DESIGN OF A HEALTHCARE SERVICE: TELEDERMATOLOGY

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ABSTRACT

Teledermatology (TD) is an application of telemedicine i.e. clinical healthcare using IT-technologies, for skin disorders. This past decade, several publications have studied its feasibility and medical interest. As any innovative system, challenges in telemedicine now stand on large-scale deployment, appropriate user identification, economical and organizational models. Ahead any technological solutions and in the perspective of TD implementation in the French medical healthcare landscape, a key factor may be to design a robust and relevant system fixing the need and the priorities to decision-makers or industry-service. Regarding a design engineering approach, we performed an original study considering TD as any complex system and innovative service to design. This approach of a healthcare system using innovation conception tools and system functional analysis, will identify specific users, use-scenarios and the main functions, which have to be carried out by TD.

Keywords: teledermatology, telehealth, design, systems engineering, functional analysis, innovation

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1   INTRODUCTION

Telemedicine is the use of telecommunication and technologies to provide clinical healthcare at distance. For skin conditions, teledermatology (TD) is the dermatological application of telemedicine. This past decade, scientific production provided a great number of publications focusing on feasibility studies and medical applications.

As any innovative service, challenges in telemedicine now stand on large-scale deployment, appropriate user identification, economical and organizational models.

In France, a legal framework recently fixed telemedicine medical practices, but no sustainable funding source or organization. Ahead any technological solutions and in the perspective of TD implementation in the French medical healthcare landscape, a key factor may be to design a robust and relevant service fixing the need and the priorities to decision-makers or industry-service.

As previously described, design engineering tools may be used to design new organizational processes in the healthcare context (Reid et al. 2005).

Regarding a design engineering approach, we propose an original study considering TD as a complex system i.e. service to design. Using a systemic approach and considering TD as an innovation, the aim of this paper is to provide an innovative service. First section of this paper provides the academic background regarding TD (limitations and issues) and describes TD as complex (multi stakeholders) innovative system. Second section presents our design process use-scenarios and the first results of functional analysis (functional tree). This approach of a healthcare service will identify specific users, use-scenarios and the mains functions, which have to be carried out by TD.

2   SYSTEMIC APPROACH TO MODEL TD

Considering TD as a complex and innovative system i.e. service, we performed a systemic approach using design-engineering tools. To model our ideal service, we first determined our system: TD, scope then its canonical description through its environment, transformation, functions and finalities (Le Moigne 1994). To set the problem associated to this innovation, we used the method of macro-stage problem setting and problem solving described in the Value & Management Radical Innovation Design (RID) Method (Yannou et al. 2013). RID specifically considers contextual factors and is used for conceptual design and process radical investigation of the highest value-creating design solution.

While TD development is an answer to provide an equal medical access with decrease delay and appropriate patients orientation in the healthcare system, problem raised by its development and implementation remain to be: Who is this service for? What is this service design for? When and how do you use this service? What is this service cost? Is this service a sustainable organization or sustainably funded? Using problem-setting approach, we identified the main locks for TD development, dissemination, implementation and the key factors as country local environment, legacy, medical healthcare and insurance, to model a relevant service.

To model the ideal service our conception process included users and index pathology identification, expert user scripts. To identify the main functions to be carried by this service, we also performed functional analysis.

3   BACKGROUND

3.1   Literature review

Our literature analysis using the following key words: "telemedicine in dermatology", teledermatology", "organization", "economic model" provided studies on medical use, feasibility, medical impact of the technology, and some economic models or description of each stakeholder (primary care doctor, dermatologist) involved in the system (Warshaw et al. 2011; Armstrong et al. 2011). Two medical practices were identified in TD, store-and-forward (SF) consisting on patient data transmission with clinical pictures and Live-Interactive (LI) consisting in a real time consult using videoconferencing system. TD was considered as a relevant answer to the decrease number of dermatologists, the improvement of medical access in rural communities, the improvement of medical delay to consult and the emergency triage or critical situations. Limitations did not rely on technological aspects but mostly on sustainable and funded organizations.

Most of the TD programs (49%) were carried by institutional organization (Armstrong et al. 2012). Cost effectiveness was raised for patients living above 75 km of a dermatologist and organizational studies of TD applications displayed a gain of time for the dermatologist (7min vs 19min) while primary care doctor investment was increased from 10 min to 20 min when comparing TD to face-to-face consultations (Eminović et al. 2010). Sustainable TD programs included a strong interest of the medical community and financing computer hardware, IT platform design, annual maintenance and doctors' retributions. Countries state authority willingness such as California medicare-financing TD consults, was one of the key factor for TD program success.

Regarding the indisputable medical interest of TD, in the medical deployment strategies, two questions were raised: how to establish a TD service in the medical landscape, regarding a pre-existing country healthcare system? How to provide a sustainable organization?

3.2 Teledermatology a complex system

Health and teleheath were previously considered as complex system regarding the multiplicity of their elements, interactions and relationship (Jean et al. 2012). As a dermatological application of telehealth, TD may be considered as a complex system involving some elements of telehealth but also having its own stakeholders, users and application fields. Table 1 identifies stakeholders' type and role in the system: financing, assessing, designing or using it.

Beside its numerous stakeholders, TD is a complex system regarding its multiple finalities i.e giving medical advice, organizing healthcare offer, and the different technological support i.e. real time LI or non real time i.e. SF.

Table 1. Teledermatology stakeholders list and role

Type	Identification	Role
Financial Investors	State Local state Universities Regional Health Agency Private and public hospitals Complementary Health Insurance French National Health Insurance Fund for Salaried Workers	Financing Limited and sustainable funds Consultations remuneration
Assessors	French National Authority of Health French National Agency for IT French Data Protection Authority Patients groups National physicians union	Assessing Guarantee the service conformity with the law, the service standard, the service quality
Requesting Physicians	Primary care doctor Emergency unit physicians Geriatric physicians Nurses Hospitals without dermatologist	Using Request dermatologist consultation
Telehealth team	Specialist (here the dermatologist) Telehealth assistant	Using Contribution to dermatologist consultation
Patients with skin disorders	Acute skin disorders Urgent skin disorders Chronic skin disorders Without dermatologist	Using Give the emergency level of the request
System Designers	IT engineer Dermatologist IT society	Designing Service design and conception
Other Systems	Conventional dermatology Dermatologist networks organizations Healthcare networks	Linked networks

To represent the complexity associated to the development lifecycle of our system, we used the v-model graphical representation. V-model objectives are to minimize project-risk, costs associated to conception process, to improve and guarantee the communication between all stakeholders and the quality of the process model (IEEE, 2012). Using this graphical representation, we decomposed our system lifecycle into the following phases:

- Need analysis expression of the ideal need
- Users requirements
- System specifications, functions analysis
- Technical architecture
- Detailed design
- Unit integration testing
- Installation qualification
- System verification and validation
- Users acceptance testing
- Users reporting

The left side of the "v" represents the decomposition of requirements and specifications of the system, while the right side represents the validation and verification of the development process (Figure 1).
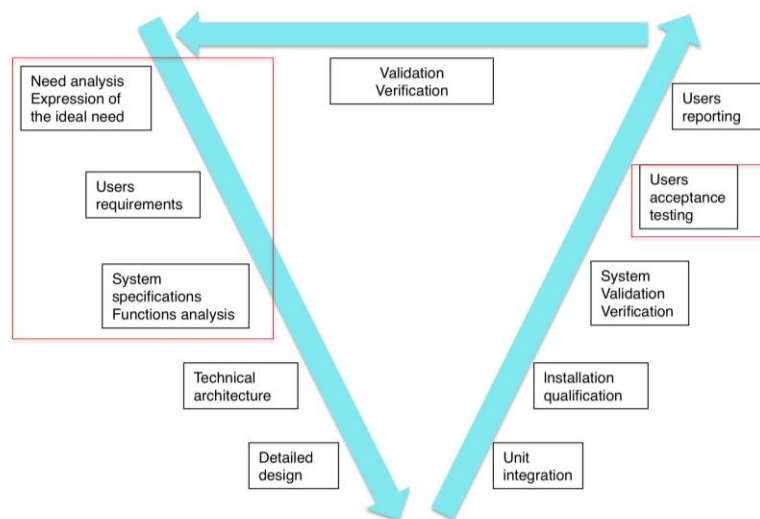

Figure 1. V-model lifecycle

At this stage of our design process, this paper presents the three first steps of the "v" left side: need analysis, users requirements and system specifications, functions analysis. In parallel to verify and validate our designed use-scenarios, we will perform users interviews (right side of the "v") to test the users acceptance and reporting of preexisting TD system.

3.3   Teledermatology an innovation service

Innovation is defined as an idea, a practice or object, perceived as new by an individual or other unit group (Zimmer 2012). Innovation can either be technological, social, organizational or economical. Innovation determinants combine new market opportunity, risk evaluation, stakeholder decisions, benefits and novelty evaluation. Its management includes the management of idea, production and new product management (Boly 2008). Innovation process is also characterized by its dissemination, adoption, implementation and continuation (Fleuren et al. 2004).

Innovation as defined by healthcare practitioners is a new way of helping medical professionals to work smarter, faster, better and more cost effectively while providing high-quality care.

In healthcare organization innovation determinants include the following characteristics social or political context, organization, users, and technological innovation. In France for a population of 60 10^6 inhabitants, the decrease number of specialists, the increase ageing population and the unequal access to dermatologic healthcare with a specialist density varying from 1 dermatologist per 20000 inhabitants to 1 per 400000 inhabitants (Syndicat des dermatologues 2010) justifies to develop a TD service to decrease time to consult delay or improve medical access. Using the development of new

information technologies (IT) and the experience of various feasibility studies on the medical impact and the comparison with conventional care lead us to consider TD as medical innovation or an innovation for dermatology practice. The novelty using TD process will be for primary care physicians (PCP) for to transfer patient data and clinical images to a dermatologist who will help them in skin disorders management. This process would not require patient presence or unnecessary travel to the dermatologist practice. If necessary, it would also give the emergency level to schedule a visit. It would also provide a new support of continuous medical education increasing PCP dermatological knowledge by including him in the dermatological consultation process. For dermatologist, this new tool will organize patients visit, and increase the quality of patients data exchange with requesting physicians.

4   CONCEPTUAL STATIC MODEL OF TD

4.1   Design an innovation service TD
A design process is initiated by the recognition of a need, leading to the establishment of requirements for the intended system ie product or service (Chakrabarti et al. 2004).
Design process of complex system may be split in 3 phases (Raymer 1999)
- Conceptual design
- Preliminary design
- Detailed design

In conceptual design phase, establishing system requirements or function analysis may be critical.
System requirements may be specified by the expression of the existing solution, the ideal need or use-case scenario. Functional Analysis is a fundamental tool to design process, to explore new concept or new product. It is also used by engineers to refine the new product's or service functional requirements, « to map its functions to physical components, to guarantee that all necessary components are listed and that no unnecessary components are requested and to understand the relationships between the new product's components » (Viola et al. 2012).
In this part, we describe the conceptual design phase via its requirements, and functional analysis. Functional analysis in conceptual design first starts with the system i.e. product or service mission statement then mission objectives. Primary results of functional analysis are functional tree then the detailed system architecture.

4.2   TD missions
To establish our system missions we used the APTE method® and assessed to the following questions:
- Who is the system designed for? (Users?): patients, dermatologists, primary care physicians, healthcare establishments.
- What is the system designed for?: access to medical care, decrease delay to consultation, to confirm the need of specialized consultation.
- Why is the system designed? (Aim?): specialized consultations, triage, gain of time (medical and patient), travel limitations.

4.3   The existing solution and the expression of ideal need
Conceptual design includes the description of the existing solution and the ideal need associated to a new product or system design (Yannou et al. 2013). The role of process modeling has been widely recognized for effective quality improvement. In healthcare, processes require the cooperation of different units and medical disciplines. To improve healthcare quality process management and organization, workflow technology and IT support display a huge potential (Lenz & Reichert 2007). In their paper Jun et al (Jun et al. 2009) described the relevant methods for healthcare process modeling. Process content diagrams were considered as helpful in making an exhaustive list of activities and flowcharts diagrams were widely used to describe the sequence of activities. To represent the existing solution, the expression of the ideal need, we used flowchart diagrams to model the conventional in person dermatological consultation and the teledermatology process (Figure 2).
In dermatology, conventional care is considered as the existing solution to provide a solution to a skin disorder problem. When happening, skin disorders lead the patient to consult either directly the dermatologist or a primary care doctor. PCP can either solve the dermatological problem or request a

dermatologist consultation. In this process, the patient has to find and schedule a dermatologist visit and perform an outward and return trip to the dermatologist practice. This process may be impaired by a decrease number of dermatologists, an increase delay to consultation. It also can create unnecessary consultation or cost (travel cost, consultation). Skin disorders triage using SF TD could either completely solve the problem or organize if necessary a face-to-face consultation, a video or LI consultation or further SF TD (Figure 2).
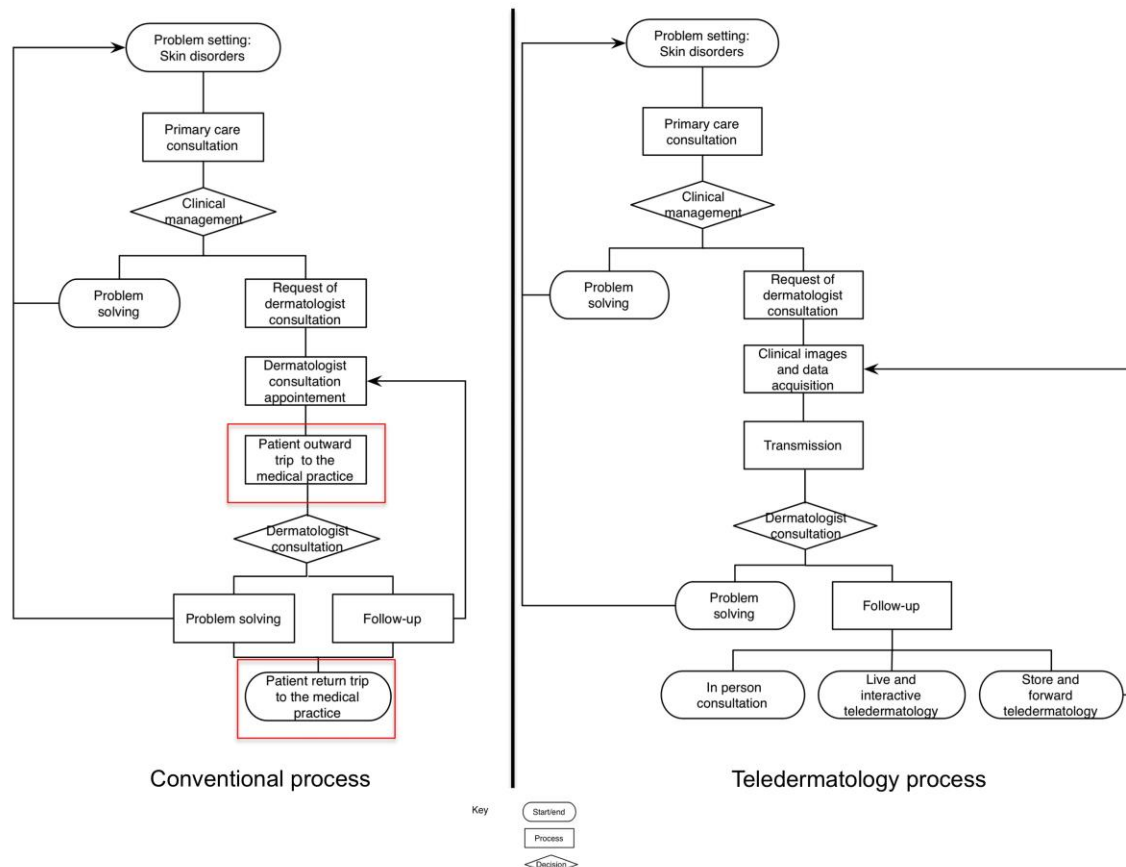

Figure 2. Description of an existing solution to solve skin disorders: the conventional process and the Teledermatology process

Regarding our literature review and the expression of the ideal need, we identified three relevant use-case scenarios (Figure 3).
- A triage scenario, to manage emergency cases
- A scenario for chronic skin disorders management
- A scenario for continuous medical education

This scenario enables an answer to the problems associated to the conventional dermatological process (Figure 3): decrease number of dermatologists, unequal medical access, increase delay to schedule a dermatologist visit, patient inefficient orientation in healthcare system. Scenario 1 facilitates patients orientation when skin disorders, and their appropriate management using either conventional or TD process, optimizing delay to consultation (Figure 3). Scenario 2 enables the management of patient with chronic skin disorders (Figure 3), avoiding their unnecessary travel to consultation.

These scenarios validate our functional analysis that characterized the main and necessary functions carried out by our system.

4.4   Results of functional analysis

Functional analysis objectives are functional or hierarchical tree. This part sets our system mission objectives, main functions and identifies some of the components to build our system i.e. service. Functional tree generates various branches from complex functions to the main functions that cannot split to another. To carry out the functional tree, each function is expressed as a verb and noun. Functions are as general as possible and more detailed in further levels of tree. Constraints functions

represent our system requirements or specifications. As previously described by Viola et al. (2012), lower level functions derived from higher level functions by asking "how" that higher level function can be performed and vice versa you can move from lower level functions to higher level functions by asking « why ».
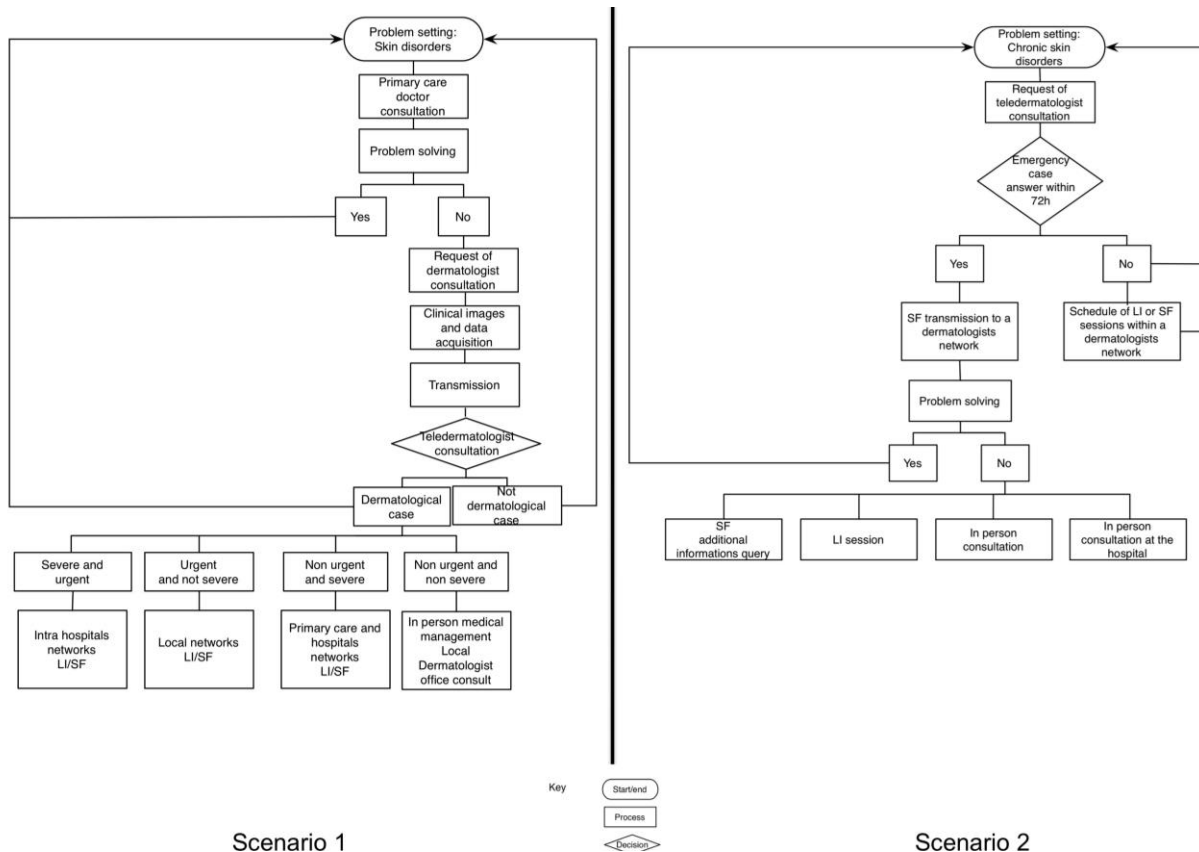

Figure 3. Scenarios identified to answer to the system ideal need. Scenario 1 is a triage scenario using TD system to facilitate patient orientation when skin disorders. Scenario 2 is a scenario for patients with chronic skin disorders to avoid their unnecessary travel. LI: live and interactive, SF: store-and-forward

Concerning TD, our system objectives are to organize as networks, to give medical consultations, to give medical educations, to get medical remunerations and to give information to learned society. We also identified some fundamental components to build the system as a consultation room, a platform (web and for teleconsultation). Any system or sub-system i.e. platform should also be sustainable and web-accessible.

Our functional analysis identified 26 main functions and 8 constraints functions (CT) (Figure 4).

Example of the functions highlighted by this hierarchical tree:

- TD as network organization has to be: CT1 link preexisting networks; CT2 link to conventional dermatology; F6 organize dermatologist in network.

- TD, to give medical consultations, has to use a platform that can welcome physical consultation, with a telemedicine assistant that would help the requesting physician to organize a LI consultation with the dermatologist.

Functional tree displays that TD aims not only at giving dermatological consultation to any requesting physicians. To ensure the quality of the process, the system has to be designed as linked to preexisting systems as conventional dermatology. Its users (requesting physicians or dermatologist) may priory be included in a network ensuring the quality of the information and data transferred for a medical advice. This functional tree highlight the main functions that have to be carry out by our system, detailed design will give the technical component requirements for our system.

At this stage of our study, we are testing a scenario triage in skin tumors that are non-urgent and severe dermatological cases. Skin cancers mainly occur in elderly patients sometimes in institutions without

dermatologist. Their management may not suffer from an increase delay to schedule a visit. This scenario tests clinical images and data transfer between the requesting physicians and dermatologist using a web-based application. It validates the functions F2, F7, F14, F15, F21, F22, CT3, CT4. Evaluation of this process including medical performance (diagnosis accuracy), users satisfaction, and cost will be performed on 60 patients.
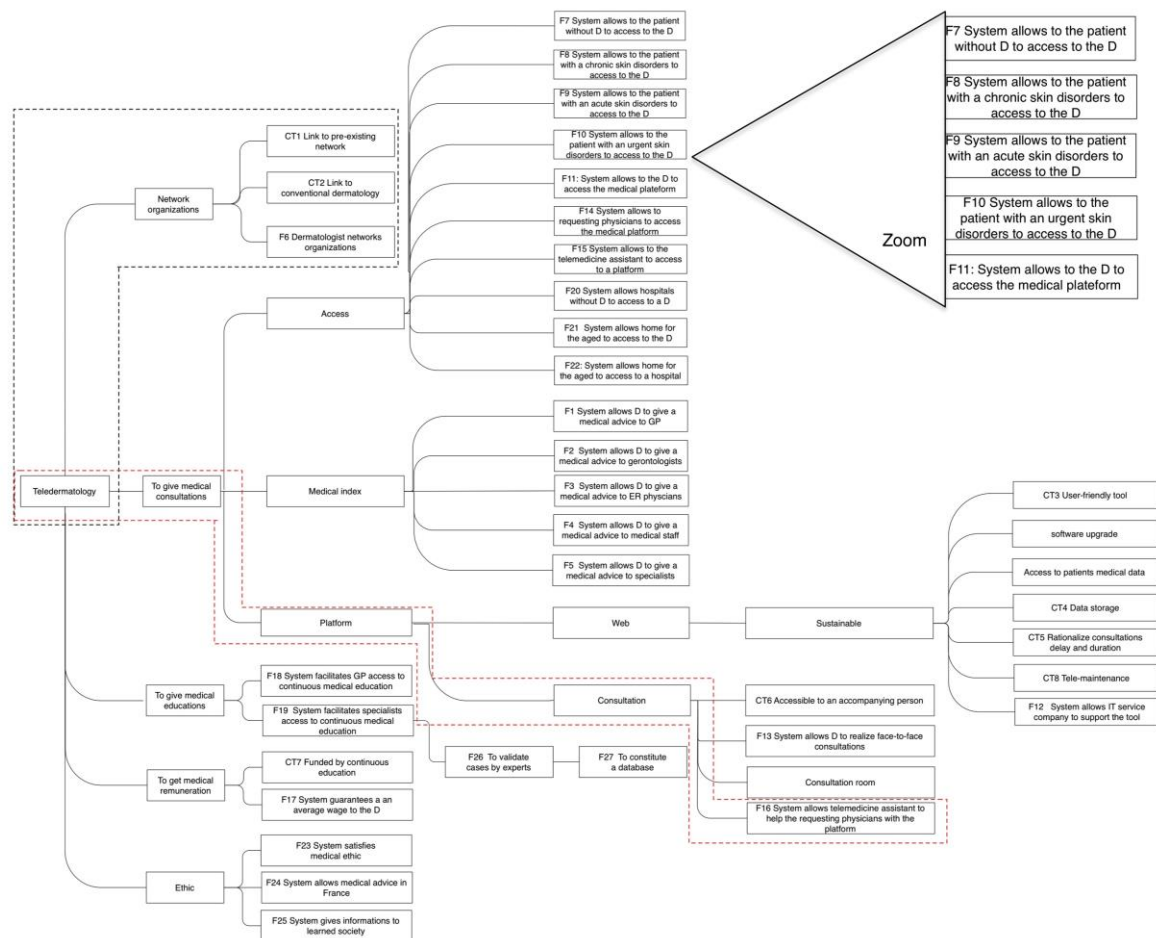

Figure 4. Teledermatology functional tree

5   CONCLUSIONS AND PERSPECTIVES

In France, a sustainable healthcare is financed either by an institution or the reimbursement of the medical activity. If lot is done and published about the medical relevance or medical accuracy of telehealth service, its sustainable development or implementation is poorly described. IT and technological issues are not a major challenge for TD implementation while the definition of a solution meeting the identification of patients, professionals and other stakeholders' needs is a cornerstone. Our systemic approach aimed to design a relevant and sustainable service to implement in the French medical landscape.

Our searches determined the expression of the ideal need and indentified three relevant scenarios. Functional tree highlighted as a main function users organization via networks. Further work includes subsystem specifications i.e. platform, specific design, technological solutions and a study of value creation, economical and organizational models. To validate our designed service, we will propose a prototype with a case study. This work may also contribute to fix priorities for healthcare decision-makers or IT-service companies concerning TD service, its development, deployment and implementation.

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