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Research Article

Role of Hospital Digital Services in Improvement of Clinical Regime of Patients

Nassim Bout[1]*, Fatima Ouzayd[1], Kawtar Retmi[2]

[1] National Higher School of Computer Science and Systems' Analysis, ENSIAS, Mohammed V University (UM5R), Rabat, Morocco
[2] Center of Biological and Medical Sciences, CIAM, Mohammed VI Polytechnic University (UM6P), Ben Guerir, Morocco

* *Corresponding Author:* National Higher School of Computer Science and Systems' Analysis, ENSIAS, Mohammed V University (UM5R), Rabat, Morocco. E-mail: nassim_bout@um5.ac.ma

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Abstract

Context: Healthcare supply chain management is the regulation of the flow of medical goods and services from manufacturers to patients. Supply chain management encompasses the planning and managing of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Therefore, it greatly helps material managers to manage through continuous improvement efforts while maintaining the quality of care. Moreover, reinforcing healthcare logistics information technology (IT) architecture immediately leads to more patient satisfaction.

Objectives: This study aimed to develop an architecture for designing efficient software aiding with the management of the healthcare supply chain.

Methods: This study showed the role of digital services in the improvement of the clinical regime of patients by presenting different approaches with distinguishing the main types of hospital logistics, such as physical flow management, food safety, and cold chain management approaches (e.g., "moving forward"), and modeling these components using the solution architecture principles of ITs, such as Business Process Model and Notation.

Results: This study proposed a hospital enterprise architecture by modeling a system to have a base for building a digital catering service that improves the clinical regime of patients.

Keywords: Hospital Logistics; Food Service; Catering Management; Hygiene; Hospital Information System; Enterprise Architecture

1. Context

A hospital is a complex technical system made up of many actions, structures, and flows of materials and individuals. Different services and sectors of operation are involved in the daily routine of a hospital. Therefore, logistics in hospitals is effective when performing its duties. In addition to medical care, hospital catering and the coordination of all logistical elements contribute to the quality of hospitals. However, to optimize the operation of services by improving the management of information and interactions between various hospital departments, the establishment of a hospital information system (IS) remains essential. Its operation increases the operating margin and guarantees the traceability of information.

Logically, the improvement of meals can hugely improve patient regime, for example, by providing support and guidance to patients during meal ordering, that electronic meal ordering (EMO) systems can do, and have an impact on hospital and patient outcomes. The digitalization of systems can provide more benefits and opens up new potential for the organization of medical care processes (e.g., enhancing the precision of diagnosis and therapy), along with conducting new technologies, such as Hospital 4.0, Artificial Intelligence, and Big Data.

This paper is organized into several sections. Section 2 reviews the importance of the hospital supply chain, and section 3 clarifies notions about the hospital catering system. Section 4 shows the way in which digitalization improves meal ordering systems, and section 5 describes a proposed hospital enterprise architecture for a digital catering system. Section 6 explores modeling hospital catering systems, and section 7 discusses conclusions and recommendations for future work related to this research.

2. Hospital Supply Chain

The main aspect related to logistics is the concept of

flow management through the application of logistics in service activities, including two types; classic logistics focused on managing the flow of raw materials required to deliver the service and service logistics designated to manage customer flows (i.e., patients in the present case) by asynchronous action on demand and capacities to arbitrate between the waiting time of customers and the desired optimization capacities (1). This study shows more interest in logistics services since hospital catering is a service; therefore, it is needed to specify the way hospital logistics optimize these flows.

2.1. Hospital Flows

As with the industrial field, hospital logistics contains the same specifics as a regular logistics function (2). Logistics is the management of the flow of things between the point of origin and the point of consumption to meet the requirements of customers or corporations. The ability to transcend the separations between trades, organizations, and functional logic is one of the main benefits of the logistics functions within hospitals; it is a global and transversal approach that promotes cooperation and decompartmentalization.

Two types of physical hospital flows are optimized by applying hospital logistics; the first one is the flow of individuals, including not only the patients' movements within the establishment but also those of staff and visitors. The second one is the flow of materials which compromises two types, namely incoming flows (e.g., patient file, meals, clean linen, and general consumables) and outgoing flows (e.g., crockery and dirty linen, waste, mail, and parcels); both flows, with their different directions, are entering the kitchen supply chain of the hospital.

Regarding the logistics of physical flows, a study (2) highlights some phases of the potential development of hospital logistics; among these phases, this study defines the embryonic logistics, including stewardship logistics (e.g., catering, laundry, and cleaning) and distribution logistics (e.g., drugs and single-use products), based on the principle of high flow management.

2.2. Benefits of Hospital Supply Chain

Supply chain logistics extends integration to external structures involved in the supply chain, such as cooperative health structures and external service providers. These two kinds of development phases are the most important ones to the objectives of this study. Briefly, supply chain management provides many benefits for hospitals and some challenges to gain success and customer satisfaction. Companies integrate supply chain management as a part of business giving them numerous benefits also similar to those for hospitals as follows: (1) boosting patients' services; (2) reducing operating costs; and (3) improving financial position.

There are many challenges facing the supply chain for hospitals, such as a lack of integration and poor workflow design caused by the disconnectivity of entities in the supply chain. In the present study, the supply chain which is tried to target is the catering service. Who says catering services notice the safety of food, which is an obligation?

3. Hospital Catering System

3.1. Social Aspect of Collective Catering (3)

The profit and non-profit of collective catering are the production of meals for a captive clientele, which has experienced rapid development since the end of the Second World War; in the Middle Ages, collective catering was practiced during the main meals for large staff with a different shape from today.

The number of meals produced and the purpose of the activity are two factors differentiating between collective catering and commercial catering. Regarding the offer, commercial catering may limit its offer to a fixed card or with a unique car theme and targets a changing clientele at a time when collective catering should offer a diversified food offer by targeting a captive and stable audience. More generally, the volume processed in production by the establishment for collective catering is greater. Likewise, the volume of the production is larger, which results in a higher material investment cost.

3.2. Medico-Social Aspect of Catering (3)

The collective catering market is divided into three parts, namely company catering, school catering, and medico-social catering. The latter type will be the focus of the current study. Indeed, the production of meals in hospitals and clinics and establishments that take care of disabled individuals are characterized by requiring proven technical mastery. The guests of a healthcare establishment can be children, the elderly, active adults, and individuals with disabilities. Catering can take many forms (e.g., self-service, dining at the table, and in the room). This heterogeneity generates not only the constraints related to patient status but also the service of the staff and accompanying individuals.

3.3. Functions of Hospital Catering

Hospital catering has particularly complex characteristics to model (Figure 1). Its process is distinguished by its complexity in the hospitality sector and catering, with many interrelated factors. The restoration occupies a decisive place in the smooth running of the patient stay in a hospital. Indeed, according to a study performed by food sociologist Jean-Pierre Poulain, the hospital meal should respond to the following functions (4):

- Hygienic function: This designates the fact that the food constituting the meal should comply with hygienic standards (without microbiological and chemical dangers).

- Nutritional function: It consists of ensuring the appropriate diet for each patient, despite the obstacles that

may constitute the initial physical state or the dietary changes induced by the pathology.

- User-friendly function: The conviviality of the meal manifests itself the moment the patient can share his/her eating experience with others. Few hospital services have a dining room where patients can gather.

- Hedonic function: It represents the feeling of well-being and pleasure that the meal brings to the patient confronted with an illness.

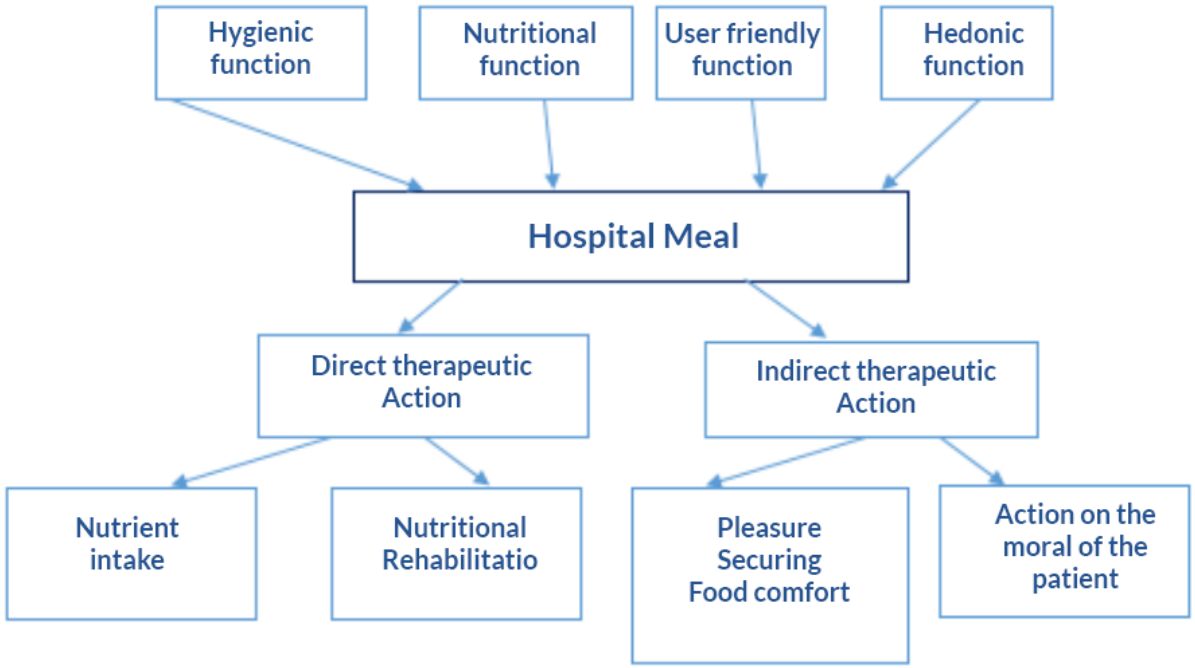

Figure 1. Functions of hospital catering according to Moret (4).

3.4. Hospital Catering Service and Food Safety Measures

Nowadays, due to the intense competition in all the fields, being in the technological and digital era is no longer a discussed issue. Hospital patients should receive safe food, especially when they are vulnerable. By going digital, many organizations could improve food safety standards.

Caterers that provide food for patients in hospitals should be aware that patients are much more vulnerable than regular customers and may have specific dietary requirements. If a patient is given the wrong type of food or unsafe food, the results could be life-threatening. However, how will a digital system help?

Several organizations, including United Kingdom National Health Service (NHS), are switching their processes to digital food safety technology and digital catering management solutions that help to bring real benefits to healthcare providers, ensuring patient safety and improving operations simultaneously (5). There are enormous benefits for using digital solutions in favor of patients and staff; for example, greater visibility and control of physical flow (e.g., managers can access in real-time mode) and digital food safety records cannot be tampered with, because they are much easier to share with supervisors. Furthermore, there is no longer a need to use paper checklists the staff needs to fill in. By switching to the digital system, productivity increases, and further food safety is ensured through automatically checking out of date products, which also saves time in total.

3.4.1. Hazard Analysis Critical Control Point

According to the literature (5), hazard analysis critical control point (HACCP) is an implementation standard intended to assess the dangers and adopt corrective measures to ensure this guarantee. This standard can be differently adapted depending on several conditions, such as equipment, design of the premises, and manufacturing procedures.

Naturally, microorganisms are spread everywhere, some of which are safe for humans, and others are dangerous (e.g., bacteria and viruses). The chance for a microorganism to grow in a traditional kitchen is high. With reference to the evidence (6), many hospitals have contracted with outside caterers for the supply of hospital meals. The NHS has set out contract standards, including a requirement that there should be a written food safety control system based on HACCP principles. Accordingly, hygiene goals in HACCP kitchens can be shortened to: (1) the prevention of contamination by microorganisms and agents harmful to food; (2) the prevention or limitation of the development of micro-

organisms already present in food.

The HACCP is based on seven principles as follows:

- Principle 1: Conducting a hazard analysis.
- Principle 2: Determining critical control points.
- Principle 3: Establishing critical limits.
- Principle 4: Establishing monitoring procedures.
- Principle 5: Implementing corrective measures.
- Principle 6: Establishing verification procedures.
- Principle 7: Establishing record-keeping and documentation procedures.

3.5. Moving Forward

Several approaches are proposed to facilitate the transition from the supply chain to the production chain. The principle of "moving forward" is among these approaches, which gives the product the possibility to advance in the production chain according to a well-established circuit and never return to avoid the crossings and the contamination of the product (4). According to a practical sheet proposed in a study (7), the authors indicate that the clean circuit should not cross the dirty circuit. Indeed, this principle conditions the design of the kitchen to limit the risks of contamination. Architecturally speaking, the kitchen should be installed to form an architectural set of distinctions (4). Respect for the "moving forward" allows for better organization (Figure 2), which is more logical and efficient and saves considerable time.

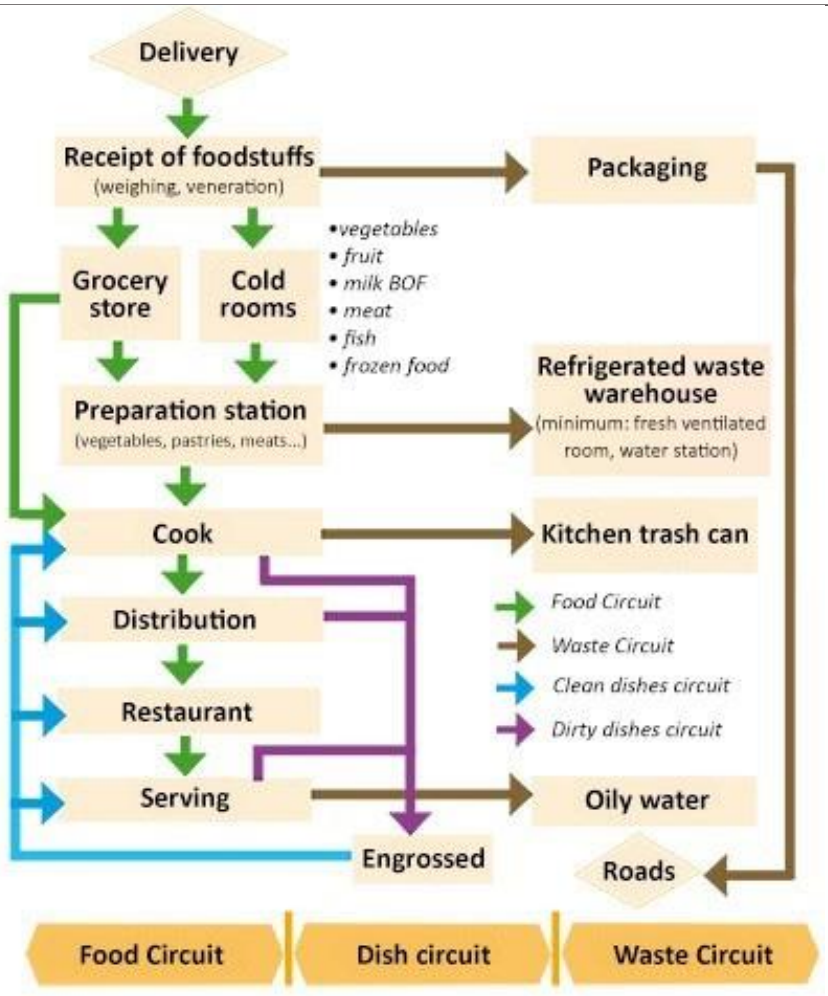

Figure 2. Flowchart for "moving forward" (7).

4. Digitalization for Improvement of Meal Ordering Systems

In the conclusion of a study (8), the patients' treatment and serving play a major role in their satisfaction, especially regarding meals. As the aforementioned study shows, the patients in hospitals have selected what they want to eat the day before via a preprinted menu. This process is problematic because when the food arrives, frequently, patients no longer feel like eating what they ordered the day before.

Most public hospitals in Morocco relied on paper menus and scheduled delivery times to deliver meals to patients; this way causes an enormous waste of food and drop-down patients' satisfaction, not to mention food serving errors which can often be damaging. Poor management

or the use of weak equipment can cause the food to go cold and get thrown away or the opposite.

Making the patient more comfortable becomes a priority for food-service staff and a responsibility. That is why computer engineers work to improve the catering service by studying the art, development, and implementation of real solutions (Figure 3). Information technologies (ITs) provide many solutions in any domain.

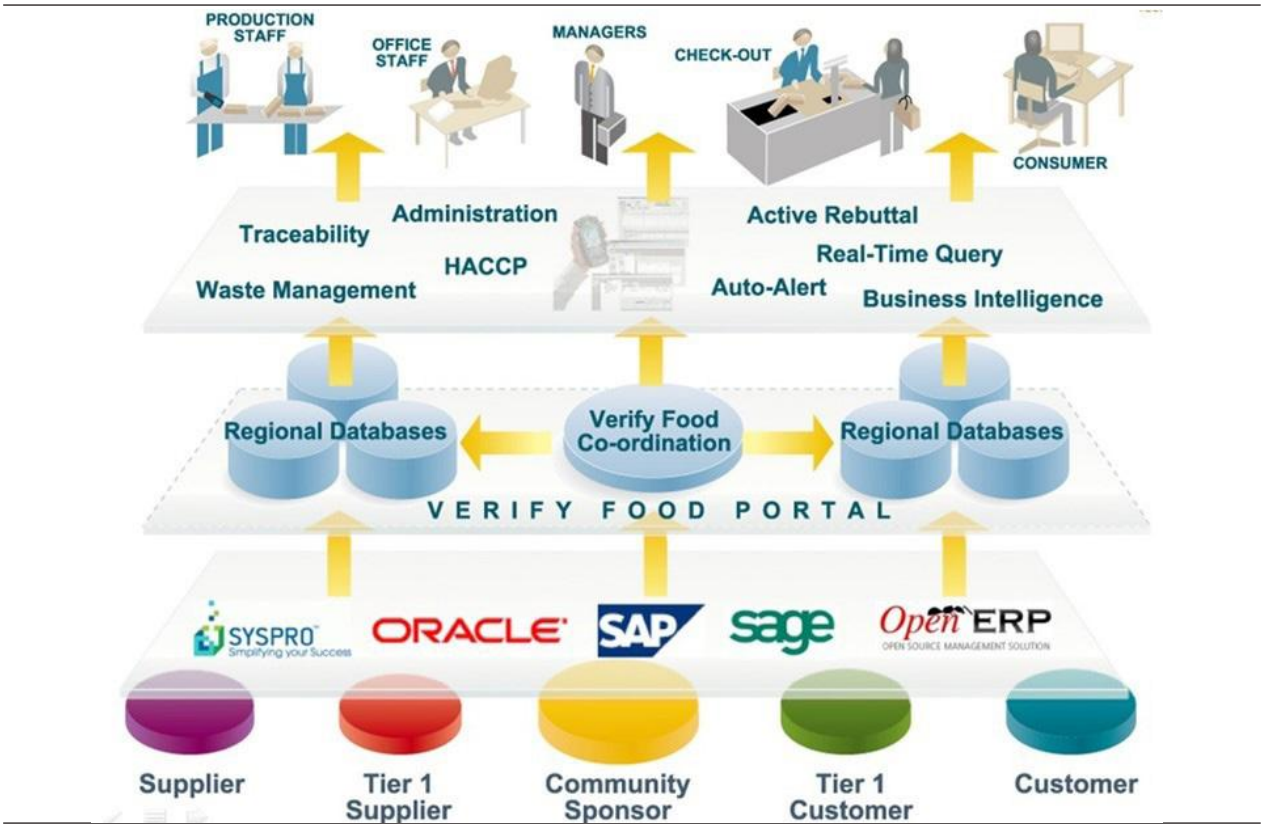

Figure 3. Usage of information technology in supply chain management (9).

It is possible to build platforms for food-service providers that link information on patients' dietary restrictions and allergies stored in their electronic health records to tablets used by staff members or connect patients to the network using their devices, enlisting staff members to take down food orders using their smartphones. Chefs and catering managers can communicate basic food orders (or custom ones from doctors) using "C-Boards" solutions or service computers.

It can also be observed in another study (10) that the identified impact of EMO systems on hospital and patient outcomes is unanswered, even if the EMO system meets the potential to support nutritional monitoring of these outcomes. The aforementioned study showed that the identification of patients in need of dietary education or those at risk of malnutrition is the critical area of focus for future studies, which pushes the researchers to close this gap and find a solution by adopting a digital catering system. In conclusion, this review article ends up admitting that hospital management currently has poor evidence based on which to make decisions about the value of implementing EMO systems. That is approval based on which it is possible to justify the need for a computerized and digitalized catering system to build.

5. Proposed Hospital Enterprise Architecture for Digital Catering System

5.1. What is Enterprise Architecture?

The last section discussed a global view of the logistics related to the catering and room services in a hospital. This section will expand and specify the previous concepts from the hospitals' enterprise architecture point of view. This study followed an approach that allows finding solutions already proposed in the field of IS urbanization. During the research period, we were looking for tools that build solid and complex formation systems without creating a spaghetti dish syndrome (i.e., spaghetti code). In short, spaghetti dish syndrome is a breakdown affecting computer systems that are too tightly coupled (11). Finally, two approaches (modeling styles) of IT urbanization were identified (Figure 4). The first one is the classical approach of urbanization of the IS. Its logic says that any IT project should aim to rationalize costs and is asked to support the company's strategy (Figure 5). This approach is broken down into business objectives

operationally achieved through functions (handling data) and executed by applications hosted on a physical infrastructure of communicating computer equipment.

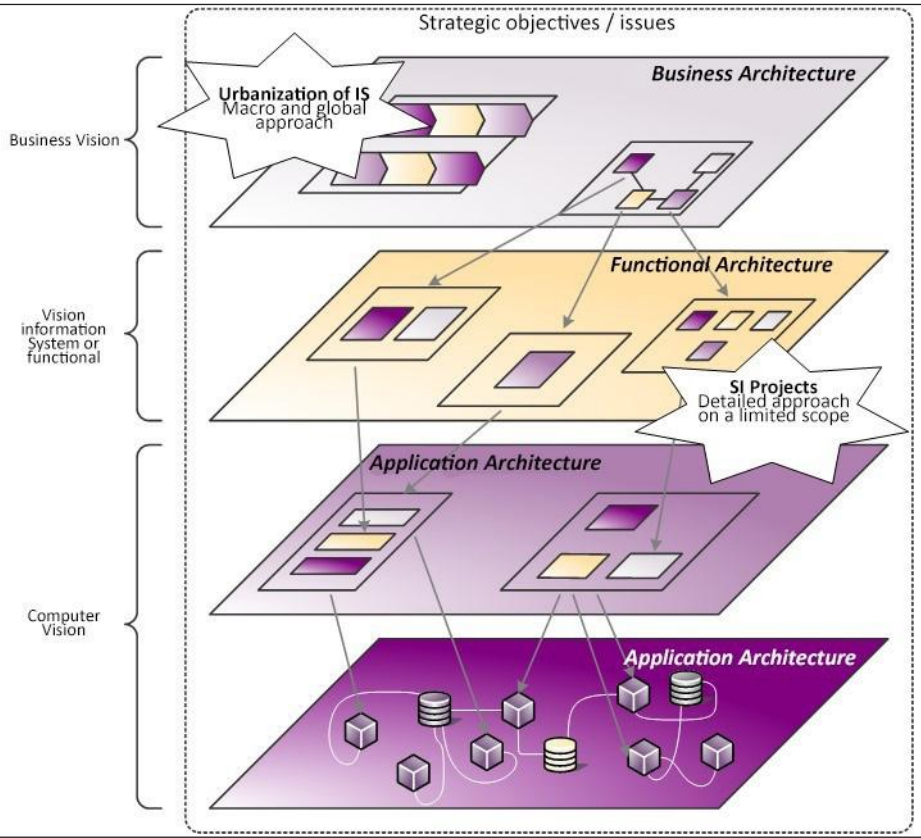

Figure 4. Cartography of the information system (11).

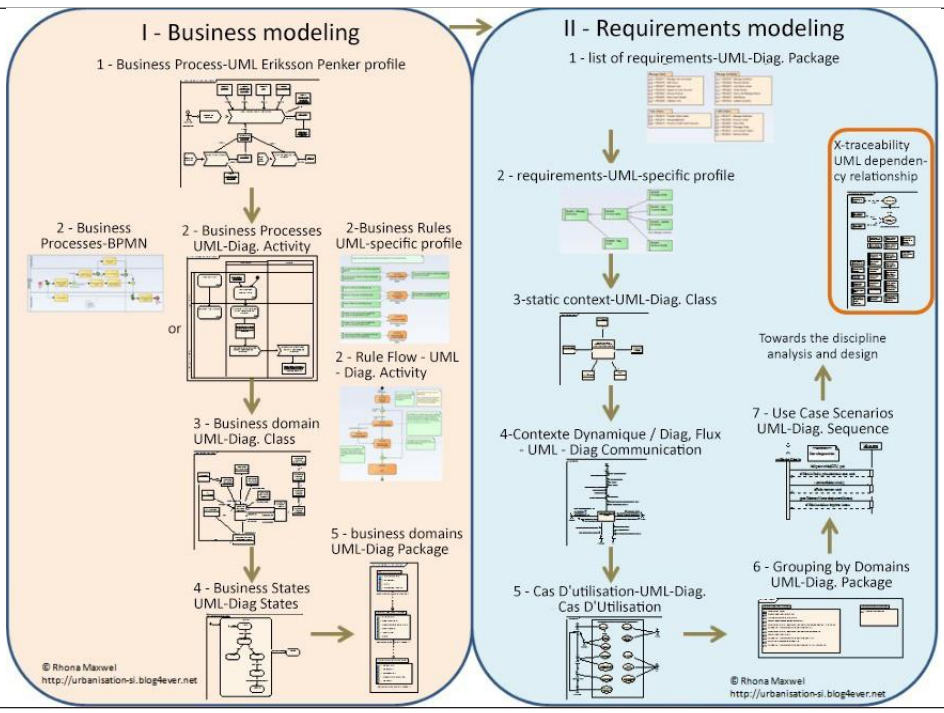

Figure 5. Information system urbanization and modeling steps (12).

The urbanization of the IS is based on the notion of cartography, such as modeling of business processes and cartography of the applications (13).

The second concept is the enterprise architecture framework. We choose the Open Group Architecture Framework, also known by the acronym TOGAF, which is a set of concepts and a popular industry standard covering the field of enterprise IT architectures. The diagram shown below is the architecture development method cycle constituting the heart of the TOGAF approach and delivering, in the form of a cyclical process, the best practices for the development of the enterprise architecture at the center of an organization. Focused on requirements, it consists of a preliminary phase and then eight phases (named from A to H) allowing to build the architecture of the business, application, data, and technical fields, plan its deployment, implement it, and finally manage the changes to be made (Figure 6). In short, TOGAF brings together computer modeling methods and languages, such as ArchiMate, Unified Modeling Language, and Business Process Model and Notation.

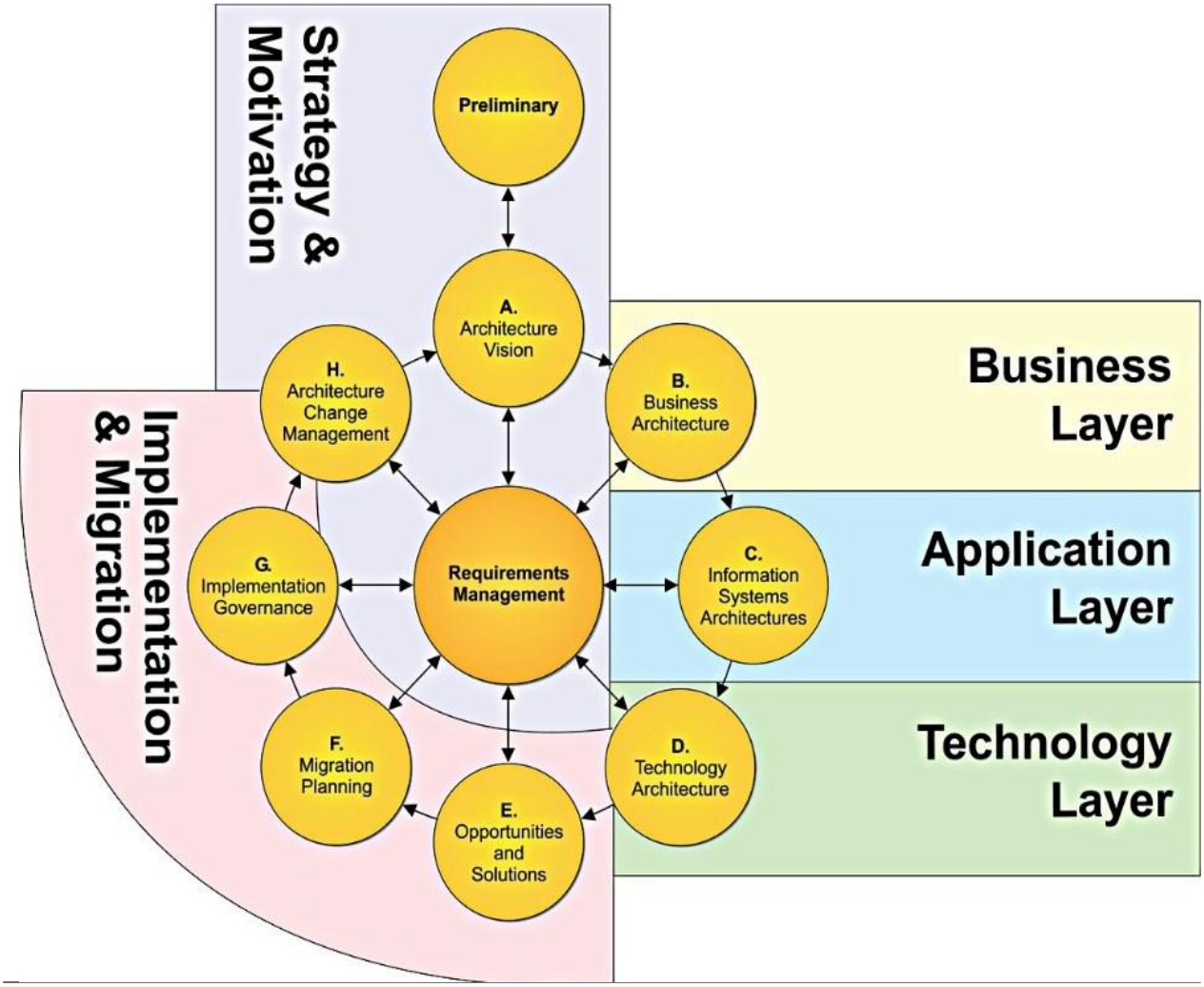

Figure 6. Enterprise architecture framework (14).

Both IS urbanization and enterprise architecture are well-defined practices for conducting enterprise analysis, designing, planning, and implementing, using a comprehensive approach at all times, for the successful development and execution of strategy.

5.2. Similar Studies Based on Hospital Enterprise Architecture

In the book "Conception des Cuisines de Restauration Collective" (15), the authors insist on the quality of the layout (i.e., productivity, quality, and risk prevention) when designing collective kitchens. The following diagram (Figure 7) is an example of optimized relations between workshops in the case of a central hospital kitchen. This helped to extract some entities for conception and modeling purposes.

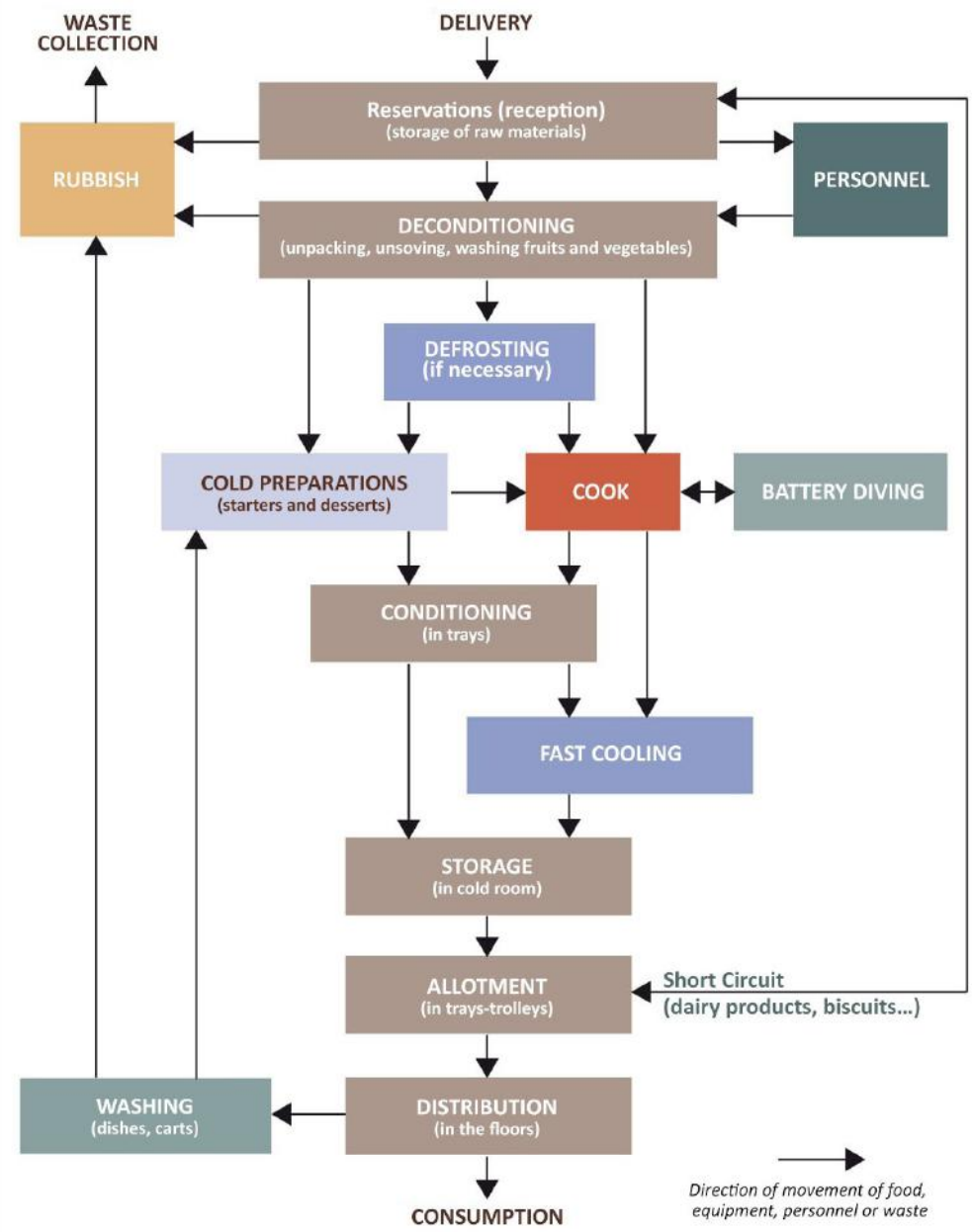

Figure 7. Optimized relations between workshops (15).

A study entitled "Nutrition Catering System of Hospitals Based on Web Services Integrating Wireless and Wired Network" presents an integration of wireless communication, wired communication, and web services technologies to implement a hospital nutritional catering system (Figure 8), in which patients can access the servers and catering ordering functions through hospital computers and office and mobile devices, such as personal digital assistant throughout an integrated local area network and/or wireless local area network (16).

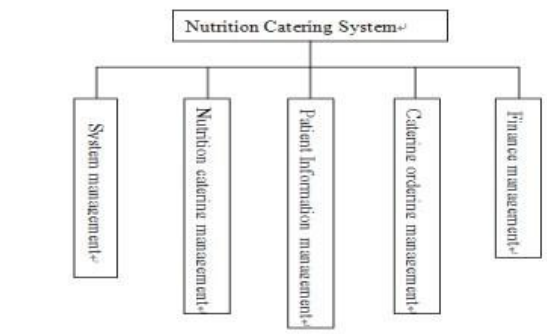

Figure 8. Function modules of the system (16).

Web services are Extensible Markup Language-based information exchange systems that use the internet for direct application-application interaction. They are also considered computer architectures for which (16) wireless applications based on web services on mobile devices provide a convenient way, improving efficiency and accuracy while saving time and reducing human error.

"Hospital Enterprise Architecture Framework (Study of Iranian University Hospital Organization)" is a very important article because it aims to present a localized enterprise architecture framework for the case of researchers based on several criteria, adaptations, methods, and information collected from several sources, especially hospitals (17). In the aforementioned study, TOGAF was chosen for its appropriate characteristics and its ability to be implemented among the reference formats. In Table 1, the last consequence of the absolute weight of the options shows that the TOGAF framework has the highest absolute weight among the decision-making options and, therefore, the highest rank.

Table 1. Absolute Weights of Frameworks Related to the Aim (17)

Rank	Item	Absolute weight
1	The Open Group Architecture Framework	0.318
2	Department of Defense Architecture Framework	0.219
3	Zachman Enterprise	0.187
4	Extended Enterprise Architecture Framework	0.144
5	Information Sharing Environment Enterprise Architecture Framework	0.132

Figure 9 illustrates the general content of the TOGAF conceptual model in a hospital by a Land Use Plan, intended to facilitate planning with regard to changes in the IS.

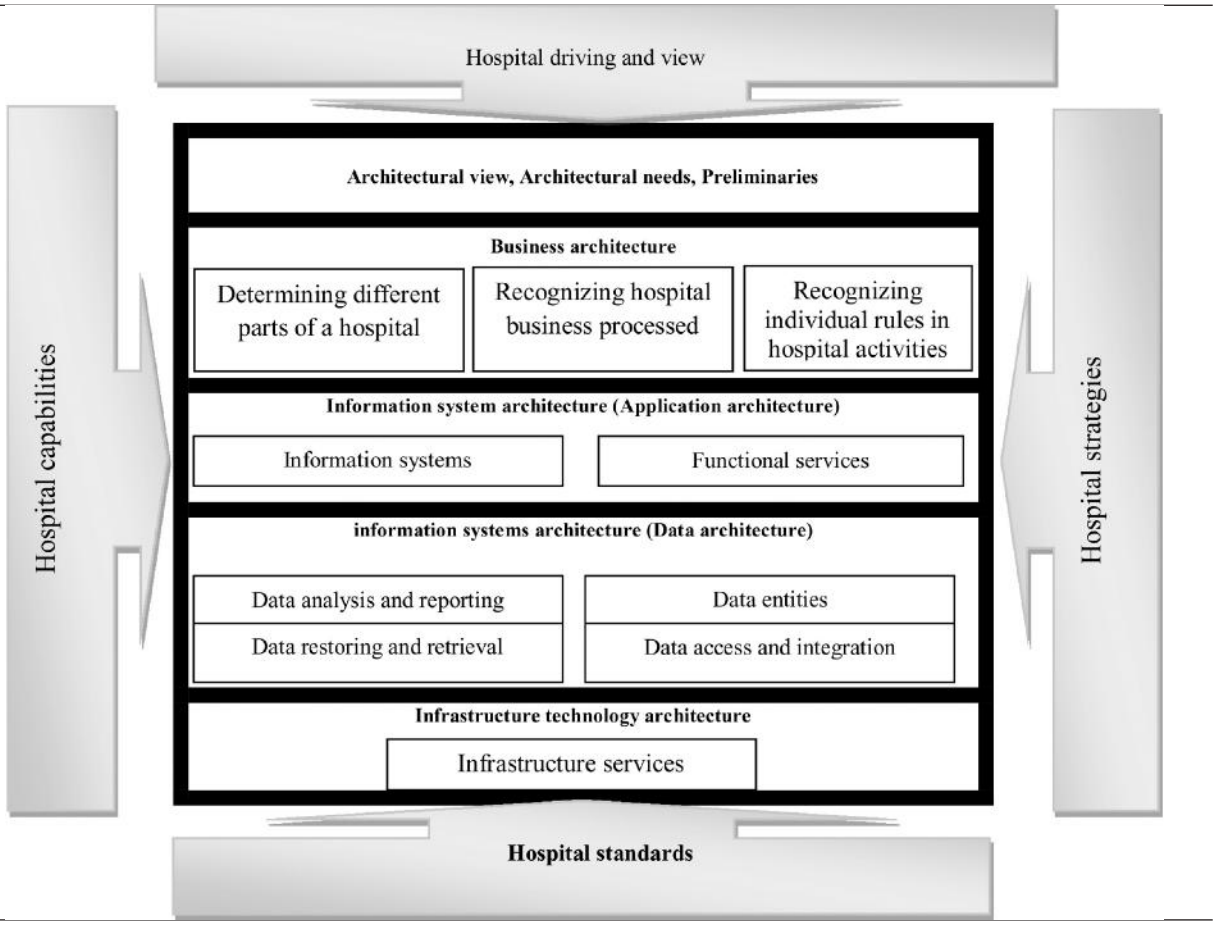

Figure 9. General Content of the Open Group Architecture Framework Conceptual Model in Hospital (17).

5.3. Proposed Conception Based on Performed Studies

As observed, any urbanization of an IS aims to organize the bricks of the IS with an objective of flexibility and responsiveness and gradually declining and integrating IS evolution requests through a streamlined approach (Figure 10). Urbanization also helps develop tools for decision-making and monitoring changes in the IS, such as target cartography (18). The cartography considers four visions of the IS as follows:

- Business vision: The processes and activities supported by the IS strategy.
- Functional vision: The functions supported by the processes.
- Application vision: The application elements of IS functions.
- Technical vision: Describing the basic technological architecture.

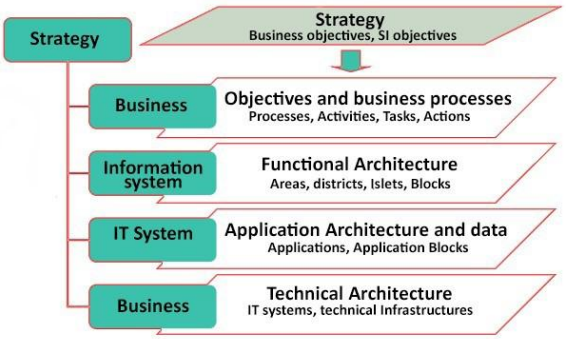

Figure 10. Four visions of the information system (18)

In the present case, to answer the questions what, how, and with what, the concentration is on the functional, application, and technical visions since these questions/visions represent 80% of the urbanization plan of this IS. In functional cartography, the functional processes are divided into separated zones, loosely coupled and highly cohesive. A zone typically corresponds to what is commonly called a system, containing districts corresponding to a subsystem; each district of a functional area is finally broken down into functional blocks. For each zone (or also district), it can be expressed as a service, function, or even a block of code in the programming phase. This study proposed some basic zones (Figure 11), such as research and decision-making, personnel management, and catering and room service. Along with some other zones already observed in hospitals, this is to keep the flexibility of the current system and avoid administrative delays and shutdowns.

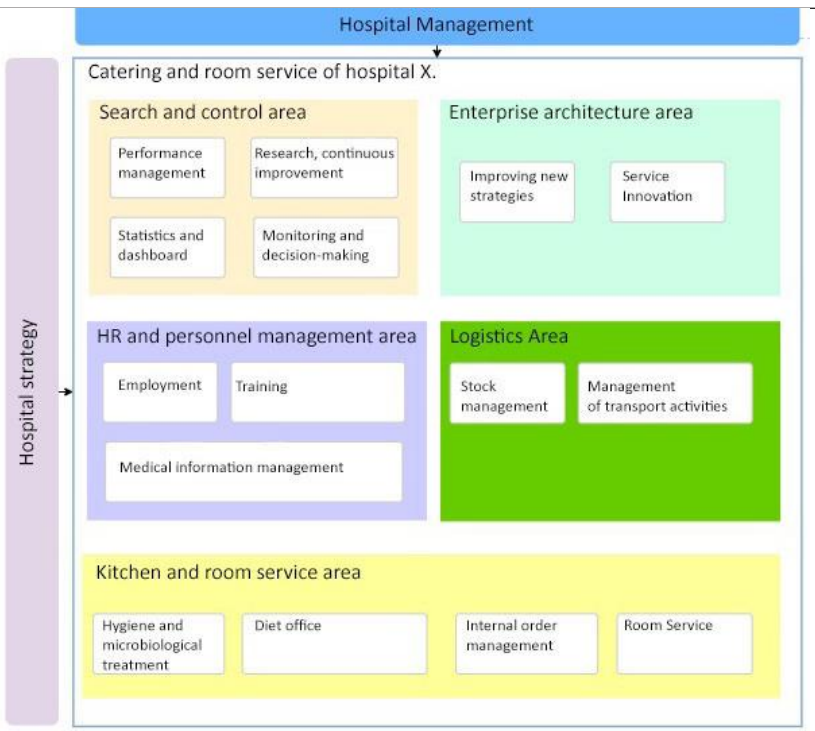

Figure 11. Current study proposition of functional cartography: Zone.

If a district is taken (e.g., the diet office district) (Figure 12), it is possible to observe the difference between a digitized functional block and a non-digitized one, giving the ability to think of the actors, the input, and the output of the specific zone (e.g., Figure 12) as a functional process entity.

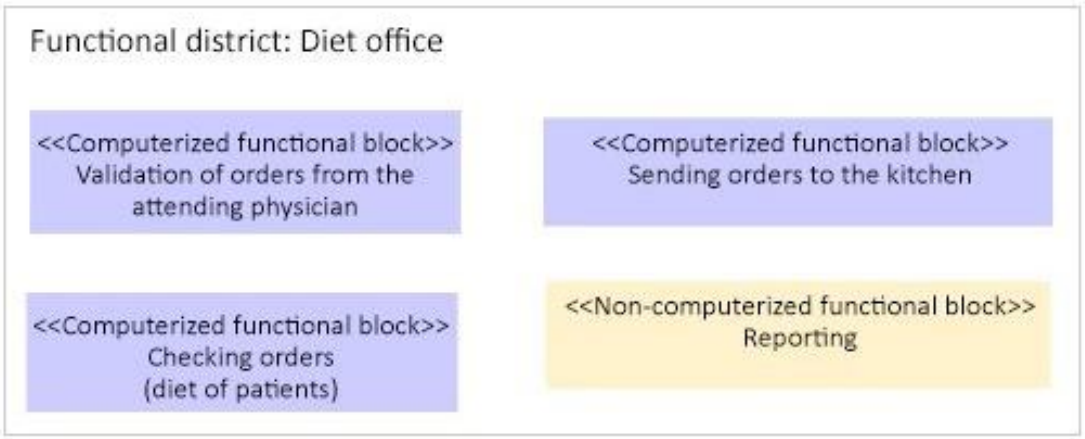

Figure 12. Current study proposition of functional cartography: District.

Applicative and technical cartography is the system that should respect the rules of IS urbanization, have a weak coupling between its components, be a service-oriented system, and have a good orchestration of its components (Figure 13). The components communicate by an enterprise service bus (i.e., a central component), which will position itself as a single point of contact for all the components of the IS.

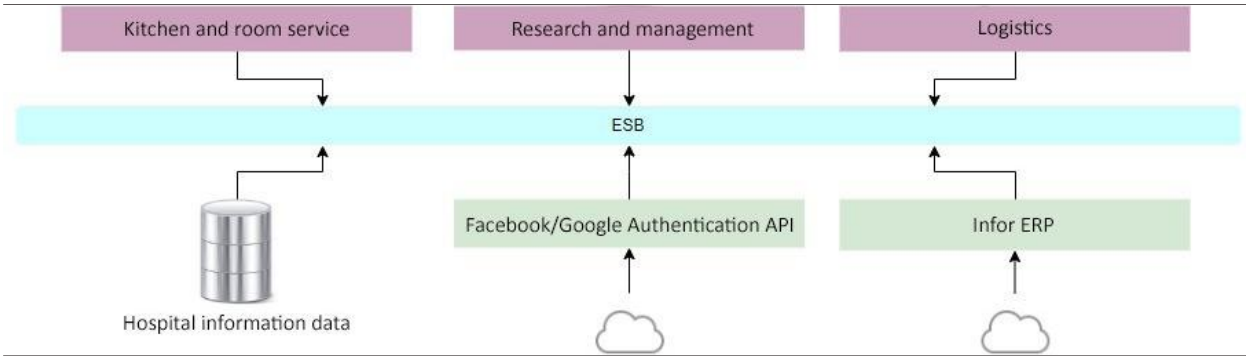

Figure 13. Current study proposition of a service-oriented architecture.

6. Modeling Hospital Catering System

The hospital catering system aims to provide food prepared according to acceptable health and aesthetic standards to satisfy hospital guests. Indeed, culinary production requires a succession of operations from purchasing food to distributing meals. The operational process can be detailed as follows:

- Raw material purchase: The team in charge of supplying the stock at each time initiates a supply request and conducts a multi-criteria analysis or another method to determine the adequate supplier's offer in terms of hygiene, quality, and cost.

- Raw material storage: Upon receipt of the order, controlling quality and quantity is required before proceeding to storage, depending on the nature of the food.

- Distinguishing two types of storage: Storage at room temperature and storage in cooling cells

- Meal preparation: Upon the receipt of meal orders from care units, the team of cooks begins the cooking phase for a pre-hot paired food before making the culinary assembly to prepare the final dish according to the particularity of each patient. Therefore, the team is responsible for ensuring the distribution of meals in isothermal trolleys to maintain the temperature of each served meal. Finally, return management is required to reduce food waste.

- Care unit: It represents the direct link between patients and service catering in terms of taking orders and delivering meals to each patient room.

In this study, the business process model notation (13) was used to describe the operational process of hospital catering (Figure 14).

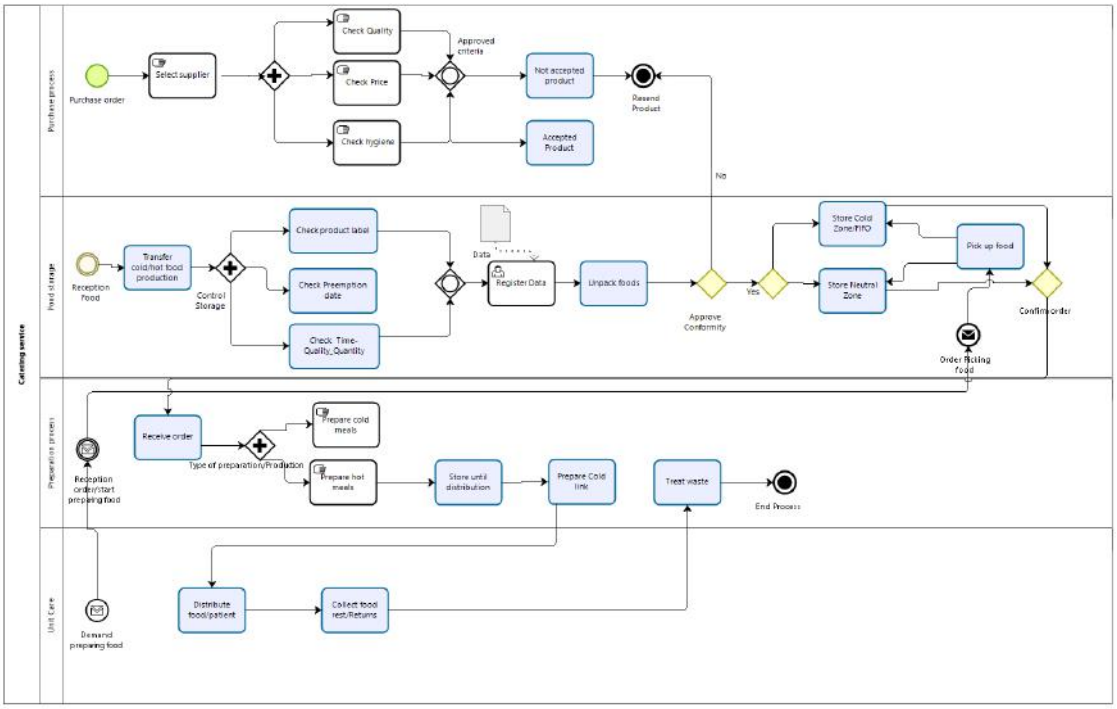

Figure 14. Current study proposition of operational process of hospital catering system.

7. Future Directions and Conclusion

This study aimed to have an understanding of the investigated topic. Based on the results, many perspectives can associate with the topic, including the identified technologies and the given propositions. To build a solid enterprise architecture in the current study, it is possible to: (1) begin field research to collect information from various sources (i.e., hospital catering and room services); (2) build a solid understanding of TOGAF and its foundations to use instead of traditional enterprise architecture methods; (3) have enough models to develop at least one prototype of this software; (4) look forward to having collaborations with catering companies that offer services to hospitals; (5) have a presence of reliable documentation that helps keep track of all aspects of an application and improves the quality of a software product; (6) offer a platform to build up new digital solutions for hospital logistics, such as agent-based systems and Hospital 4.0.

To make catering and room service more responsive and flexible toward strategic business changes, while relying on technical opportunities of the market, it is needed to develop a solid IS urbanization plan, for which this paper was prepared, collect information of the domain to have a global view, identify the problems, and push to start building of IT projects respecting hospital management rules and requirement, and touch the maximum level of accuracy toward objectives.

The improvement of the clinical regime of patients depends on the intensification of efforts in including hospital logistics and services within the digital area; accordingly, the organization of the hospital's digital catering system is extremely useful in several ways, especially providing evolution and innovation for the healthcare sector.

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All the authors reviewed and edited the manuscript and approved the final version.

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The authors declare that there is no potential conflict of interest.

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