these responses can be returned:

- Similar cases founded, then the server return the different procedures to follow in order to efficiently treat the patient;
- Similar cases not founded, and then the server informs the geriatrician that there is no such similar case.

As said previously in the sequence diagram's comments, the message giveAdvices() should have some functional parameters in order to distinguish the physician from whom advices have been received by the server.

In the following, we show the different steps to follow for the decision making process. We believe that the reasoning elements set out in this case study is helpful for the purposes of illustrating the essential dimensions of the suggested decision making process on teleexpertise with traceability of the reasoning. We also subscribe to the view that the described elements are only the very noticeable parts of that proposed framework, whereas others are under development and not yet consolidated. In other words we will link the different components and also include conceptual graphs in the design to easily permit the visualisation of the reasoning.

[9] Unified Modelling Language.

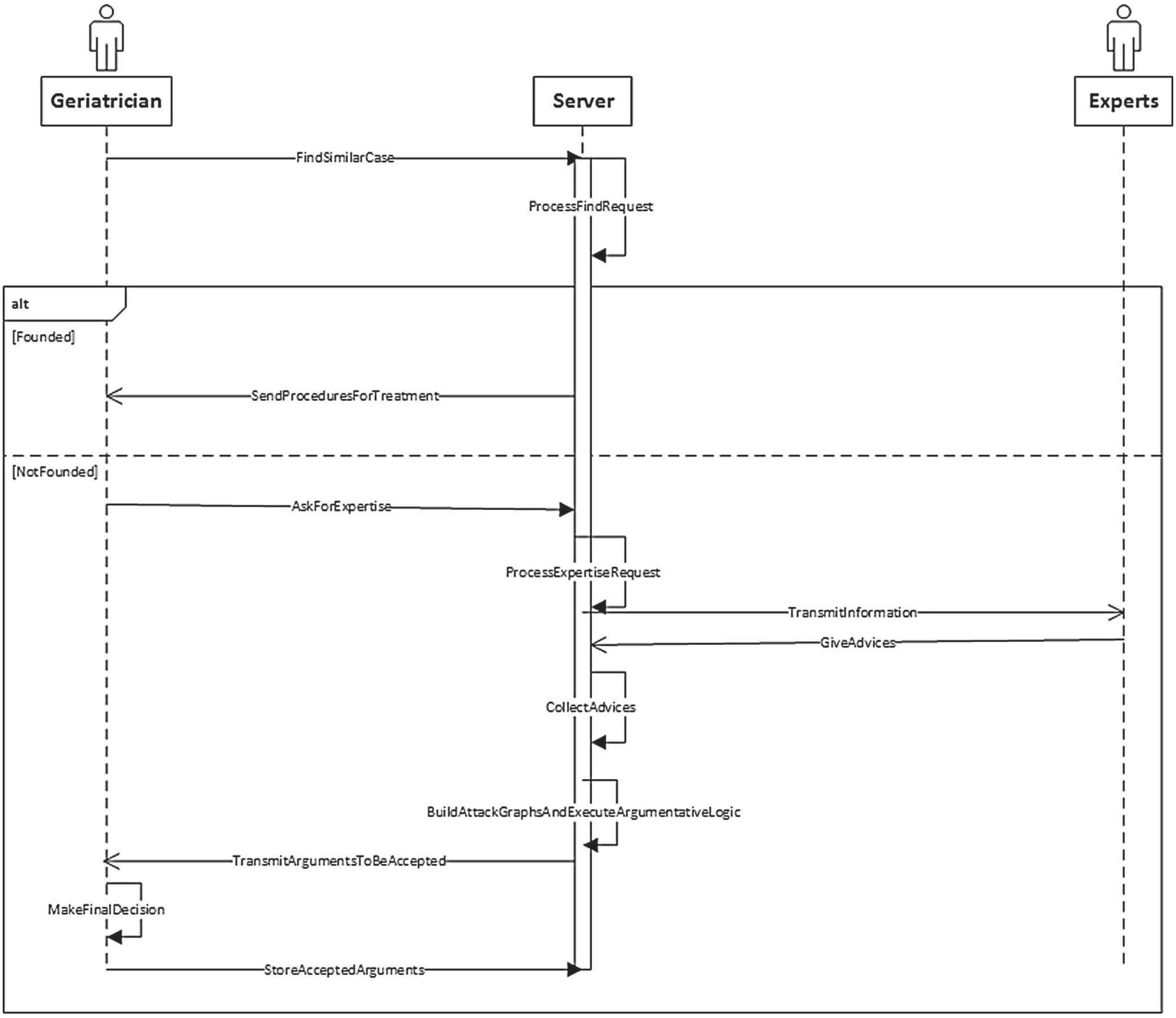

Fig. 3. Sequence diagram.

5.1.1. Positioning of the stakeholders

- **Internist** is a medical professional dealing with adult diseases. He is a polyvalent care giver, particularly skilled in the multi-system disease processes. He would not make invasive investigations or treatments yet because the results of invasive techniques proposed are diverse (benefit, risk, patient satisfaction, etc.) In this particular case, he is against invasive investigations or treatments yet in this elderly woman taking into account the age of the patient and the risk-to-benefit ratio of invasive acts in this context he would not make invasive investigations. He prefers medication approaches in this context with less of side effects and the prevention of further micro-vascular (eye and kidney) and macro-vascular complications of Diabetes Mellitus.
- **Ophthalmologist** is a medical professional for eye diseases. He wants to perform invasive investigations on the eye to appreciate the extent of retinal vein thrombosis and the importance of the associated oedema. He advocates then an intra-ocular injection of an anti-oedematous treatment.
- **Geriatrician** is a medical professional for the elder person. He would administer treatment to the patient to prevent cognitive impairment such as Alzheimer disease common in the elderly.
- **Diabetologist** is a medical professional for diabetes. He would prescribe as soon as possible treatments to the patient in order to prevent his loss of sight, knowing he already has visual disorders and type 2 diabetes which can lead to the blindness of the patient.

5.1.2. Modelling information available in structured arguments

The medical professional has the choice between minimising and maximising diagnostic procedures [28]:

- ***Procedures minimisation***($\searrow$ *Proc*): it limits the care's invasiveness, risks such as selection of resistant bacteria,

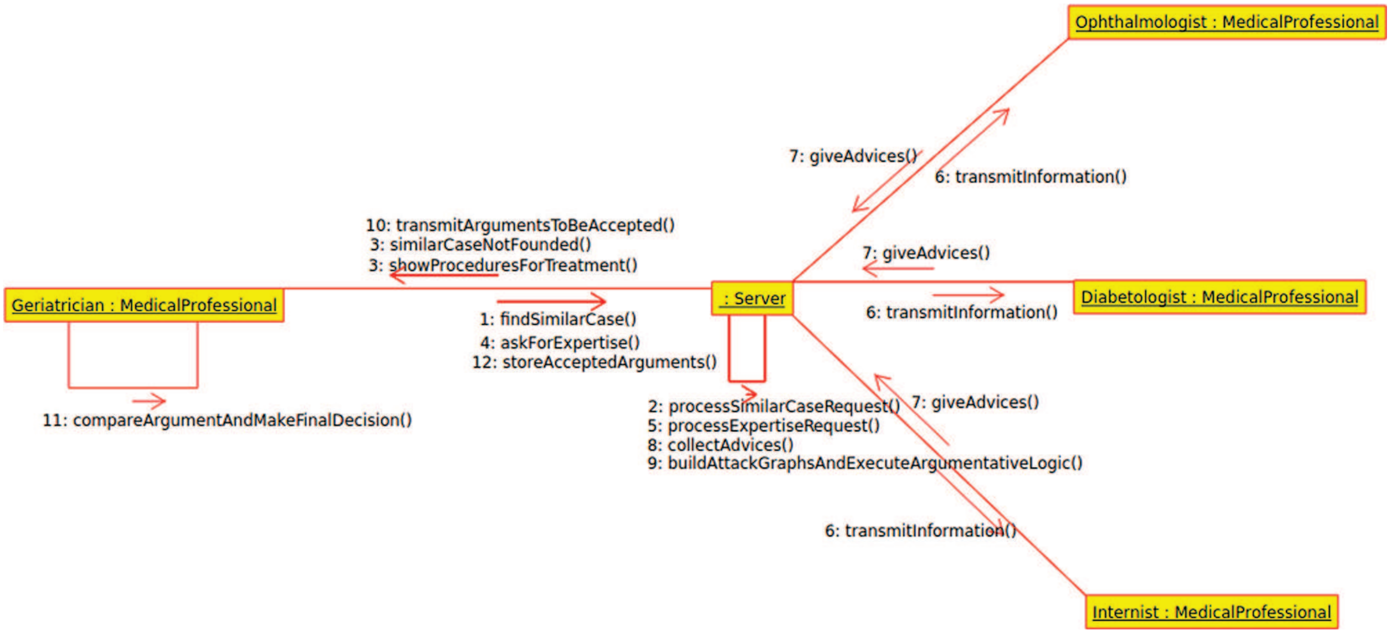

Fig. 4. Collaboration diagram.

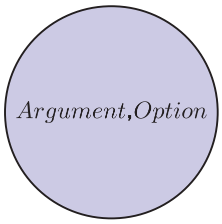

Fig. 5. Node representation.

nosocomial infections, adverse drug reactions, the vagaries of interventions, . . . and their costs; but diagnostic and therapeutic delays are observed; which can lead to severe ethical and medico-legal consequences.

- ***Procedures maximisation*** ($\nearrow$ *Proc*): it permits to reduce the risk of missing diagnostic or therapeutic opportunities (e.g. emerging medical problem such as bacterial infection with possible longer-term effects). However individual and collective risks increase significantly due to human errors and medical device safety. Thus medical decisions are taken by the comparison of the threats of a health status to its related strengths.

These two diagnostics procedures represent the options (actions) of our decision system that will permit to determine the arguments which are for or against an option. Table 1 gathers the different arguments (Reason) which will promote a goal and support action (Option).

5.1.3. Graph of attacks

The Graph of attacks consists of a set of nodes with oriented links between them. A node is represent by the couple *Argument, Option*, this is depicted in Fig. 5.

According to Table 1, the different arguments support by the stakeholders are:

- α = He does not want to make invasive investigation, he prefers medication approaches in this context with less of side effects and the prevention of further micro-vascular (eye and kidney) and macro-vascular complications of Diabetes Mellitus,
- β = He wants to perform invasive investigations on the eye to appreciate the extent of retinal vein thrombosis and the importance of the associated oedema. He advocates then an intra-ocular injection of an anti-oedematous treatment,
- γ = He would administer treatment to the patient to prevent cognitive impairment such as Alzheimer disease common in the elderly,
- δ = He would prescribe as soon as possible treatments to the patient in order to prevent his loss of sight, knowing he already has visual disorders and type 2 diabetes which can lead to the blindness of the patient.

Since the graphs of attacks [25] are made from arguments with the same concern, so we assume here that all stakeholders have the same concern as follows: *Ensuring a good quality of life for this elderly patient*. More arguments with the same option do not attack each other [25]. Thus the graph of attacks obtained is depicted in Fig. 6.

The graph of attacks achieved above will permits to identify the different possible extensions (representing the *acceptability semantics*) on which we will based for decision making. According to the arguments the different sets we can have are:

- $\{\emptyset\}$
- $\{\alpha\}$, $\{\beta\}$, $\{\gamma\}$, $\{\delta\}$
- $\{\alpha, \beta\}$, $\{\alpha, \gamma\}$, $\{\alpha, \delta\}$, $\{\beta, \gamma\}$, $\{\beta, \delta\}$, $\{\gamma, \delta\}$
- $\{\alpha, \beta, \gamma\}$, $\{\alpha, \beta, \delta\}$, $\{\alpha, \gamma, \delta\}$, $\{\beta, \gamma, \delta\}$
- $\{\alpha, \beta, \gamma, \delta\}$

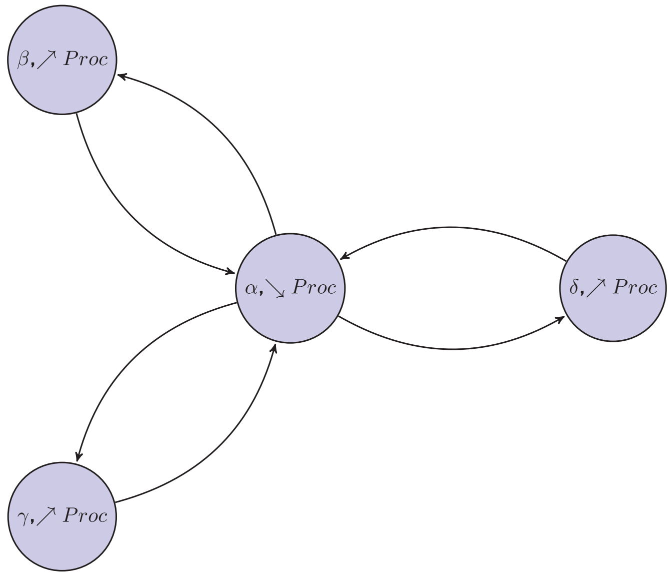

Fig. 6. Graph of attacks.

Decision making process

The different extensions below are determined according the definitions above.

- **Determination of conflict-free sets**: the conflict-free sets are: $\{\emptyset\}$, $\{\alpha\}$, $\{\beta\}$, $\{\gamma\}$, $\{\delta\}$, $\{\beta, \gamma\}$, $\{\beta, \delta\}$, $\{\gamma, \delta\}$, $\{\beta, \gamma, \delta\}$.
- **Determination of admissible extensions**: the admissible extensions identified are: $\varepsilon_1 = \{\emptyset\}$, $\varepsilon_2 = \{\alpha\}$, $\varepsilon_3 = \{\beta, \gamma\}$, $\varepsilon_4 = \{\beta, \delta\}$, $\varepsilon_5 = \{\gamma, \delta\}$, $\varepsilon_6 = \{\beta, \gamma, \delta\}$.
- **Determination of preferred extensions**: according to the definition above the preferred extensions that we can have are $\varepsilon_2 = \{\alpha\}$ and $\varepsilon_6 = \{\beta, \gamma, \delta\}$.

So according to Definition 5, all the arguments are credulously accepted in this case study. And then they are all returned to the requesting physician for the final decision, i.e. making a choice of "maximising or minimising the procedure".

In this case the final decision is to "maximise the procedure" because the patient is an elderly and a priority is given to the advice provided by the geriatrician which is conducive to the "maximisation of the procedure".

6. Discussion

Generally in the case of telemedicine, patients with diabetes are supported with telemonitoring which will ensure patient's daily stabilisation. However, in the case of chronic diseases such as diabetes the telemonitoring must be accompanied by teleexpertise [3] because diabetes can have several effects on other organs, hence the necessity of multidisciplinary team to provide better treatment to the patient.

For cultural and financial reasons some people are suspicious of new medical technologies. That is why the point of view of the patient's family has consolidated the decision of the internist in making non-invasive actions. However, he considered fundamental to implement actions *(quality of life, teledialysis, telemonitoring)* for the management of this chronic disease.

Given that the argumentative logic ensures the traceability of reasoning: this traceability will support the decision-making process and its understanding for favouring the checking of telemedicine's procedures quality. Thus in case of judicial proceedings the responsibilities of each of the stakeholders will be identified.

The solicitation of Artificial Intelligence techniques to deliver a support for decision makers at the operational, tactical or strategic levels has likewise been established in some comparable research works. From that point, the provision of decision support tools is very significant for problem solving in crisis management efforts (e.g. environmental, financial and health crisis). In particular, the PANDORA system [29] is an advanced learning environment that can focus more on the adaptable training services tailored to the respective experiences of the strategic decision makers. On the one hand, the strong point of the PANDORA general architecture is the integration of a Timeline Reasoning Environment (Behaviour Planner, Crisis Planner, and Scenario Executor) with an Emotion Synthesizer to support personalisation. On the other hand, the strength of our proposal is to improve collaboration between health professionals for the implementation of teleexpertise processes, whether in private clinics or in public hospitals (e.g. collaborative activities for the management of critical situations). The principles upon which the telemedicine is founded, by promoting conditions of information distribution and knowledge sharing, engage in continuous learning and experiential development with a practical emphasis on generating a learning organisation.

For the security and the data privacy point of view since we are handling medical data which are very sensitive, hence these constraints should be taken into consideration for the telemedicine acts. In this framework, the manipulation of data and preparation of data needs an informed consent process of the concerned patient, so that he could know how and what his personal data is used for. Given that we use secured webservices based on Https protocol to retrieve remote medical information, the data security is thus guaranteed on our side. From the remote sites, the data must be encrypted: this will then depend on what security protocol the remote site uses. It is right that in Europe there is no such system like HIPAA[10] which guarantees data privacy and security [30,31], but some efforts are currently being made for the introduction in France of the Personal Medical Record called in French DMP [32]. These two conceptions have some similar points such as authentication before access, patient's medical data protection, secure electronic transfer of medical data.

7. Conclusion

In this paper we proposed a methodological framework adapted to the telemedicine concept, particularly for the act

[10] Health Insurance Portability and Accountability Act.

of teleexpertise involving collaboration between several health professionals and or medical professionals for decisions making. The designed architecture includes an important component called *argumentative logic* which permits to ensure the traceability of the decisions making process. The *argumentative logic* has been illustrated by a use case in which many participants (internist, opthalmologist, geriatrician, diabetologist) collaborate to take the right decisions to treat the patient with diabetes and visual disorders. In this case study the conclusion is that the arguments supported by opthalmologist, geriatrician and diabetologist (the latters sustain the ***Procedure maximisation***) are accepted while the argument of the internist (for ***Procedure minimisation***) is rejected. This shows that the treatments that will be administer to the patient have to maximise the procedure.

The *argumentative logic* guarantees the traceability of the decision since it shows that different steps which lead to the decisions making and at last shows which decisions can be taken. So that, by ensuring this traceability, it will permit to favour the checking of telemedicine's procedures quality, also by the use of Cogui software the reasoning could be easily visualised. In this perspective, the traceability considerations are of relevance for legal procedure to identify and assess the specific responsibility of each stakeholders [33–42].

In further work, we will implement our proposed architecture in order to verify it feasibility. This implementation will consist to instantiate the proposed argumentation system in conceptual graphs which permit to represent rules and constraints. The interest of introducing such formalism is dual: (i) the same way that it can handle the abstraction of the system by redefining the logical framework of acceptability, (ii) it may also be an appropriate model to represent the internal structure of arguments and generate conventional interactions previously introduced (graph of attacks). Finally, an important prerequisite to generate the maximum advantage from our framework is the development of an accurate software to the proposed architecture.

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Mamadou Bilo DOUMBOUYA: He is a PhD student at the University of Toulouse and he is affiliated to two units of research namely the Institute of Private Law of and the Production Engineering Laboratory (LGP) of National Engineering School of Tarbes (ENIT). He received his Research Master Degree from the University Paul Sabatier of Toulouse and the National School of electrical engineering, electronics, computer science, hydraulics and telecommunication of Toulouse (ENSEEIHT) in 2011. His research activities deal with Telemedicine generally and teleexpertise particularly. His work is focused in Artificial intelligence, semantic modelling for improving the collaboration between remote medical professionals while taking in consideration the ethic side.

Bernard KAMSU FOGUEM: He has a PhD in Computer Science and Engineering from the University of Montpellier 2 in 2004. He got the "accreditation to supervise research", abbreviated HDR from University of Toulouse in 2013. He has obtained the status of Visiting Professor at international universities: United Kingdom (e.g. Oxford Brookes University, Oxford), Finland (e.g. Aalto University, Helsinki University of Technology, VTT Technical Research Centre of Tampere, University of Oulu, Åbo akademi of Turku University). His current interests are in Knowledge Discovery and Data Mining, Knowledge Representation, Formal Visual Reasoning, Ontology-based Semantic Analysis, Knowledge Exploitation for remote Collaboration, Decision Support Systems and Intelligent Systems. Application domains include industrial Continuous Improvement processes, Telemedicine services and Health Information Systems. He is a reviewer for a large number of international scientific journals such as Computers in Biology and Medicine, Knowledge Management Research & Practice, Interacting with Computers, Sensors, Engineering Applications of Artificial Intelligence and Knowledge-Based Systems. He is a member of the thematic group: e-Health of InterOP-VLab (International Virtual Laboratory for Enterprise Interoperability).

Hugues KENFACK: He is the Dean of the faculty Law and vice president for academic affairs at Toulouse's University. He has the status of Visiting Professor at American universities: Saint Louis University School of Law – USA (2009, 2011, 2013, 2014) and San Diego University School of Law – USA (2013). Professor of Law in University of Toulouse since 2004 (PhD in Law, University of Toulouse I (1996)), he is particularly expert in Law of Obligations and Contracts, Business Legal Instruments, Payment and Credit Instruments and International Law (Trade, Financial, Distribution, Commercial, Bankruptcy and Foreign Investment). He had other administrative positions at national universities: member of the specialist's commissions at the University of Poitiers, Nantes and La Martinique. He is member of jury panel (Bar Examination and Admission of notaries). He has editorial charges: editorial-in-Chief of the Transportation Law Chronicle and Co-Editor in Chief of the Commercial Lease Chronicle.

Clovis FOGUEM: He is an Internal Medicine and Geriatric medical doctor and has undertaken a PhD on 'Olfaction and Elderly: study of the olfactory (CN I) and trigeminal (CN V) sensitivities interactions in a geriatric population; constants and pathological specificities'. He is also particularly interested in neurodegenerative diseases (as Parkinson disease or Lewy Body dementia), elderly epilepsy and whether pathogenic inflammatory or autoimmune responses can contribute to these disorders in the elderly. Moreover he is also interested in medical knowledge representation and medical clinic design guidelines. For his work on 'Olfaction and Elderly', Dr C. Foguem was laureate of Health Research Award for emerging health researchers from the corporate foundation 'Groupe Pasteur Mutualité' in 2011. He is grounded in medical research applications of Information and Communications Technology. Former Faculty of Medicine's Clinical Instructor, he is now Hospital Practitioner in France. He is peer-reviewer of many scientist journals among which: Clinical Interventions in Aging; Degenerative Neurological and Neuromuscular Disease; International Medical Case Reports Journal; Neuroscience and Neuroeconomics; Clinical Medicine Insights; Journal of the Pancreas; International Scholars Journals (ISJ); Cancer Therapy; Indian Journal of Critical Care Medicine and, African Journal of Environmental Science and Technology.