International Journal of Scientific Research & Engineering Technology (IJSET)
Vol.6 pp.47-52

MOROCCAN WEARABLE ARTIFICIAL KIDNEY (MorWAK): REQUIREMENT AND USE CASE DIAGRAMS

Yassine Zahidi[#1], Abdellah Ait taleb[*2], Abdellah Boualam[**3], Mohammed Zamd[**4], Benyounes Ramdani[**5]

#Engineering Research Laboratory, ENSEM, Hassan II University, Casablanca, Morocco.

[1]yassineezahidi@gmail.com

**Laboratory of Renewable Energies and Systems Dynamics, Faculty of Science Ain Chok, Hassan II University, Casablanca, Morocco.*

[2]abdellah_aittaleb@yahoo.fr

***Laboratory of Cellular, Molecular, Inflammatory, Degenerative and Oncological Pathophysiology, Hassan II University, Casablanca, Morocco.*

[3]boulam05@yahoo.fr

[4]zamdia@gmail.com

[5]benyounsramdani@gmail.com

***Abstract*— The aim of this work is to characterize a portable ultrafiltration system allowing the treatment of hypervolemia encountered mainly in situations of End-Stage Renal Failure (ESRD) and Congestive heart failure (CHF). Indeed, changing needs and better understanding of the Pathophysiology of uremia and understanding the limitations of current ultra-filtration techniques have been challenged by the design of MorWAK overcoming the drawbacks of current techniques of liquid extraction extracorporeal way. The MorWAK device will be described according to a functional approach by the requirement and use case diagrams. Structural and behavioural approaches will be the subject of future studies.**

***Keywords*— MorWAK - ESRD - CHF - Hemodialysis - Ultrafiltration - Functional Approach - Requirements Diagram - Use Case Diagram**

I. INTRODUCTION.

Extracorporeal fluid extraction techniques, used in the treatment of hyper-volemia mainly encountered in End-Stage Renal Failure (ESRD) and Congestive heart failure (CHF) situations require hospitalization in an intensive care unit and the use of costly and bulky machines driven by a highly skilled workforce [1] - [2]. These are survival techniques rather than real alternatives to the physiological functioning of the native kidney which functions 24 hours a day. In order to improve the quality of life of dialysis patients, reduce cardiovascular morbidity and mortality mainly [3], prevent and correct the metabolic complications of kidney disease, the research team Engineering and Biomedical has developed the portable device MorWAK (Moroccan Wearable Artificial Kidney) [4] allowing the simplification of procedures for the treatment of hyper-volemia, that is defined by the increase in extracellular volume. Our team is affiliated to the Laboratory of Cellular, Molecular, Inflammatory, Degenerative and Oncological Pathophysiology (LPCMIDO) of the Faculty of Medicine and Pharmacy of Casablanca in Morocco. The critical study of current extracorporeal fluid extraction techniques as well as the assessment in 2015 of the carbon printfoot of the dialysis activity at the Ibn Rochd University Hospital Center in Casablanca demonstrated that only the development of portable hemodialysis technologies seems to be the medium- and long-term outcome to dramatically reduce the suffering of patients with ESRD and the disastrous impact of one of the most expensive and polluting health care activities on the planet.

II. TOOLS AND METHODS

To satisfy the need, you have to know it. To understand it, it must be expressed in terms of functions. To identify the functions it is necessary to have the methods and tools of analysis.

During this study, we will use a number of problem solving tools to better explain the need and characterize the MorWAK device.

A. ISHIKAWA DIAGRAM

This diagram will be used to group by category the causes that may cause a problem. In our case, it is a critical study of dialysis as it is currently done in intensive care centres with the aim of improving the quality of life of dialysis patients [5].

ISSN 2356-5608

B. FUNCTIONAL SPECIFICATIONS

The functional specification presents all the functions grouped by family. Each function is characterised by a number of assessment criteria with their levels and flexibility. The functions are ordered by importance. [6].

C. SOFTWARE Modelio SA - SysML

Maintaining the consistency and compliance with the specifications of multidisciplinary systems requires a modelling language that makes it possible to group together in a model all the trades, specifications, constraints and parameters of the entire system. Systems Modeling Language (sysML), which approaches design using the notion of blocks, is best suited to the MorWAK device. [9].

D. REQUIREMENTS DIAGRAM

This functional diagram will describe the requirements of the functional specifications. Each requirement expresses an ability or constraint to be met by the system. A requirement may express a function to be performed by the system or a condition of technical, physical, reliability, safety, ergonomics, esthetics performance [7].

E. USE CASE DIAGRAM

This functional diagram highlights the functional interactions between the actors and the system studied. It precisely delineates the system being studied and describes what the system will do without alluding to the technological solutions adopted. [8].

III. HEMODIALYSIS IN CENTRE: THE PROBLEM

Hemodialysis was introduced in the 1950s as a renal replacement technique. The first works of Willem Johan Kolff have made it possible to set up hemodialysis generators: bulky devices requiring prior water treatment but which have also saved thousands of lives. It is primarily intended for patients with chronic end stage renal failure [10]. This is the most used technique for this indication in the world. Indeed, after more than sixty years of use, few changes have been made to the basic principle [11]. The main improvements have been in accessories such as the addition of performance monitoring tools such as ionic dialysis or blood volume monitoring modules to almost all generators.

Hemodialysis is a heavy and very expensive technique. It undermines the health budget in all countries regardless of their GDP. Access to this type of treatment is therefore very limited in developing countries [12]. The high technicality of hemodialysis requires a particular organization. It is very often carried out in a centre where a machine is "made profitable" by its use for several patients in the same day. Whereas the ideal solution seems to be that each patient should have a "personal" or "individual" machine. This would make the technique overpriced and therefore inaccessible for the vast majority of patients.

IV. RESULTS

The multidisciplinary Engineering and Biomedical research team is aware of the various needs in dialysis field. It includes the improvement of the quality of life, the reduction of morbidity and mortality, the prevention and correction of the metabolic complications of kidney disease. Then, we developed MorWAK (Moroccan Wearable Artificial Kidney), a portable device that simplifies hemodialysis procedures.

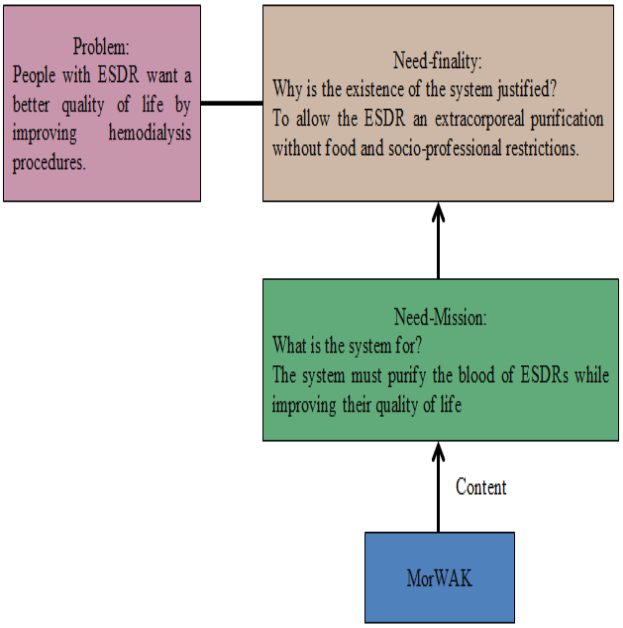

Figure 1: Initial Needs Diagram

MorWAK is therefore defined as a set of solidarity and organized elements to meet the expectations raised by ESRD patients.

The set of functions allows to identify the limits of the MorWAK, the elements which constitute it and its frontier including all the elements necessary for its functioning in all its phases of use.

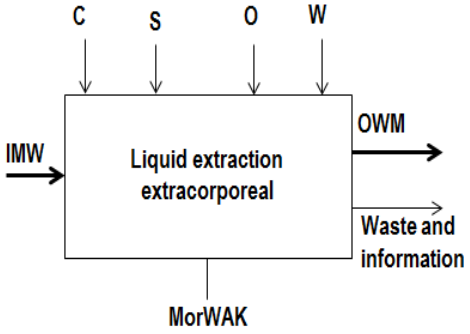

Figure 2: MorWAK SADT Model

The Incoming Work Material (IMW) contains:

- Patient in ESRD.
- Electrical energy.
- Drug.

The Outgoing Work Material (OWM) consists of:

- The dialysis patient.

ISSN 2356-5608

- Solid and liquid waste.
- The data files.
- Real-time information on the progress of the purification operation.

The energy (W), setting (R), control (C) and operating (E) parameters allow the user to customize the purification operation.

A. NEED IDENTIFICATION

The main causes affecting patient's quality of life are grouped into five main families (5M) as follows [5]:

- **Machine (Dialyzer):** The machine is profitable by its use for several patients in the same day.
- **Material:** The dialysis of an individual greatly reduces its autonomy and socio-professional performance. The life of the patients is rhythmic (3 times 4 hours per week); which restricts their movements in addition to drastic food restrictions.
- **Manpower**: the quality of service depends on the qualification of the personnel controlling the dialysis equipment
- **Method (process):** the quality of service depends on the qualification of the personnel controlling the dialysis equipment.
- **Medium:** it is at the origin of the expansion of previously known pathologies (manual transmission in dialysis centers) and the emergence of new diseases associated with dialysis

B. FUNCTIONAL SPECIFICATIONS

The critical study of current extracorporeal purification techniques has made it possible to draw up a not exhaustive list of requirements specifying the capacities or constraints that the MorWAK must satisfy. [8]

In order not to weigh down the presentation, we have grouped the requirements:

- Functional requirements.
- Technical requirements.
- Security requirements.
- Environmental requirements.
- Interfacing requirements.
- Practical requirements.
- Marketing requirements.
- Energy requirements.

These requirements constitute the technical functional specifications of MorWAK. The criteria and levels of appreciation of the functions and constraints specified by the requirements will appear in the requirements diagrams. [6]

In the following, each requirement category will be treated separately.

C. REQUIREMENT DIAGRAMS

Each of the previously defined requirements will be broken down into several unit requirements:

Functional requirements:

These requirements describe the extracorporeal treatment function for which the system is designed.

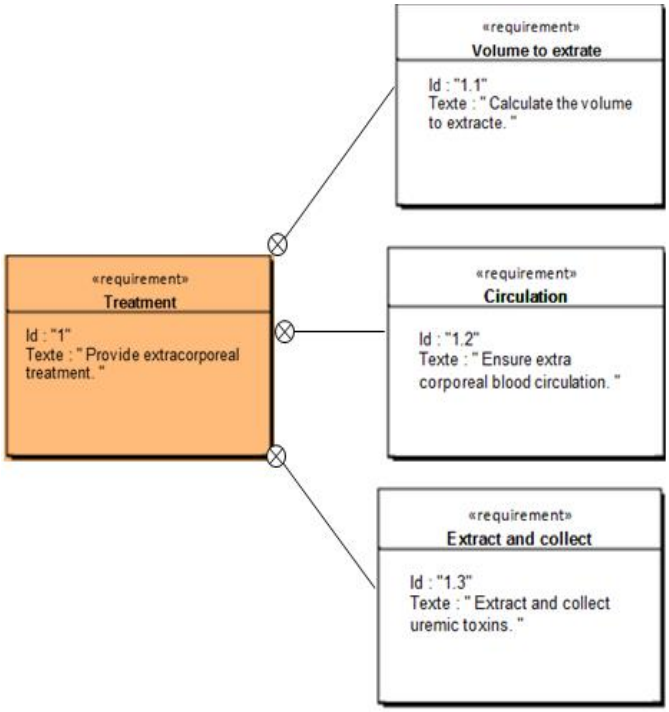

Figure 3: MorWAK Functional Requirements

Technical requirements:

This type of requirement specifies the MorWAK's performance and capabilities.

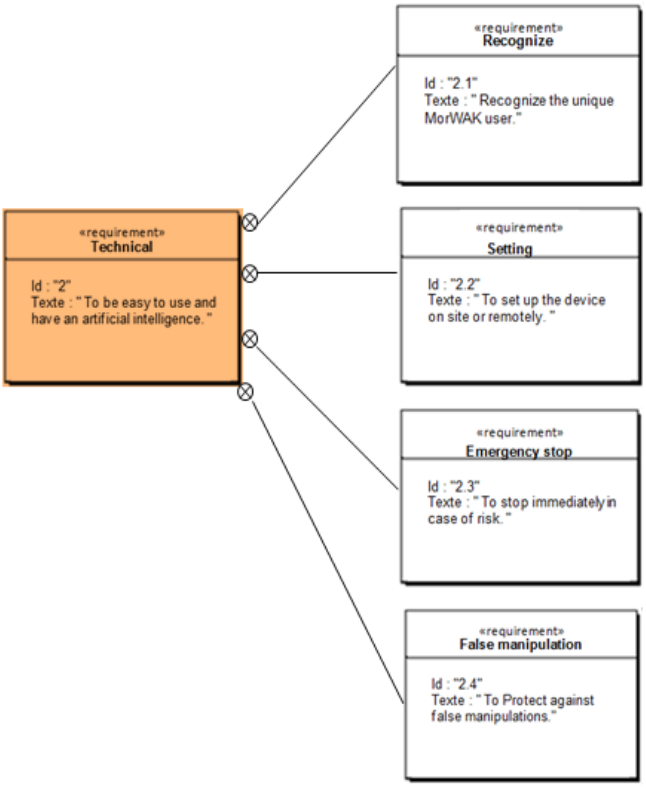

Figure 4: MorWAK Technical Requirements

ISSN 2356-5608

Security requirements:

These requirements highlight the dangers involved in using the device for better protect the patient.

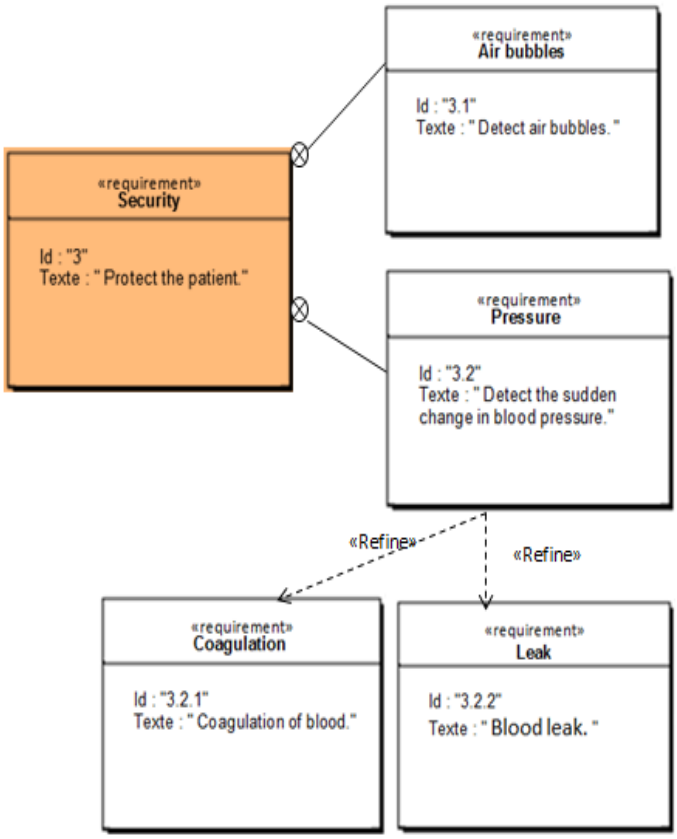

Figure 5: MorWAK Security Requirements

Environmental requirements:

Respect for the environment is imperative; the device must produce minimum solid and liquid waste.

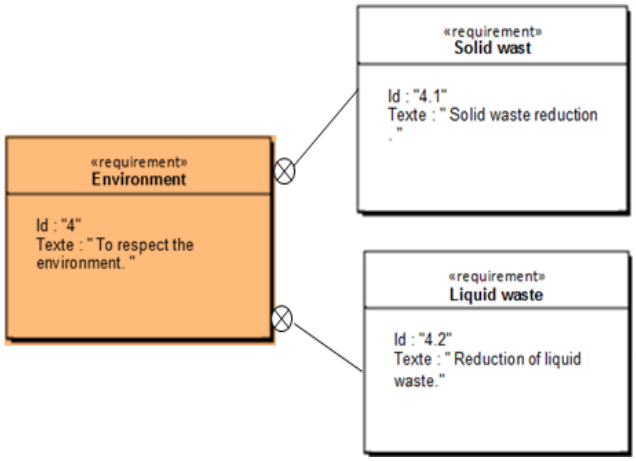

Figure 6: MorWAK Environmental Requirements

Interfacing requirements:

The use of a Human Machine Interface (HMI) is essential to allow a better interaction with the MorWAK.

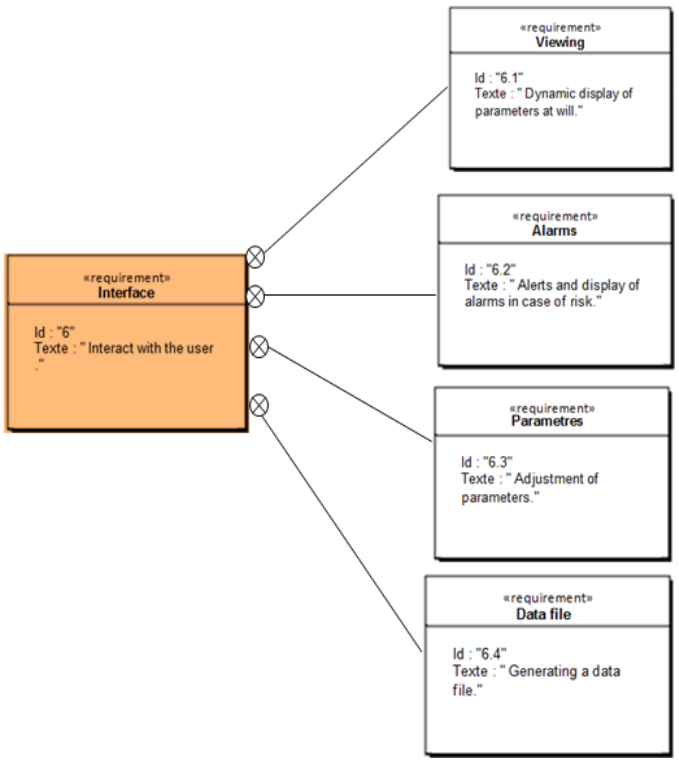

Figure 8: MorWAK Interface Requirements

Practical requirements:

Users are not necessarily technicians, which is why MorWAK must be easy to use and intelligent enough to manage risk situations independently.

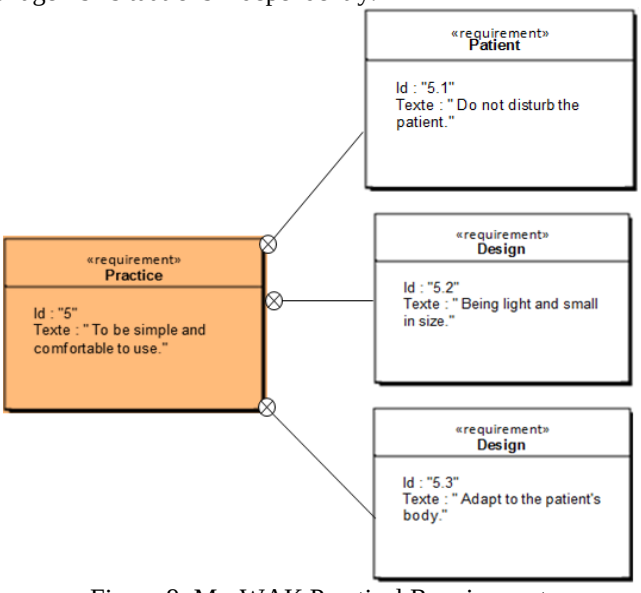

Figure 9: MorWAK Practical Requirements

Energy requirements:

The portability of MorWAK requires better management of electrical energy. The technological solutions thus adopted must not be energy-intensive.

ISSN 2356-5608

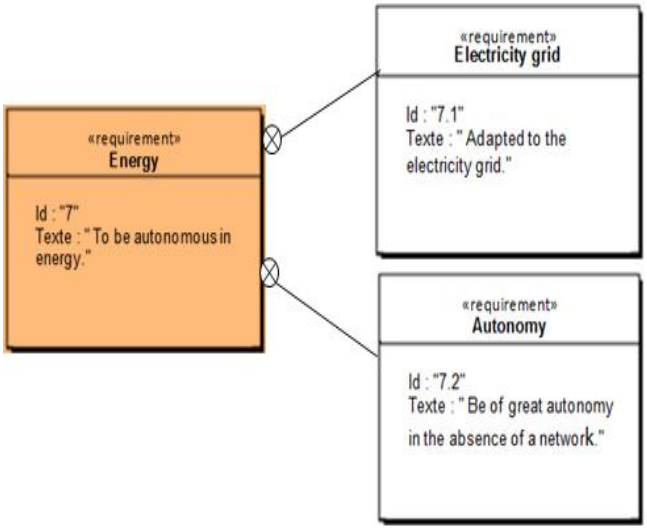

Figure 7: MorWAK Energy Requirements

Marketing requirements:

The cost of the device and its estimation functions will influence its marketing. Great attention must be focused on the choice of technological solutions.

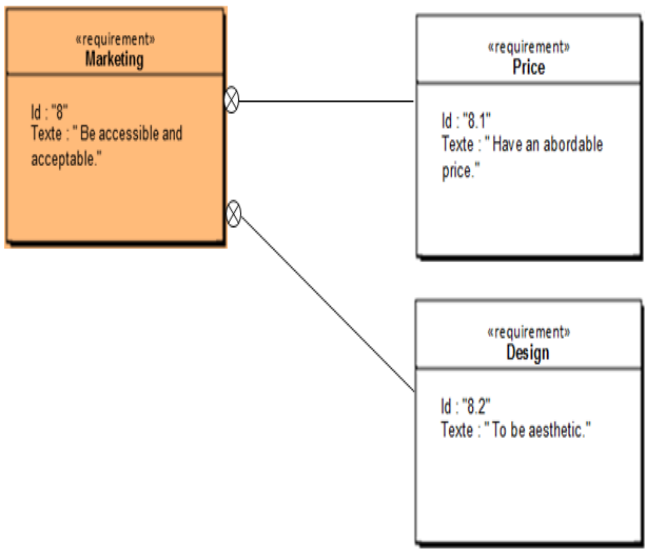

Figure 10: MorWAK Marketing Requirements

D. Use case diagram

All features visible from outside the MorWAK represent its use cases that can be summarized in four major families of features as shown in Figure 11.

V. DISCUSSIONS

The first research works of the Engineering and Biomedical team concerned research on optimal volume control means and portability in hemodialysis.

A first patent concerning a portable hemofiltration device (MorWAK1) has been published on the WIPO website under the number WO2016/072826A1 [13]. A second patent for a portable hemodialysis device has been published on the WIPO website under number WO2017/164722 [4].

The characterization of the MorWAK was the main result of the critical study of the current techniques of extracorporeal purification. A prototype satisfying the maximum requirements of the functional specifications was build. In vitro tests were carried out on whole bovine blood units using our first prototype. The results will be published soon. The animal tests are ongoing and will test the reliability, efficacy and safety of MorWAK.

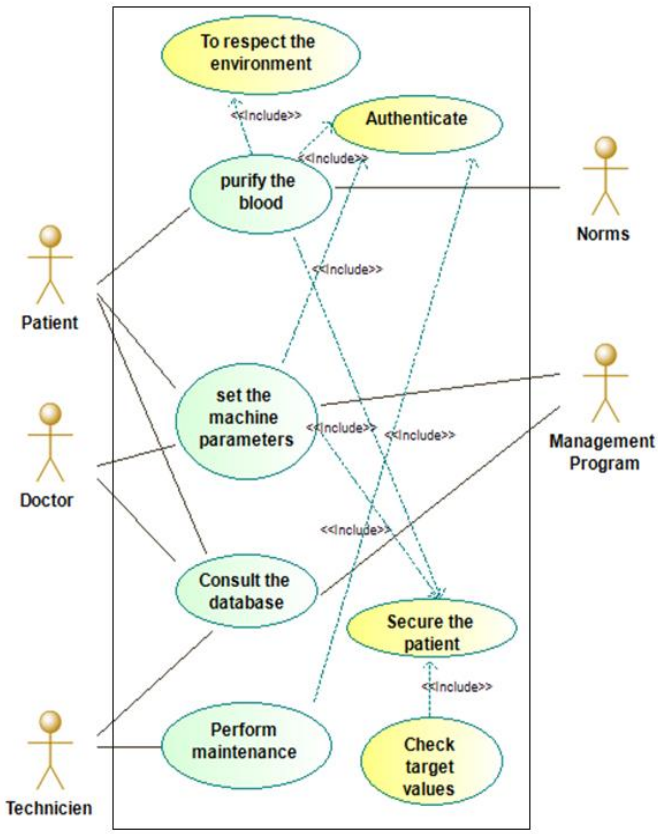

Figure 11: MorWAK Use case diagram

VI. CONCLUSIONS

The systems engineering approach adopted in this study made it possible to describe the system according to a functional approach in the form of graphs (SysML diagrams). The decomposition of requirements has simplified the representation of the system. The structural approach will define the overall hardware and software architecture of the MorWAK. This architecture is summarized under a tree representation of the blocks as well as the material, energy or information flows between the internal blocks. The behavioural approach will describe the states and transitions governing state changes and the sequence of messages between actors and MorWAK for each use case. Both approaches will be the subject of future studies.

ISSN 2356-5608

REFERENCES

[1] K.Moqadem, "Aspects méthodologiques, mesure et facteurs associés à l'autonomie des patients utilisant les technologies de dialyse péritonéale à domicile," thése.doctorat, Université de Montréal Faculté des études supérieures, Montréal, canada, mars, 2011.

[2] N. Racine, B.Cantin, A.Ducharme, È.Gagné, F.Grenier, S.Kouz, S.Lepage, V.Nguyen, F.Philippon, and S.Rinfret "l'ultrafiltration appliquée au domaine de l'insuffisance cardiaque," La Direction des communications du ministère de la Santé et des Services sociaux du Québec.Rep. 978-2-550-51034-5, 2008.

[3] RN Foley, PS Parfrey, MJ Sarnak, "Clinical epidemiology of cardiovascular disease in chronic renal disease," AMERICAN JURNAL OF KIDNEY DISEASES., vol. 32, pp. S112–S119, Nov. 1998.

[4] M.zamd, B.Ramdani, A.Ait taleb, A.Boualam, "DISPOSITIF PORTABLE POUR HÉMODIALYSE". Patent WO2017/164722, sept.28, 2017.

[5] K.ishikawa, *Guide to Quality control*, Ed.IMPRINT, 1976.

[6] R.tassinari, PRATIQUE DE L'ANALYSE FONCTIONNELLE, Ed., DUNOD, 2006.

[7] P.Roques, *Modélisation de systèmes complexes avec SysML*, Ed. Eyrolles , 2013

[8] P.Roques, SysML *par l'exemple - Un langage de modélisation pour systèmes complexes*, Ed. Eyrolles, 2009.

[9] The modeliosoft website. [Online]. Available: https://www.modeliosoft.com/

[10] W.J. KOLFF"First clinical experience with the artificial kidney," Ann Intern Med, vol.62, pp. 608–619, 1965.

[11] J.Olson, "DESIGN AND MODELING OF A PORTABLE HEMODIALYSIS SYSTEM," M. Eng. thesis, Georgia Institute of Technology, U.S, May. 2009.

[12] P.Just, F. de Charro, E. Tschosik, L. Noe, S. Bhattacharyya1 and M. Riella"Reimbursement and economic factors influencing dialysis modality choice around the world,"Nephrol Dial Transplant, vol. 23,pp. 2365–2373, January.2008.

[13] M.zamd, "DISPOSITIF PORTABLE POUR HEMOFILTRATION" patent WO2016/072826A1 nov. 03. 2014

ISSN 2356-5608