Spatial Analysis of Sanitary Buildings Applying BIM

The Case Study: Molinette Hospital

Turin-Italy

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Abstract

Spatial analysis in architecture involves with the space and function distribution in a building and space syntax regards all methods and theories to recognize and demonstrate the composition of spaces considering their relationship with access possibilities and with particular usage of these spaces.

Spatial analysis, generally is applied in the earlier stage of architectural construction and rarely has any connection with other stages and phase of construction namely structure and infrastructure while they are connected in deed. In addition, real features of the space cannot be perceived by graphs and diagrams and it requires new technique to demonstrate the actual space relations and pedestrian flow in the space.

In this research, after illustration of parameters dedicated to each space, BIM was applied in order to achieve more intelligent space syntax as well as attaching this analysis with other stages in the building. The results of the information analysis of the floor plan presented as the recognition of false or true distribution of activities in the building according to the space composition.

Key words: BIM, Space syntax, Sanitary Buildings, Hospital architecture.

Acknowledgment

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INTRODUCTION

Architecture is a science and a practice in dominant of built environment in relationship with natural surroundings. This field contains a range of involving factor in human life and knowledge. Like all of the human endeavors to develop his life, architecture passing through the time faces with progress in theoretical aspects and tools.

To have an example all the famous styles in building architecture, in the history, where not only depending on the change of philosophy or religious- cultural belief, but above all, shaped regarding the advancement of technology and available material and techniques. This advancement regards not only to structure and the frame of the buildings but also to the language of architecture, methodology of representation of architectural documents and definition of architectural cooperation to approach the best possible products and design solutions.

On the other hand, these two different aspects in architecture (architectural practice and architectural language) affect each other. Advancement in material and techniques which resulted in more complicated and adopted structure, design solutions and infrastructure, need more complicated method to represent the idea, and on the contrary, better technology to demonstrate the architectural concepts, make architects more free in terms of developing their main concept.

Explaining this relationship, it is clear that, in the course of time, each style contained a specific level of development and detail in the both area. For instance, on the most famous movement in art and architecture, is known by Renaissance. In that time the level of available technologies in the both methods of presentation and structure of buildings shifted from basic methods to a higher degree. This resulted in the changes in buildings, life style and urban vision. Regarding this fact that architecture itself due to its nature affects many factors in human life as he is passing a major part of the daily actives in the built environments.

As all of the human science and practice, architecture faced with an enormous shift in development level during the last century. And it continues to modify each year in recent decade. To have a clear example, Autodesk company releases a new version of its products each year. And this new product by itself, have new effects on the architecture and relating science such as engineering, management and construction in the bidirectional way, as they are affecting architecture in the same way and as the result each year, each of these sectors needs new version of involving technologies.

One the main section in the last century, involved with the IT sector as the Information technology. And an important branch of this attitude is the ICT (Information & Communication Technology), more than knowing as an approach or package of techniques it is called as an industry.

ICT has been affecting architectural domination by providing its required technology in information sector. And started its first well- known help to architect by introduction of the Computer-aided design technique or as its abbreviation, CAD. This step changed architectural language as well as the availability of architectural explanation in documents.

In the further steps, ICT developed more and introduced BIM (the abbreviation of Building Information Modelling) as a new technology with the must adopted level of process and production.

Nowadays, analyzing BIM and its tools to provide the better architectural language is top topic in theoretical or practical bodies. Each of involving individual, respect to the arguments due to its needs and limits to delete.

In the presenting document as a thesis of master degree of architecture (construction and city), it has been analyzing the possibility of using BIM approach to develop and elevate the level of architectural efforts in the earlier stage as it is known by design step.

The main idea of the architectural design, that the thesis is focused on is the composition of spaces and their relations regarding the distribution of functions and activities in the building. This new topic, known as space syntax, regard the make-up of the space in terms of their accessibility and the depth that is shaped through this make-up.

This sort of spatial analysis is well-used in the urban architecture in the recent years. The result of the urban space syntax was released as the series of approach about distribution of urban spaces regarding urban path and public space and access in the neighborhood unit. The most important factor in these arguments was the meaning of privacy in the city scale.

Figure N: Fractional Axial analysis of the combined car path and road system (Vaughan, 2007).

The selected case study to be analyzed has a particular character which suits the complexity of the space syntax analyzing in the case of the building paths and circulation.

Sanitary building due to their particular characters, require a specific type of design and space distribution to reach to the most efficient pattern to obtain the best performance in sanitary activities and caregiving usages.

Methods of research

In the thesis, in person survey has conducted to obtain the maximum information about the hospital. As the case study is classified as the existing building and at the moment it is in use. Except some part of the building all rooms contain their actives. The positive aspect of the matter is that all information about the functions running in the building could be obtained and directly by in person survey.

On the other hand, the negative view regards to the difficulties of obtain all information about internal parts of some rooms, due to importance of keeping privacy of the users during their presence in the building. All efforts forced on the obtaining the maximum possible information with minimum interaction with the main activities in the building.

Providing all needed information about the building construction and containing activities, the model of the building is created in the Revit 2019. With the attached information to each room separately. Following the definition of the function of each room in the circulation classification, the main circulation access is demonstrated. This circulation path was compared with the main existing models of circulation wards models in theoretical support of the argument. The result of this comparison was to recognition of the circulation model of under analysis hospital.

In the Revit the rough model of surrounding buildings was created as well in the format of mass to illustrate better the position of the hospital in Citta di Salute in Turin. And as the consequence the relationship between the inner circulation path and connecting path between buildings is derived from the BIM model.

In continue the schedule of all rooms is provided to accelerate the analysis. the main data of this schedule were the code presented the depth of the rooms regarding the main pedestrian circulation path. On the other side inserted information about the functions and their classification are provided to obtain the interface code of activities. This code could be compared with depth code to analysis the distribution of the rooms according to their specific function.

The result of the thesis will be presented in the schedule analysis of rooms. To understand the level of optimization of spatial distribution of spaces regarding the provided and obtained information. It can be also explained as recognition of space position errors in design process.

Surrounding of the hospital contains a site with other sanitary buildings. This could be useful to develop other further research about the spatial analysis of sanitary sites and sanitary zones. It could be also developed to the spatial analysis of the other buildings in the site with regard to the same approach used in Molinette.

It can be also interesting for the BIM involving sector to provide new algorithms to find a way to make the process of modeling and information analysis in the more automatic way using the additional script such as dynamo.

BUILDING INFORMATION MODELLING

Introduction

Building information modeling or as it is called BIM is a new approach in all sectors of built environment providing facilities in all of the production chain of a building. Unless its fresh attitude and new developed technology, it could be also regarded as an evolution in management and presentation of construction procedure. The development of the approach will be presented in continue.

The majors of the constructive object that could be affected by BIM are known as (AEC-FM), with following definition:

- Architecture
- Engineering
- Construction
- Facility Management

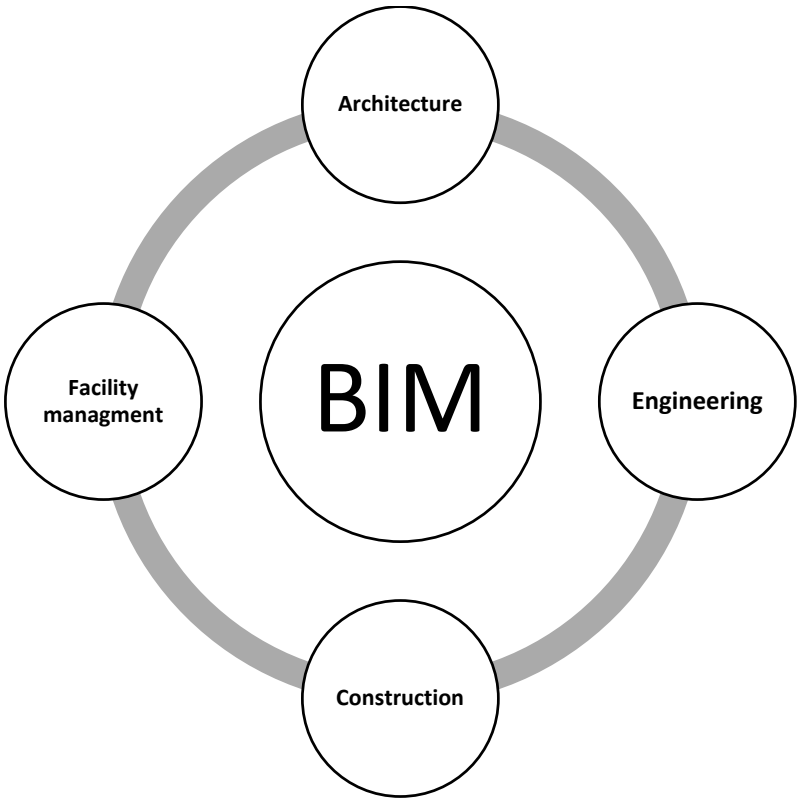


Figure N: AEC-FM sectors in BIM dominance

Building information modelling can affect the two main features of an architectural or engineering work:

Process: from the early stage of a construction, which is commonly involved in providing required input and labor, time and cost scheduled and collaboration management, up to the latest stage, even after usage stage, alike maintenance, recycling activities and demolishment of the building, BIM will provide a wide range of tools and theoretical support to organize a better process in an efficient model. This could be reached by making possible to have a conversation between all involved individuals and companies in one hand and to imagine a unique shape of the result in such language that could be legible for all of them on the other hand.

Definition of BIM is changing by the course of time as the BIM indeed is changing. The modification in instruments and tools, expectation and program frame of BIM, justifying according to the new needs and adaptation. As the result to define BIM, definition of aims and goals, the time that definition is needed, and targets are required.

As an example, we could regard to definition published by Wikipedia in two different times.in 2014, BIM ‘s definition regards to a serious of creation and management of “Data related to a building in all its stages”, but in 2017 the meaning of BIM changed as it was creation and management of “representing of reality of a built environment”.

Building information modelling also affected the procedure of “Decision-making”, as it provides data and information about alternatives for each sector and contains useful tools to analyze them due to demonstrate advantages and disadvantages of each option. Regarding the provided data intelligent comparison is illustrated in favorite scale.

From Cad to BIM

Up to the 80's, architectural representations were limited by a serious of hand-drawing documents with a limited level of preciseness and minimum ability to having option to choose the favorite style and scale. This mode of presentation applied by high amount of educated people.

In this decade, the main revolution in presentation of architectural work occurred and AEC industry introduced 2D CAD model to use instead of hand draws documents. In this step presentation became faster and more precise. But as the main idea it was the same as hand draws.

After introduction of 3D model in CAD, for the first-time virtual reality made by digital process became represented by AEC. At that time idea of architectural presentation became changed and third dimension added to the model of a space. But still there were limits as architecture and civil engineering is not limited by three dimensions only.

In the 90's, theoretical research started in Sanford University to add forth dimension to the models. The aim of this efforts was to develop the information that could be attached to a model in addition of only geometrical shape.

4D CAD in collaboration with 3D CAD model was developed to attach time factor or another scheduled parameter regarded with the geometrical model. To provide more information in order to have a more advanced decision-making. But still the work of organizing this separated parameter and correspond them to each other were in earlier stage and it was time consuming as well. By the revolutions happened in the course of time and as other parameters added to the model scheduled the name was also upgraded as 5D model.

For the first time in early 2000, the raw introduction to the BIM arguments occurred and AEC industry, presented this new attitude to the construction sector. The main aim of the new technique was to develop management, collaboration and decision making in all steps of an architectural production.

In BIM model instead, we can have a huge number of parameters attached to each elements of the construction site, and corresponding with the reality in which each single elements has different kind of information and by this information this object is affect its environment.

To illustrate the gap between a CAD output and BIM output is aimed of a range of theoretical and practical efforts. As many of authority define BIM model with its Differences comparing with a CAD model. It should be mentioned that many consider a BIM model as a developed version of a CAD model.

A three-dimensional exported model from CAD is composed by only formal elements alike Plan, Line and Point. These elements could create various geometrical shapes that are aimed of CAD process. These shapes are evoking the real objects in the world according to their formal similarity. On the other hand, a BIM model is composed by digital presentation of the mentioned objects with their own information that correspond to the reality. For instance, a cost of a specific beam is derived from its 3D BIM model as well as its geometrical description.

Two main terminology inside a BIM model make it different from other 3D models. Firstly “Information” as the data attached to its shaped model. The important of information of each element and the whole of the construction is a key to represent the best imagination of alternatives due to provide enough data for the best decision-making. As a 3D cad model with only three-dimensional representation of the places in unable to do the same.

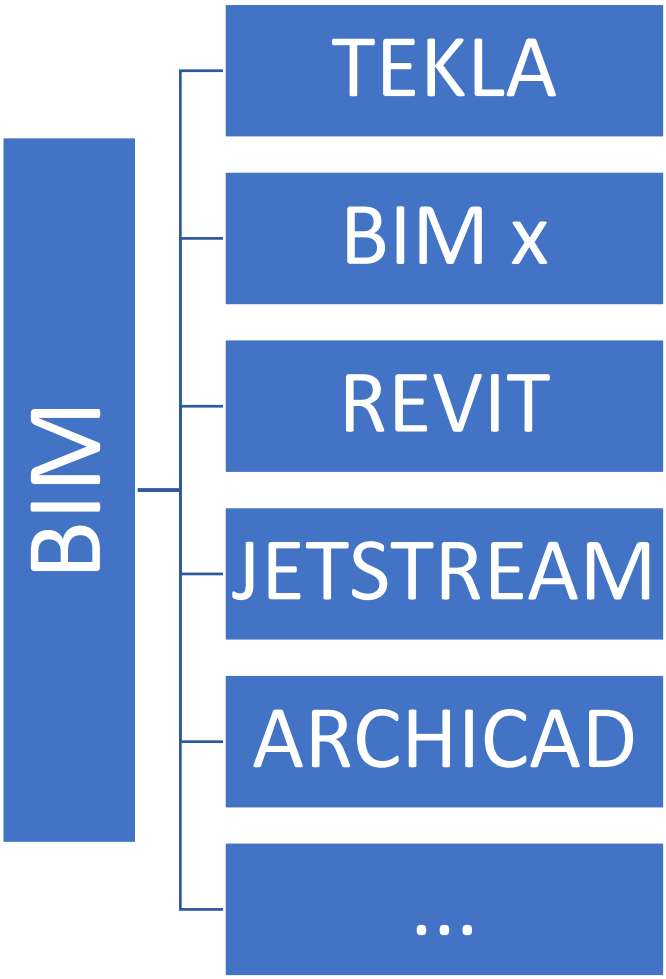
The second term is parameter. This feature makes it possible to have parametric design or parametric comparison and decision. Parameters are information define for each aspects of elements.

Evolution of BIM is as the consequence, result of development in information. As more updated information and developed model of management will attach to the BIM model, the result will be more upgraded and desirable.

Building management is another possibility, followed by BIM usage which is not developed in other modeling systems such as CAD models. Regarding the type of information attached to model we can use the same model as civil BIM model, Urban plan BIM model, Infrastructure BIM model or other kind of BIM models that are inside the same model but derived from different information and scheduled with range of various parameters.

But on the contrary a unique CAD model could be used only as one single propose. And if different aspects and stage are required in the construction the album of documents will be provided with different files and formats. This make the construction procedure longer and expensive. In such way, a change in one sector cannot be automatically updated in other sectors and a lot of time needed to organize all documents with new orientation in one of them. The result of this approach cannot be free of errors.

In terms of tools and software, they are a various kind of application that are used to create a BIM model. The logic of using any of them relies on the project, scale of construction, the main stage of the work if it is an engineering work rather than architectural one and many other factors. A project manager should take into consideration all of these factors before starting to advise a specific tool.



Importance of BIM

Despite all opportunities and advantages of BIM, still there are some resistance against using this tool with regard to classical methods. This could be occurred in traditional companies as they find the BIM environment not enough user-friendly comparing with the methods that they used to work with.

But following reason are mentioned to have a brief list of benefits taken from BIM technology:

- Reduction in labor: as the many of information like the 3D model will not be repeated for each needed document, spam information is automatically deleted, as the result less input labor will employ to reach the objective result.
- As input labor reduced, the cost of each stage will be decreased, and the total budget needed for a construction work is more economic in comparison with traditional methods
- Less errors will occur, and this is due to direct relation and correlation between involved sections.
- Change management is the one of the best possibility in BIM model,

To sum up, the procedure of construction using BIM is more efficient and the result is more desired and adoptable. In addition, integration of many aspects of the building in reality only is possible using BIM model, due to their different nature and various mode of presentation that cannot be demonstrate in a unique traditional tool.

LOD and BIM

Within definition inside a BIM model, a user might be wanted to define LOD of the project. LOD in a specific BIM model is the Level of Development. It should be mentioned that many times this abbreviation might be in confusion with Level of Detail which is the false definition. Not only in this abbreviation terminology, but in general these two terms might be used instead of each other. This confusion also might be according to this fact that in the GIS (Geographic Information System) the LOD regards the Level of Details.

But as it is officially stated, LOD regards to the completeness of the way that the BIM model is created. To make the definition clearer, taken into account an single element can be simply an individual object or on the contrary a system subdivided in other elements inside it. The development of an object is in higher level in the second example comparing with the first one.

In the AIA document, LOD summed up with Model Element Author (MEA) is required to provide Model Element Table (MET). This table is helpful to recognize for each type of work, which LOD is desired. So, this is not the case that more detailed element is desirable always but indeed it depends on the type of project.

The major body of LOD developed by the BIMForum of the Associated General Contractors of America (AGC) in the year 2000.

LOD is graded between LOD 100 and LOD 500 and their nominal logic is presented as bellow:

- LOD100: level of completeness in the primary stage of design process as it is known as conceptual presentation.
- LOD200: the model is required to be presented in the schematic mode
- LOD300: regards to a model when it is created as a generic model with graphical appearance. This level is also used to demonstrate details.
- LOD350: the perfect model to be considered in this level is a network of single element with different features.
- LOD400: assembly procedure is considered the best example of this level of development.
- LOD 500: as-built projects are classified in this level.

On the other hand, LOD in existing building modelling differs from the LOD in BIM model of new construction, while in new design LOD is much related to the level of complexity of geometrical shape that are created to develop the idea of designer, in the context of the existing buildings, LOD regards about the details and scale of information collecting from the existing situation. This regards to a

whole buildings or small elements. The difficulty here is to obtain more information about element in historical buildings as they are affected by many factors during the time(Fai, Rafeiro, 2014).

In addition, obtaining information in existing building in detail, might face difficulty about the activity that is running into the building. Some specific activities due to privacy required, cannot be modelled or attached to the model.

BIM and Design Process

As a specific design activity involves with two main objectives, BIM could be useful to obtain higher level of development in both. Firstly, design is defined as a process. This process contains individuals, goals and firms. During this procedure being update about the current situation of another element is important. In addition, the best organization between them is required to approach the main goal. Secondly, the result of each designing activity is another object. To obtain the best result, an optimized procedure and best input will be required.

BIM affect the architectural design in the both objects, as it provides situation to make collaboration between individuals and optimize the dialog between them. In addition, it helps designer to develop their result with the aid of better procedure and optimized input and output organization.

Within all advantages of BIM comparing with CAD (Computer-Aided design), it is taken into consideration the elevate the design goal from Geometric Shape to Information Model. Regarding this benefit, Information contains also the Geometrical features of a space (Lee, Kim, 2014).

With regard to the sector of sanitary buildings, according to the speed of changes in technologies and tools in the sanitary field, the built environment of this section must be up dated accordingly. But the fact that an architectural building provides changes in the more complicated ways than a sanitary tools or instrument, the balance between these two different arguments must be kept.

the key solution to keep this balance is to provide a flexible architectural production against changes in the whole considered time for the building to be in use. To obtain this flexibility, the optimized organization between multitasks individual is required an as the consequence all collaboration must be managed. Despite all the mentioned needs, health care buildings sector still suffers from many factors alike limited budget and limited energy source. This will lead to more problems added to the management complexity (Sebastian, 2010).

Virtual Reality

Introduction

The Idea of Virtual reality is not only limited by the sort of tools and technology to visit a scene at time, but it is more focused on emerging the present in the past or future.

Designing a production involved with a range of tools and materials as well but after designing stage, representation of the product is important in the same way. To be able to make dialog between designer and user, creator and client and in deed all involved individuals.

The terms interaction design regards to all methods and context by which involving individual in the design of a production as they are from different bodies, it is feasible to create a dynamic unique language between them.

VR provide environment that simulate the presence in reality. This experience of being in totally similar to reality up to totally different from reality varies according to the need of project.

RESEARCH PRESENTATION

Addressing the issue

Building information Modelling will provide all tools and features to organize a whole project from earlier stage up to maintenance and demolishment. But during its process to be completed, BIM software were used mainly in particular stages and in specific areas more than others.

In project management for example there are a range of tools to apply better management between all involving sectors. Another example could regard to the energy performance of the building, predefined instrument will collaborate with the model of the building and other information correlated to this to provide data about building energy efficiency rank.

Mentioned all views in construction of new built environment, it should be also taken into consideration the BIM role to develop management of existing building and cultural heritage on the other hand. HBIM is a term to introduce a range of tools and software to manage, preserve and restoration of historical building in the cultural heritage context. This will provide all needed information about the historical and topological character of a historic building up to materials and the chemical ways to preserve them in small scale of an historical object up to whole built site.

As before start of implementing any change or restoration plan, provision of full information about the all details of the historical buildings in the field of structure, history, design style and holding element is needed, and they must be documented in order to process the application. In the past all surveys used to be done by human as a range of in person measurements and calculations, and in continue all recorded data were presented in the traditional representation of engineering documents alike 2D plans and sections with written details manually attached to important elements. HBIM is a new approach to preservation of historical buildings in which all efforts in provision of data, calculating the secondary information and managing the restoration application is atomized by digital tools namely point cloud and laser (Murphy, McGovern, & Pavia, 2009).

Named sector are developed and employed in use in practical process in all of the world in different level. Such approach promised a better organization and more sufficiently in result, enough to take this into consideration for all other context of the building.

One of the most important stage of an architectural work is introduced as the conceptual design of the building. This level occurs in primary works of a building but define the main character of the building as well. In the creature of a concept

of a building a lot of features might be taken into account by architect and designer, namely:

- Climate
- Cultural context of environment
- Desired function and space organization
- …

Within all mentioned terms, function is much more regarded by modern architecture, which considers other aspects in correspond to the main character of the building. In their work the architect might start with a diagram so called Building Program Bubbles. In this primary diagram which is normally a draft document in architectural process, designer mention all function needed in a certain building and the relationship between the spaces in balance between them.

The main problems involved in this approach is mentioned below:

The building program sketches are normally a draft document hold by designer. The poor quality of presentation and errors in understand by all involved person might result in huge shortage and disordination in the building. As all designers are blabbing that they are not well understand by other construction sectors. in particular, technical stockholders. This is because this diagram has its own specific language only understood by architects and who passed educational background in the terminology.

Lack of formal united language in the concept design will be followed by errors in this stage or consequences. Each architect has its own parameters to consider and to value. This is perceived when two architects in the same level cannot value the work of others. “A good space” can be defined in enormous number of concept as there is unique parameter to have a unified definition.

BIM and conceptual design stage

Regarding all problems in the previous section, it turns to analyses the solution presented in this thesis. All problematic emerges that are mentioned are due to lake of parametric definition of the ‘Space’ and its quality. As a lot of features of the space and distribution of spaces in the building are assumed to be aesthetic, the architecture has a regard known as a non-parametric character of the Concept.

But on the other hand many features of the space can be calculated or named ore leveled at once. The size of a room or the level of artificial provided light in the room can be scheduled. And in this thesis a sense of depth of a room as it is connected with the access definition can be scheduled as well. This methodology

to schedule and provide chart of the characteristic information of the space can be followed by possibility of organizing them with other sectors of the building

Building Information Modelling, as it is represented in previous chapter will help architect and construction manager to unify all information of the built environment. As an example, when the depth of the space can be scheduled and attached to the model of the building as well as number of needed bars in a specific column, they can be changed regarding each other with less errors and more efficiency. As the result concept details can be balanced with other technical aspects in the building and change in them can be occurs correspondingly.

In this thesis, as a sample of work in providing parametric schedule of spatial features in building, mentioned aspects are presented to be created in Revit Model of the building as the sort of parametric information and to make architect possible to share the detail of their idea with all other sectors:

- Access class
- Path class
- Depth code
- Interaction code

Between them, access and path class and also depth code could be provided directly from plan floor, with the interaction code needs real information derived from in use building and with regards to their function and topological content of each space. To predefine the content of them it is needed to present to kind of information that are used in this thesis:

Nominal information: the path class and access class are nominal information, as they have a name to present the specific character of a space. For example, a room can be classified as or “path” or “point” in the floor plan.

Numerical Information: depth code and interaction code are assumed as counting information. As each class is presented by a number. This counting level are defined before about theoretical background of each indicator.

As the conclusion to introduce the conceptual stage of architectural design, it is needed to recognize a Space as a parametric object. With numerical and nominal information about not only a certain enclosed space but also considering distribution of spaces and their composition. It also contains tools to analyze

topological information in each space and in the range of spaces together as a group of space. This topological information is about social activities inside the space as a container.

Virtual Reality and conceptual design stage

Development in architectural technologies, helps architect to represent their idea each century better than previous one. In earlier time of architectural timeline, an idea of an architect used to be represented in a poor way comparing with nowadays methods. To make an example when looking at the presentation methods in the last century it is obvious that providing all the handmade drafts of the building needed a lot of endeavor and effort in the long time and with huge budget needed. In addition, an enormous number of educated labor input was employed and in the same time the result contained a lot of drawing errors and technical shortage. As human preciseness is limited and once come to group works, this preciseness might short more.

Now, in the 21the century with the most developed tools of the architectural presentation it is possible to create documents in the most precise level according to their real information. In the same time modeling software as Rhinoceros or 3D studio max in combination with Most Advanced Render motors like V-Ray or Lumion made it possible to create the real scene of an architectural output. By them now it is possible to present the idea of designer about a space and its quality better than before.

But as the main drawbacks of these tools it can be mentioned as listed:

- As they are static presentation, the lack of dynamic character of a specific enclosed room occurs. Architects used to justify a virtual camera on a desired point of a scene in with at the best situation maximum information can be transformed to graphical presentation. But still a lot of invisible items are underestimated.
- The level of details presented in a one specific render is not depending on the choice of the viewer. Indeed, it is predefined by architect and can’t be changed in the same time. If the level of detail is not desirable or legible by client all process should be start from the first point to produce another render obtaining favorite scale.
- A rendered view in architectural documents provide a vision to single point of the building, as the consequence, it became difficult to understand the relationship between views. To explain better, even a huge number of best quality renders are unable to provide comprehensive understand of the whole building.
- Classical rendering and modeling presentation of an architectural job are failed to translate the feeling of “Flow “in the building. Due to their static nature, it is impossible to produce a presentation of how different spaces are

gathered to gather as a unique building. As the result the quality of the combination of spaces will be deleted by these kind of representation.

As the solution of the mentioned problem of old-fashioned methods and tools of presentation, new technologies came to help architects to make them able to present their concept about the organization of spaces in the dynamic manner.

Virtual Reality (VR) and Augmented Reality (AR) are a group of tools and instrument with the logical content to be presented in the non-existing situation. The all background and ability of them is mentioned in the separate section by which it is possible to:

- Provide dynamic scene for viewer. This can be making the options for client to choose what is to see and what is to eliminate in the view.
- At the same time viewer can decide about the level of detail that he needs. He can focus on the desirable object that matters for him or on the other hand not giving too much attention to an object which is not aimed by the project.
- By using virtual reality, it is possible to have the comprehensive vision of the whole building or a site thanks to its dynamic presentation.
- In the virtual reality in contrast to old methods it is possible to walk in a corridor and enter to an attached room.by this path all qualities and quantities related to the composition of different spaces can be reached. Visibility, spatial flow and real accessibility are between these qualities.

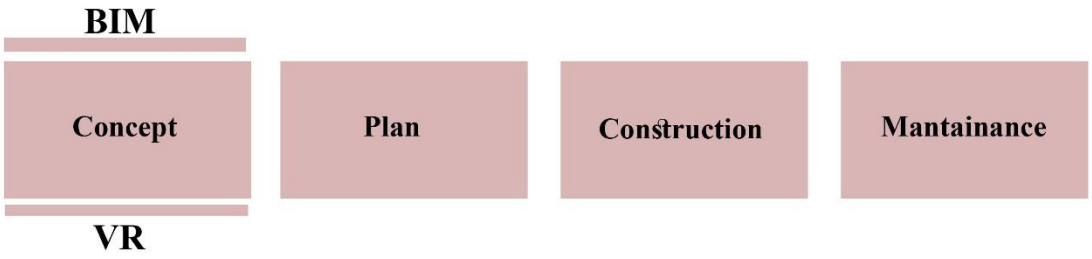


Figure N: Application of BIM and VR in Concept stage as a primary step

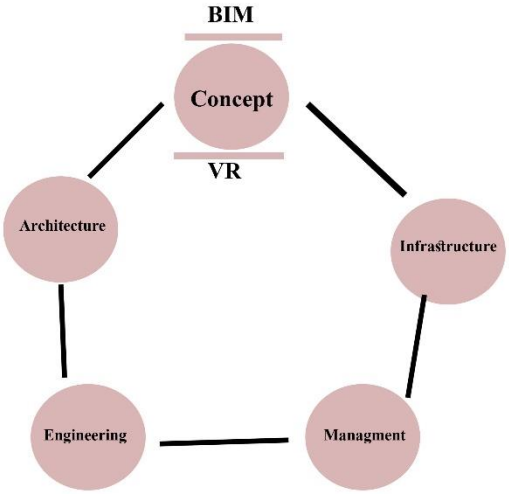


Figure N: application of BIM and VR into concept stage as an independent sector

CASE STUDY

Molinette Hospital

Regional context

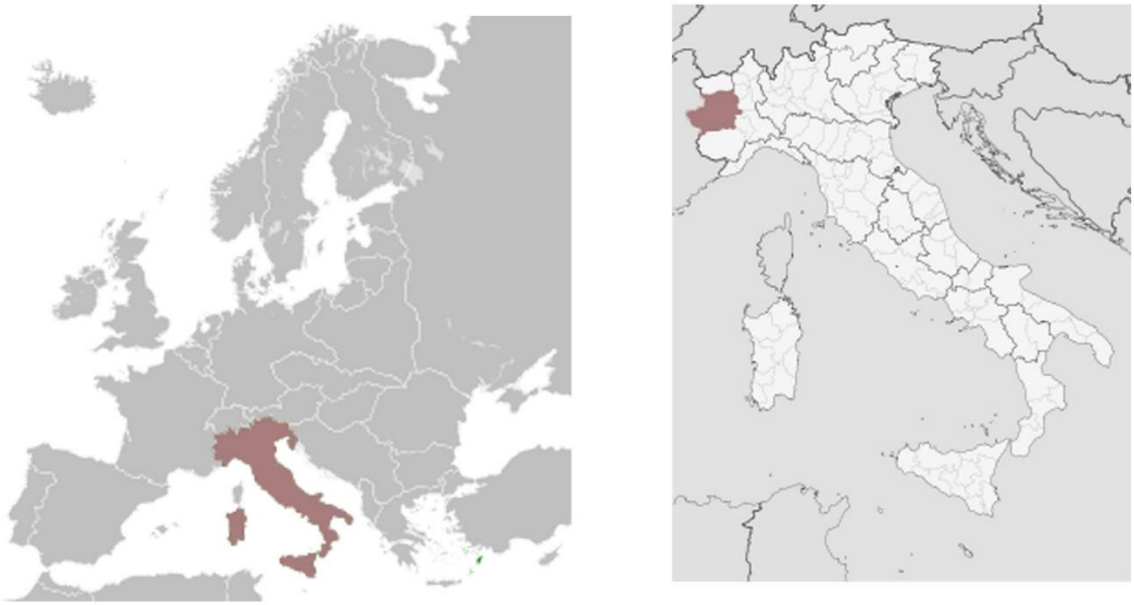


Figure N: Position of Italy in the world and Position of Turin in Italy

The case study analyzed by the current thesis is in Turin, the capital city of the region Piedmont, located in the north Italy.

In terms of population, according to the survey in 2017, the population of Turin is published as 886,837. Comparing with the population of all of the Piedmont region as 4,377,941, Turin is also the main human center of the its region. The meaning of this human distribution is illustrated in the centralized professional and vocational activities in the city.

The climate of the city is classified as Mediterranean category including high level of humidity and subtropical character. In terms of urban architecture as the main fabric is known as “gridiron” character, generated from the cross of the two main urban paths: Corso Vittorio Emmanuelle Secondo and Corso Re Umberto. The city center is located in the north-east of the gridiron pattern and this zone is return back to Roman times. The scape of the city is homogenous as the main part of the buildings are built in the same century and public regards to the façade style is homogenous.

The case of the thesis is located in the south of the city and in vicinity of the Po river.as the site of the building, in the Corso Bramante, there is a sanitary site composed by various building types and with different construction style. Each of

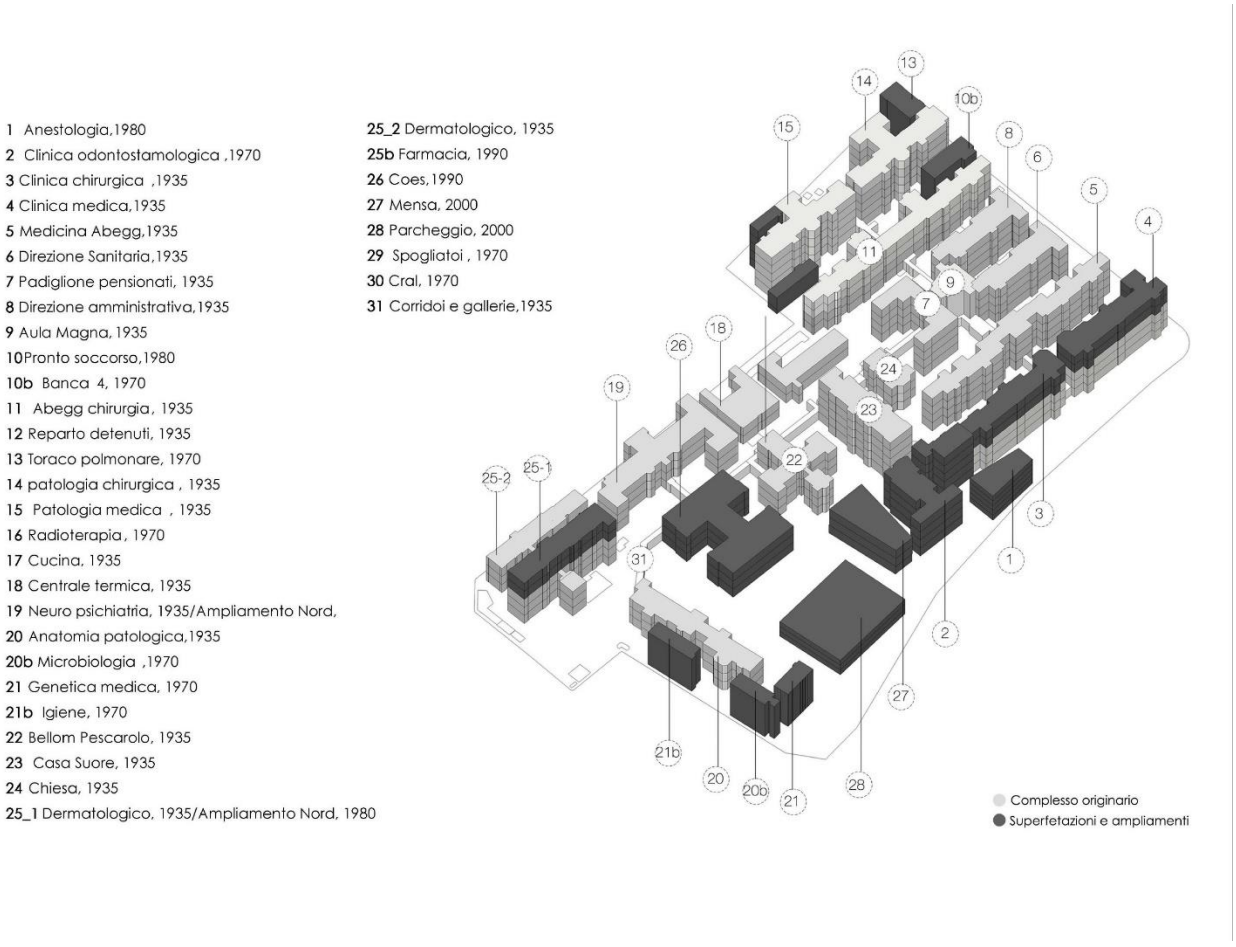
this building is under use of a specific activity in the site. But in the same time there is a internal path by which they are connected to each other.

The administration of the hospital is grouped in the “ Azienda Ospedaliero-Universitaria” and Citta di Salute e della Scienza di Torino.

The group is multi tasking part of the municipality of Turin with mix activities in educational and caregiving. As there are a various number of the composition in collaboration with the Politecnico di Torino and University of Turin (Universita di Torino) to reach to the educational aims defined by the group.

The main entrance of the site is located in the Corso Bramante, but there are also other entrance to the more public buildings to ease the access of citizens to their activities:

- Via Genova,3
- Via Cherasco, 15
- Via Santena,5



As presented above 31 separated buildings are recognized with independent specific function. In the same time all of the buildings are related in terms of activity. They are supporting and affecting each other.

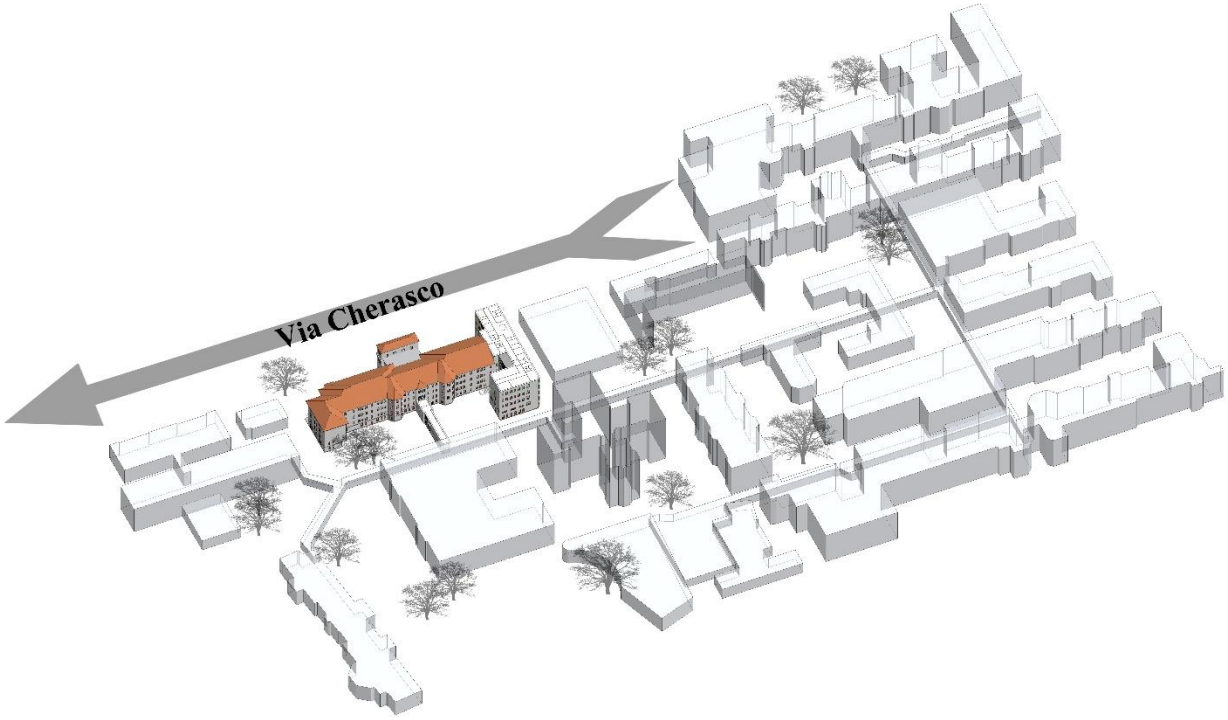


Figure N: Position of Molinette Hospital regarding Site and Via cherasco

But as it is mentioned before by the inner path all buildings are related to each other and access to the each of them is possible from another entrance and also the main entrance.

As it is published by the hospital official website, the molinette hospital is the oldest hospital in Turin, the largest in Piedmont and the third in Italy(“ presentazione Molinette Dermatologico San Lazzaro, San Giovanni Antica Sede,” 2019).

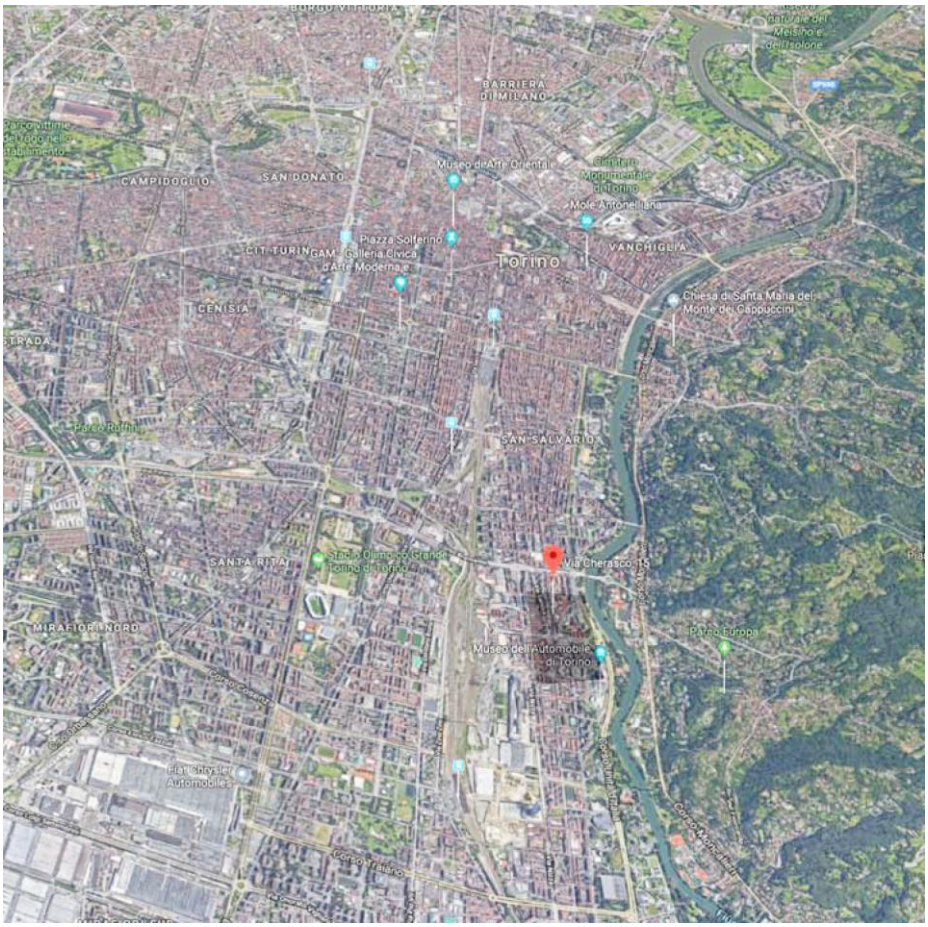


Figure N: position of Citta di salute in Turin

Molinette Hospital

The group of Citta di Salute is a multi-specialist organization, integrated with Universita di Torino to provide facilities for assistance, teaching and research, and on the other hand provide features of the aimed national health services. In detailed scale, the organization focused on providing such services for the Piedmont's population needs and the related universities network. Educational activities focus on a range of traineeship and courses in medicine and surgery.

As the main character of the composition of building vary, also the style of their architectural presentation changes from building to building. But as the main theme is sanitary and educational, all of the buildings are designed around a central corridor as the core of the building and these corridors continuo to the connectional path inside the side to be related to other type of building. This sort of pedestrian circulation could be considered as the main feature of the entire site. And in the same way this includes each single hospital.

Recognition of the site of the case study matters because natural and artificial environment of the hospital affect the way that is designed and organized. This environment can be natural landscape or as in the Mollintte a composition of other sanitary buildings. As the consequence to have a sufficient architectural vision about the hospital its environment and the characteristic of existing elements should be analyzed as well (James, Noakes,1994).

As it will be demonstrated in following documents attached to the thesis, it is obviously seen that the main characteristic of the existing site component as the surrounding built environment of the Molinette, is the pedestrian path through which it is possible to pass from one building to another.

It can be explained that as in hospital building or in the sanitary buildings in general, most important feature that all characteristic of the whole architecture will be defined is the pedestrian circulation in the building. So to develop this to the site composed by many caregiving construction, the main character of this composition should be an element to join this network of circulation path.

As it is shown on the maps, this main path is organized in such way that in some part could be recognized as the part of the building rather than a separated element located in the site.

Analysis of this path values due to the subject of this thesis. The circulation path inside the building and developed to all of the site, provide access to activities inside each building and in the same time define the level of accessibility inside the site.

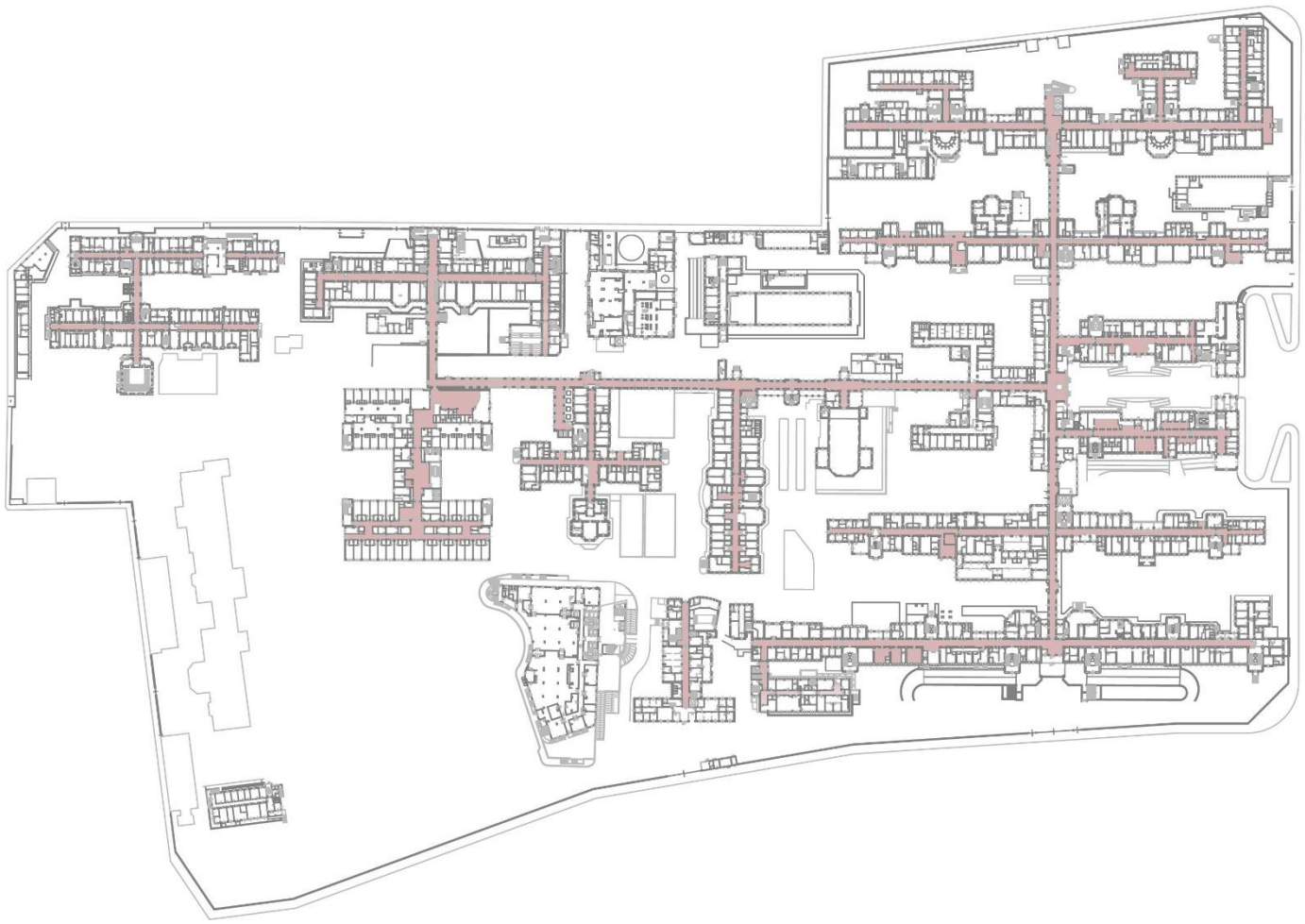


Figure N: general path in the Citta di Salute

CIRCULATION

Introduction

If we consider a hospital alike a city, as well as in this city there are a sort of different function namely shops, residential and industrial blocks, a hospital contains educational department, nurse station and rooms, caregiving rooms and other different functions. All of this rooms are working as a single unite. In this example, the main pedestrian path inside the mentioned hospital plays the same role as the main street of the city. This path connects and assembles separated elements of the unique built environment. Returning back to the example of the city, the main street. As flows the traffic inside the urban zone and so provide needs and services of the city, creates the main character of urban fabrication and texture (James, Noakes,1994).

Circulation is one of the most important spatial features in architecture. Circulation network in a building is the system of horizontal and vertical access between spaces. They are predefined as corridors or stairs. In typology analysis of circulation, it is possible to name three different kind of attributing elements:

I-path: most presentative concept of circulation as the linear spaces which are linking different spaces with different function.

II- zone: rooms in architecture or specific area design for particular functions. As the function and social activities in these rooms are connected together it is important to provide physical link between them.

III- node: the points in spatial distribution. The nodes could be the center of an important and emphasized usage area or the point which zones are linked to each other or a zone and a path are faced, or two paths are linked (a path is divided). In this category most, important node known in architecture is “Door”.

To analysis of circulation system in a certain building there are many factors that can be observed based on the function of the building. In sanitary buildings as well, it is possible to take into account a sort of feature that are associating with the efficiency of circulation network. Among them this research will focus on two main groups and regarding the applied tools BIM and VR there will be analyzed.

Quantity based features: when the circulation system is linked with the terms of “distance” it is important to calculate quantities adjective of the length. Distance as a parametric feature of the space can be defined with many measures namely time consumed to pass from a start point to destination

Circulation and architecture

A building is composed by many factors and includes different systems in collaboration through them it is possible to run a specific function in the building. As a result, architectural process is divided into separated stage namely design, construction and maintenance. Or is represented by different documents namely electricity sheets, structural documents and conceptual diagrams.

All of the contributing factors are recognizable as qualification factors or quantification factors or a combination of these two.

Function and space are two aspects of building which are including both qualitative and quantitative information. They are interacting each other and creating other features. About space and function Among space has two duties about function:

1-It provides container to run function as the any activity of human occur in a specific place and it needs a certain location with particular adjectives. The theme of the building is defined by its function and in smaller scale the theme of the space is due to its function.

1- Space provides access to function, to pass toward a specific activity, user need to pass the space

Circulation in Sanitary Buildings

Circulation in Sanitary Buildings is defined as the network of paths which are contributing in the provide access between functions in the sanitary building of between each room and Exit/Entrance point which can be the stairs in multistore buildings. In sanitary building there is an additional and competing definition of functions and paths and accesses which are assigned to the special usage.

Regarding to Nazarian 2011 different typology of circulation network can be defined as the ward layouts. Classification of these ward is due to the access and circulation running by them. In this attitude ward is combined by a circulation path as the core of ward and different spaces attached with their various function which are spatially organized around the main circulation path(Nazarian, Price, Demian, 2011).

Spaces category is presented as the three main function in the all sanitary buildings:

1-Pation space: the most popular part of the building which is mostly accessible by public and not inclusive users. According to Dowdeswell et all 2004 capacity of these space is playing important role in the access definition. It is divided into two main categories as single-bed (or private rooms) or multi-bed rooms. in some of hospitals there is a system combined of these two categories. Also, it should be mentioned that there are various roles in different national standards which allow the limits of maximum capacity of multi-users room. It varies from only one patient (single) priority in Scandinavia up to 6 bed bays allowed in UK. In this section respecting to patient privacy and decreasing cross-infection is considered. (Dowdeswell et al, 2004)

2-Staff Space: this section is utilized by employees and personnel; as the result they are less popular and accessible for the public. Staff space could be considered as the nurse's' room, doctors' room, treatment room, staff hall, cleaning services and other services locations.

3-nurses base: this part is the most important known function in circulation distribution which can be altered as the information station in mixed sanitary buildings. Efficiency of the circulation system is a function of possibility of nurses to cover the largest part of the ward provided by access paths.

There is different approach to classify the circulation systems in sanitary buildings but all of them are based on how the mentioned spaces are designed around the main access path and as the result how they are linked together (Nazarian, Price, Demian, 2011).

James and Tatton-Brown (1986) recognized seven categories as: Simple open or Nightingale; Corridor or Continental; Duplex or Nuffield; Racetrack or Double corridor; courtyard; Cruciform or Cluster and Radial (Alalouch et al 2009)

Another categorizing approach is presented by HBN4 (1997) as: Nightingale; Sub-divided ward; Nuffield; Falkrik and Nucleus.

Nazarian, Price and Demian are using their classification which is based on the mixture of the two attitudes mention above. In this research I will use this classification as it is comprehensive and simplified in the same time.

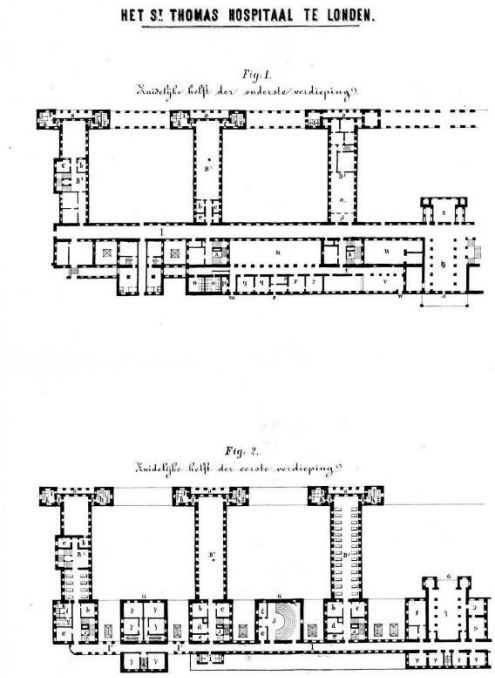
Corridor ward

Corridor ward is transformed shape of Nightingle ward or Long Nave ward. As the original form it was a vast unmixed hall with no subdivision. In the late 1870 this form was extended and renamed to Florance Nightingale. Some secondary rooms might be attached in the use of services and peculiar patient.

The main hall was occupied with 30 beds, in some occasion there were some division. Namely as HBN 04 mentioned male and female patient were allocated in separate wards.

Improved form of this spatial strategy is what is now accepted as Corridor ward (or Continental ward). New forms are adopted to provide users with more reverence and privacy and to guarantee less prevalence of infections (Pattison et al.1996). as the result in Corridor form tow sides of a main corridor is divided into multi-users room. The main corridor might be recognized in the shape of a ‘T’, ‘C’, or ‘L’.(catrambone et al 2008).

Example



St Thomas hospital in London

The most important modification of corridor style is the centralized part which is dedicated to nurse point, information station and/stairs with a single room. This stage devised the long corridor into two parts and allows the nurse station to be out of the main path of corridor. This style also provides division for the unique corridors. This division will help to separate patients in function of their gender or

other classifications. As the result instead of having one long corridor there are center point and two wings.

Duplex ward

The special ward in the 1950s. the design of the Duplex is also named as Nuffield is the mixture of two separated corridor wards with their separated nurse point but the space between them is covered with both.

This style was emerged after increasing attention given to importance of sanitary division. Following the new roles and standards the design of hospitals became more complicated and more subdivided in function of the type of illness and patient so more hygienic environment became provided.

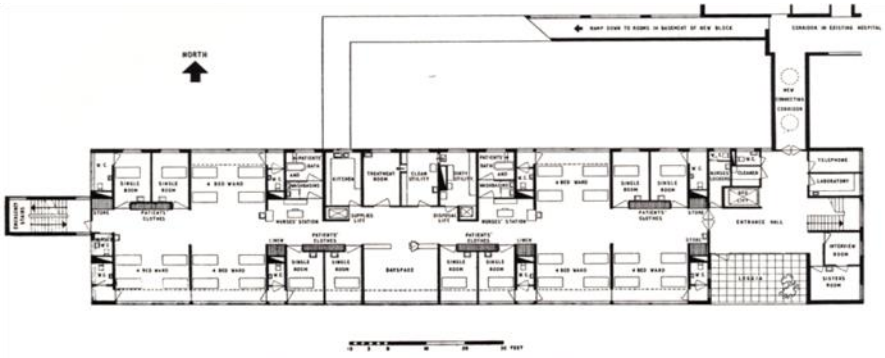


Fig. 222. Plan of experimental ward unit, Larkfield Hospital, Greenock, Scotland, 1956.

Racetrack ward

Style for the years 1950s-60s with the capacity up to 60 beds providing personal privacy.in this spatial division the center of the rectangular plan is located for services rooms and nurse point or information station. It is developed shape regarding provision of more sub-division to guarantee privacy and hygiene in one hand and covering as biggest part of plan as possible by exit/entrance access and nurse/information station. This typed is also named as double corridor because in the linear plans nurse center divides the plan into two corridors. This style is very in used in US (page and page 2004).

Falkirk ward is the most famous adopted design from Racetrack ward in the 1960s (HBN 04 1997) in this type in the core of the plan services are located.

Transparent partitions which provide division in patient rooms is one of the known features in this design.

Disadvantages: It is taken into consideration that this plan type is the problem of lack of natural light and ventilation in particular in central corridors.

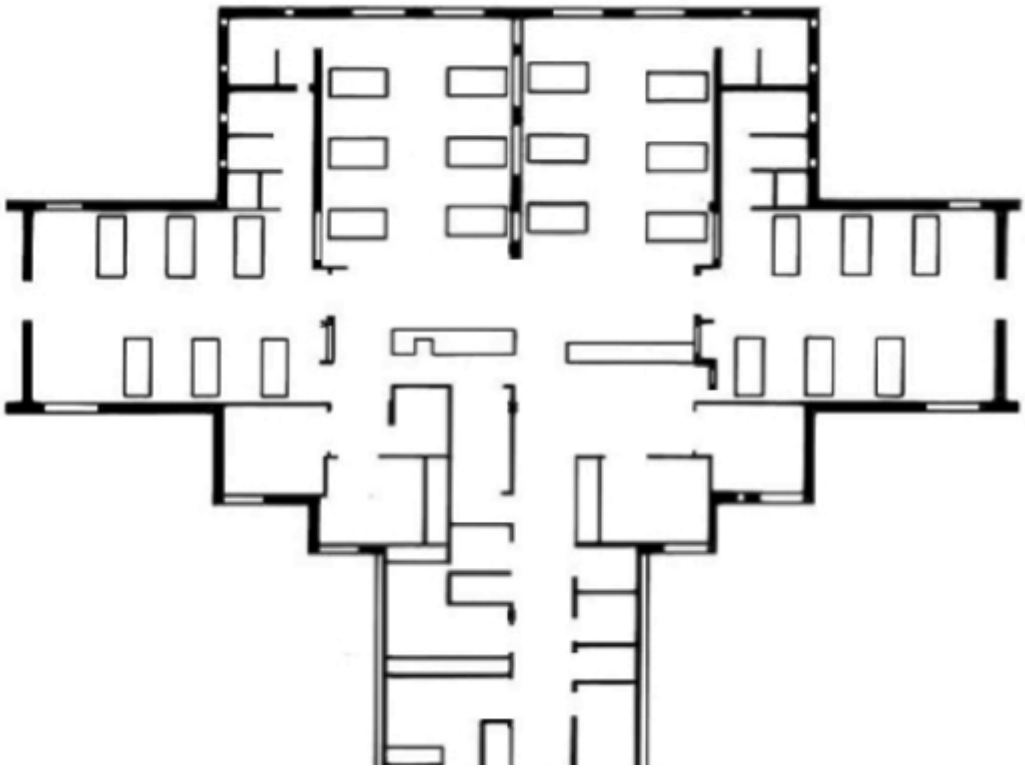
Example:

High Wycombe hospital Buckinghamshire

Cluster ward

This style is a result of geometric development of a rectangular core. Horizontal and vertical corridors intersect in the core station and create axis network. Geometric extension of the core is useful to utilize as most natural light as possible as it increased exposed facades area.

Example



Weston general hospital ,UK

Radial ward

In some approved theories Radial style is announced as the most efficient shape and design in terms of contributing factors such as possibility of natural light and ventilation use and also accessibility of each room from information/nurses station.

Example

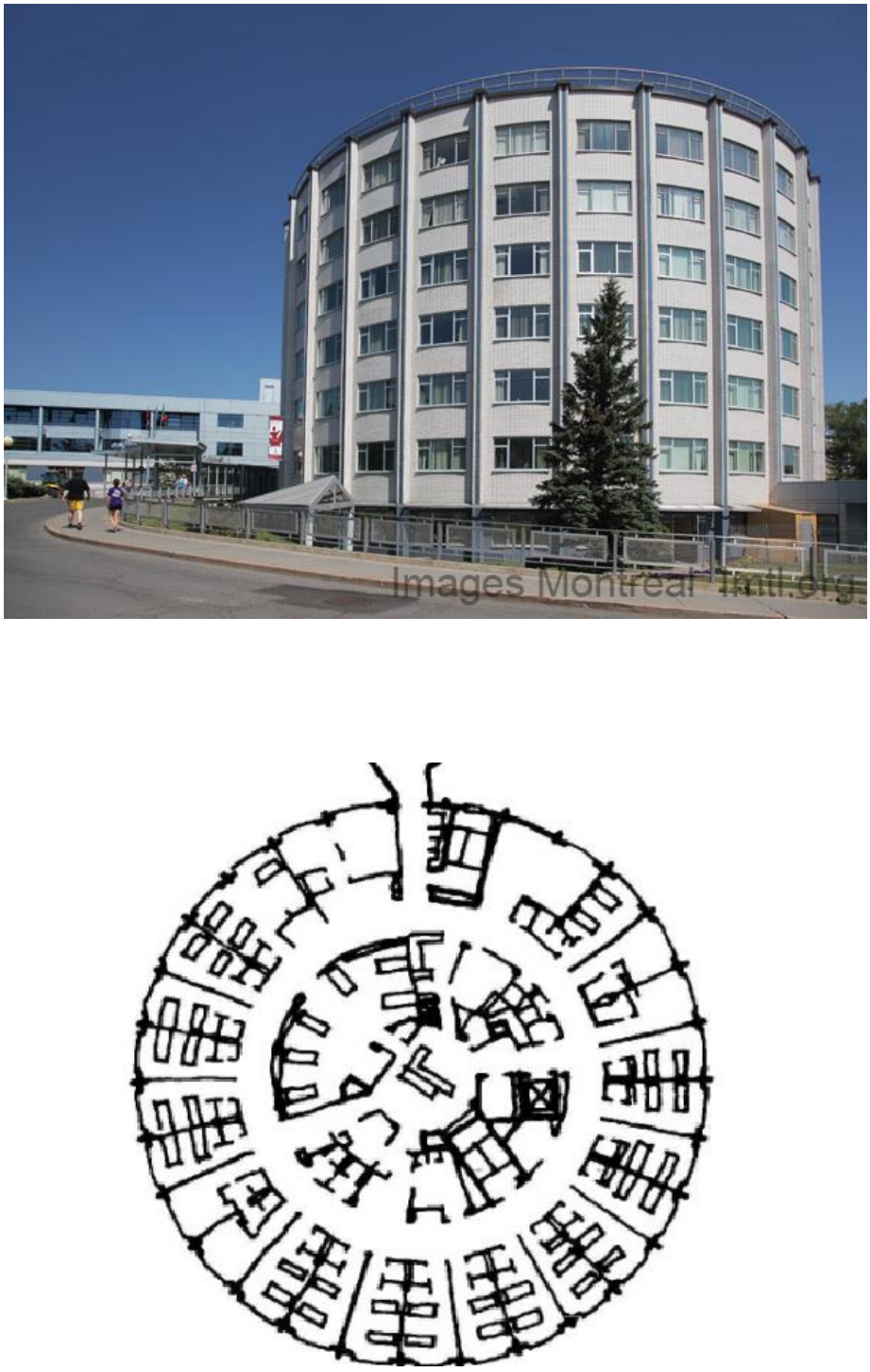


Figure N:Francis Xavier Cabrini Hospital, Montreal, Canada.

Analysis of models:

Circulation network in the building might define the concept of the architectural design in the earlier stage of the construction. It will present the main line and division of building and it is contributing with distribution of spaces and function.

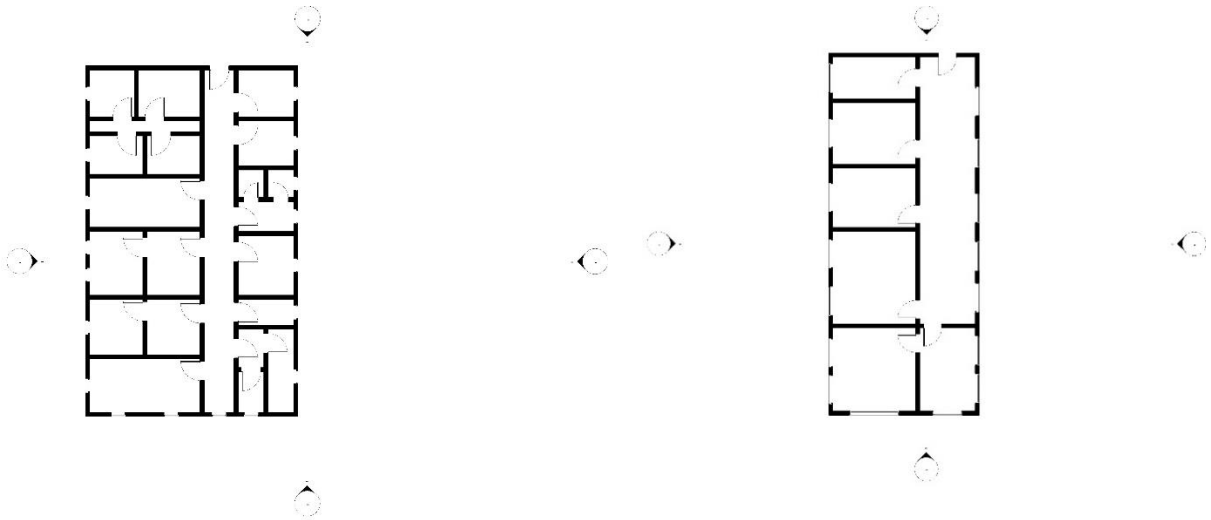
In addition to the role of circulation path in conceptual analysis, it is associated with two main factors that their efficiency is based on circulation system:

Accessibility: the main role of the vertical and horizontal paths through building is to provide access to other function. Accessibility in different kind of building might vary to be “efficient”. In the airport for instance safety and legibility may assume as the most important factors. In a residential house on the other hand the most important feature of the circulation could be provision of privacy and comfort.

In sanitary buildings in particular, it is matter to have the shortest travel time and distance between two pair of the space and much more importance between information spot or nurse spot and all other rooms. This factor enhances its values in emergency situation and with special sanitary sub-division as well. The two parameters Traffic and Distance are introducing the Circulation value in each two point of the part of a sanitary building (Shirley, 1974).

Environmental qualities: considering the special usage of the sanitary space, it gains value to provide maximum mental and physical hygiene for users. This could be reach by providing followings:

- Natural Light
- Natural Ventilation
- Vision Flow



Environmental essentials regulate the shape of the sanitary buildings. It will be resulted in avoid of having deep and narrow spaces with no relation to outdoor. And tendency to design slender corridors.

Figure N: environmental essentials force architects to avoid deep plans in sanitary buildings.

Classification of Molinette Hospital regarding circulation types

According to the classification mentioned in previous section it is time to assign a ward type for the case study. For this purpose, first the wards of circulation axis should be recognized. The combination of wards will demonstrate the total style and following this step it will be possible to introduce new circulation proposed regarding provide more space to provide needed function.

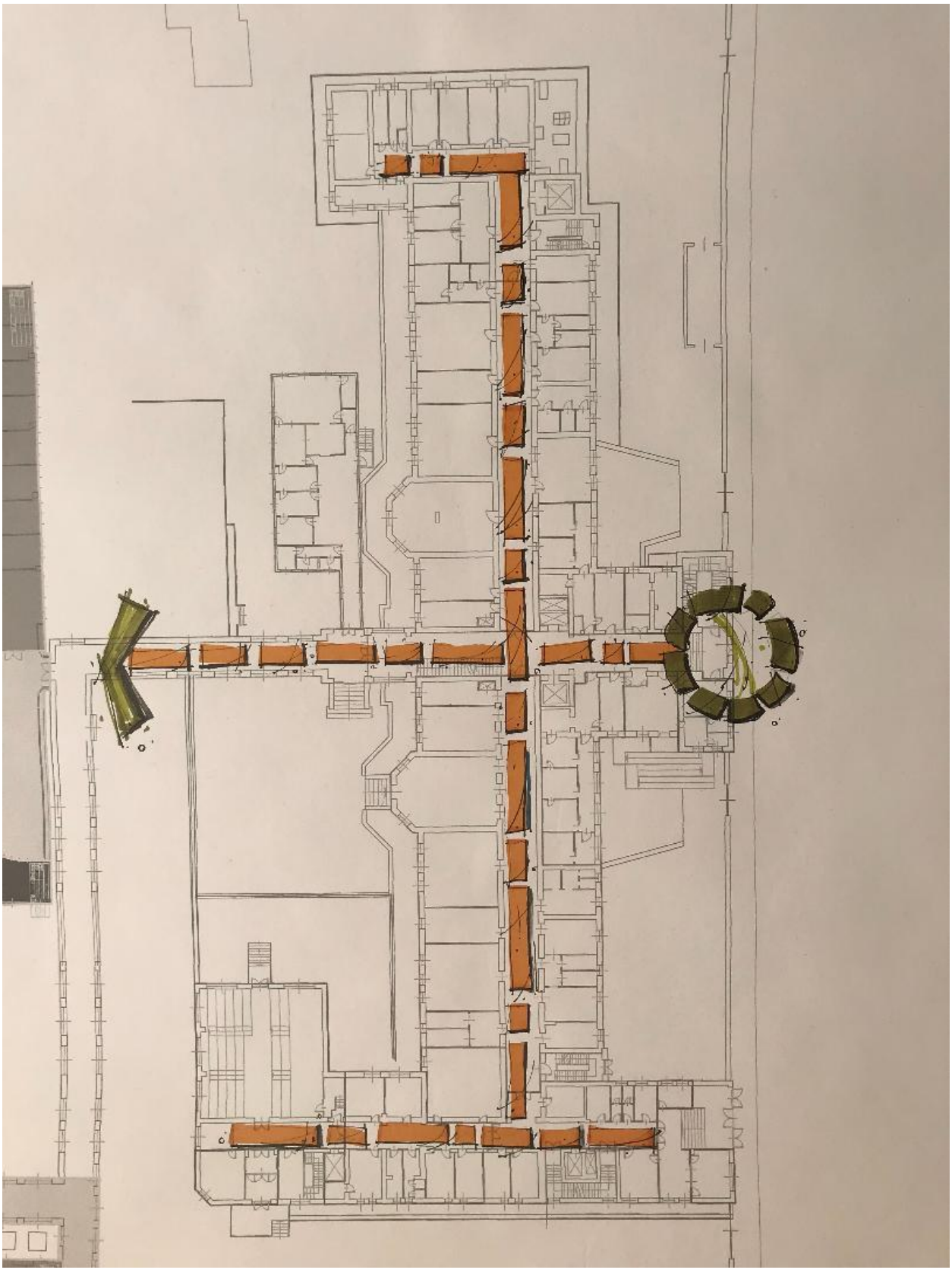
In classical representation of Architectural distribution of space, followed by circulation analysis, the main part of approach and attitude was illustrated by conceptual design on the paper. As this sheet is normally not included in official presentation of building to construction nor in restoration, is not attached to the building documents. In the classical spatial analysis of architectural design, circulation features are assigned to the plan. In the convental methods architects used to attach some additional diagrams to the specific plan to illustrate the circulation system as well as other spatial features.

The mentioned conceptual designs are known as architectural styles and attitudes of designer in primary stage of analysis. To understand this Idea, it could be needed to ask directly from the architect(s).

The issues and problems of such manner is lack of a unique comprehensive document including all aspects of design and construction. Secondly as the different aspects are not connected together it is impossible of hardly difficult to manage the changes during design and construction procedure.

Regarding these issues circulation network inside the design process, affected by other aspects namely mechanical, structural and electrical systems running into the construction, could be neglected.

In addition, the primary concept of design which is followed by more specific and detailed procedures, expected to be fix and unchangeable.



Applying BIM to classify and modify circulation Path

Circulation system as a parametric network

Pedestrian circulation running into a building is a network of vertical and horizontal connection between spaces through which access to content these spaces become possible.

In this terminology all of the surface of plan is divided into two categories:

1- **Path**: All vertical and horizontal connection running into building. This class could have subdivision of main path or secondary path. Normally main horizontal paths determine the circulation model in the building. In the classical presentation it used to be illustrated by a thick line or sharp colored signs.
   1-1- **Vertical path**: composed by **stairs** and **elevators** to provide access between different floors. These vertical connections can provide access between only two or three certain floors plan or they are main vertical connection for all of the buildings to access to any floor. In the determination of circulation class.
   Vertical paths have no horizontal flow through the building and so are less contributing in definition of circulation model. They can be recognized as the point in path class.
   1-2- **Horizontal path**: the main feature to define the circulation model in the building is the network of horizontal paths developed in the plan. started from a point or vertical path going to other point. In these spaces there is no function but provide access.
2- Point: points in circulation classification are the spaces that are not providing access but are aimed to provide access. All rooms and spaces in the building with specific function can be recognized as a point. Points are dived into two major group regarding their side in access activity as following:
   2-1- **Start Point**: a certain pedestrian travel is always starts from specific point. This start point could be the main entrance or other space with other activity. In this terms if travel is between two special space with two function, they have no fix class as start point and destination. Entrances, Information desks and nurse station are among important start points.
   2-2- Destination Point: the destination space for which travel occurred. This point is final point that could be reached by circulation or it is a middle destination point. That means arriving to this point will not finish

the travel and it is the middle function to reach. After this point circulation still may flow.

The mentioned terminology is assumed as the information of space. The definition and role of each single enclosed space in the Building Information Modelling can be attached to space model. So all analysis and proposal can be obtained directly from model and all its information.

In the following, the classification of circulation system in the building is illustrated. So all of the existing room are sorted by their classification in the circulation network.

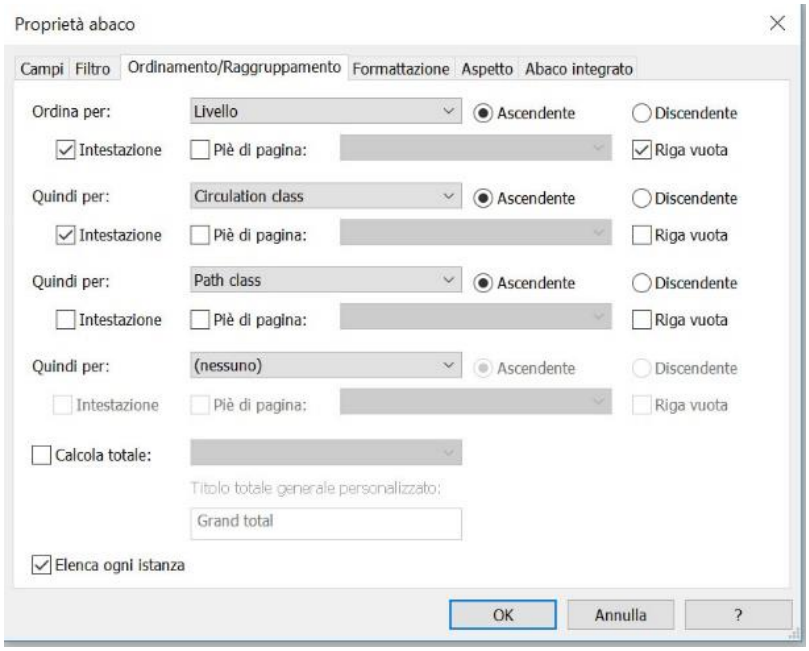
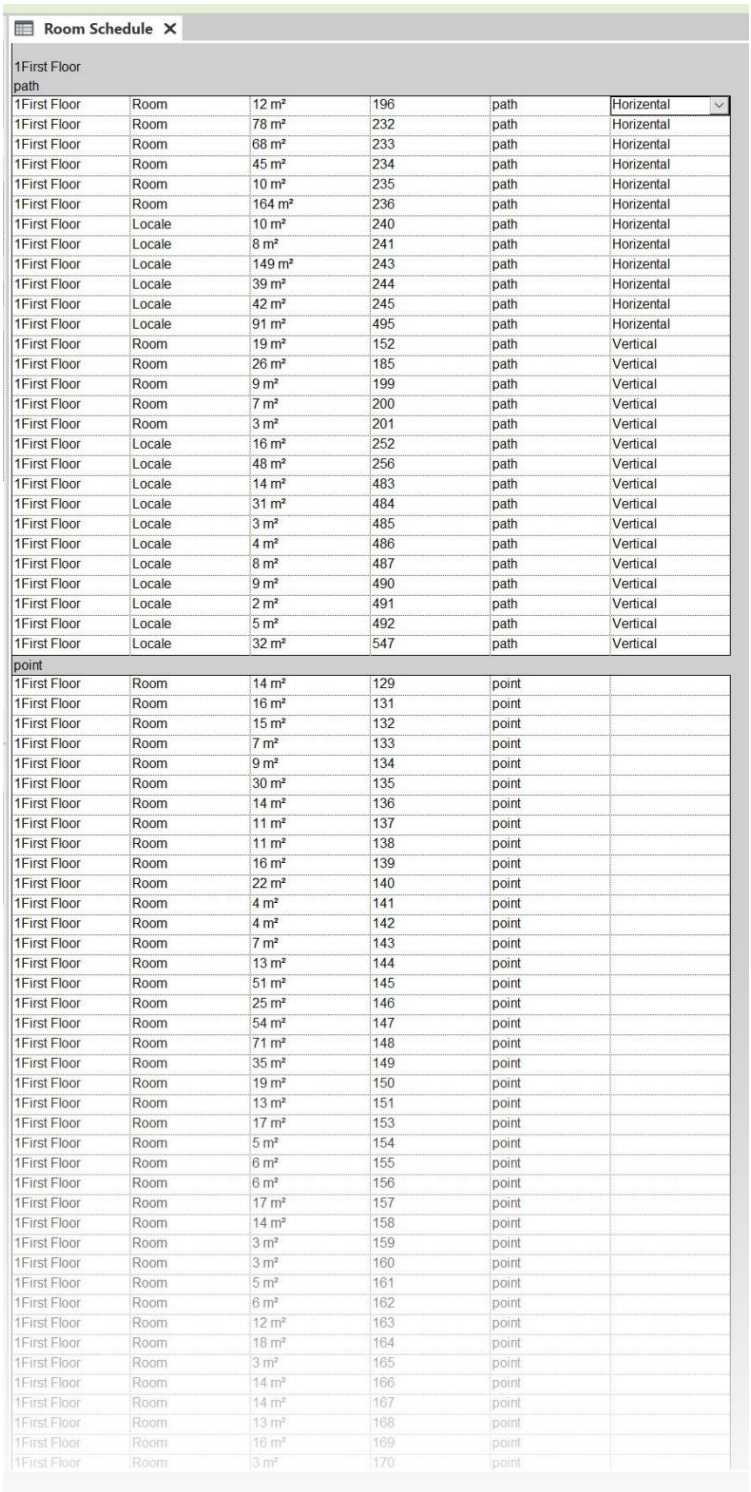


Figure N: sort the information about circulation component in Revit.

According to this classification the following chart is exported for each floor plan. In the schedule all space component is classified. As an example the schedule of first floor is presented below.



Room Schedule

1First Floor					
path					
1First Floor	Room	12 m²	196	path	Horizental
1First Floor	Room	78 m²	232	path	Horizental
1First Floor	Room	68 m²	233	path	Horizental
1First Floor	Room	45 m²	234	path	Horizental
1First Floor	Room	10 m²	235	path	Horizental
1First Floor	Room	164 m²	236	path	Horizental
1First Floor	Locale	10 m²	240	path	Horizental
1First Floor	Locale	8 m²	241	path	Horizental
1First Floor	Locale	149 m²	243	path	Horizental
1First Floor	Locale	39 m²	244	path	Horizental
1First Floor	Locale	42 m²	245	path	Horizental
1First Floor	Locale	91 m²	495	path	Horizental
1First Floor	Room	19 m²	152	path	Vertical
1First Floor	Room	26 m²	185	path	Vertical
1First Floor	Room	9 m²	199	path	Vertical
1First Floor	Room	7 m²	200	path	Vertical
1First Floor	Room	3 m²	201	path	Vertical
1First Floor	Locale	16 m²	252	path	Vertical
1First Floor	Locale	48 m²	256	path	Vertical
1First Floor	Locale	14 m²	483	path	Vertical
1First Floor	Locale	31 m²	484	path	Vertical
1First Floor	Locale	3 m²	485	path	Vertical
1First Floor	Locale	4 m²	486	path	Vertical
1First Floor	Locale	8 m²	487	path	Vertical
1First Floor	Locale	9 m²	490	path	Vertical
1First Floor	Locale	2 m²	491	path	Vertical
1First Floor	Locale	5 m²	492	path	Vertical
1First Floor	Locale	32 m²	547	path	Vertical
point					
1First Floor	Room	14 m²	129	point	
1First Floor	Room	16 m²	131	point	
1First Floor	Room	15 m²	132	point	
1First Floor	Room	7 m²	133	point	
1First Floor	Room	9 m²	134	point	
1First Floor	Room	30 m²	135	point	
1First Floor	Room	14 m²	136	point	
1First Floor	Room	11 m²	137	point	
1First Floor	Room	11 m²	138	point	
1First Floor	Room	16 m²	139	point	
1First Floor	Room	22 m²	140	point	
1First Floor	Room	4 m²	141	point	
1First Floor	Room	4 m²	142	point	
1First Floor	Room	7 m²	143	point	
1First Floor	Room	13 m²	144	point	
1First Floor	Room	51 m²	145	point	
1First Floor	Room	25 m²	146	point	
1First Floor	Room	54 m²	147	point	
1First Floor	Room	71 m²	148	point	
1First Floor	Room	35 m²	149	point	
1First Floor	Room	19 m²	150	point	
1First Floor	Room	13 m²	151	point	
1First Floor	Room	17 m²	153	point	
1First Floor	Room	5 m²	154	point	
1First Floor	Room	6 m²	155	point	
1First Floor	Room	6 m²	156	point	
1First Floor	Room	17 m²	157	point	
1First Floor	Room	14 m²	158	point	
1First Floor	Room	3 m²	159	point	
1First Floor	Room	3 m²	160	point	
1First Floor	Room	5 m²	161	point	
1First Floor	Room	6 m²	162	point	
1First Floor	Room	12 m²	163	point	
1First Floor	Room	18 m²	164	point	
1First Floor	Room	3 m²	165	point	
1First Floor	Room	14 m²	166	point	
1First Floor	Room	14 m²	167	point	
1First Floor	Room	13 m²	168	point	
1First Floor	Room	16 m²	169	point	
1First Floor	Room	3 m²	170	point	

Figure N: presentation of Circulation system in the Revit schedule.

To combine data information and illustration of building documents as the necessary representation of architectural concept, circulation data and their graphical presentation are always available in the same time. The small change in the function of each space could be modified in the data sheet as the schedule in the same time and the result will be updated automatically.

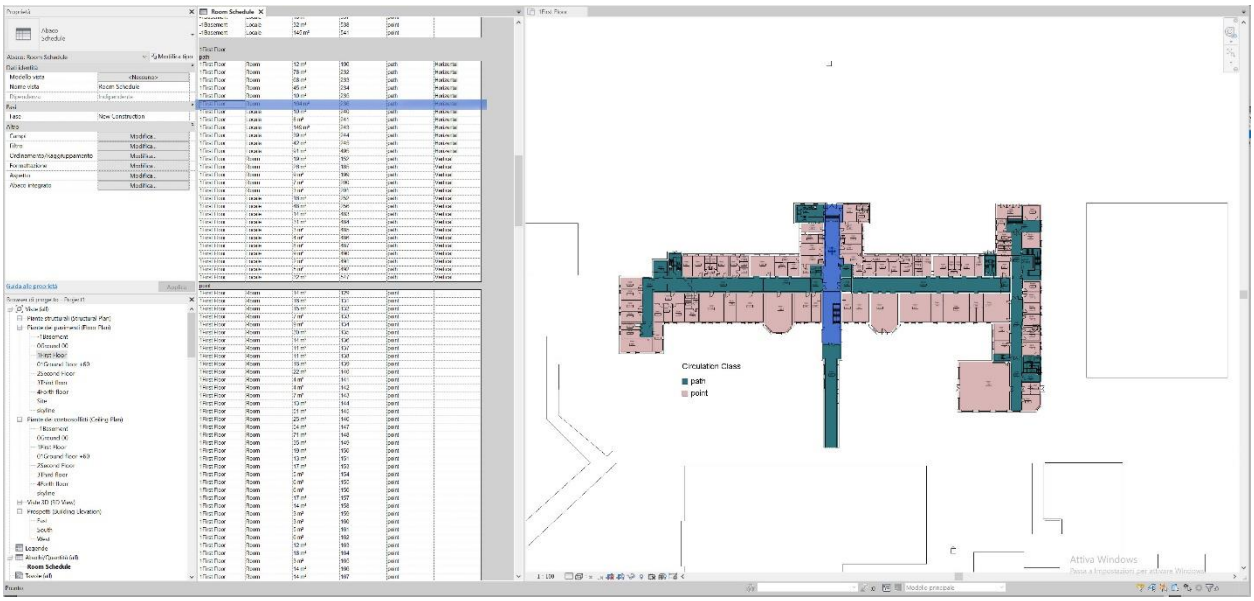
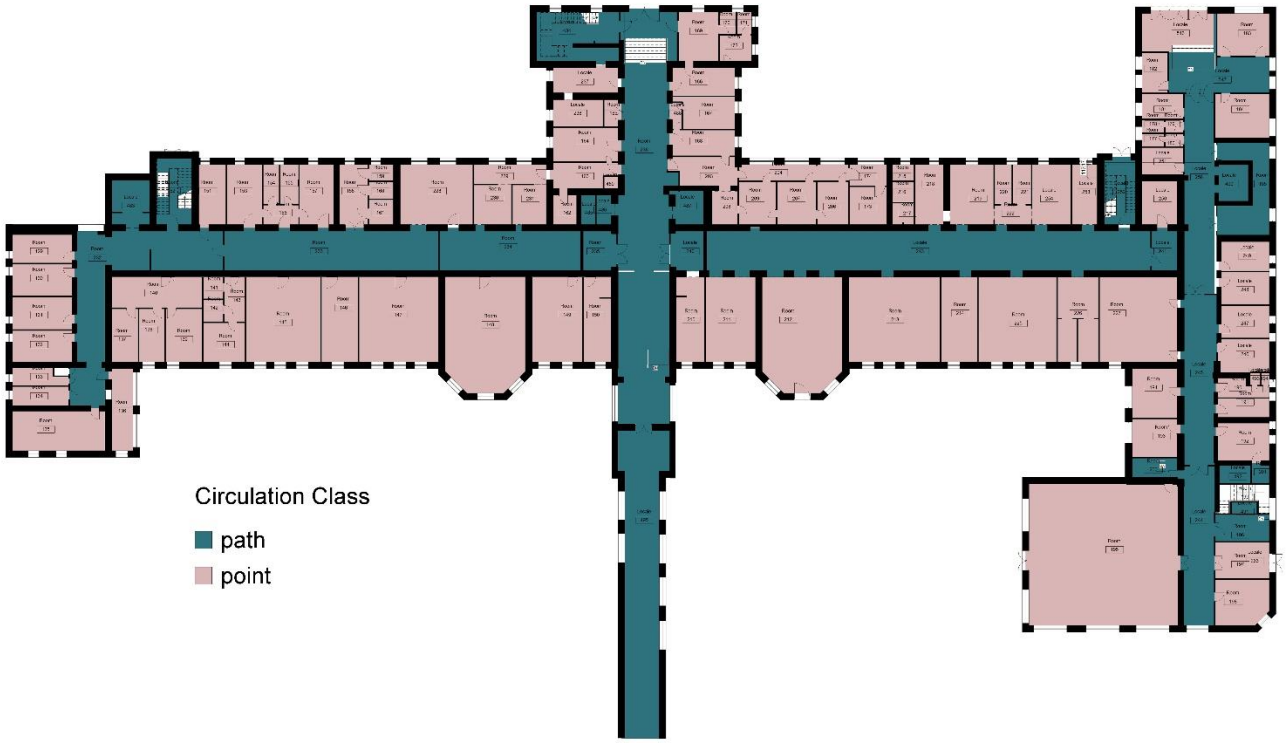


Figure N: representation of the graphical illustration and corresponding attached space data

With the all data and information made by Revit, now it is possible to classify the Circulation of Mollinette Hospital by presenting the circulation Paths and their distribution in the building. The following figure is the example of circulation system in the first floor. It should be mentioned that as the floor plan in the all stores of the building are similar with small different which are not attributing to the main image of circulation it is possible the example of first floor could be taken to recognize the model of circulation network in the building as general.


Circulation Class
path
point

Conclusion

Regarding the provided information, it is feasible to categorize the circulation network into the existing models. As the matter of fact presented model are mail circulation modes existing with one of their obvious example. it is less aimed to classify into one specific model. A certain sanitary building can be recognized as having one of them clearly or it is the combination of two or even more classes. Explained that, the Circulation path through the Molinette hospital is more likely to be recognized as the Corridor ward circulation model. With the certain modification in the center of ward. As the main entrance and horizontal connection to the other buildings in the site, divide the main corridor into two wings.

Advantages and disadvantages

With regards to different aspects that can be analyzed beside the circulation system as **environmental qualities** and **accessibility.**

Corridor ward with two side rooms and central circulation as the Molinette Hospital is designed is composed by drawbacks and benefits about these two features. As rooms in both side are taking benefit of natural light and ventilation, corridor in the core of the plan is suffering from lack of these.

Nucleus or **deep plan ward** is classified in the same model corresponds more the case study. This type is changed version of corridor ward due to lack of fuel epidemic in 1980-1990s. Nucleus Hospital are tending more to provide energy efficiency rather than environmental essences (Nazarian, Price, Demian, 2011).

One of the most shortage of all architectural presentation is lack of ability to demonstrate environmental and qualificative features in Architecture. As the best render with high artistic quality is not able to illustrate the spatial adjective of building and in addition they are static documents. The Time is demolished in these documents and passing through spaces is impossible. While on the other hand architecture is not static concept and it is involving with much more dynamic presentations of space.

New technologies add the lost feature as the time to the architectural documents and made human to walk inside and outside of the building to understand and feel the real sense of being in the space.

SPACE SYNTAX

Introduction

There are several methods to analysis of architectural space namely climatic, formal or historical. The methodology known as Space syntax has been presented to architectural terminology since 1970s in England. This method has been known for the first time by Steadman and Bill. Hillier and Julian Hanson and introduced new aspects to Architectural Morphology.

The main concept of space syntax is to involve with social relations carried by space, for example creating perceptual margin of user or degree of privacy or public of a space.

History

In the 70th after presentation of formal method by Rob Krier, Space Syntax has been introduced by English authors. Steadman, the writer of the book Architectural Morphology regarded to the subject several times in his new books. In this book, he took into consideration the theoretical aspects of morphology. in the other worlds he comprised the different geometrical composition of spaces with other possible compositions. For example, he made comparison between all possible composition of a room and a corridor and has chosen the option which corresponded more with functional state.

On the other hand, Hillier and Hanson tended to more practical side. In their earlier stage of work, they tried to release hidden logic and motivation to shape the spatial forms of real environment, local buildings and organic multiplexes. In the second step in 80s, they introduced “Justified Graph” as the new drawing methodology. By this technique it was possible to model different spatial algorithms. They published their theory and methods in the book “The social logic of space”. In this step Space Syntax methods became public an international.

Presentation

Authors of this technique, have social regard to any artificial creators in general and buildings in particular. They announce that to shape a work, style and its function have an important role. Analysis of a building will release a series of social interact of creators and users of it.

This attitude will regard the two main object in a specific architectural analysis.

- Space: the container of all of event and manner in the building. The most important adjective of a space is its shape. And shape is a consequence of “form”.
- User: the content of space is user and its usage of space. Specific character of a building may apply special usage to it. As the consequence particular users will utilize the space with their aim. Following their activities, **social character** will be applied to the space (Hiller, Hanson, 1984).
- The relation of space: space and users shape each other in the bidirectional way. To start from the effect of space on users, design of the building applies limits and freedoms to human. It evokes them to particular activity and even forces them to do special behavior. As a door is to pass from not to sleep in. in the contrary side, reverse might occur and users can create or modify their environment according their needs and desires. Taking into consideration both flow, space syntax, mainly is providing tools to analyses the first effect.

Methods and tools

The main target of the space syntax in any scale is the two or more space and their composition. One space only cannot present any configuration in space syntax. Traditionally the most important material of the analysis is “plan”. In urban scale this plan illustrates the configuration of buildings around a road and in architectural scale the plan is graphical illustration of rooms in inner circulation path so the “Topology” of the space is discussed mainly. The logic is that the topological aspect of a building involved in both formal and social features of the space.

In addition, topological methods of representation of plans, are more precise and obtain more information, rather than description documents or graphical or geometrical. As the result in the first steps of space syntax methods and in theoretical stage, spaces are categorized in topological classification (Bafna,2003).

Topological description of a space can be started from the simply oral presentation of a building up to two dimensional diagrams of the space relations and finally in recent analysis it is applied a series of complicated tools to provide more precise illustration.

Space syntax Diagram

In space syntax presentation of relations of space is started with diagrams. Space diagrams are similar to special organization bubble which are mainly presented in

earlier stage of conceptual design of the building. But they gained their legend and form to reach closely to the object of spatial analysis.

Space syntax diagrams differ based on scale and graphical presentation but they are mainly contained similar information:

- **Space**: a room or any other enclosed space which can be defined in three dimensions. The space could be covered like inner room of a building or non-covered like urban squares. In most diagrams, defined space is a **circle** or a **point**.
- **Access**: access to defined room can be simply provided by a door. Access to a space is represented as a line.

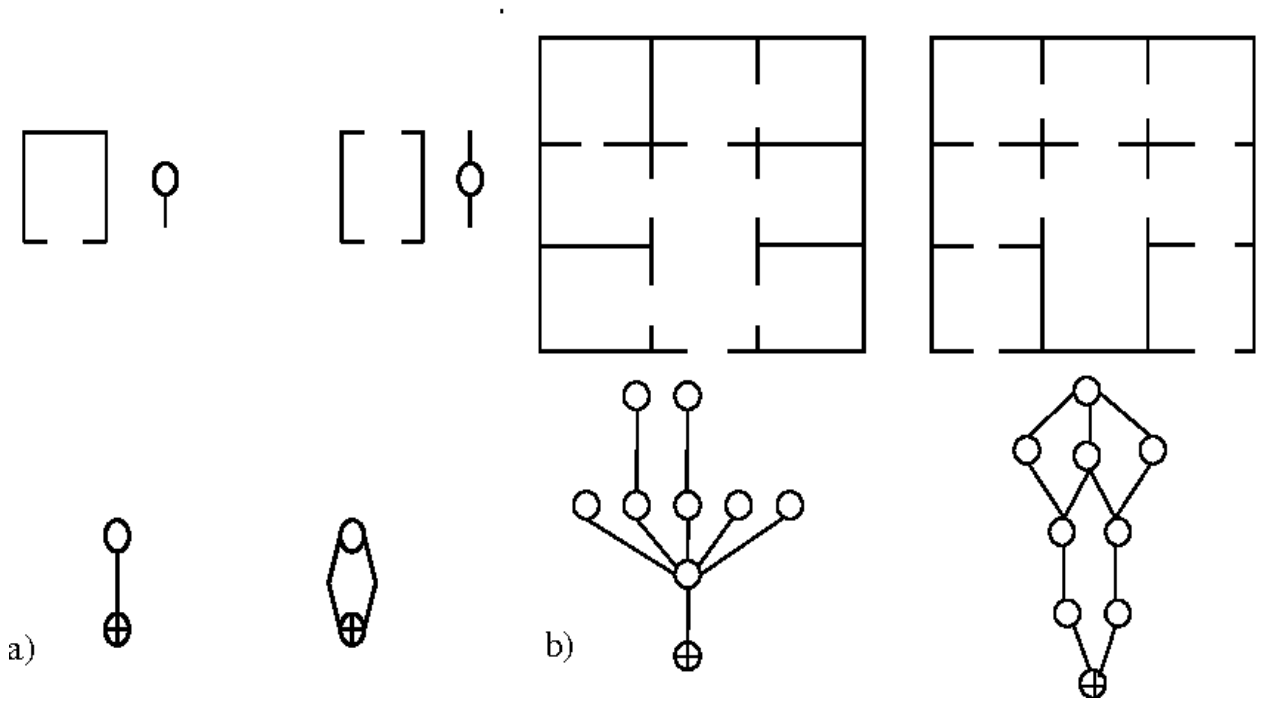


Figure N: space syntax presentation

Spatial analysis of sanitary buildings

Regarding that function and the use of space have important part of the space syntax, and all analysis of distribution of space consider the behavior of users; this type of analysis depends on the special character of the building. The main character of the architectural work defines the best option to compose the spaces together. For an example, space syntax attitude to a residential house differs to a factory. And in residential sector, single-family detached house must be analyzed in different way than a complex multi-family tower.

Space syntax of a sanitary building is close analysis of internal space to circulation analysis. as mentioned in the previous section, accessibility and providing hygienic environment is the most important role of the pedestrian circulation network, following that, space distribution and connection must be organized in the same way. To achieve the main goals to enrich the spatial design of hospital, as mentioned, two main aspects much be taken into consideration.

Accessibility: to be able to reach to a specific point through the most fluent path. The meaning of fluent in access analysis could be the shortest. But in space syntax this will be involved with the question: how many space should be passed after entrance to reach a specific point. As the passing through a room will occur when user pass a door, the question will be modified to: How many doors should be passed to reach to specific point.

Space Syntax applied to Molinette Hospital

After classifying the circulation network in the hospital, now it is possible to analysis of spaces in related to circulation path. As mentioned in previous section the main characteristic of the pedestrian circulation is the main corridor in the core of the plan. All rooms and functions are configured around it.

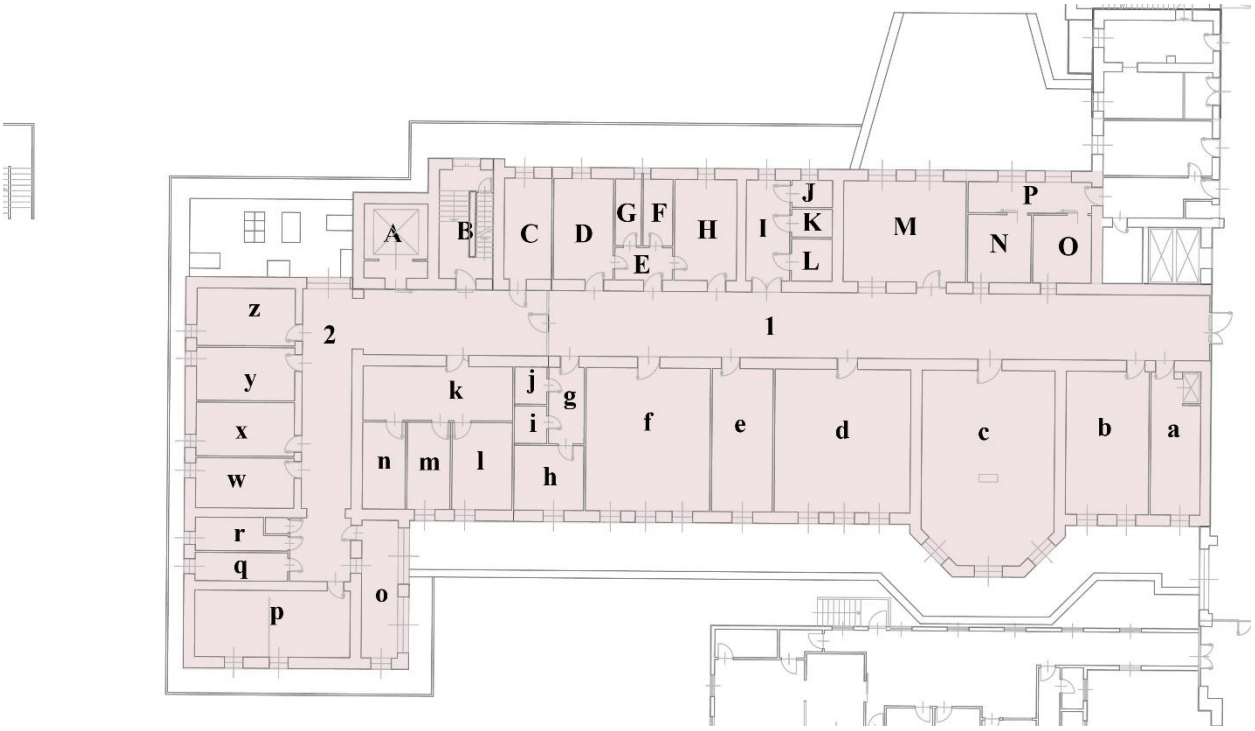
On the other hand, in space syntax diagrams even the corridor itself in considered as the point. As it is necessary to pass it to achieve an objective goal.

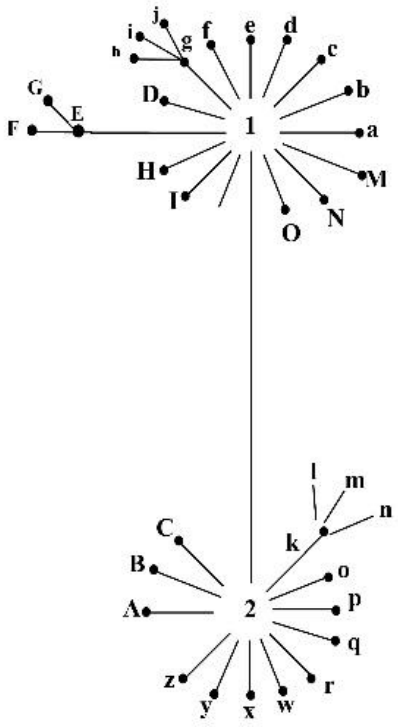
Classical diagrams

To analysis of spatial distribution of rooms around circulation path, it could be useful to start from the classical diagrams, draw to illustrate the space configuration.

To define the path from points, path is named in number while point is named alphabetic. But graphical presentation of them are same. Both path and point are

illustrated as a solid circle. On the contrary physical access between them is represented as a line.





Failures of classical diagrams

Space configuration diagrams are good way to explain the relationship between spaces, but in the same time these documents have some shortages that could be resulted in misunderstanding. In particular, between different specialist involved in the building construction.

1- Due to few information putted into diagrams, they could be not legible for all involving persons. Especially non-educated readers of documents.
2- There is no difference in the points in function of shape, form of size. For example, a linear long corridor has the same presentation point as the vast

hall. But in reality the quality of space will affect the accessibility and passage line.

3- The length of the lines is not corresponding to any qualification of access but to presentation methods.
4- In the enormous project, containing complicated relations between spaces, it is not possible to draw a legible and clean diagrams. Increasing the number of points and lines, the diagram failed to be useful to present any information.

Depth analysis of spatial distribution applying Revit

To analysis of the space characters in BIM, first the space should be considered as an object with parametric features. One the most important feature of the space that can be transformed to parametric information is its depth. How many doors or other spaces should be passed to reach to the objective rooms. Each number dedicated to a room, is its level of depth. The higher code gained, the deeper the space is.

0- The entrance itself: in the building there are some rooms that have no usage but entrance. These rooms are located normally between the door and stairs or between door and corridor. All path in the building could be named as zero level as they are directly providing access to other spaces.
1- Room level one is the room to reach after passing one other space with the code of zero or passing after one door.
2- Room level one is the room to reach after passing two other space with the code of one or passing after two doors. A room with the code of 2 is deeper comparing with the space with code number 1.

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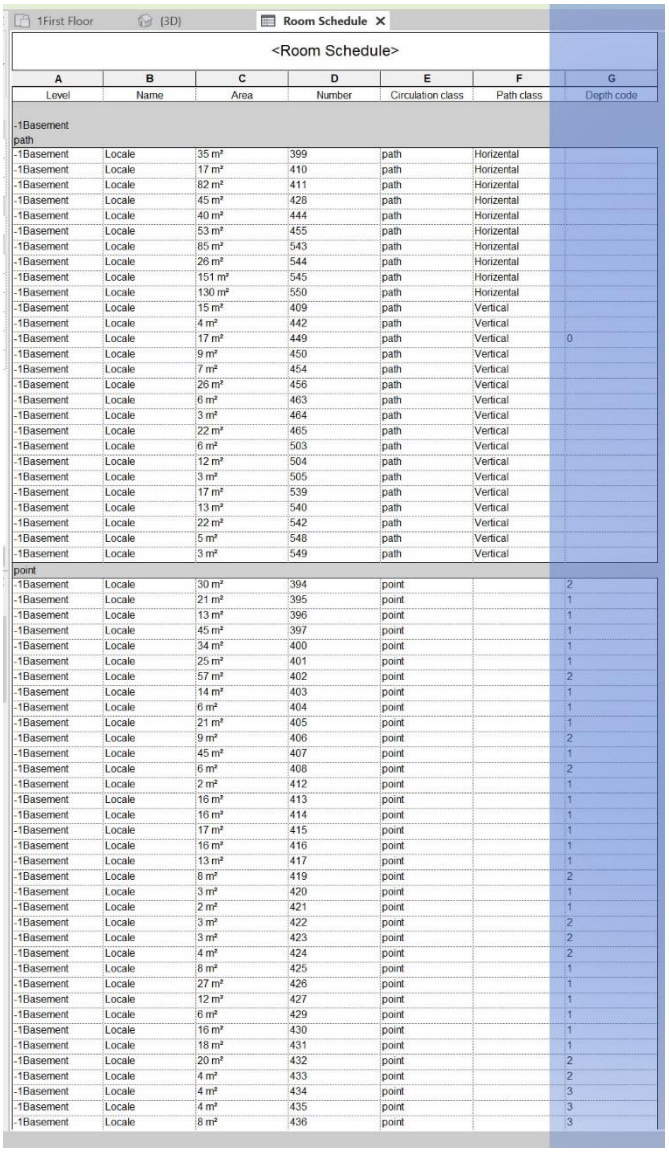
Depth Information

The depth of a closed room can be assumed as a parametric information of space. In BIM it is possible to perceive it directly from the graphical model of the building and in collaborate with other information. The value of depth is recognized as a numeric parameter and to demonstrate the depth map of the building, depth code of points is much more useful.



1First Floor | {3D} | Room Schedule

<Room Schedule>

A	B	C	D	E	F	G
Level	Name	Area	Number	Circulation class	Path class	Depth code
-1Basement						
path						
-1Basement	Locale	35 m²	399	path	Horizental	
-1Basement	Locale	17 m²	410	path	Horizental	
-1Basement	Locale	82 m²	411	path	Horizental	
-1Basement	Locale	45 m²	428	path	Horizental	
-1Basement	Locale	40 m²	444	path	Horizental	
-1Basement	Locale	53 m²	455	path	Horizental	
-1Basement	Locale	85 m²	543	path	Horizental	
-1Basement	Locale	26 m²	544	path	Horizental	
-1Basement	Locale	151 m²	545	path	Horizental	
-1Basement	Locale	130 m²	550	path	Horizental	
-1Basement	Locale	15 m²	409	path	Vertical	
-1Basement	Locale	4 m²	442	path	Vertical	
-1Basement	Locale	17 m²	449	path	Vertical	0
-1Basement	Locale	9 m²	450	path	Vertical	
-1Basement	Locale	7 m²	454	path	Vertical	
-1Basement	Locale	26 m²	456	path	Vertical	
-1Basement	Locale	6 m²	463	path	Vertical	
-1Basement	Locale	3 m²	464	path	Vertical	
-1Basement	Locale	22 m²	465	path	Vertical	
-1Basement	Locale	6 m²	503	path	Vertical	
-1Basement	Locale	12 m²	504	path	Vertical	
-1Basement	Locale	3 m²	505	path	Vertical	
-1Basement	Locale	17 m²	539	path	Vertical	
-1Basement	Locale	13 m²	540	path	Vertical	
-1Basement	Locale	22 m²	542	path	Vertical	
-1Basement	Locale	5 m²	548	path	Vertical	
-1Basement	Locale	3 m²	549	path	Vertical	
point						
-1Basement	Locale	30 m²	394	point		2
-1Basement	Locale	21 m²	395	point		1
-1Basement	Locale	13 m²	396	point		1
-1Basement	Locale	45 m²	397	point		1
-1Basement	Locale	34 m²	400	point		1
-1Basement	Locale	25 m²	401	point		1
-1Basement	Locale	57 m²	402	point		2
-1Basement	Locale	14 m²	403	point		1
-1Basement	Locale	6 m²	404	point		1
-1Basement	Locale	21 m²	405	point		1
-1Basement	Locale	9 m²	406	point		2
-1Basement	Locale	45 m²	407	point		1
-1Basement	Locale	6 m²	408	point		2
-1Basement	Locale	2 m²	412	point		1
-1Basement	Locale	16 m²	413	point		1
-1Basement	Locale	16 m²	414	point		1
-1Basement	Locale	17 m²	415	point		1
-1Basement	Locale	16 m²	416	point		1
-1Basement	Locale	13 m²	417	point		1
-1Basement	Locale	8 m²	419	point		2
-1Basement	Locale	3 m²	420	point		1
-1Basement	Locale	2 m²	421	point		1
-1Basement	Locale	3 m²	422	point		2
-1Basement	Locale	3 m²	423	point		2
-1Basement	Locale	4 m²	424	point		2
-1Basement	Locale	8 m²	425	point		1
-1Basement	Locale	27 m²	426	point		1
-1Basement	Locale	12 m²	427	point		1
-1Basement	Locale	6 m²	429	point		1
-1Basement	Locale	16 m²	430	point		1
-1Basement	Locale	18 m²	431	point		1
-1Basement	Locale	20 m²	432	point		2
-1Basement	Locale	4 m²	433	point		2
-1Basement	Locale	4 m²	434	point		3
-1Basement	Locale	4 m²	435	point		3
-1Basement	Locale	8 m²	436	point		3

Figure N: Depth code as a space numeric parameter in the Revit schedule

Depth Map

Regarding the schedule parameters of space include depth code of each space, the depth map could be derived directly on the plan of building.

In this visualization provided by Revit it is possible to illustrate the overall view of the depth organization for all spaces and their combination.

Figure N: The Depth map of plan in Revit

Conclusion

Taking into consideration the depth map of the type plan, in collaboration with circulation analysis of plan in previous section, to provide two main mentioned factors, the plan with less rooms in depth is recognized as the desirable plan of sanitary building.

As the deeper rooms suffer from lack of natural light and natural ventilation and in the same way, they are not connected to the main circulation path in directly. As the result, more spaces are involved to access them. This also could affect the function of other rooms in between.

In the Revit schedule it is possible to run a conditional filter to recognize the deeper room than a specific code. Below the number 2 is an example to understand how many rooms in deep more than 2 exist in the floor plan.

The meaning of this condition is recognition of the rooms which are accessible passing two other rooms. And so two other function are involved with their usability. The most of the rooms with high depth code are located in the core of the plan.

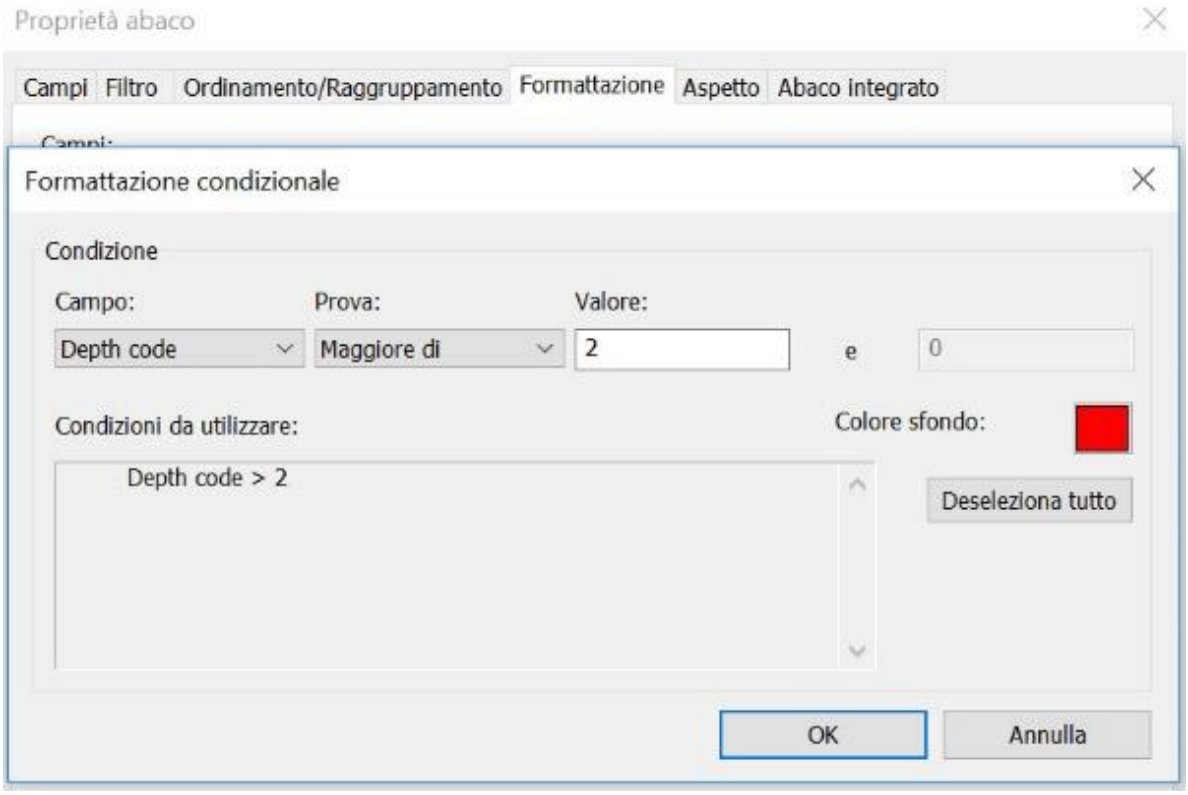


Figure N: applying conditional Format to recognize the rooms deeper than code 2 in the plan floor

1First Floor | Room Schedule

1First Floor	Room	7 m²	143	point		1
1First Floor	Room	13 m²	144	point		2
1First Floor	Room	51 m²	145	point		1
1First Floor	Room	25 m²	146	point		1
1First Floor	Room	54 m²	147	point		1
1First Floor	Room	71 m²	148	point		1
1First Floor	Room	35 m²	149	point		1
1First Floor	Room	19 m²	150	point		1
1First Floor	Room	13 m²	151	point		1
1First Floor	Room	17 m²	153	point		1
1First Floor	Room	5 m²	154	point		2
1First Floor	Room	6 m²	155	point		2
1First Floor	Room	6 m²	156	point		1
1First Floor	Room	17 m²	157	point		1
1First Floor	Room	14 m²	158	point		1
1First Floor	Room	3 m²	159	point		2
1First Floor	Room	3 m²	160	point		2
1First Floor	Room	5 m²	161	point		2
1First Floor	Room	6 m²	162	point		2
1First Floor	Room	12 m²	163	point		1
1First Floor	Room	18 m²	164	point		1
1First Floor	Room	3 m²	165	point		1
1First Floor	Room	14 m²	166	point		1
1First Floor	Room	14 m²	167	point		2
1First Floor	Room	13 m²	168	point		1
1First Floor	Room	16 m²	169	point		1
1First Floor	Room	3 m²	170	point		2
1First Floor	Room	3 m²	171	point		3
1First Floor	Room	7 m²	172	point		2
1First Floor	Room	11 m²	173	point		3
1First Floor	Room	6 m²	174	point		3
1First Floor	Room	2 m²	177	point		2
1First Floor	Room	2 m²	178	point		2
1First Floor	Room	2 m²	179	point		1
1First Floor	Room	2 m²	180	point		1
1First Floor	Room	8 m²	181	point		1
1First Floor	Room	8 m²	182	point		1
1First Floor	Room	18 m²	183	point		1
1First Floor	Room	19 m²	184	point		1
1First Floor	Room	6 m²	190	point		1
1First Floor	Room	8 m²	191	point		1
1First Floor	Room	15 m²	192	point		1
1First Floor	Room	14 m²	193	point		1
1First Floor	Room	18 m²	194	point		1
1First Floor	Room	170 m²	195	point		1
1First Floor	Room	7 m²	197	point		1
1First Floor	Room	19 m²	198	point		1
1First Floor	Room	15 m²	203	point		1
1First Floor	Room	14 m²	204	point		2
1First Floor	Room	11 m²	206	point		4
1First Floor	Room	13 m²	207	point		3
1First Floor	Room	7 m²	208	point		2
1First Floor	Room	13 m²	209	point		3
1First Floor	Room	20 m²	210	point		1
1First Floor	Room	34 m²	211	point		1
1First Floor	Room	71 m²	212	point		1
1First Floor	Room	62 m²	213	point		1
1First Floor	Room	25 m²	214	point		1
1First Floor	Room	3 m²	215	point		2
1First Floor	Room	4 m²	216	point		2
1First Floor	Room	4 m²	217	point		2
1First Floor	Room	14 m²	218	point		1
1First Floor	Room	21 m²	219	point		1
1First Floor	Room	5 m²	220	point		2
1First Floor	Room	6 m²	221	point		2
1First Floor	Room	6 m²	222	point		1
1First Floor	Room	54 m²	225	point		1
1First Floor	Room	27 m²	226	point		1
1First Floor	Room	53 m²	227	point		1
1First Floor	Room	35 m²	228	point		1
1First Floor	Room	11 m²	229	point		2

Figure N: illustration of rooms with more than number 2 as the depth code in the floor plan

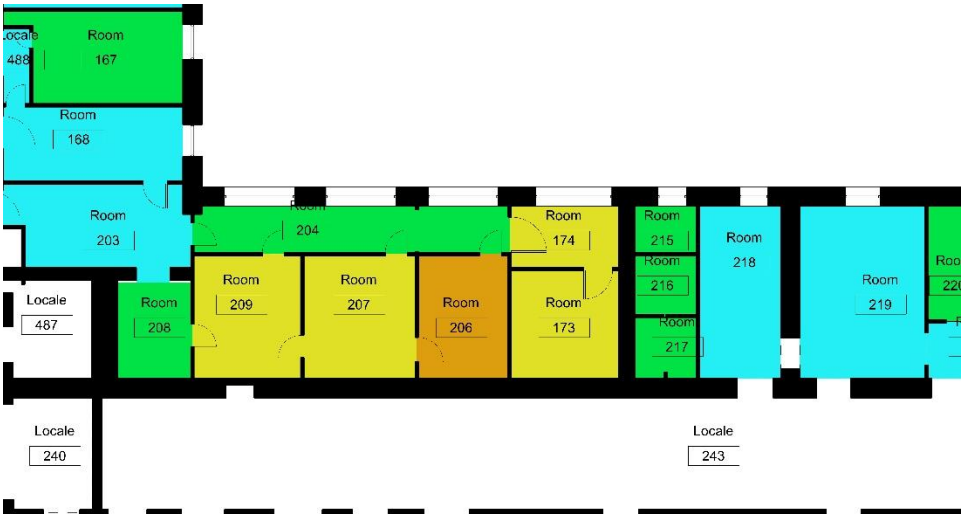


Figure N: Room 206 suffer from lack of direct accessibility and natural light and ventilation with high deep code.

Applying BIM schedule, more than showing the non-desirable composition in the space syntax point of view, it is also possible to analysis of alternative proposed plan to new design. As it can be applied to illustrate the parametric information of the rooms depth in each option.

FUNCTION

Introduction

As it was mentioned in previous sections, spatial analysis of a building involves both analysis of form and function.

Function is the main characteristic of the architectural work. As being school or being a factory define general concept of the building. About the question if Form follows Function or function follows form there are a lot of discuss and contrast arguments. What is clear for everyone in any style of organization is that form and function are affecting each other.

Form follows function: different activities of human needs different type of space and different environmental equipment. Running and sleeping require two kind of space with specific qualifies. Following particular “type” of building introduce its physical desirable aspects. Architecture in the first stage, shapes with the knowledge about the function of building in long terms and with it details.

Function Follows Form: physical offers and limits of a space can evoke and force some activities to users. In urban design it is discussed to provide privacy in urban space. Dark, deep and non-accessible corner of an alley can provide appropriate environment to comet a criminal action. On the contrary, a pleasant green space even without any planning to use, will be used by people to pass their recreation activities.

To start to design or analyzing a design of a hospital, the most essential factor is the propose of which the sanitary unite is built or going to be built. Recognition of all activities that are expected to occur in the hospital is important and all subdivided and mixed usage of the building must be known in detail. Within this list it is also required to stabilize the main and major activities comparing to that others are recognized as the secondary activities. In addition, possibility of conversion of the current usage to the future planned activities (James, Noakes,1994).

In the procedure of architectural design some other aspects might affect the responsibility of architect about the main users of a sanitary building. This main group are named patient and all effort during the building construction should be focused on providing the best possible alternative regarding their needs and natures. It could be reached only by the design alternative in which the best

possible “Environment” is created in the way that the activity of “Caregiving” is done in the most efficient way (L.Kobus, L.Skaggs, Bobrow, & Thomas, 2000).

The social logic of space

The space is created to contain a specific activity. So the form of space must correspond to this activity and as a building is a place of more than one activity, the composition of spaces inside must regard the relationship of activities inside them.

According to the classification of the enclosed rooms inside the building in terms of circulation, all spaces are divided into path or point. A point is a space in which specific human action will occur while a path provides access to this point and so to its usage. In addition, points can provide access to each other when to reach to a room it is needed to pass through another room. In this situation rooms and circulation path are classified in the new hierarchy. A room with direct access to circulation path are more accessible than the one with indirect access. And on the contrary, far rooms in terms of number of spaces needed to pass to reach are more **depth** than rooms with no **mediator space**.

But in the sanitary building, having deep room is unavoidable regarding to the limits of plan design and distribution of spaces around the circulation path. On the other side the question will be introduced:

- Which feature can value a room to be in depth or accessible?

According to the theoretical introduction to space syntax argument, classification of social activity can define if a room must be accessible or remote.

For an example, in urban space, a common public square must be accessible directly from more path and pedestrian road but on the other hand the entrance of a residential house is desired to be located in depth and far away from main roads to have more **privacy**.

To determine this value, two main feature are attached to a specific function:

- **Level of control**: some function of a complex architectural emerge are created to control the other spaces while other needed to be controlled:

controlling space like a police station in urban zone, information and\or security desk in the public building and an office of headmaster in a school are examples of controlling spaces. In these mentioned types, the particular activity between all activities running into the building, demand a position of its space with high access. Is a police station of a neighborhood is located in the depth of the zone, it is impossible to control and access most possible spaces at the moment.

On the contrary, a bathroom in a house, service rooms or laundry are demanding less access degree than the others. And some particular access in deed need to be in depth. Private rooms in a building require a position with most silence and privacy as possible. Following more depth code is desirable for them.

- **Level of interface:** the relationship of space in terms of interface, is based on the relationship of social activities running in them. Some human activities are with the higher degree of interaction than the others. It will be more clear in with the series of activities in the urban space. National ceremony or festivals are activities with the highest level of interactivity and that is why they are emerging the more public space in the zone. While family life in private house is with minimum interface with each other.

The two mentioned features define if it is suitable for a function of space to be located in depth whether with better access.

Users

Traditionally, a room dedicated to nurses' activity is a main argument of program planning of sanitary building. This station could be defined as nurse room, nurse information room, sister rooms or other terminology dedicated to a specific space in which caregiving activities is providing and developing to other parts of the hospital. This station is programmed not contemporary commonly but as the main stable function into the hospital.

It could be important to mention that the main idea dominant on the design of a sanitary building from private Clinique to public hospital drive originally from religious architecture, with the same formal language and same categories of styles, up to a time that the importance of the nurse station is perceived by public and then the style category changed according to the position of nurse station and its composition of other spaces. But during the time, this position and type changed and as a consequence design category of hospitals changed correspondingly (L.Kobus, L.Skaggs, Bobrow, & Thomas, 2000).

In sanitary buildings instead, to determine this, firstly the list of the activity should be provided and they must be grouped according their level of interaction or control. To define the needed degree of depth first all users in the hospital must be grouped:

Figure N: users' classification according to level of control and interface

Floating \permanent users: Users in a hospital have different degree of permanency in the building. This factor is much more related to the level of control. Some users can be considered as permanent users or inhabitant. Like a teacher or administer in a school, or owner of a shop store.

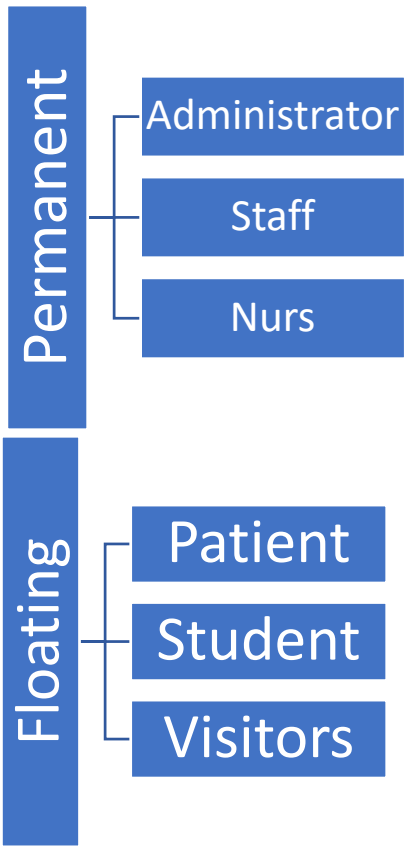


Figure N: Classification of users regarding their level of permanency or floating

Degree of privacy/Publicity

Each space is dedicated to a specific activity and as a result specific group of people are aimed to use this space. in higher level some roles can force or limit a group of people to use a space. these roles may be not official but social. For instance, pupils in a school will not be punished if enter in the room of school administrator normally but the function definition of that space evoke them not to go there. One the other hand main users of class rooms are teachers and pupils. This to group are classed in different level of controlled, with different class of interface.

In architecture it is accepted that some spaces with some function are more public than others. It can be explained that these space are more used by **Floating users**. While private rooms are frequently used by permanent users. But as a matter of fact in more public spaces more people from varying classes are in charge. In other world the number of groups of people using this space

is higher. In conclusion the following codes are introduced to present the degree of privacy or publicity of a room.

Code 0. The highest level public space. in architecture opposite of urban spaces, the building itself defines with a door. All spaces are accessible after passing a door. And this door is under control and they have limited opening hours. But in the hierarchy of privacy the first group is the level of all spaces of the building for which access for all people in the urban zone is possible. It is

This code can be defined in hospital as all spaces before information desk or control station. As all people and citizens who are using the urban space nearby can enter to this rooms and utilizing the facilities provided in them.

Interface code:

Regarding the previous states, now the interaction codes of the spaces can be analyzed and mapped into Revit. The first step to determine this code is to classify the spaces of the hospital regarding their users and usage and taking into consideration the level of control or interface of them.

The interaction code is a sum up and balance spot between the all mentioned category in function divisions. The level of control for instance is the reason for which a room must be closed to or far away from main path but in the same time it is also affected by the interface level. If a particular activity is involved with less interface between users, it could be placed far away from the main circulation path.

Code 0: the entrance or public circulation path of the building: these spaces can be used by everyone, from different degrees of control or interface. It should be noted that excusive path or elevator are not considered in this level and they are attached to the users that are exclusively using these spaces.

Code 1: Nurse Station/ information desk: all the spots and rooms dedicated for centralized activities of nurses. They have maximum interaction with other users and their activities are related to the maximum number of activities in the sanitary building. Also all secondary path and access (internal corridors are classified in this category.

Code 2: Patients general care rooms: all spaces dedicated to patients in general level. Waiting room or general hospitalization are located in this class. General ambulatory are best example and main usage in this class. In addition,

all patient waiting room, visitors waiting room and stay hall are put into this code.

Code 3: specific care rooms: Laboratory, Surgery, X ray or other specific sanitary function related to the patient are coded one degree lower. As to reach to this activity a patient may need to be in general care station first. Ambulatories with specific caregiving role are classified in this code. Medicate stores.

Code 4: Administrator(s) room.

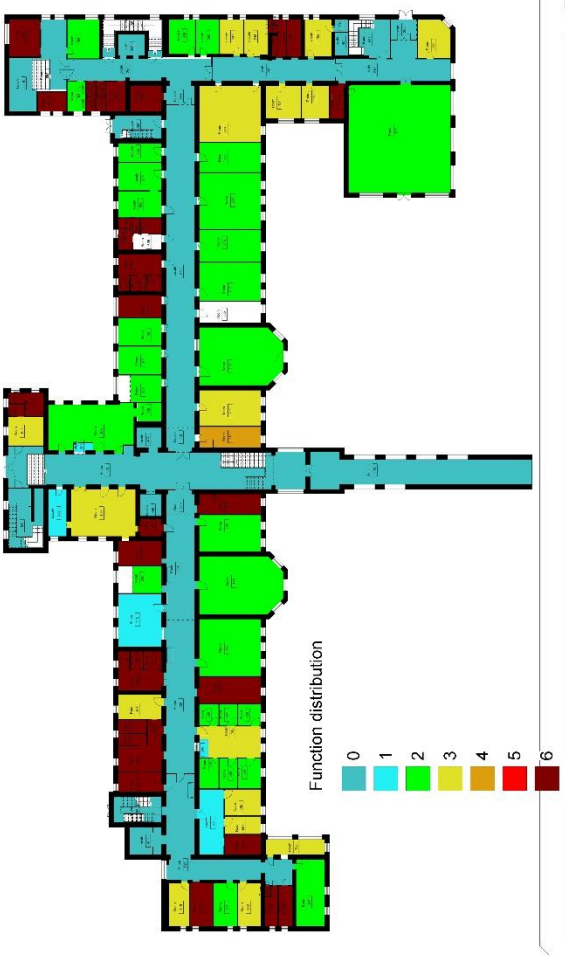
Code 5: Staff rooms: with less degree of interaction comparing with nurse and caregivers, staffs and their spaces are classified in the fourth degree. In addition, all of the private access or corridors with limited access for staff or limited persons have got this code.

Code 6: services: all activities with aim of providing services for other sectors and the utility rooms. Storages and store rooms for sanitary equipment's are classified in this sector.

Function distribution map

Following page contains the map of first floor with the color legend according to the interface code.

With the provided visualization in Revit according to the data attached to the first floor.


Function distribution
0
1
2
3
4
5
6

Qualificative analysis and Virtual Reality

While space syntax methods are applied to analysis of space distribution in the building, there are some shortage and failure in the theoretical and practical methods that are involved in the terminology. Using BIM might accelerate the process and could attach all maps needed to approach the result but following failure due to basis of present approaches are still taken into consideration:

1. All information of distribution of spaces that are driven from floors plan are two dimensions, while space could be defined by at least three dimension. What is introduced to space as spatial information, is not enough to perceive the characteristic of space and relationship existing between them. The third dimension will elevate the given information in documents. The height of a room affects the way that this room is understood by users and the way that they will access to the function. A vast room (in terms of height) with large door to access is much more inviting comparing to a short ceiling room with a short and limited door the same plan design. This three dimensional information cannot be easily mapped and documented.
2. Only quantities information is not playing role in the analysis. the spatial qualities are important to introduce a space and spatial characteristic. Namely color of walls, furniture and equipment, the artificial and natural light in the building. Mentioned feature are involved to access to a room in a indirect way. A dark room without enough opening to obtain the natural light and with dark or sharp color is perceived as an inaccessible and deep even with the same access code and the same quantitative information.
3. Fourth dimension: time
   All theories of space syntax are arguing about the possibility of movement and access from space to space it is impossible to have a comprehensive view toward the argument without having possibility to move in the building or urban zones.
   By passing as a pedestrian it become possible to analyses the sequence of spaces. With this possibility human is perceiving the built environment and he judge them and regarding that he is going to name the different qualities of space with the specific terminology. For instance, Welcoming space or receptive zone…
   The best quality traditional render of 3D modelling done by architectural software are providing the enormous information about architecture but are unable to make users able to understand the sequence and flow of space.

Introduction to Virtual reality

From Revit to Unity

After creating the model of the building with attached information as defined regarding with the aim of the project. It is needed to export and represent the provided data and graphical document. In this stage as Revit offers we could have the Excel files outputted from the schedule with all information created into it. At the same time, it possible to have graphical export from the unique scene as it is wished. Also, in a specific environment in the Revit, dynamic vision considering the time is provided.

But as it is mentioned before in the aim of the thesis, better quality render with the more dynamic option is made by a software in VR and AR environment called Unity. In this thesis after crating model with all attached information the process of presentation will continue to have a dynamic on-time render in the Unity Software. In this stage one of the main shortages of the procedure occurs as it is impossible to convert the Revit model with All of the information about materials and families into the Unity.

The solution is obtained by using a bridge software as 3D Studio Max. in this transforming the meaning of FBX is used. As they are files in between a lot of modeling tools. A FBX file is a file with formal data of a three dimensional model to make users possible to transfer between them.

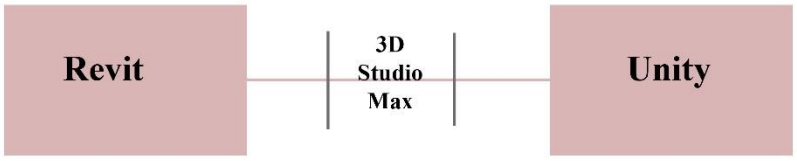


Figure N: a Mediator software will be needed to keep the detail of model

The mentioned stages are presented to convert the Revit model into the Unity Environment with all details and information:

1- Exporting a BIM model from the source environment as a FBX file with .fbx suffix. It should be mentioned that LOD level must be justified as Medium.
2- Import the FBX file in the 3D Studio Max with the modified Preset and Bind the imported model
3- Applying Converter Scene and using Standard Material to Physical Material.
4- Re-Export the file in to FBX file another time
5- Import the defined file into Unity as a new asset.

Addressing the issue

One of the most important issues involving in this method is that there is no direct way to import the BIM model into Unity as a complete asset with all materials attached to the objects.

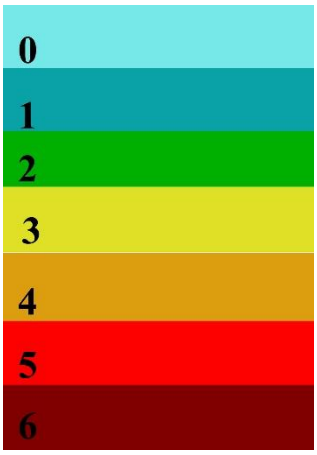
RESULTS AND CONCLUSION

Results of the analysis

Regarding the all methods a use applied to analysis the spatial distribution of the function in the hospital, the main question can be introduced as follow:

- Activities in to the hospital have an interface degree, this level of interaction could define if the space which contain the activity is located in the optimal position in combination with other spaces and the circulation path.

Providing the map of the distribution of spaces according to their depth code, and in continue map of the interface distribution of activities, it is possible to compare the two maps to recognize balance between subdivided function and their attached space depth.



FigureN: depth codes and interface codes color legend in their maps

To obtain this goal mixing the conditional format of the provided schedule is required. According to this definition if an activity in the hospital with high level of interface (with the minimum code number) is located in the space with low level of accessibility (high code number) is not desirable function distribution in the point of view of space syntax.

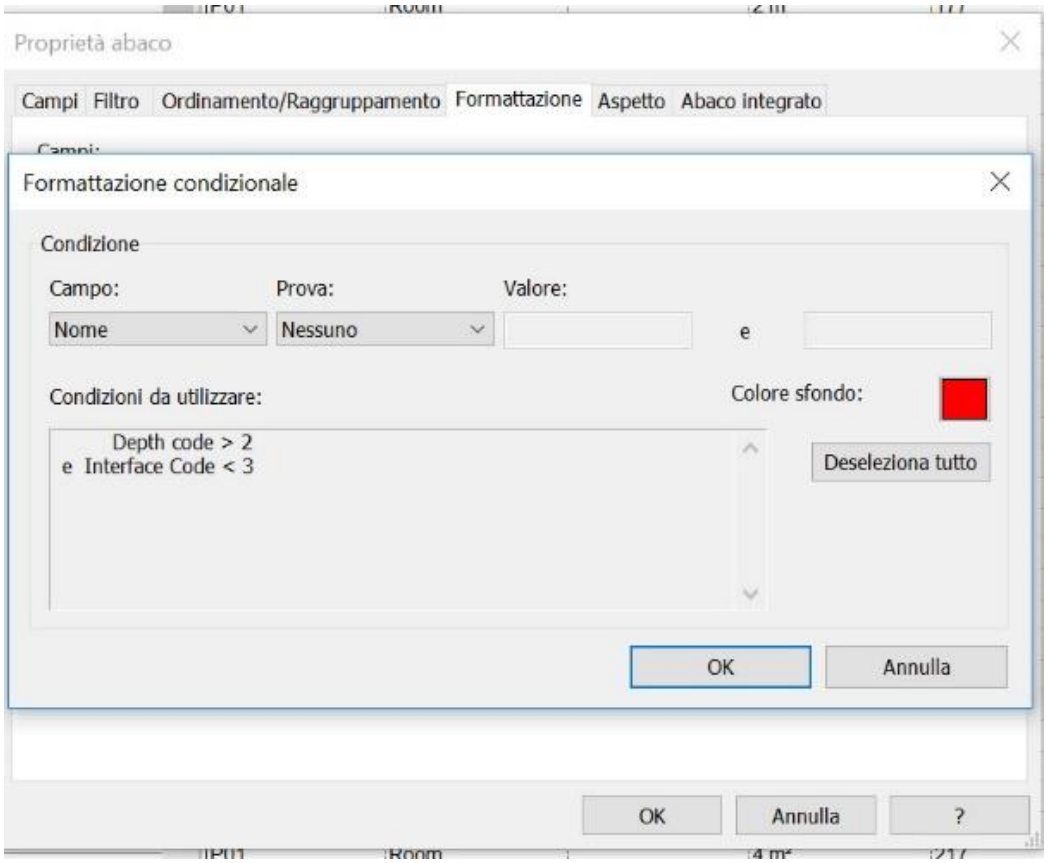
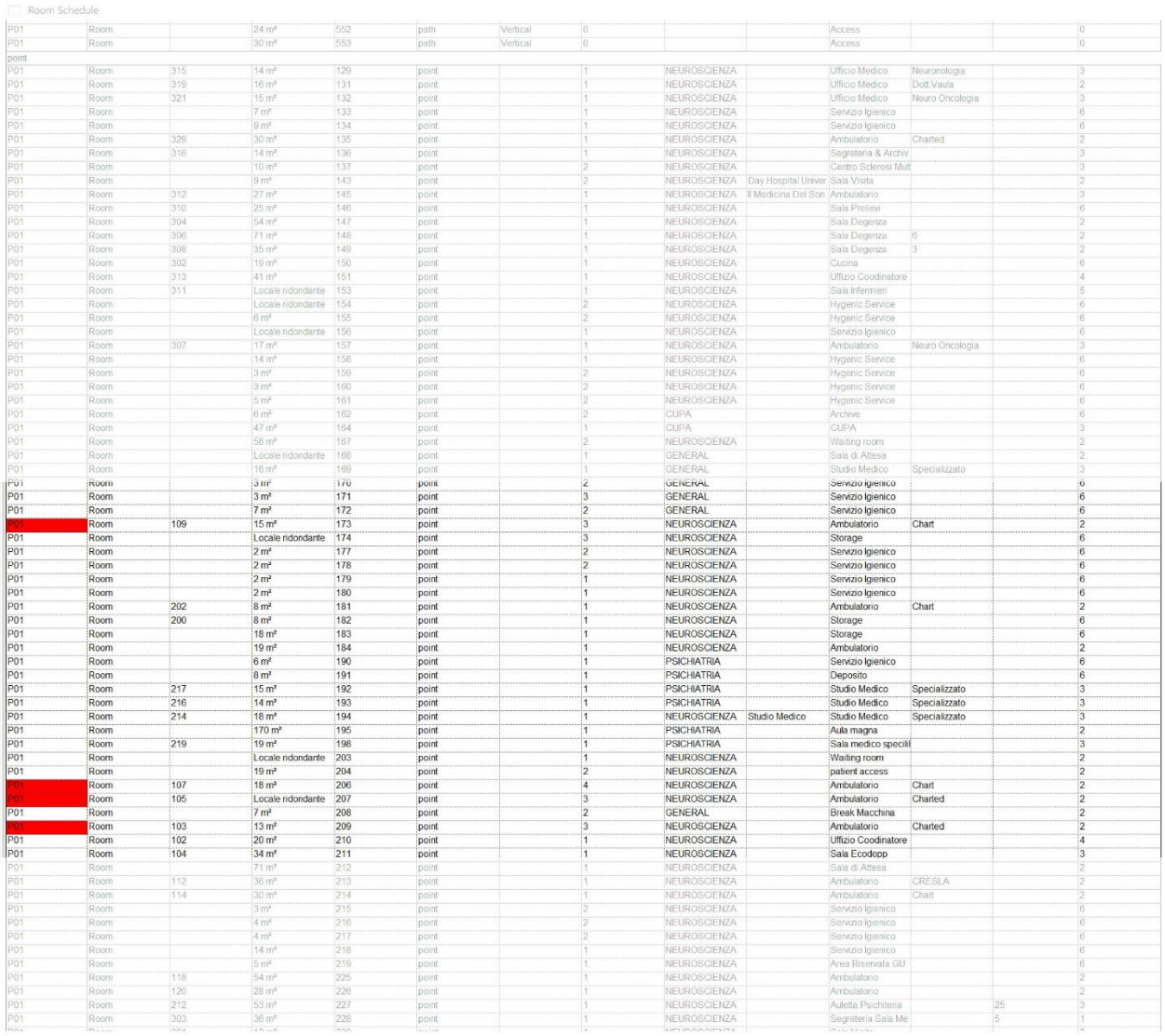


Figure N: application of conditional formula to analysis of the distribution of spaces regarding the depth code

With the aid of the conditional formula in the first floor, 4 rooms are recognized as false distributed in terms of space syntax. The false rooms are shown in the chart as follow:



Room Schedule

P01	Room		24 m²	552	path	Vertical	0			Access			0
P01	Room		30 m²	553	path	Vertical	0			Access			0
point													
P01	Room	315	14 m²	129	point		1	NEUROSCIENZA		Ufficio Medico	Neuronologia		3
P01	Room	319	16 m²	131	point		1	NEUROSCIENZA		Ufficio Medico	Dott.Vaula		2
P01	Room	321	15 m²	132	point		1	NEUROSCIENZA		Ufficio Medico	Neuro Oncologia		3
P01	Room		7 m²	133	point		1	NEUROSCIENZA		Servizio Igienico			6
P01	Room		9 m²	134	point		1	NEUROSCIENZA		Servizio Igienico			6
P01	Room	329	30 m²	135	point		1	NEUROSCIENZA		Ambulatorio	Charted		2
P01	Room	316	14 m²	136	point		1	NEUROSCIENZA		Segreteria & Archiv			3
P01	Room		10 m²	137	point		2	NEUROSCIENZA		Centro Sclerosi Mult			3
P01	Room		9 m²	143	point		2	NEUROSCIENZA	Day Hospital Univer	Sala Visita			2
P01	Room	312	27 m²	145	point		1	NEUROSCIENZA	Il Medicina Del Son	Ambulatorio			3
P01	Room	310	25 m²	146	point		1	NEUROSCIENZA		Sala Prelievi			6
P01	Room	304	54 m²	147	point		1	NEUROSCIENZA		Sala Degenza			2
P01	Room	306	71 m²	148	point		1	NEUROSCIENZA		Sala Degenza	6		2
P01	Room	308	35 m²	149	point		1	NEUROSCIENZA		Sala Degenza	3		2
P01	Room	302	19 m²	150	point		1	NEUROSCIENZA		Cucina			6
P01	Room	313	41 m²	151	point		1	NEUROSCIENZA		Uffizio Coodinatore			4
P01	Room	311	Locale ridondante	153	point		1	NEUROSCIENZA		Sala Infermieri			5
P01	Room		Locale ridondante	154	point		2	NEUROSCIENZA		Hygenic Service			6
P01	Room		6 m²	155	point		2	NEUROSCIENZA		Hygenic Service			6
P01	Room		Locale ridondante	156	point		1	NEUROSCIENZA		Servizio Igienico			6
P01	Room	307	17 m²	157	point		1	NEUROSCIENZA		Ambulatorio	Neuro Oncologia		3
P01	Room		14 m²	158	point		1	NEUROSCIENZA		Hygenic Service			6
P01	Room		3 m²	159	point		2	NEUROSCIENZA		Hygenic Service			6
P01	Room		3 m²	160	point		2	NEUROSCIENZA		Hygenic Service			6
P01	Room		5 m²	161	point		2	NEUROSCIENZA		Hygenic Service			6
P01	Room		6 m²	162	point		2	CUPA		Archive			6
P01	Room		47 m²	164	point		1	CUPA		CUPA			3
P01	Room		58 m²	167	point		2	NEUROSCIENZA		Waiting room			2
P01	Room		Locale ridondante	168	point		1	GENERAL		Sala di Attesa			2
P01	Room		16 m²	169	point		1	GENERAL		Studio Medico	Specializzato		3
P01	Room		3 m²	170	point		2	GENERAL		Servizio Igienico			6
P01	Room		3 m²	171	point		3	GENERAL		Servizio Igienico			6
P01	Room		7 m²	172	point		2	GENERAL		Servizio Igienico			6
P01	Room	109	15 m²	173	point		3	NEUROSCIENZA		Ambulatorio	Chart		2
P01	Room		Locale ridondante	174	point		3	NEUROSCIENZA		Storage			6
P01	Room		2 m²	177	point		2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		2 m²	178	point		2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		2 m²	179	point		1	NEUROSCIENZA		Servizio Igienico			6
P01	Room		2 m²	180	point		1	NEUROSCIENZA		Servizio Igienico			6
P01	Room	202	8 m²	181	point		1	NEUROSCIENZA		Ambulatorio	Chart		2
P01	Room	200	8 m²	182	point		1	NEUROSCIENZA		Storage			6
P01	Room		18 m²	183	point		1	NEUROSCIENZA		Storage			6
P01	Room		19 m²	184	point		1	NEUROSCIENZA		Ambulatorio			2
P01	Room		6 m²	190	point		1	PSICHIATRIA		Servizio Igienico			6
P01	Room		8 m²	191	point		1	PSICHIATRIA		Deposito			6
P01	Room	217	15 m²	192	point		1	PSICHIATRIA		Studio Medico	Specializzato		3
P01	Room	216	14 m²	193	point		1	PSICHIATRIA		Studio Medico	Specializzato		3
P01	Room	214	18 m²	194	point		1	NEUROSCIENZA	Studio Medico	Studio Medico	Specializzato		3
P01	Room		170 m²	195	point		1	PSICHIATRIA		Aula magna			2
P01	Room	219	19 m²	198	point		1	PSICHIATRIA		Sala medico specilil			3
P01	Room		Locale ridondante	203	point		1	NEUROSCIENZA		Waiting room			2
P01	Room		19 m²	204	point		2	NEUROSCIENZA		patient access			2
P01	Room	107	18 m²	206	point		4	NEUROSCIENZA		Ambulatorio	Chart		2
P01	Room	105	Locale ridondante	207	point		3	NEUROSCIENZA		Ambulatorio	Charted		2
P01	Room		7 m²	208	point		2	GENERAL		Break Macchina			2
P01	Room	103	13 m²	209	point		3	NEUROSCIENZA		Ambulatorio	Charted		2
P01	Room	102	20 m²	210	point		1	NEUROSCIENZA		Uffizio Coodinatore			4
P01	Room	104	34 m²	211	point		1	NEUROSCIENZA		Sala Ecodopp			3
P01	Room		71 m²	212	point		1	NEUROSCIENZA		Sala di Attesa			2
P01	Room	112	36 m²	213	point		1	NEUROSCIENZA		Ambulatorio	CRESLA		2
P01	Room	114	30 m²	214	point		1	NEUROSCIENZA		Ambulatorio	Chart		2
P01	Room		3 m²	215	point		2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		4 m²	216	point		2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		4 m²	217	point		2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		14 m²	218	point		1	NEUROSCIENZA		Servizio Igienico			6
P01	Room		5 m²	219	point		1	NEUROSCIENZA		Area Riservata GU			6
P01	Room	118	54 m²	225	point		1	NEUROSCIENZA		Ambulatorio			2
P01	Room	120	28 m²	226	point		1	NEUROSCIENZA		Ambulatorio			2
P01	Room	212	53 m²	227	point		1	NEUROSCIENZA		Auletta Psichiteria		25	3
P01	Room	303	36 m²	228	point		1	NEUROSCIENZA		Segreteria Sala Me		5	1

Figure N: Recognition of false rooms in first floor in terms of spatial distribution

The opposite approach can be explained when an activity with less need of access has the false position with maximum access availability. The automatic analysis can be reached in the contrary conditional formula.

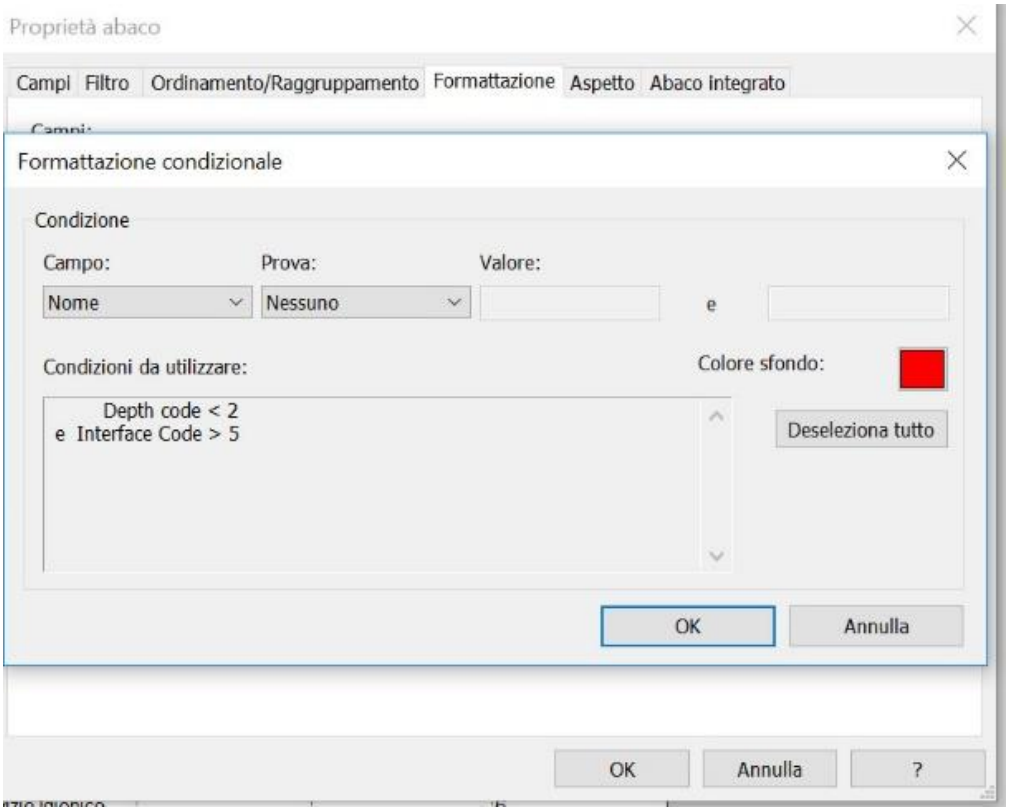
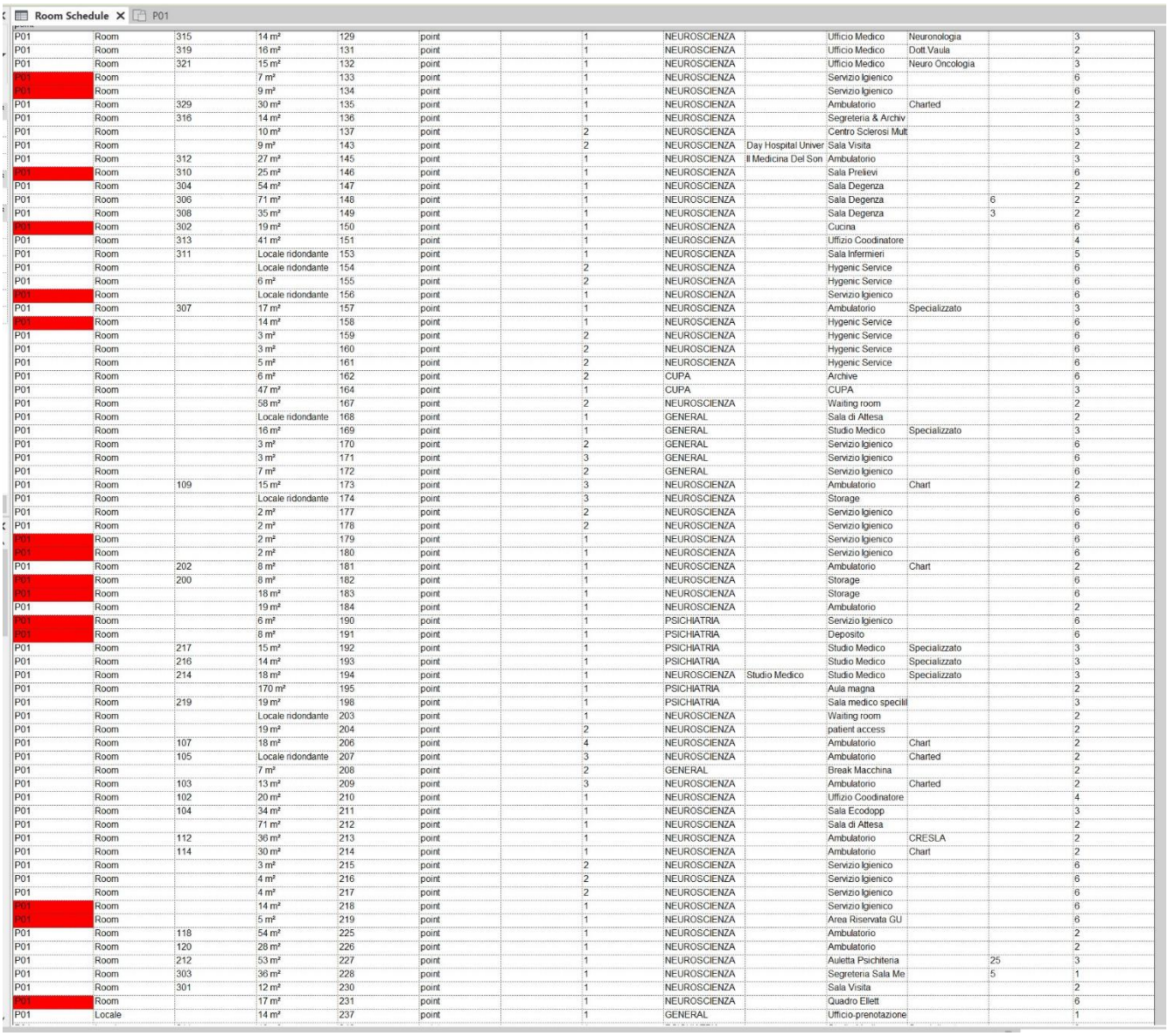


Figure N: application of conditional formula to analysis of the distribution of spaces regarding the depth code

As the result of running the formula, 20 rooms were recognized as the rooms with less requiring access function but located in the must accessible location with the less depth. In the schedule the mentioned rooms are presented in the customized color.



Room Schedule | P01

P01	Room	315	14 m²	129	point	1	NEUROSCIENZA		Ufficio Medico	Neuronologia		3
P01	Room	319	16 m²	131	point	1	NEUROSCIENZA		Ufficio Medico	Dott.Vaula		2
P01	Room	321	15 m²	132	point	1	NEUROSCIENZA		Ufficio Medico	Neuro Oncologia		3
P01	Room		7 m²	133	point	1	NEUROSCIENZA		Servizio Igienico			6
P01	Room		9 m²	134	point	1	NEUROSCIENZA		Servizio Igienico			6
P01	Room	329	30 m²	135	point	1	NEUROSCIENZA		Ambulatorio	Charted		2
P01	Room	316	14 m²	136	point	1	NEUROSCIENZA		Segreteria & Archiv			3
P01	Room		10 m²	137	point	2	NEUROSCIENZA		Centro Sclerosi Mult			3
P01	Room		9 m²	143	point	2	NEUROSCIENZA	Day Hospital Univer	Sala Visita			2
P01	Room	312	27 m²	145	point	1	NEUROSCIENZA	Il Medicina Del Son	Ambulatorio			3
P01	Room	310	25 m²	146	point	1	NEUROSCIENZA		Sala Prelievi			6
P01	Room	304	54 m²	147	point	1	NEUROSCIENZA		Sala Degenza			2
P01	Room	306	71 m²	148	point	1	NEUROSCIENZA		Sala Degenza		6	2
P01	Room	308	35 m²	149	point	1	NEUROSCIENZA		Sala Degenza		3	2
P01	Room	302	19 m²	150	point	1	NEUROSCIENZA		Cucina			6
P01	Room	313	41 m²	151	point	1	NEUROSCIENZA		Uffizio Coodinatore			4
P01	Room	311	Locale ridondante	153	point	1	NEUROSCIENZA		Sala Infermieri			5
P01	Room		Locale ridondante	154	point	2	NEUROSCIENZA		Hygenic Service			6
P01	Room		6 m²	155	point	2	NEUROSCIENZA		Hygenic Service			6
P01	Room		Locale ridondante	156	point	1	NEUROSCIENZA		Servizio Igienico			6
P01	Room	307	17 m²	157	point	1	NEUROSCIENZA		Ambulatorio	Specializzato		3
P01	Room		14 m²	158	point	1	NEUROSCIENZA		Hygenic Service			6
P01	Room		3 m²	159	point	2	NEUROSCIENZA		Hygenic Service			6
P01	Room		3 m²	160	point	2	NEUROSCIENZA		Hygenic Service			6
P01	Room		5 m²	161	point	2	NEUROSCIENZA		Hygenic Service			6
P01	Room		6 m²	162	point	2	CUPA		Archive			6
P01	Room		47 m²	164	point	1	CUPA		CUPA			3
P01	Room		58 m²	167	point	2	NEUROSCIENZA		Waiting room			2
P01	Room		Locale ridondante	168	point	1	GENERAL		Sala di Attesa			2
P01	Room		16 m²	169	point	1	GENERAL		Studio Medico	Specializzato		3
P01	Room		3 m²	170	point	2	GENERAL		Servizio Igienico			6
P01	Room		3 m²	171	point	3	GENERAL		Servizio Igienico			6
P01	Room		7 m²	172	point	2	GENERAL		Servizio Igienico			6
P01	Room	109	15 m²	173	point	3	NEUROSCIENZA		Ambulatorio	Chart		2
P01	Room		Locale ridondante	174	point	3	NEUROSCIENZA		Storage			6
P01	Room		2 m²	177	point	2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		2 m²	178	point	2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		2 m²	179	point	1	NEUROSCIENZA		Servizio Igienico			6
P01	Room		2 m²	180	point	1	NEUROSCIENZA		Servizio Igienico			6
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P01	Room	200	8 m²	182	point	1	NEUROSCIENZA		Storage			6
P01	Room		18 m²	183	point	1	NEUROSCIENZA		Storage			6
P01	Room		19 m²	184	point	1	NEUROSCIENZA		Ambulatorio			2
P01	Room		6 m²	190	point	1	PSICHIATRIA		Servizio Igienico			6
P01	Room		8 m²	191	point	1	PSICHIATRIA		Deposito			6
P01	Room	217	15 m²	192	point	1	PSICHIATRIA		Studio Medico	Specializzato		3
P01	Room	216	14 m²	193	point	1	PSICHIATRIA		Studio Medico	Specializzato		3
P01	Room	214	18 m²	194	point	1	NEUROSCIENZA	Studio Medico	Studio Medico	Specializzato		3
P01	Room		170 m²	195	point	1	PSICHIATRIA		Aula magna			2
P01	Room	219	19 m²	198	point	1	PSICHIATRIA		Sala medico specilil			3
P01	Room		Locale ridondante	203	point	1	NEUROSCIENZA		Waiting room			2
P01	Room		19 m²	204	point	2	NEUROSCIENZA		patient access			2
P01	Room	107	18 m²	206	point	4	NEUROSCIENZA		Ambulatorio	Chart		2
P01	Room	105	Locale ridondante	207	point	3	NEUROSCIENZA		Ambulatorio	Charted		2
P01	Room		7 m²	208	point	2	GENERAL		Break Macchina			2
P01	Room	103	13 m²	209	point	3	NEUROSCIENZA		Ambulatorio	Charted		2
P01	Room	102	20 m²	210	point	1	NEUROSCIENZA		Uffizio Coodinatore			4
P01	Room	104	34 m²	211	point	1	NEUROSCIENZA		Sala Ecodopp			3
P01	Room		71 m²	212	point	1	NEUROSCIENZA		Sala di Attesa			2
P01	Room	112	36 m²	213	point	1	NEUROSCIENZA		Ambulatorio	CRESLA		2
P01	Room	114	30 m²	214	point	1	NEUROSCIENZA		Ambulatorio	Chart		2
P01	Room		3 m²	215	point	2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		4 m²	216	point	2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		4 m²	217	point	2	NEUROSCIENZA		Servizio Igienico			6
P01	Room		14 m²	218	point	1	NEUROSCIENZA		Servizio Igienico			6
P01	Room		5 m²	219	point	1	NEUROSCIENZA		Area Riservata GU			6
P01	Room	118	54 m²	225	point	1	NEUROSCIENZA		Ambulatorio			2
P01	Room	120	28 m²	226	point	1	NEUROSCIENZA		Ambulatorio			2
P01	Room	212	53 m²	227	point	1	NEUROSCIENZA		Auletta Psichiteria		25	3
P01	Room	303	36 m²	228	point	1	NEUROSCIENZA		Segreteria Sala Me		5	1
P01	Room	301	12 m²	230	point	1	NEUROSCIENZA		Sala Visita			2
P01	Room		17 m²	231	point	1	NEUROSCIENZA		Quadro Ellett			6
P01	Locale		14 m²	237	point	1	GENERAL		Ufficio-prenotazione			1

Figure N: Recognition of false rooms in first floor in terms of spatial distribution

According to this result, as the proposal of new organization of the existing room composition in the interior design of the hospital, the alternatives can be proposed as changing the function with false location with the right position.

To create the proposal clear, the colored room in false position in the first formula can be replaced by the colored rooms in the second applied formula.

With another word, the 20 rooms recognized in the second formula are best option and potential position to change the 4 activities resulted in the second formula.

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