

Building Information Modeling

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Project Description

The aim of the project is to establish a methodology and prepare UML diagrams for building designs representation at a higher level of abstraction. Then this well defined methodology and UML diagrams will forms a basis for tool development so as to automatically check potential building designs against specification quickly, easily and in early phases of design. It also involves identification of validation parameters, which the tool is going to use for validation of its own building design against the proposed floor plan.

Now for building design representation, it can be looked upon from multiple viewpoints:

- Architectural viewpoint
- Structural viewpoint
- Plumbing viewpoint
- Electrical viewpoint
- Security viewpointso on

Here in this project, due to initial project complexity and an abstract concept (absence of explicit system behavior), we first consider only architectural viewpoint and a simple one-bedroom apartment floor plan. We try to establish the architectural viewpoint for this one bedroom apartment's floor plan as shown in fig 1.0.

The future work involves establishing the methodology for other viewpoints and integrating them in such a manner so that they should conflict with each other.

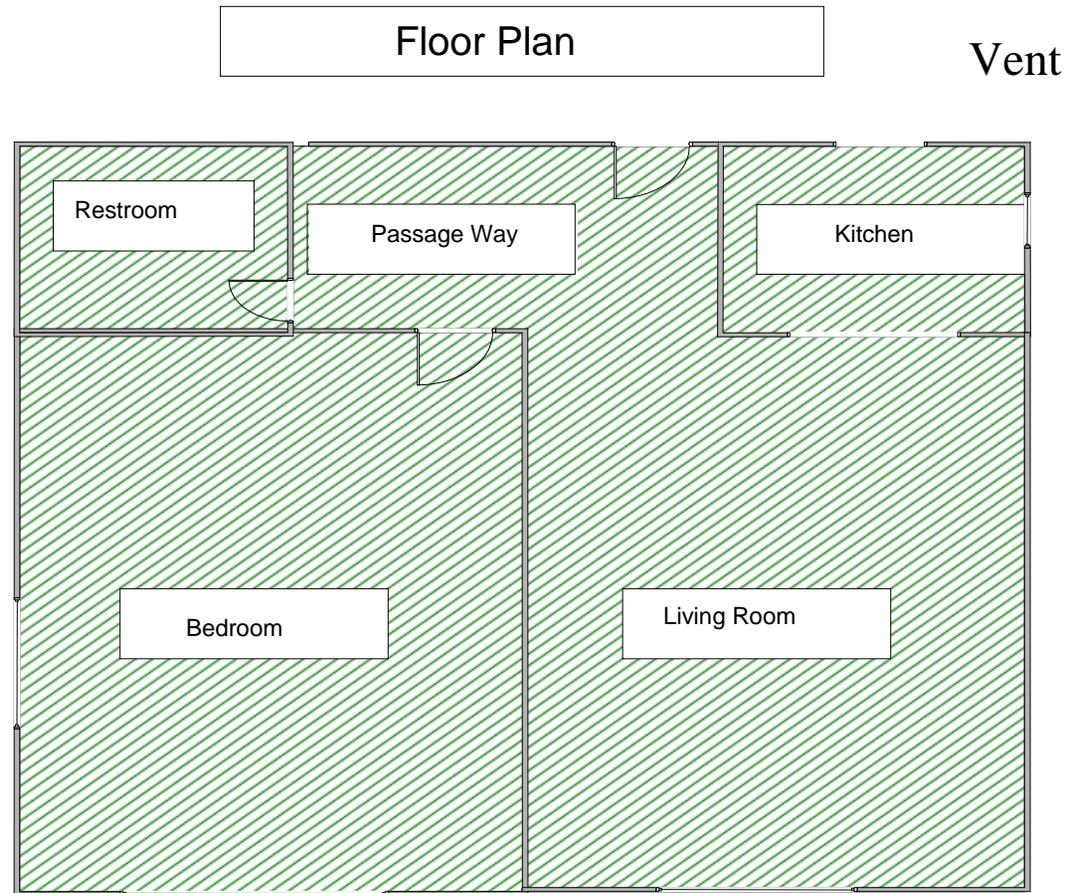


Fig 1.0 One-Bedroom Apartment Floor Plan

Architectural viewpoint of the building design is concerned with the hierarchical decomposition of spaces within blocks. In this view point, shapes are transformed into “architectural regions” (rooms) during the early phases of the design and it also involves preliminary evaluation of properties (like size, shape, orientation, and adjacency) coupled with the assignment of properties to regions.

So the project involves following tasks:

- Defining and categorizing the design requirements of a building from an architectural viewpoint. It includes writing down all the architectural requirements and arranging them in a hierarchical way.

- Preparing the System Structure diagrams (Class Diagram) at a higher level of abstraction, which involves identification of objects and their attributes.
- Defining Validation Parameters like proximity, access type, area, adjacency, orientation so as
 - To allow the architect to check potential building designs against the specification
 - Quickly
 - Easily &
 - In early phases of the design

Opportunity for Improvements (O.F.I.) in Architectural design

There are basically four types of constraints in an architectural design process:

- Topological (i.e. orientation, traffic/pathway, and location/adjacency concerns)
- Dimensional (i.e. size and space concerns)
- Functional (i.e. aesthetic concerns)
- Geometric (i.e. shape)

These constraints are difficult to reconcile and tedious to verify and hence result in design process that often leave a poor record of why certain design decisions or implementation choices have been made. In this project, we try to address these constraints by verifying them automatically through a tool.

Goals

The goal of our project is a front-end development of a Tool for both architects and their clients, which should be

- Simple and compact
- Sufficiently powerful to capture the wishes of the client and the architectural design constraints
- Enable the clients to formally specify design requirements for a building

- Allow the architects to check potential building designs against the specifications
 - Quickly
 - Easily
 - During the early phases of the design
- Provide consistency
- Provide meaningful feedback about any discrepancies
- To help architects and clients to come up with a floor plan that achieves high optimality in the desired functionality.

Therefore we can summarize the functionality of a tool in a nutshell through fig 2.0 as shown below. That is how the tool basically be working. It shows the pathway of End to End development from requirements to UML representations and to engineering drawings i.e. how the requirements will be traced from a requirements diagram to structure diagram, behavior diagram and finally on floor plan.

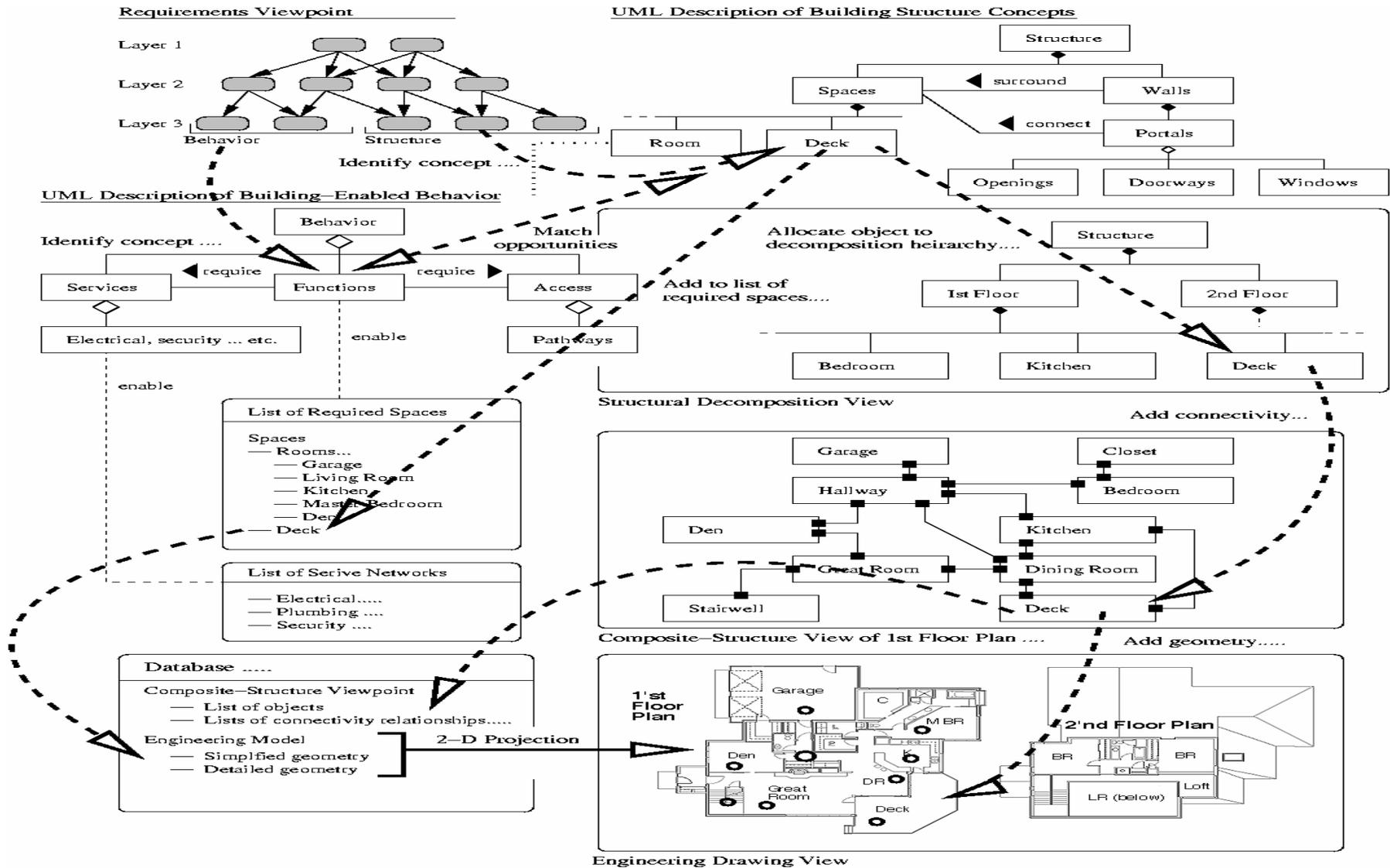


Fig 2.0 End-to-End development from requirements to UML representations and to engineering drawings

Benefits

The benefits of this project would be

- Well-defined methodology for verifying architectural viewpoint
- Building design with fewer errors
- With better compliance among client's goals and building specifications
- Assisting carrying out the unavoidable low level tasks such as consistency checking, drafting, area calculations, book-keeping
- Allowing the user to quickly describe relatively complex relationships between rooms in a building
 - Like in an academic building
 - All classrooms should be relatively close together
 - But visually and acoustically separated
 - Every office should be close to one print/copy facility
 - Secretarial offices should be distributed among and visible from the faculty offices....and so on

Requirements Analysis

The architectural requirements of one bedroom apartment shown above can be broadly categorized in two ways:

- Apartment Level
 - An apartment should have one bedroom, one living room, one restroom and one kitchen
 - An apartment entrance should not be through bedroom
 - An apartment should have easy pathway towards exit in case of emergency
- Room Level
 - Size of bedroom should be X Sqft.
 - Rest room should be close to bedroom

- Rest room should be far from kitchen

However all the requirements are as follows:

Apartment Level:

1. Area of the apartment should be at least 10000 sq units.
2. The apartment should have 1 bedroom, 1 living room, 1 kitchen, 1 restroom and one passageway.
3. The entrance of the apartment should not be through bedroom.
4. The apartment should have easy access to exit in case of fire.

Room Level:

5. Occupancy of the bedroom should be two.
6. Area of the bedroom should be 3500 sq. unit.
7. Bedroom should be adjacent to the restroom.
8. Bedroom should have a closet.
9. The closet in the bedroom should be a walk-in closet.
10. Proximity strength between restroom and bedroom is 1.
11. Bedroom should be properly ventilated.
12. Bedroom should have two windows.
13. Bedroom should be sound proof.
14. Bedroom should have air tight doors.
15. Orientation of the bedroom should be towards the west.
16. Occupancy of the Kitchen should be two.
17. Area of the kitchen should be 900 square units.
18. Kitchen should be far from rest room.
19. Kitchen should be adjacent to living room.
20. Proximity strength between Kitchen and living room is 1.
21. Proximity strength between Kitchen and restroom is greater than eight.
22. A joint in the wall separates living room and kitchen.
23. Occupancy of the rest room should be 2.
24. Area of rest room is 600 sq units.
25. Occupancy of the passageway should be for two people crossing each other in opposite direction.
26. With of passage way is 30 Sq. units.
27. Living Room occupancy should be 4.

28. Area of living room is 3500 sq. unit.
29. Living room should be properly ventilated.
30. Living room should have a opening and a window.

All these requirements can be visualized using a tool known as PaladinRM whose screen shots for code and output are shown in the following diagrams.

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- <Req ROIN="1-8" type="Level 1" level="1">
  <Title text="Living room requirements" />
  <Description text="Apartment should have one Livingroom" />
  - <ReqList>
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    <CompReq ROIN="2-12" />
    <CompReq ROIN="2-13" />
  </ReqList>
  <Attribute text="ID" value="" />
  <Attribute text="Requirement Title" value="Apartment should have one Living room" />
  <Attribute text="Assigned To" value="none" />
  <Attribute text="Requirement Status" value="inactive" />
  <Attribute text="Criticality" value="None" />
</Req>
- <Req ROIN="2-11" type="Level 2" level="2">
  <Title text="Living room distance from Kitchen" />
  <Description text="Living room should be adjacent to kitchen" />
  - <ReqList>
    <CompReq ROIN="3-8" />
  </ReqList>
  <Attribute text="ID" value="" />
  <Attribute text="Requirement Title" value="Adjacency to Kitchen" />
  <Attribute text="Assigned To" value="none" />
  <Attribute text="Requirement Status" value="active" />
  <Attribute text="Criticality" value="None" />
  <Attribute text="Req Type" value="topological" />
</Req>
- <Req ROIN="3-8" type="Level 3" level="3">
  <Title text="Proximity strength" />
  <Description text="Proximity between Living Room and Kitchen should be less than 1" />
  <Attribute text="ID" value="" />
  <Attribute text="Requirement Title" value="Proximity requirement" />
  <Attribute text="Assigned To" value="none" />
  <Attribute text="Requirement Status" value="active" />
  <Attribute text="Criticality" value="None" />

```

Fig 3.0 PaladinRM Requirement Code

Paladin Requirements Manager

File Graph View Help

Requirement Link Zoom 35

Properties

Common Other

ID	
Requirement Title	ximity requirement
Assigned To	none
Requirement Status	active
Criticality	None
Req Type	topological
distance	less than 1 ft
Connecting Portal type	Opening
Description	ould be less than 1
Level	Level 3
Level Type	3

requirement1.xml

```

graph TD
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    R1 --> R3["1.2 A platform shall have a 99.99% uptime"]
    R1 --> R4["1.3 A platform shall have a 99.99% uptime"]
    R1 --> R5["1.4 A platform shall have a 99.99% uptime"]
    R1 --> R6["1.5 A platform shall have a 99.99% uptime"]
    R1 --> R7["1.6 A platform shall have a 99.99% uptime"]
    R1 --> R8["1.7 A platform shall have a 99.99% uptime"]
    R1 --> R9["1.8 A platform shall have a 99.99% uptime"]
    R1 --> R10["1.9 A platform shall have a 99.99% uptime"]
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    R1 --> R21["1.20 A platform shall have a 99.99% uptime"]
    R1 --> R22["1.21 A platform shall have a 99.99% uptime"]
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    R1 --> R31["1.30 A platform shall have a 99.99% uptime"]
    R1 --> R32["1.31 A platform shall have a 99.99% uptime"]
    R1 --> R33["1.32 A platform shall have a 99.99% uptime"]
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    R1 --> R37["1.36 A platform shall have a 99.99% uptime"]
    R1 --> R38["1.37 A platform shall have a 99.99% uptime"]
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    R1 --> R40["1.39 A platform shall have a 99.99% uptime"]
    R1 --> R41["1.40 A platform shall have a 99.99% uptime"]
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    R1 --> R77["1.76 A platform shall have a 99.99% uptime"]
    R1 --> R78["1.77 A platform shall have a 99.99% uptime"]
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    R1 --> R97["1.96 A platform shall have a 99.99% uptime"]
    R1 --> R98["1.97 A platform shall have a 99.99% uptime"]
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    R1 --> R100["1.99 A platform shall have a 99.99% uptime"]
    R1 --> R101["1.100 A platform shall have a 99.99% uptime"]
  
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C:\Documents and Settings\abhinav\Desktop\test\requirement1.xml is opened

start We... abhi... 646... wbs... Co... Pala... com... Pala... 8:47 PM

Fig 4.0 Requirement Diagram

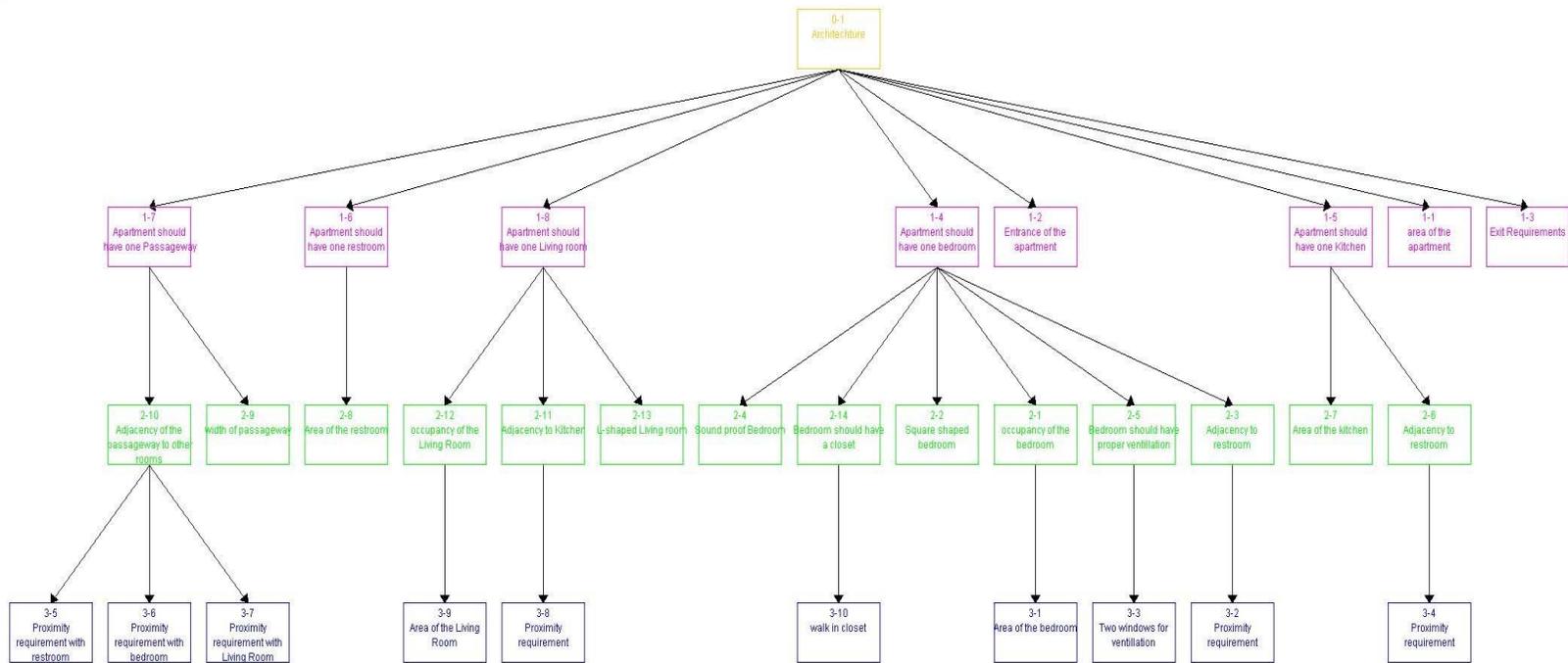


Fig 5.0 Requirement Diagram

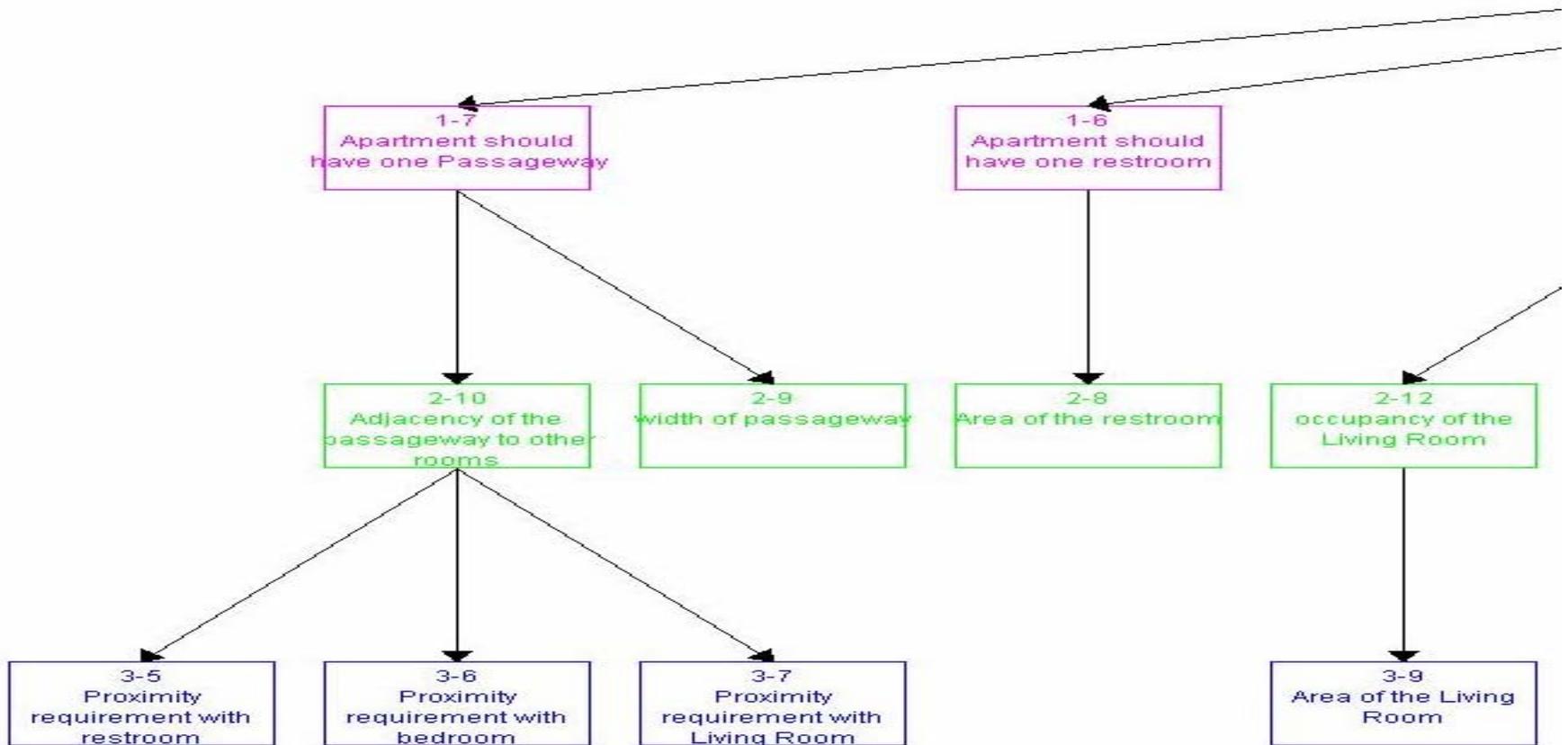


Fig 6.0 Requirement Diagram

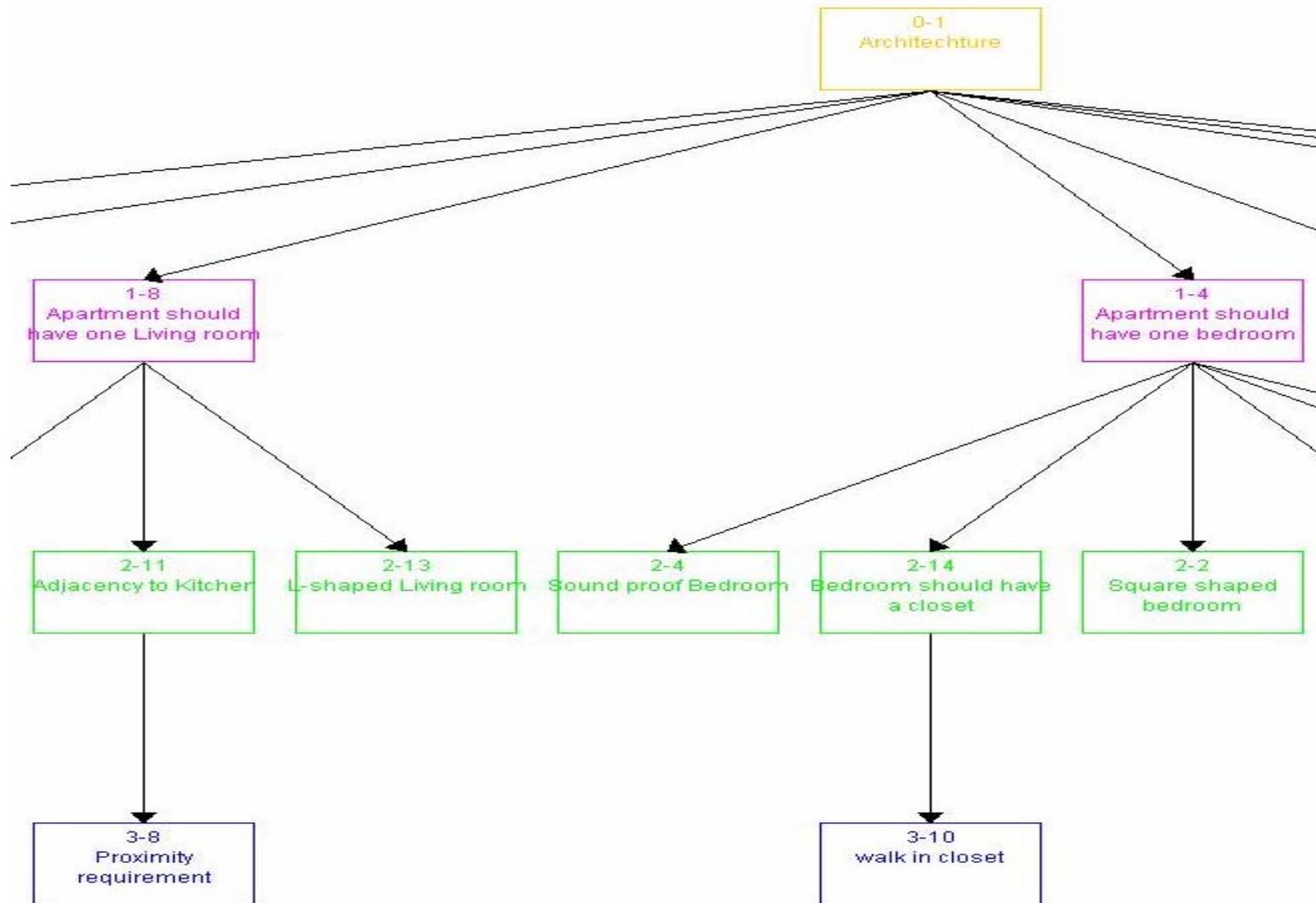


Fig 7.0 Requirement Diagram

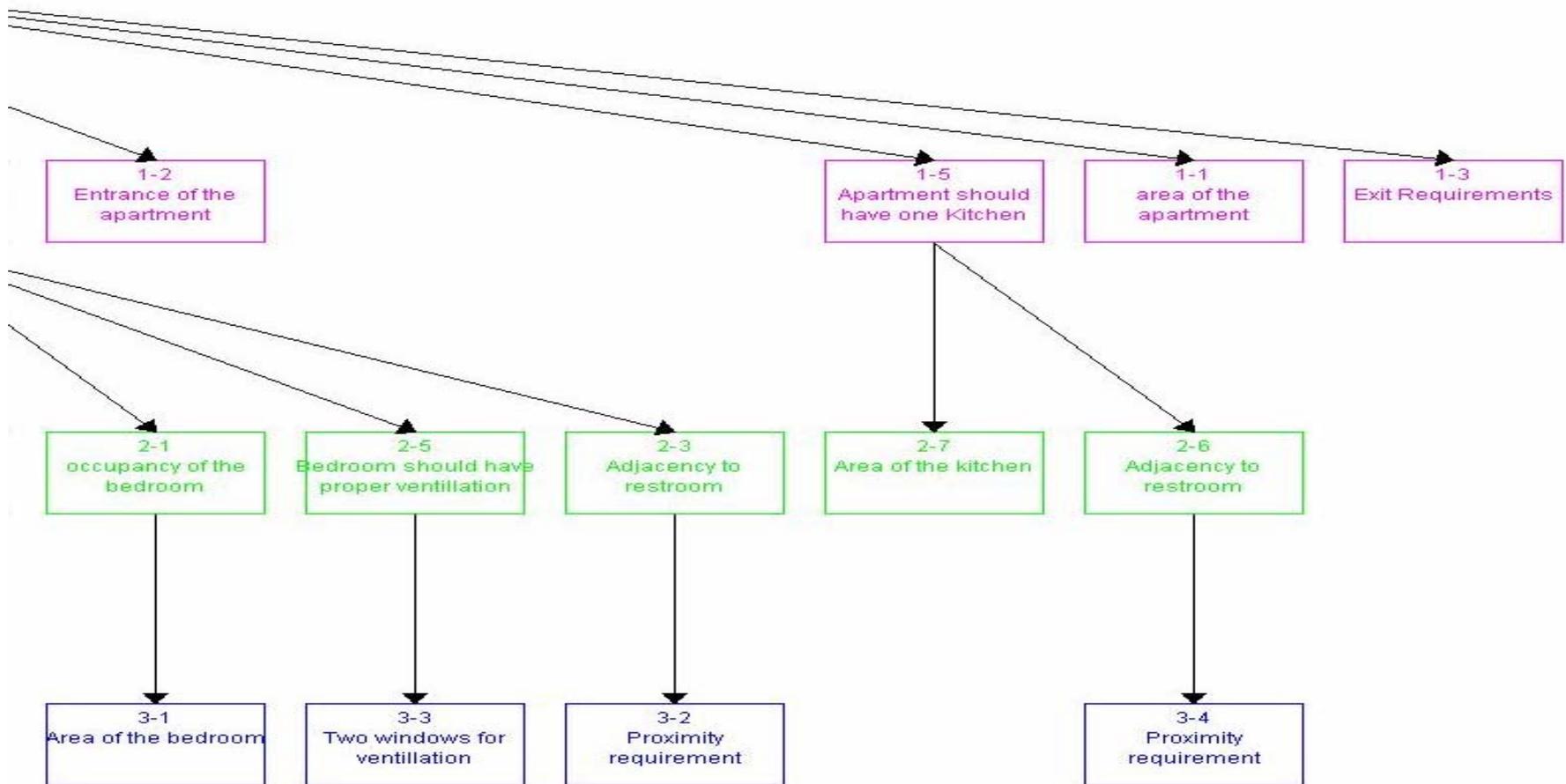


Fig 8.0 Requirement Diagram

System Structure - Generic Class Diagram

The system structure is designed for an architectural viewpoint as shown in the generic class diagram. The complete architectural viewpoint is divided into three sub classes:

- Spaces
- Dividers
- Portals

Spaces consist of each type of room, which includes bedroom, kitchen, living room, restroom and passageway. Whereas dividers consists of floor and walls which basically divides the spaces horizontally and vertically respectively. And the third category of portals includes doors, windows, joints (opening without door) and vent (for ventilation).

Now in order to show relationship between different rooms (Association_Rooms), between rooms and walls (Association_Rooms_Walls), and between walls and portals (Association_Walls_Portals), we use different association classes as shown in fig 9.0. The properties of these association classes will address the different kind of relationships between rooms, walls and portals.

These properties are

Proximity strength - which address the proximity issue between different rooms I.e. are they close or apart.

Access Type – What type of access is available

Access Vent – Is it for ventilation purpose

Access Light – Is it allowing light to pass through i.e. is it transparent

Access admit – Is it allowing people to enter or exit

Access audible – Is it sound proof or not

After the generic class diagram, we try to draw this class diagram specifically as per our floor plan as shown in fig 10.0.

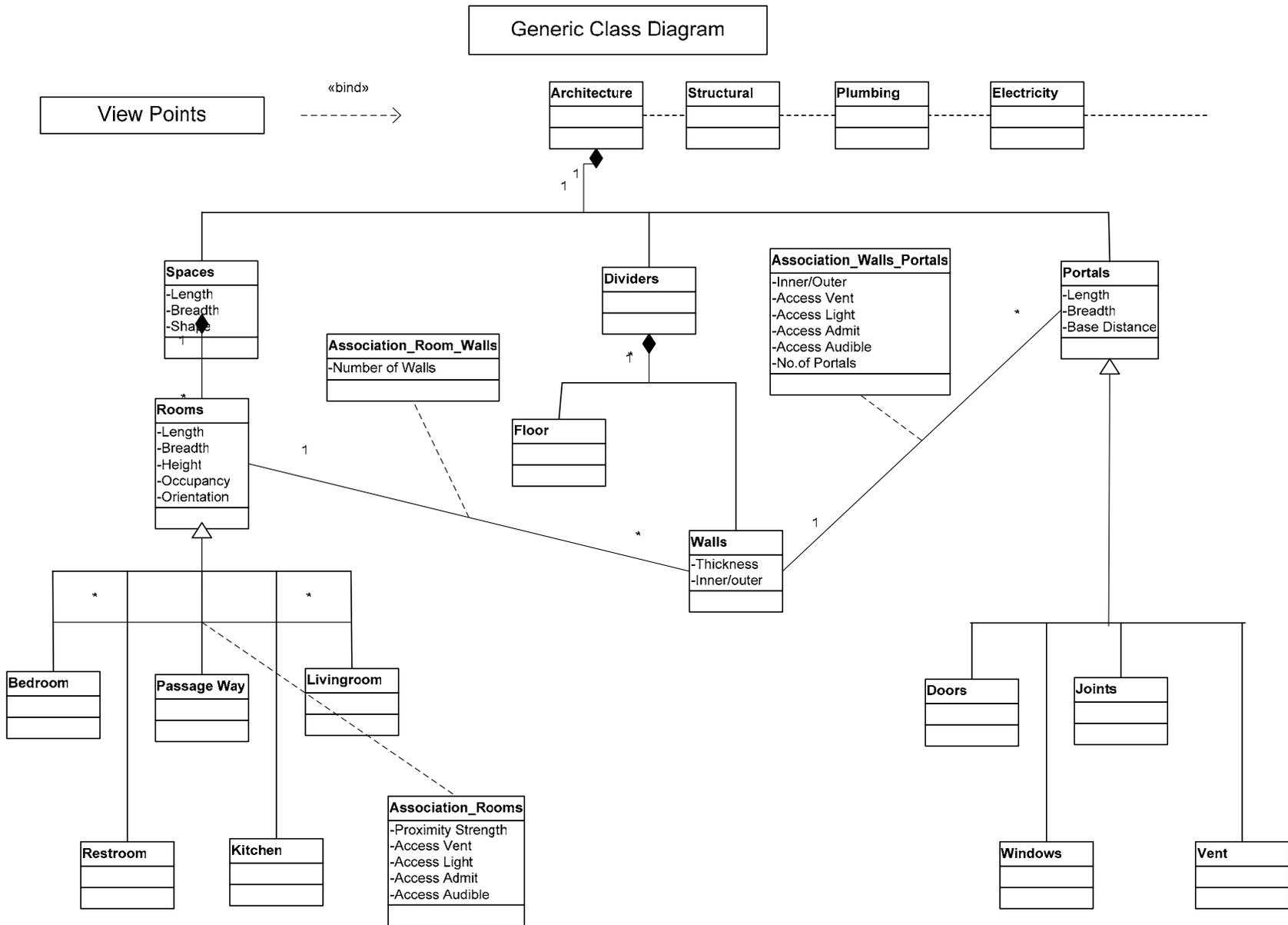


Fig 9.0 Generic Class Diagram

Class Diagram - Floor plan

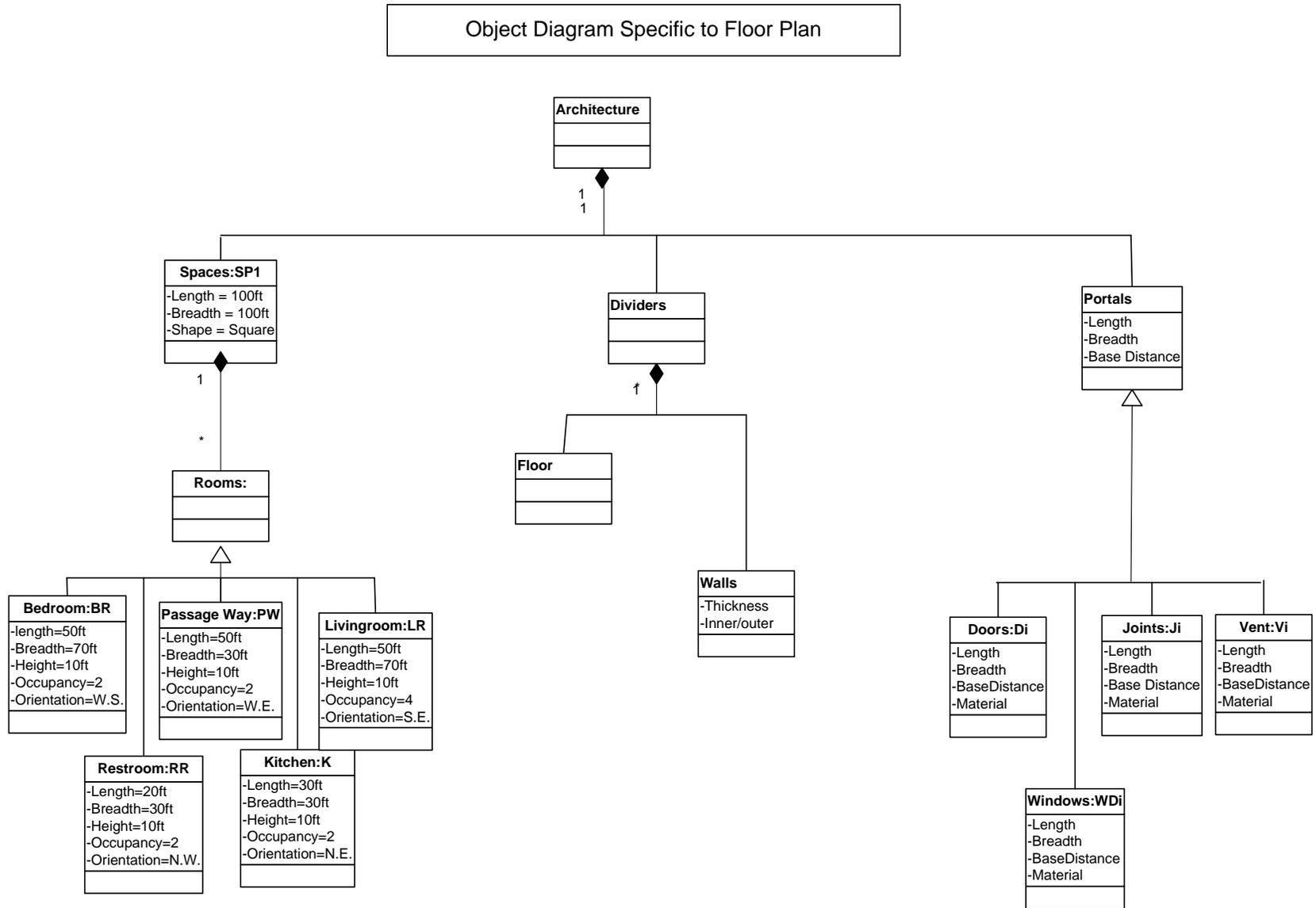


Fig 10.0 Class Diagram according to proposed floor plan

Object Diagram - Bedroom

We draw object diagram specific to each room in our floor plan as shown in following figures.

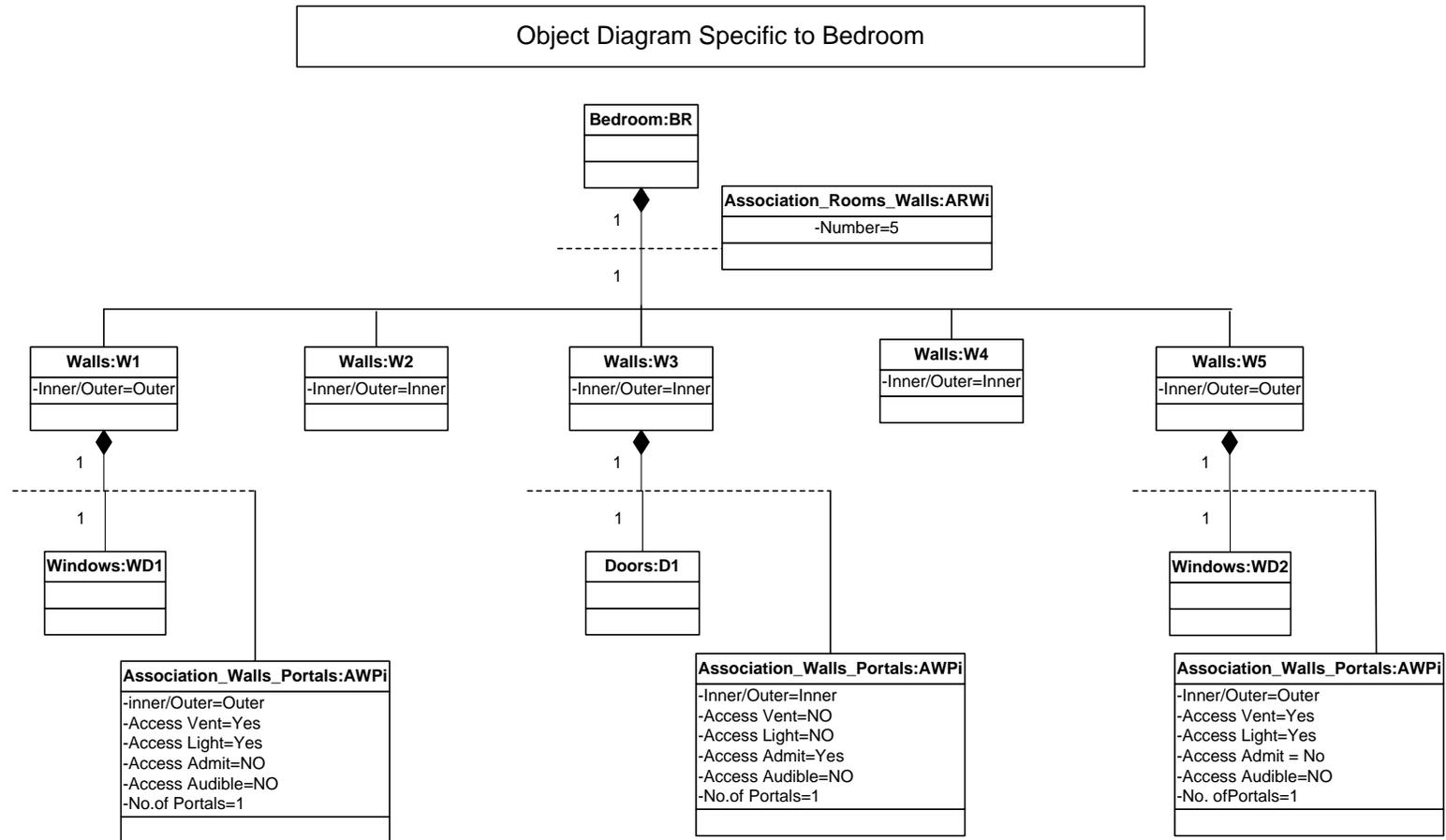


Fig 11.0 Object Diagram - Bedroom

Object Diagram - Restroom

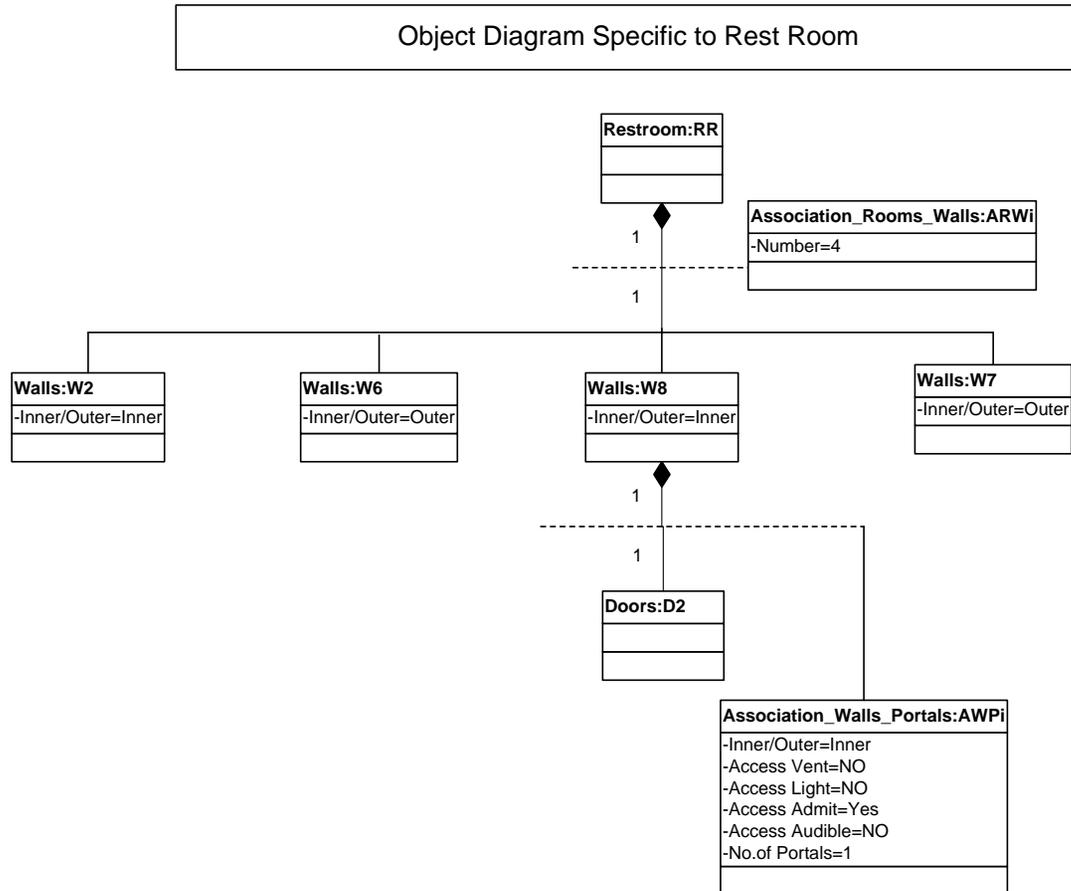


Fig 12.0 Object Diagram - Restroom

Object Diagram – Passage Way

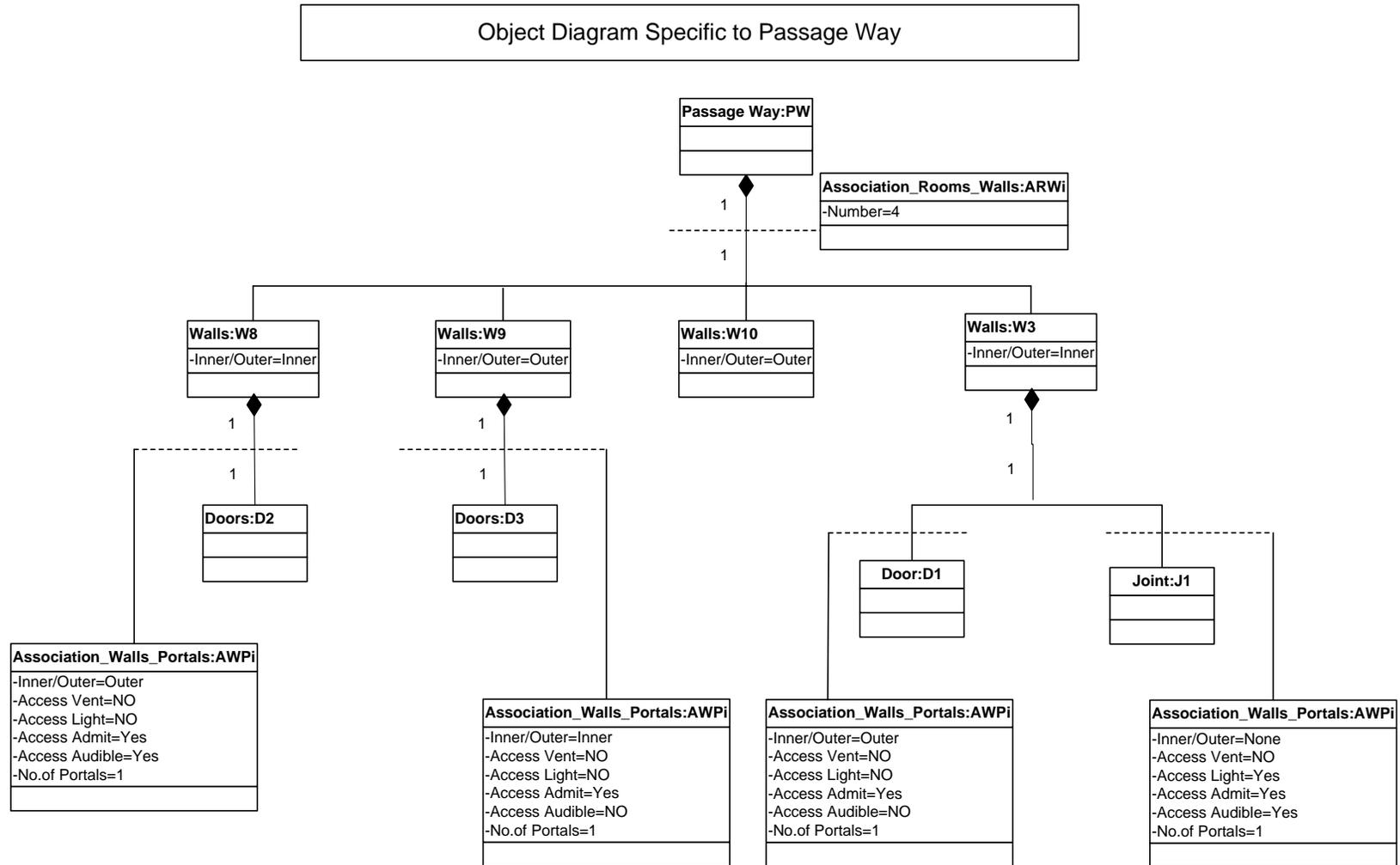


Fig 13.0 Object Diagram – Passage Way

Object Diagram - Kitchen

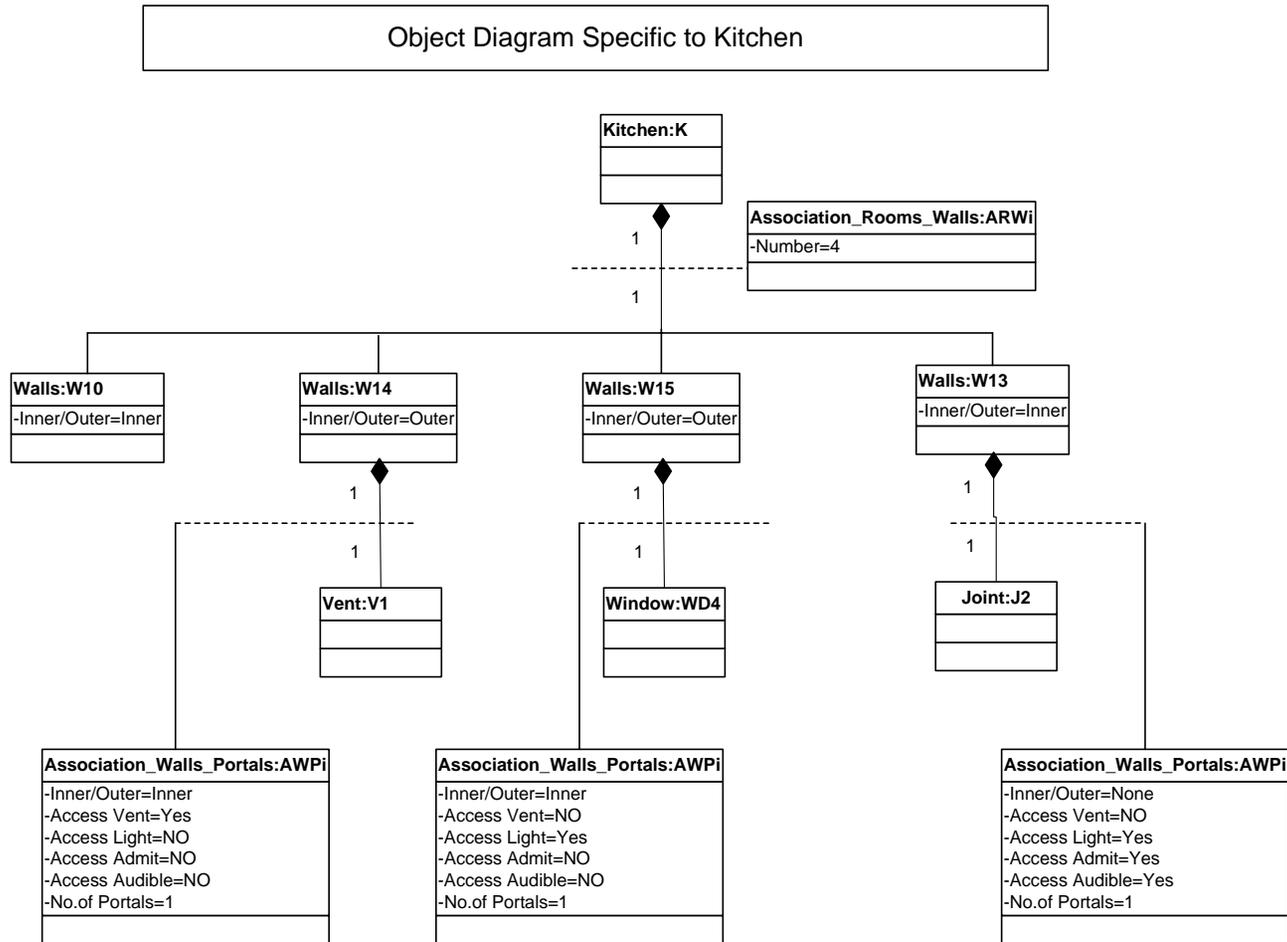


Fig 14.0 Object Diagram - Kitchen

Object Diagram – Living Room

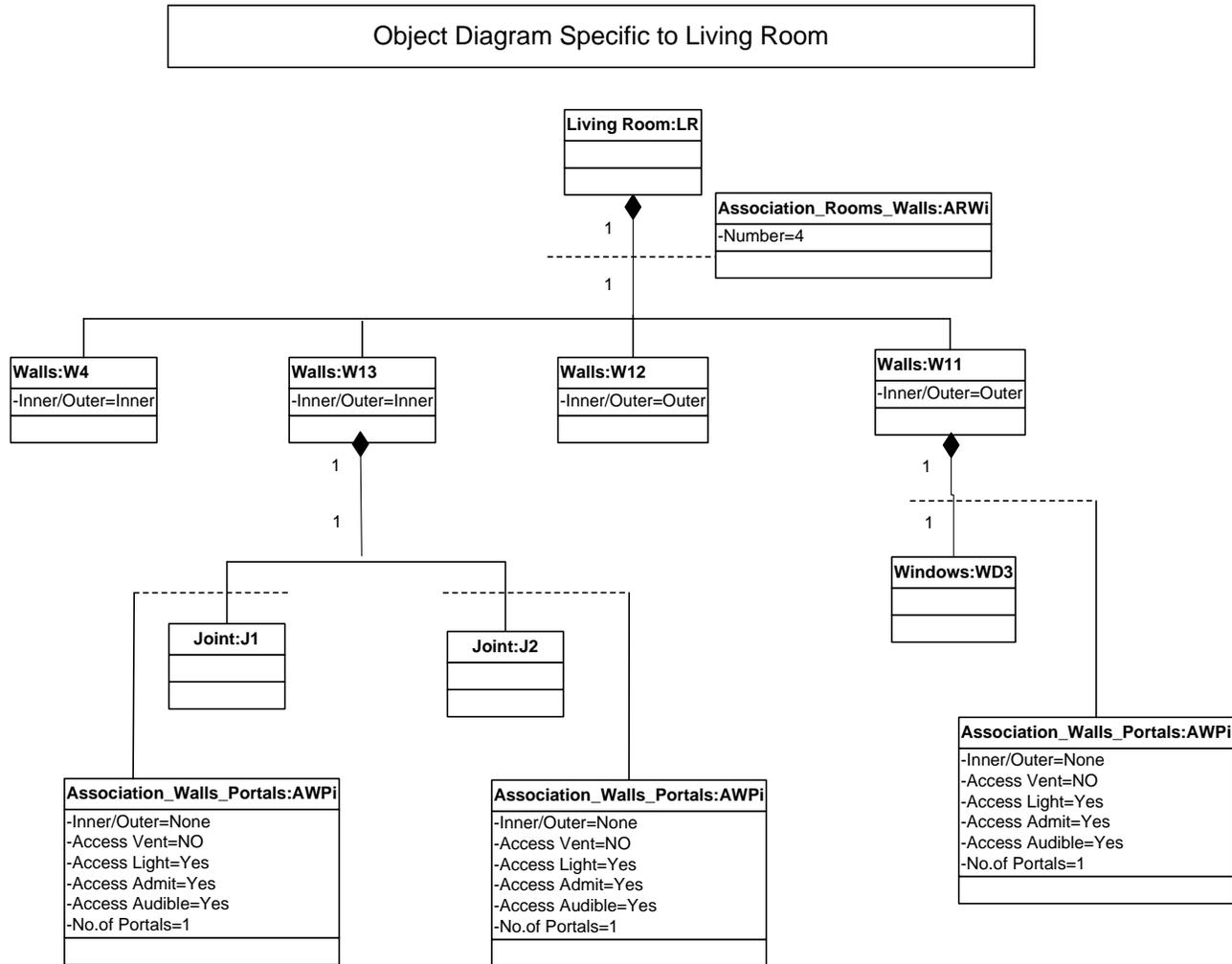


Fig 15.0 Object Diagram – Living Room

Generic Relation Diagram

We also try to address all the relationships between different rooms through generic relation diagram and then making it specific to our floorplan.

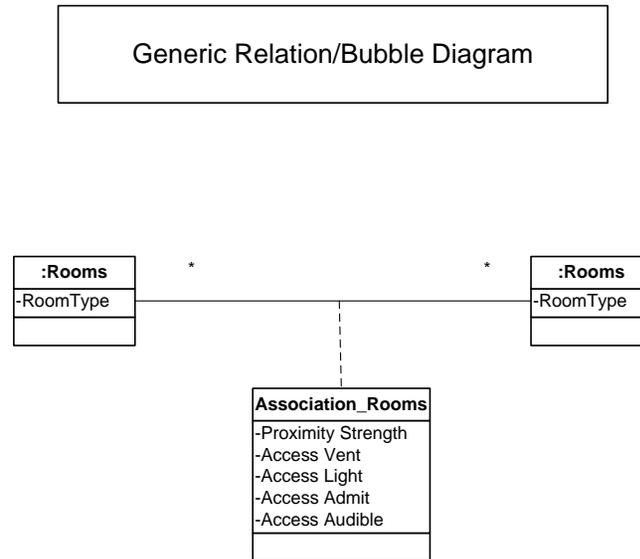


Fig 16.0 Generic Relation Diagram

Relation Diagram - All Rooms

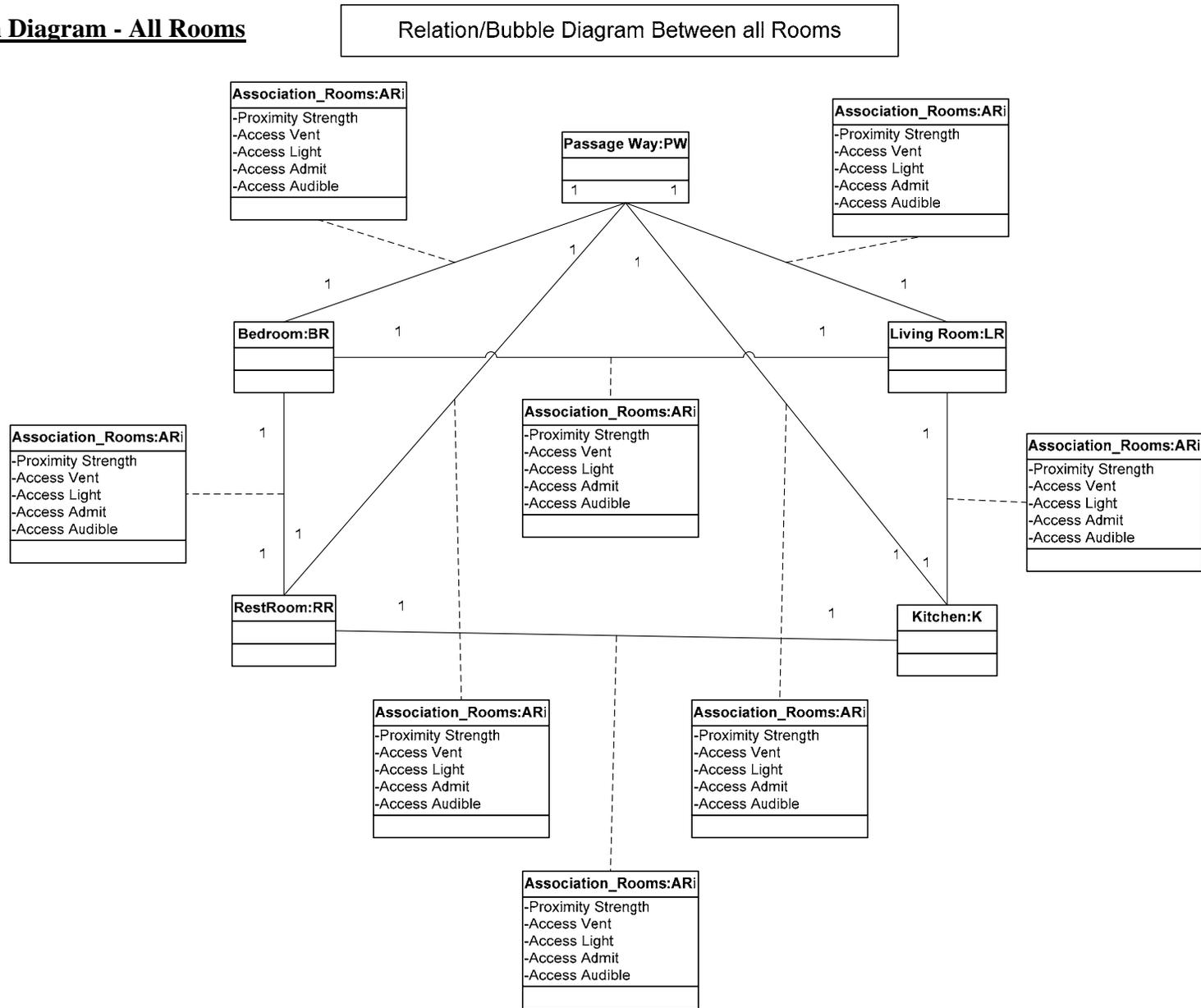


Fig 17.0 Relation Diagram - All Rooms

Challenging Aspects

The challenging aspects of our project can be summarized as follows:

- Abstract Concept
- Absence of explicit system behavior – As buildings on its own doesn't have very explicit behavior, which makes it very difficult for us to analyze the system.
- Figuring out the approach
- Iterations – We went through number of iterations for finalizing the approach and UML diagrams which will form the basis for tool development in future.
- Concession and Agreement – To obtain concession and agreement between various team members view points was also a challenging aspect of our project.
- Integration of different view points – In future after developing the methodologies for different view points, the challenging aspect would be to integrate them in a cohesive manner without contradiction.

Conclusion

- Defined methodology
- UML Diagrams as a basis for tool development for an architectural view point
- Known Validation Parameters

Future Work

- Defining methodology for other view points
- Integration of different view points
- Development of tools that allow
 - Formal basis for describing and reasoning about high level system architectural connection
 - Synthesis and checking of building architectures
 - Interact with other engineering disciplines
 - Vertical Integration of topological and geometric information
 - Promote single representation
- End to End development from requirements to UML representations and to engineering drawings

Software Packages Used

- PaladinRM
- MS Visio
- MS Office

References

- ENPM 642 Class Notes by Prof. Mark Austin
- Interchange Format for Symbolic Building Design by Laura Downs, University of California, Berkeley
- Graph-Based Visualization of System Requirements Organized for Team-Based Design by Mark Austin, Natalya Kositsyna, and Vimal Mayank
- Representation and Visualization of Engineering Requirements attached to Multidisciplinary Engineering Models and Drawings by Mark Austin and Natasha Shmunis
- IFC 2x Edition 2 Model Implementation Guide by Thomas Liebich, Version 1.7
- Modeling multiple views of design objects in a collaborative CAD environment by M A Rosenman and J S Gero

Appendix:

Copy of the code used for generating requirements:

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<?xml version="1.0" encoding="UTF-8" ?>
<!--comment SLATE Database sampled 11/26/2003 11:20:25 -->
<ReqFlow>

<Req ROIN="0-1" type="Apartment architecture requirement" level="0">
  <Title text="Architecture Requirements"/>
  <Description text="The requirements will comply with the user needs and architectural standards"/>
  <ReqList>
    <CompReq ROIN="1-1"/>
    <CompReq ROIN="1-2"/>
    <CompReq ROIN="1-3"/>
    <CompReq ROIN="1-4"/>
      <CompReq ROIN="1-5"/>
      <CompReq ROIN="1-6"/>
  </ReqList>
</Req>

```

```
<CompReq ROIN="1-7"/>
<CompReq ROIN="1-8"/>
```

```
</ReqList>
```

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  <Attribute text="Requirement Title" value="Architechture"/>
<Attribute text="complies with user requirements" value="Not Assigned"/>
<Attribute text="Criticality" value="None"/>
<Attribute text="ID" value=""/>
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</Req>
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```
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```

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  <Title text="Apartment area requirements" />
```

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    <Description text="The area of the apartment should be atleast 1000 Sq ft." />
```

```
      <Attribute text="ID" value=""/>
      <Attribute text="Requirement Title" value="area of the apartment" />
      <Attribute text="Assigned To" value="none" />
      <Attribute text="Occupancy" value="2" />
      <Attribute text="Criticality" value="None" />
```

```
</Req>
```

```
<Req ROIN="1-2" type="Level 1" level="1">
```

```
  <Title text="Entrance requirements" />
```

```
    <Description text="The Entrance of the apartment should not be through bedroom." />
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Entrance of the apartment" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="high" />
<Attribute text="Proximity between bedroom and entrance " value=">3" />
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</Req>
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<Req ROIN="1-3" type="Level 1" level="1">
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<Title text="Exit Requirements" />
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<Description text="The apartment should have an easy access to exit in case of emergency." />
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```
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<Attribute text="Requirement Title" value="Exit Requirements" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="high" />
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</Req>
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<Req ROIN="1-4" type="Level 1" level="1">
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<Title text="Bedroom requirements" />
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<Description text="The apartment should have one bedroom." />
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```
<ReqList>
  <CompReq ROIN="2-1" />
  <CompReq ROIN="2-2" />
  <CompReq ROIN="2-3" />
  <CompReq ROIN="2-4" />
  <CompReq ROIN="2-5" />
  <CompReq ROIN="2-14" />
</ReqList>
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Apartment should have one bedroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="Medium" />
</Req>
```

```
<Req ROIN="2-1" type="Level 2" level="2">
```

```
<Title text="Occupancy requirements" />
```

```
<Description text="Occupancy of the bedroom should be 2 or more" />
```

```
<ReqList>
  <CompReq ROIN="3-1" />
</ReqList>
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="occupancy of the bedroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Dimensional" />
```

```
</Req>
```

```
<Req ROIN="3-1" type="Level 3" level="3">
```

```
<Title text="Area requirements" />
```

```
<Description text="Area of the bedroom should be greater than 400 Sq ft" />
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Area of the bedroom" />
<Attribute text="Assigned To" value="none" />
```

```
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
```

```
</Req>
```

```
<Req ROIN="2-2" type="Level 2" level="2">
```

```
<Title text="Bedroom Shape" />
```

```
<Description text="Shape of the bedroom should be square" />
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Square shaped bedroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Geometric" />
```

```
</Req>
```

```
<Req ROIN="2-14" type="Level 2" level="2">
```

```
<Title text="Closet in the bedroom" />
```

```
<Description text="Bedroom should have a closet" />
```

```
<ReqList>
  <CompReq ROIN="3-10" />
</ReqList>
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Bedroom should have a closet" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
```

<Attribute text="Criticality" value="None" />

</Req>

<Req ROIN="3-10" type="Level 3" level="3">

<Title text="Admit all" />

<Description text="The closet should be a walkin closet" />

<Attribute text="ID" value="" />

<Attribute text="Requirement Title" value="walk in closet" />

<Attribute text="Assigned To" value="none" />

<Attribute text="Req Type" value="functional" />

<Attribute text="Requirement Status" value="active" />

<Attribute text="Criticality" value="None" />

<Attribute text="depth" value="5 ft" />

</Req>

<Req ROIN="2-3" type="Level 2" level="2">

<Title text="bedrooms distance from Restroom" />

<Description text="Bedroom should be adjacent to restroom" />

<ReqList>

<CompReq ROIN="3-2" />

</ReqList>

<Attribute text="ID" value="" />

<Attribute text="Requirement Title" value="Adjacency to restroom" />

<Attribute text="Assigned To" value="none" />

```
<Attribute text="Requirement Status" value="inactive" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
```

```
</Req>
```

```
<Req ROIN="3-2" type="Level 3" level="3">
<Title text="Proximity strength" />
<Description text="Proximity between restroom and bedroom should be less than 2" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Proximity requirement" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
<Attribute text="distance" value="less than 5ft" />
</Req>
```

```
<Req ROIN="2-4" type="Level 2" level="2">
<Title text="Bedroom should be sound proof" />
<Description text="When the doors are closed, noise should neither enter nor leave the room" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Sound proof Bedroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Functional" />
<Attribute text="Door Type" value="Air tight" />
</Req>
```

```
<Req ROIN="2-5" type="Level 2" level="2">
<Title text="Bedroom Ventillation" />
<Description text="The bedroom should have proper ventillation" />
```

```
<ReqList>
<CompReq ROIN="3-3" />
```

</ReqList>

<Attribute text="ID" value="" />

<Attribute text="Requirement Title" value="Bedroom should have proper ventillation" />

<Attribute text="Assigned To" value="none" />

<Attribute text="Req Type" value="functional" />

<Attribute text="Requirement Status" value="inactive" />

<Attribute text="Criticality" value="None" />

<Attribute text="Criticality" value="None" />

<Attribute text="Admit" value="all" />

</Req>

<Req ROIN="3-3" type="Level 3" level="3">

<Title text="Admit all" />

<Description text="The bedroom has two windows" />

<Attribute text="ID" value="" />

<Attribute text="Requirement Title" value="Two windows for ventillation" />

<Attribute text="Assigned To" value="none" />

<Attribute text="Number of Windows" value="Two" />

<Attribute text="Req Type" value="functional" />

<Attribute text="Requirement Status" value="active" />

<Attribute text="Criticality" value="None" />

</Req>

<Req ROIN="1-5" type="Level 1" level="1">

<Title text="Kitchen requirements" />

<Description text="Apartment should have one Kitchen" />

<ReqList>

<CompReq ROIN="2-6" />

<CompReq ROIN="2-7" />

</ReqList>

<Attribute text="ID" value="" />

<Attribute text="Requirement Title" value="Apartment should have one Kitchen" />

<Attribute text="Assigned To" value="none" />

<Attribute text="Requirement Status" value="active" />

```
<Attribute text="Criticality" value="None" />
</Req>
```

```
<Req ROIN="2-6" type="Level 2" level="2">
<Title text="Kitchen's distance from Restroom" />
<Description text="Kitchen should be far from to restroom" />
<ReqList>
<CompReq ROIN="3-4" />
</ReqList>
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Adjacency to restroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="inactive" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
</Req>
```

```
<Req ROIN="3-4" type="Level 3" level="3">
<Title text="Proximity strength" />
<Description text="Proximity between restroom and kitchen should be more than 6" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Proximity requirement" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
<Attribute text="distance" value="more than than 15 ft" />
</Req>
```

```
<Req ROIN="2-7" type="Level 2" level="2">
<Title text="Area requirements" />
<Description text="Area of the Kitchen should be large enough for two people to cook (greater than 200 sq ft)" />
<Attribute text="ID" value="" />
```

```
<Attribute text="Requirement Title" value="Area of the kitchen" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Dimensional" />
</Req>
```

```
<Req ROIN="1-6" type="Level 1" level="1">
<Title text="Restroom requirements" />
<Description text="Apartment should have one restroom" />
```

```
<ReqList>
<CompReq ROIN="2-8" />
</ReqList>
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Apartment should have one restroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="inactive" />
<Attribute text="Criticality" value="None" />
</Req>
```

```
<Req ROIN="2-8" type="Level 2" level="2">
<Title text="Area requirements" />
<Description text="Area of the restroom should be greater than 100 sq ft" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Area of the restroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Dimensional" />
</Req>
```

```
<Req ROIN="1-7" type="Level 1" level="1">
```

```
<Title text="Apartment should have one Passageway" />
<Description text="Apartment should have one Passageway" />
<ReqList>
  <CompReq ROIN="2-9" />
    <CompReq ROIN="2-10" />
</ReqList>
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Apartment should have one Passageway" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="inactive" />
<Attribute text="Criticality" value="None" />
</Req>
```

```
<Req ROIN="2-9" type="Level 2" level="2">
<Title text="Width requirements" />
<Description text="Width of the passageway should be such that two people can pass each other simultaneously in opposite directions" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="width of passageway" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Dimensional" />
</Req>
```

```
<Req ROIN="2-10" type="Level 2" level="2">
<Title text="Adjacent to bedroom , livingroom and restroom" />
<Description text="Passage way should be connected to Bedroom,Restroom and livingroom" />
```

```
<ReqList>
  <CompReq ROIN="3-5" />
    <CompReq ROIN="3-6" />
    <CompReq ROIN="3-7" />
</ReqList>
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Adjacency of the passageway to other rooms" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Topological" />
</Req>
```

```
<Req ROIN="3-5" type="Level 3" level="3">
<Title text="Proximity strength" />
<Description text="Proximity between restroom and Passageway should be less or equal to 1" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Proximity requirement with restroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
<Attribute text="distance" value="less than 1 ft" />
<Attribute text="Connecting portal type" value="door" />
</Req>
```

```
<Req ROIN="3-6" type="Level 3" level="3">
<Title text="Proximity strength" />
<Description text="Proximity between Bedroom and Passageway should be less or equal to 1" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Proximity requirement with bedroom" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
<Attribute text="distance" value="less than 1 ft" />
<Attribute text="Connecting portal type" value="door" />
</Req>
```

```
<Req ROIN="3-7" type="Level 3" level="3">
```

```
<Title text="Proximity strength" />
<Description text="Proximity between Livingroom and Passageway should be less or equal to 1" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Proximity requirement with Living Room" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
<Attribute text="distance" value="less than 1 ft" />
<Attribute text="Connecting portal type" value="Opening" />
</Req>
```

```
<Req ROIN="1-8" type="Level 1" level="1">
<Title text="Living room requirements" />
<Description text="Apartment should have one Livingroom" />
<ReqList>
<CompReq ROIN="2-11" />
<CompReq ROIN="2-12" />
<CompReq ROIN="2-13" />
</ReqList>
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Apartment should have one Living room" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="inactive" />
<Attribute text="Criticality" value="None" />
</Req>
```

```
<Req ROIN="2-11" type="Level 2" level="2">
<Title text="Living room distance from Kitchen" />
<Description text="Living room should be adjacent to kitchen" />
<ReqList>
<CompReq ROIN="3-8" />
</ReqList>
<Attribute text="ID" value="" />
```

```
<Attribute text="Requirement Title" value="Adjacency to Kitchen" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
</Req>
```

```
<Req ROIN="3-8" type="Level 3" level="3">
<Title text="Proximity strength" />
<Description text="Proximity between Living Room and Kitchen should be less than 1" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Proximity requirement" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="topological" />
<Attribute text="distance" value="less than 1 ft" />
<Attribute text="Connecting Portal type" value="Opening" />
</Req>
```

```
<Req ROIN="2-12" type="Level 2" level="2">
<Title text="Occupancy requirements" />
<Description text="Occupancy of the Livingroom should be 4 or more" />
```

```
<ReqList>
<CompReq ROIN="3-9" />
</ReqList>
```

```
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="occupancy of the Living Room" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Dimensional" />
</Req>
```

```
<Req ROIN="3-9" type="Level 3" level="3">
<Title text="Area requirements" />
<Description text="Area of the Living room should be greater than 600 Sq ft" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="Area of the Living Room" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
</Req>
```

```
<Req ROIN="2-13" type="Level 2" level="2">
<Title text="Living Room Shape" />
<Description text="Living Room should be L-Shaped" />
<Attribute text="ID" value="" />
<Attribute text="Requirement Title" value="L-shaped Living room" />
<Attribute text="Assigned To" value="none" />
<Attribute text="Requirement Status" value="active" />
<Attribute text="Criticality" value="None" />
<Attribute text="Req Type" value="Geometric" />
</Req>
```

```
</ReqFlow>
```