Developing the system requirements for a local health care system in Cameroon

By Mario Kossmann

Abstract

Using the example of a charity project that is concerned with the development of a local health care system in a deprived region of Cameroon, this article illustrates a systematic mind-mapping based approach [1] to developing system requirements. Particular emphasis is placed on the parallel development of a high-level system concept, representing first architectural decisions that have an influence on the development of the system requirements, which can then be mapped to specific system elements. These high-level conceptual views on the future system together with the derived system requirements can subsequently be used to launch a bidding process for the realization of specific system elements such as the construction of modular buildings of a health center by suppliers, e.g. local building companies or sub-contractors.

The project context of the system

The population in the region around the village of Siliyegue, which is about 60 km from the capital of Cameroon Yaoundé and surrounded by villages with similar needs, is suffering from multiple diseases; lack of pastoral and spiritual care; lack of secondary education, professional training and employment perspectives; lack of infrastructure such as proper roads, electricity, running drinking water and waste disposal; as well as lack of medical care in case of emergencies, in particular regarding first aid and related transportation capabilities [2].

The system under consideration is a comprehensive local health care system with a secondary school based around a new Salvatorian mission that address the needs identified above; in order to increase the spiritual and physical wellbeing of the local population in general, and thereby improve the average life expectancy and perceived quality of life. The local health care system is being designed, realized, integrated and delivered to the local population by means of an international charity project [2].

A system can be defined as an integrated set of interacting elements such as products, services, people, processes, hardware, software, firmware and information. It serves a defined purpose, may consist of a number of integrated sub-systems (‘system of systems’), and may be integrated itself into a wider system (the ‘served system’). Within a system, a number of people perform generic roles, operating different processes while using appropriate facilities, equipment and supplies, in order to serve the defined purpose of the system.

The Salvatorians (Society of the Divine Saviour) are a Roman Catholic religious order that operate globally. Salvatorian priests, sisters and brothers in the Katanga province of the
Democratic Republic of the Congo have already been running a number of nurseries, primary schools and secondary schools in the Congo, as well as two missions in Cameroon. At the global level, the Salvatorians are supported by the Salvatorian Office for International Aid (SOFIA), which is based in Rome, Italy, and facilitates financial support of development projects through governmental institutions, charity organizations and even individual donors [3].

In the following, the paper looks in turn at (1) a generic, mind-mapping based approach to develop system requirements and the importance of developing a high-level system concept in parallel; (2) a step-by-step example from the development of a health care system in Cameroon, covering the parallel development of both the system requirements and the high-level system concept; and (3) the emerging system elements and the high-level system concept of the health center that forms part of the local health care system.

**The approach applied in order to develop the system requirements and a high-level system concept**

The approach that was applied to develop the system requirements in the given example is based on mind-mapping, and systematically moves from the identification of the main stakeholders in the system and their high-level needs, via the derivation of goal hierarchies for each such need, to the derivation of system requirements based on the identified root goals in the goal hierarchies [1, 2]. For this particular application the mind-mapping tool MindManager [4] was used.

Figure 1 provides an overview of a typical mind map that was developed following this approach in order to visualize the structure and color code used. Starting from the center, one of the identified main stakeholders (white) and their high-level needs (blue) are displayed. For each of the identified high-level needs, a hierarchy of goals is derived, with each contained goal representing a decision of how we want to satisfy the identified high-level need. These goals can then be further broken down until a level is reached where we do not wish to further break down a sub-goal.

Such a sub-goal is called a root goal (orange) and will serve as the basis to derive one or several requirements (green). The decision where to stop the process of breaking down goals within the goal hierarchy depends on the specific system we wish to develop and its intended context. The underlying assumption regarding the requirements is that if all requirements of a high-level need are satisfied, the need is considered to be satisfied.
Figure 1: From stakeholders and their needs to requirements (typical structure and color code of an example mind map)

Figure 2 highlights the fact that as the system requirements are being developed, the system concept will have to be developed in parallel. In other words, decisions regarding the elements of the system at hand will have to be made that have an influence on the system requirements; whereas the system requirements specify what each system element will have to satisfy.

At the time the system requirements are validated and subsequently used for the development of the ‘real’ system, a detailed system concept should be available; i.e. first concrete ideas about the system elements and how they should interact, the physical and functional layout of the system, perhaps the location, generic roles and processes they have to perform, as well as the needed equipment and supplies – without prematurely going into too much detail.
The following section describes how this generic approach was used in order to develop the system requirements for the local health care system at hand, as well as the detailed system concept.

Developing the system requirements

The generic approach described above was used in three steps in order to develop the system requirements: (a) identify the system stakeholders’ high-level needs; (b) derive the goal hierarchies for each identified need; and (c) derive the system requirements based on the root goals of these goal hierarchies. Throughout this process the system concept was also developed in parallel.

(a) Identifying the system stakeholders’ high-level needs

Once the stakeholders of the system had been identified and grouped into a smaller number of main stakeholders (usually groups of people, many of which were generic in a sense that the individuals behind these groups were not necessarily known yet), their high-level needs were elicited and analyzed. Figure 3 gives an overview of these high-level needs.
(b) Deriving the goal hierarchies

Figure 4 displays one part of a goal hierarchy that was developed in response to the high-level need ‘The system needs to provide the population of the region with health care (medical & psychological)’. The goals could be further broken down into several levels of sub-goals until root goals (orange) were identified. Depending on the subject at hand, these root goals may be at different levels in the goal hierarchy. In Figure 4, root goals were identified at 4 different levels of the hierarchy. For example, the root goal ‘HCS_N03_G17’ is at the third level of the goal hierarchy, counting from the need on the left to the right; whereas the root goal ‘HCS_N01_G94’ is at the sixth level of the goal hierarchy. The identifiers used for needs, goals and requirements serve to uniquely identify each of them. For instance, ‘HCS_N03_G17’ stands for a goal that was developed as part of the ‘HealthCare System’ under the third ‘Need’ and was allocated the number ‘17’ within this goal hierarchy.
(c) Deriving the system requirements

Figure 5 shows an example view on how the goal hierarchies can be further extended by system requirements (green) that are based on the identified root goals (orange). In many cases the requirements are merely enriched and reformulated versions of the root goal, though in some cases several requirements are needed to sufficiently cover one root goal.

For example, the high-level need ‘The system needs to provide the population of the region with health care (medical & psychological)’ can be broken down into the goal ‘Provide health care services (at the health centre)’ and other goals. This can be broken down, in turn, into a number of sub-goals such as ‘Provide health centre facilities’, which leads to another set of sub-goals, including ‘Provide buildings’. The latter can be broken down into a set of root goals, including ‘Provide one modular building with one combined triage and reception room, unisex toilets, shower/bath room, and individual interchangeable multi-function rooms (emergency/operation room, bedrooms, consultation rooms, class room, staff room, office, canteen, kitchen, chapel, safe storage, waiting room) during stage 1’. The following two requirements can be derived from this root goal: ‘The Health Centre shall include 6 modular buildings as indicated in the System Concept’.

Figure 5: Deriving system requirements (example)
System Concept.’ and ‘Each modular building of the Health Centre shall include one combined triage and reception room, unisex toilets, shower/bath room, and individual interchangeable multi-function rooms (e.g. emergency/operation room, bedrooms, consultation rooms, class room, staff room, office, canteen, kitchen, chapel, safe storage, waiting room).’.

These system requirements were developed having already a high-level idea of the system concept or architecture in mind, and they could be allocated to specific system elements as will be shown in the next section.

Developing a high-level system concept

As mentioned above, the system concept or early ideas on the system architecture should already be developed in parallel, and in fact allow refining the goal hierarchies and deriving the system requirements in the light of these early decisions or assumptions. This process is one of convergence towards having a set of mature system requirements and at the same time a detailed and relatively stable high-level concept of the system to be realized, as was briefly explained in Figure 2.

Figure 6 presents the identified elements of the system to be developed. Cutting the system into such elements allows defining concrete work packages that can be specified by the relevant system requirements and implemented by the project that is concerned with developing the system.

![Figure 6: Elements of the local health care system](image-url)

Each of these elements can then be planned and managed individually, keeping in mind of course that the system elements later have to be integrated into the complete system by the project. Based on the developed system requirements and in light of the high-level system concept that was developed in parallel, Figure 7 provides a limited, schematic view of what the system
element ‘Health Centre’ could look like. This high-level view of the system together with the relevant system requirements can then be used to launch a bidding process with local companies, in order to receive quotes and be able to make a decision regarding the provider of this system element.

Figure 7 shows that the Health Center is intended to be located at the main road between the two neighboring villages of Siliyegue, i.e. Mawel and Nguimakong. It consists of 6 modular buildings that will be constructed in three stages, with their purpose being adjusted to different main functions depending on these stages. Each of the modular buildings is fitted with a rain water collector and connected to the road and the other modular buildings by a tarmacked surface including a small road and a car park that can also be used as a helicopter landing area in emergencies.

The modular building closest to the main road is the only building to be constructed during the first stage, and it provides a protected on/off-loading area next to the building so that patients can be on/off-loaded without getting wet in case it rains.

In the vicinity of the modular buildings and next to the main road, there is a central waste disposal and recycling area. There are two existing buildings on the plot of land on which the health center is to be built. There will be running drinking water provision for the health center that consists of a well, a pump and a reservoir that is connected to one of the existing buildings and all new modular buildings; and that has an interface to the water distribution network for the surrounding village of Siliyegue.
Conclusion

The article illustrated a systematic, mind-mapping based approach to developing system requirements, and a corresponding high-level system concept, for the development of a local health care system in a deprived region of Cameroon.

Doing so, the paper looked at a generic, mind-mapping based approach to develop system requirements and the importance of developing a high-level system concept in parallel. Then, a step-by-step example was given, starting from the identification of the main system stakeholders’ high-level needs, via the derivation of goal hierarchies for each such need, to the derivation of the system requirements based on the identified root goals of the different goal hierarchies. The emerging system elements and the high-level system concept of the health center that forms part of the local health care system were discussed.

Particular emphasis was placed on the parallel development of a high-level system concept, representing first architectural decisions that have an influence on the development of the system requirements, which could then be mapped to specific system elements. These high-level conceptual views on the future system together with the derived system requirements can
subsequently be used to launch a bidding process for the realization of specific system elements such as the construction of modular buildings of the health center by suppliers, e.g. local building companies or sub-contractors.

Finally, it is hoped that this article will be helpful reading for project leaders, project managers, system engineers and requirements engineers, in particular to those who are involved in charity projects in developing countries; who despite all the difficulties and obstacles that can be expected strive to bring about concrete improvements of the quality of life of people they may not even know, in one of the many deprived areas of our planet. May the systems they develop be successful and touch many lives.

References

About the Author

Dr. Mario Kossmann is an experienced Systems Engineer and Capability Integrator for Airbus, having previously worked for Blohm & Voss as Systems Engineer, Technical Manager and Consultant in Services Marketing. He has served as a naval officer with the German and French navies, and was awarded an MEng in Aerospace Technology from the University of the Federal Armed Forces in Munich (Germany), an MBA from the University of Warwick (UK) and a Ph.D. in Requirements Engineering from the University of the West of England. He is the author of the books Delivering Excellent Service Quality in Aviation (Ashgate 2006) and Requirements Management – How to ensure that you achieve what you need from your projects (Gower 2013), as well as numerous research publications in the field of Systems Engineering. Mario is also a certified Project Manager and a Certified Systems Engineering Professional (CSEP).