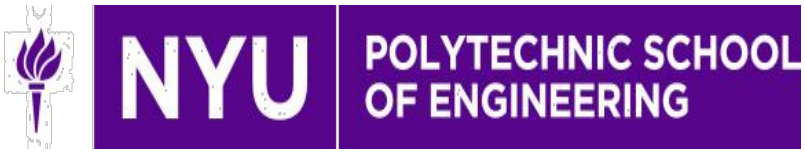

Computer Science and Engineering

Course: CS 6063 Software Engineering – I

Semester: Spring 2015

Advisor: Professor Fred Strauss

BUILDING MANAGEMENT SYSTEM (BMS)

Analysis Specification – Version 1

Document Number: AnalysisSpecification-001

Team Number: **D4**

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Revision History:

Date	Version	Description of change
03/18/2015	1.0	Initial Document
04/08/2015	1.1	Requirement
04/22/2015	1.2	Analysis

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1. Introduction

1.1 Purpose :

As per the statistics reported by New York Times in August 2014, it was noted that there were ~5700 commercial premises in Manhattan and the operational costs to manage them and provide the services to the corporate tenants was recorded to be $210 Billion. This operational cost is expected to escalate up to $370 Billion by the end of 2015. However, as per the survey our clients' market research team, commercial rental property owners seek a system that shall efficiently manage their premises. They believe that, Building Management System (BMS) shall bring down their operational cost by 14 % and reduce the operational time to serve their corporate tenants giving them a competitive advantage.

2. Scope

Before beginning of building any system, we must identify its scope. The scope contains the following. To build a system that shall help property owners in offering a higher level of services to their lessees and by that making them more competitive in their business. The emphasis is on three primary requirements to achieve the goal, which are Office Rental Requirements, Climate Control Requirements and Security Requirements. Actors of the system are employees, building owners, tenants and building supervisor.

2.1 Identification:

Building Management System's Business Requirements Documentation

Document Number: 1

<version 1.0>

2.2 Bounds:

2.2.1 In-scope

The Building Management System (BMS) shall provide the following services to the building owner:

- Zone Allocation as per building owner's convenience
- Initial set-point specified by business tenant
- Accessing system over the network
- Report generation for availability, performance, maintenance
- Generate bills and invoices on regular-basis
- Enforcing Security Services
- Facilitating Climate and Light Control Services

2.2.2 Out of the scope

The following functionalities are listed below that system shall not provide:

- Keeping records of rental payment to the property owner.
- Effect on access to the rooms and their climate control and security for the business zone due to payment irregularities are out of the scope for the system.

- The system provides its functionalities and services only to the rooms, which are rented in the building. Making services accessible to the rooms, which are not rented, are also out of scope.

2.3 Objectives:
The goals that we need to accomplish during the course of this project development are given as the deliverables along with their scheduled dates.

No.	Date	Deliverables
1	02/25/2015	Project Proposal
2	03/18/2015	Project Business Requirements
3	04/08/2015	Project Requirements
4	04/22/2015	Project Analysis
5	05/06/2015	Presentation

2.4 System Overview:
Building Management System (BMS) is a proposed computer-based system that shall help building owners to manage, control and monitor building's technical services such as the light, ventilation, and internal security of the system. It shall improve the space management ability for building owners, so that they shall efficiently offer the units to maximize the profits for themselves.

Therefore, the owners of the office rental properties throughout the county require a system that revitalizes the Real Estate Market. Their focus is mainly to automate two main areas: office security and office climate control. Their ultimate objective is to have a system that provides better service to tenants leading to minimized expenses and improving the business process.

To provide the highest standard of automated services and to serve liaison between tenants and building owner, BMS shall meet the following key utilities:

- **Office Rental Services:** BMS shall provide the building owner to form zones by grouping individual rooms to increase the rental profitability. BMS shall store the details/information of tenant /owner. Once zone is assigned to the business tenants, the BMS shall facilitate the business tenants to establish and manage the climate conditions during the lease tenure.
- **Climate Control Services:** BMS shall provision business tenants to set points that control the lighting and temperature of the rooms managed at the zone level. It shall also be maintained with the help of external systems: Heating, Ventilating, and Cooling (HVAC) Systems and Lighting System.

- **Security Services:** BMS shall make the security as an integral part of its services. It shall allow each business to enable or disable authorization levels. On the occurrence of any potential breach, the security guards shall be notified.

3. Business Requirements

3.1 Technology:

- **Easy to form best-fit rental zones through user-friendly interface to increase business profitability:** BMS system shall allow building owners to make room allocations to business tenants' to maximize profitability and the flexibility to redefine zones at their convenience.

- **Platform for tenants to set initial climatic conditions:** Business tenants' shall have the ability to specify initial set points for the climate and light control system. They shall be able to only maintain the security aspect of the BMS by either enabling or disabling the system. There is a minimum requirement for business tenants' to establish a default setting prior to working. The settings shall be fixed throughout the lease period or changed on a rotational basis.

- **Connectivity over the network:** Instead of maintaining physical records locally, a centralized system shall allow system users to access data from any machine over the network. On the basis of authorization, users shall perform dedicated tasks even remotely.

- **Report Generation:** These reports shall be fetched at any point of time to review the statistics. The reports shall be classified accordingly:
  - **Tenant Maintenance Report:** based on assigned facility usage (light, temperature, etc.)
  - **Performance Reports** to provide customized revenue reports.
  - **Office Space Availability Reports**

3.2 Economics:

- **Cash Flow:**
  The economic status of the organization depends on the inbound and outbound monetary flow. The outbound cash flow depends on the money incurring from the investors, and the capital that is raised for building the system. The inbound depends on the profitability of the system success. For the growth of the business, other revenue generation factors shall be as advertisements, marketing, etc. shall be very critical.

- **Initial Capital Investment:** To establish a project, some initial investment shall be required to back up the success of the business, which shall play a crucial role till the project kick starts and the cash flow begins. As the profitability factor kicks in, it shall help the building owner to include more project resources to improve the overall quality of the system.

- **Business Strategy:** The market research shall help in deciding if a co-space environment shall be successful among the building tenants. This shall match the market trends and help suffice needs of every tenant providing a personalized set-up to help them function successfully.

3.3 Regulatory and Legal:

- **Terms and conditions:** Business tenants shall be informed about the various clauses and it shall be included in the lease contract. Deposit and fees, lease duration, ground for termination of lease, condition of rental unit, permissible business type, threshold limit for number of employees, attorney fees and court cost in lawsuit, etc. shall be explicitly mentioned in the contract. BMS shall maintain the soft copy for each tenant. Violation of any ethical or contracted condition shall give the right to the building owner to terminate the contract.

- **Location-specific tax law and legislative law:** Each state, and even the city shall have different legislative and tax laws. Considering the probability of business growth all over the country, BMS shall consider location-specific laws while generating the invoices, monthly bills etc.

- **Background verification:** Prior to applying for the office space, the business tenants need to sign a few documents that specify past quarterly revenue history, if or any previous debt history, and or prosecution information. These requirements are further verified by the building owner to help check for compliance issues. The verified documents are then stored in the BMS database for future reference. The business owner signs a non-disclosure agreement with the business tenant to protect its nonpublic information.

3.4 Market Considerations:

- **Opportunity in market:** Formation of rental zones gives building owners flexibility to target versatile customer group. Building owners shall identify the current market need, real estate rates, and property trends to attract the tenants among small, medium or enterprise business groups.

- **Branding/Marketing:** It is essential to build and develop a strong brand. This is crucial to build the link between the values of the building owner and it's respective tenants. With a strong brand image, it helps create brand recognition, emotional connection with the user, loyalty to tenants, and reduction in customer retention costs. To market the product, it is important to reach out to the customers through campaigns, advertising, and even word of mouth.

- **Competition:** Building owners need to understand the competitor's products and their strategy in the market. To retain the existing tenants and engage new ones building owner shall build different strategy for each customer group (small, medium or Enterprise). Their strategy shall include factors such as innovative services, low cost offering etc.

3.5 Risk and Alternatives:

3.5.1 Business Risk

- **Lack of Demand:** If there is already a stable system, which serves the purpose of the building owners, or if competitors are producing similar system within a low budget then replicating or building similar software shall not create value for the business. Investing time, cost and human efforts on building such system shall not guarantee prolific business value.
  Probability: Medium-High
  How discovered: Market Research
  Responsible Party: Market research team
  Mitigation Plan: Identify the additional functionality, which shall completely change the future tenants experience and add value to the owners business. Marketing such functionality to the business tenants shall help generate the demand.

3.5.2 Operational risk:

- **Lack of expertise in using the system:** Lack of knowledge in real estate area or in usability of BMS system shall cause incorrect flow of data and wrong business operations.
  Probability: High
  How Discovered: Inaccurate system reports, unable to complete activities.
  Responsible Party: System Users
  Mitigation Plan: Provide system training to system users and enlighten them about the working of overall system.

- **Improper Mitigation plan:** There shall be an escalation channel for the employees/system users to reach out to the company for issues pertaining to the employees/system users itself.
  Probability: Medium-High

  How discovered: Employee dissatisfaction/participation
  Responsible Party: Human Resource Team, Building Owner
  Mitigation Plan: Proper escalation procedure informed to the employees/system users at the time of joining.

- **Potential Investment Decisions:** It is crucial to include the investors and the clients in the decisions at every phase of the development cycle to help prepare for potential issues like increase in costs or loss, and even benefits like share profits**.**
  Probability: High
  How discovered: Quarterly results
  Responsible Party: Business Owners, shareholders, angel investors, business Tenants**.**
  Mitigation Plan: Regular and timely discussions for effective decision-making.

- **Lack of system capability:** Some issues with the system shall arise due to unforeseen calamities or even through human errors.
  Probability: High
  How discovered: Natural disasters, human errors.
  Responsible Party: Database Management Administrator, Development Team.
  Mitigation Plan: Proper training of system usage to employees and escalation procedure for the administrator to help the system restoration.

3.5.3 Technology risk:

- **Hardware Failure:** Considering the case where HVAC and Lighting system or even the security mechanism fails, so in such scenario system users shall not be able to access the BMS.
  Probability: Medium
  How discovered: hardware not providing desired functionality.
  Responsible Party: System administrator
  Mitigation Plan: periodic backups, routine maintenance.

- **Network Failure:** Since operations are carried out over the network on the centralized database of BMS, failure of network shall act as a barrier to centralized database and the system completely.
  Probability: High
  How Discovered: System is not accessible over the network.
  Responsible Party: Network Administrator, Development Team
  Mitigation Plan: Robust network design where failure of one node shall not Affect the other systems.

- **Malfunction of software:** Software update when not done shall not allow to run the BMS, hence crashing the Operating System shall result in downtime**.**
  Probability: Low
  How Discovered: Operating system fails to load BMS
  Responsible Party: Network Administrator, Development Team
  Mitigation Plan: Periodic update of software and Operating System, installation of malware removal software.

3.5.4 Economic risk:

This is important to financing of the project, wherein the project output shall cover the revenue generated with the project's operating and maintenance costs in total along with the incurring losses. The project shall consider unforeseen expenses in terms of resources, development and quality costs to meet the requirements of the customer. The project shall also be able to sustain change in the trends of economy especially recession, and any unlawful activities that shall affect the net output of the company at large.
Probability: High.
How discovered: To identify patterns by conforming to the quarterly results and the production costs of the system.

Responsible Party Status: Business Analyst Team
Mitigation Plan: following the schedule religiously and involving customers at early phase in development to make sure the right product is developed meeting the cost requirement shall achieve this.

3.6 Human Resources and Training:

People are crucial asset to any organization. The objective of Human Resource is to provide guidance and support to company employees, business client groups and maintain the ergonomics of the company. Each individual in the organization shall have stake in the BMS system.

There is a need of system users who shall operate the BMS and carry out transaction such as zone creation for tenants, generate reports, maintain digital copies of the documents etc. Such users need to be trained to operate the system.

To train the system users there is a need of individuals who has massive knowledge about the system domain and architecture of the system. Trainers must have technical expertise, so if required they shall guide technicians to resolve the problem

There is a need of a technicians who shall fix hardware, network, OS failure issues and work to mitigate them.

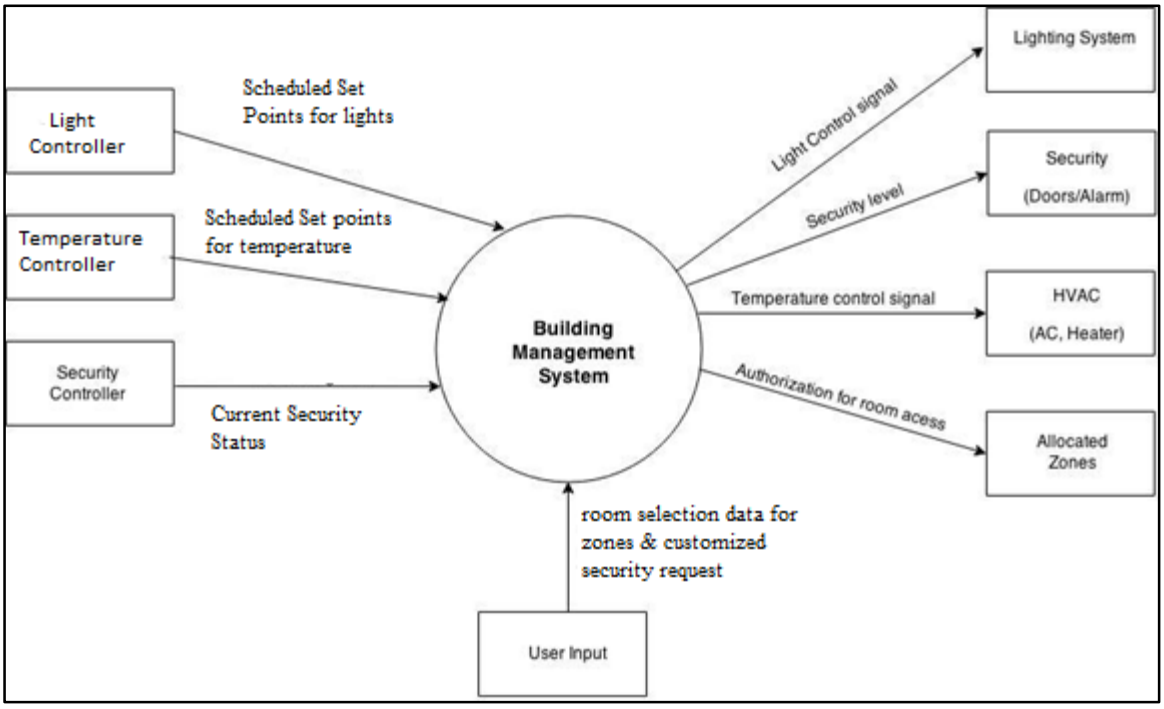
There is a need of a Manager who shall monitor the system performance, manage employees.

Lack of training reduces efficiency, increases efforts and thus increasing the maintenance costs.

Following are the main areas:

1. Staffing
2. Policies at Workplace
3. Benefits and Compensation
4. Community Affairs,
5. Employee Training,
6. Laws regarding employees
7. Employee Protection
8. Employee retention

4. Context Diagram



5. Requirements

- Secure System Access Module
- Zone Allocation Module
- Set-Point Establishment Module
- Report Generation Module
- Bill and Invoice Generation Module
- Premises Security Services Module
- Climate and Light Control Module

5.1 Functional Descriptive Detailed Document

1. Zone Allocation as per building owner's convenience

1.1 BMS shall provide the building owner to form zones by grouping individual rooms to increase the rental profitability.

1.2 BMS shall store the details of building owner along with each business tenant.

2. Initial set point specified by business tenant

2.1 Once the zone is assigned to the business tenants, the BMS shall facilitate them to establish and manage the initial climate conditions.

3. Authorization and Authentication of BMS

3.1 Login credentials to the BMS system need to be provided to every legitimate user.

3.2 The building owner shall have complete access over the system, with the privilege to delegate the authorization level to different system users including the business tenant.

4. Accessing system over the network

4.1 BMS shall be hosted over centralized network, so any user from any machine as per the authorization levels to the system shall access it.

5. Report generation for space availability, system performance and maintenance

5.1 For the smooth functioning of the system flow between building owner and the different business tenants, the reports generated shall be customizable to provide a detailed inward outlook on various issues regarding lease duration, zone or individual room allocation, security logs, light and climate, etc. The idea is to identify any flaw that exists or shall exist to hinder smooth flow of each business and identify prospective opportunities for competitive advantage.

6. Generate bills and invoices on regular-basis

6.1 To keep a check on services consumed and respective charges incurred for each business tenant, bills and invoices shall be generated by BMS, keeping in consideration location-specific tax and legislative laws.

7. Enforcing Security Services

7.1 BMS shall make the security as an integral part of its services.

7.2 BMS shall allow each business to enable or disable authorization levels.

7.3 On the occurrence of any potential breach, the security guards shall be notified.

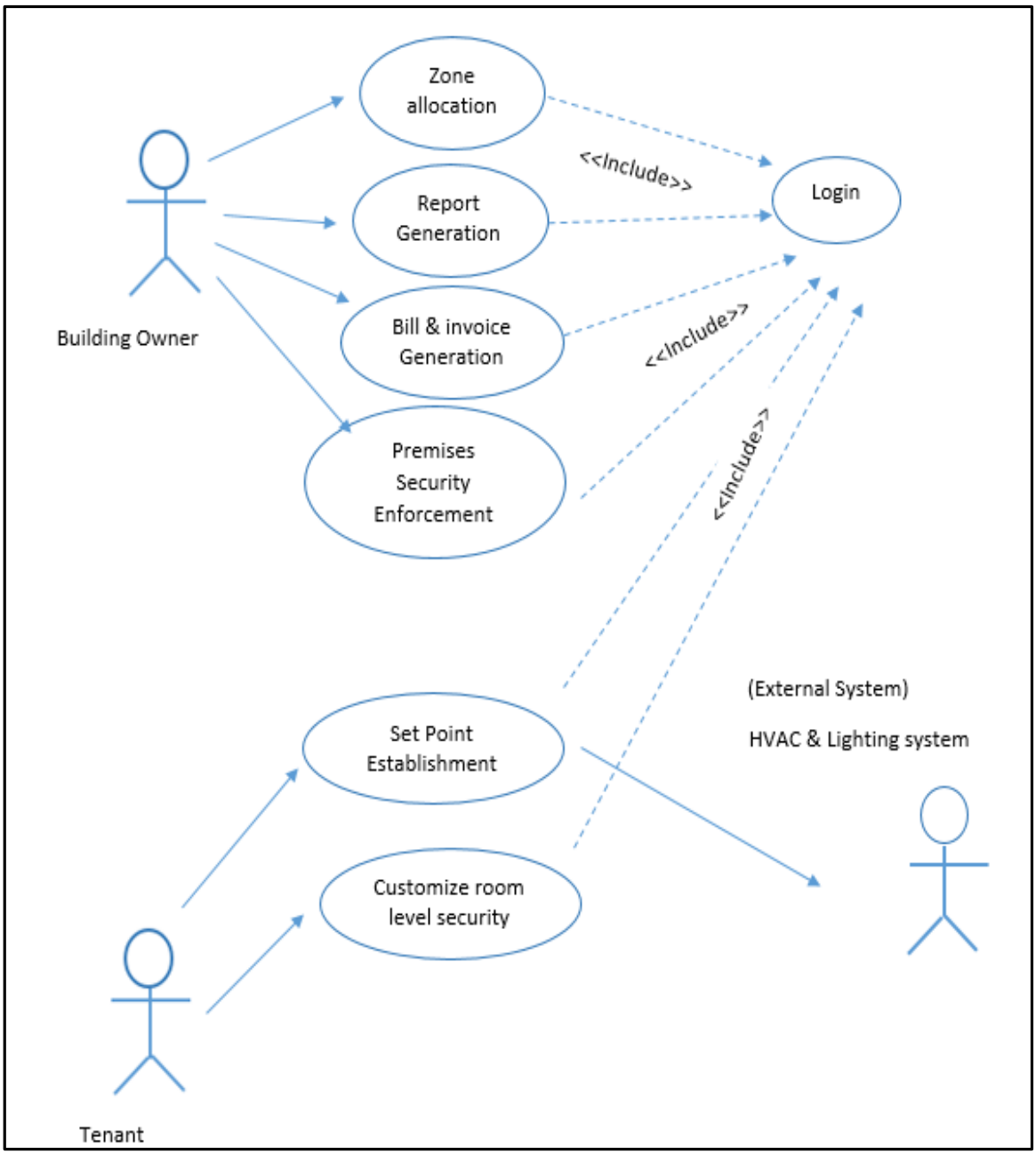
8. Facilitating Climate and Light Control Services

8.1 Based on the timeline of the set-points established by each business tenant, BMS shall provision controlling the lighting and temperature of the rooms at the zone level, along with the help of external systems: Heating, Ventilating, and Cooling (HVAC) Systems and Lighting System.

5.2 Requirement Use cases:

1. **Secure System Access Use case:** This use case helps to authenticate legitimate users and identify their authorization level.
2. **Zone Allocation Use case:** This use case helps to provide the building owner to form zones.
3. **Set-Point Establishment Use case:** This use case helps the business tenants to specify the initial set points for light and climate control.
4. **Report Generation Use case:** This use case helps to provides customizable reports to business covering a detailed business analysis with each tenant.
5. **Bill and Invoice Generation Use Case:** This use case helps to generate bills and invoices of services consumed and charges incurred for each tenant.
6. **Enforcing Premises Security Services Use case:** This use case helps each tenant to customize explicit security.
7. **Facilitating Climate and Light Control Services :** This use case helps each tenant to customize climate and light

5.3 Use case Diagrams



Use Case Descriptions

Secure System Access		
Description	This use case helps to authenticate legitimate users and identify their authorization level.	
Pre -conditions	● Must be registered in the System ● Shall have at least one time valid credentials	
Flows	**Basic flows**	1. Provide BMS credentials. 2. Validate user credentials and authorization level 2.1. If legitimate user, Show authorized functions to perform 3. 2.2. Else, show login failure message
	Alternate flows	1. If new user, request Building owner to grant access to the system 2. Use one time BMS credentials 3. Generate permanent credentials
Post -conditions	Different users shall be encouraged to add, modify or delete information in the system according to their authorization levels.	
Special Requirements	● System generates messages for the users encouraging to change their passwords in every 3 months. ● System removes the business tenants as soon as the lease expires unless the tenants apply for extension in lease.	
Extension Points	Not Applicable	

Zone Allocation		
Description	This use case helps to provide the building owner to form zones.	
Pre -conditions	● Must be a legitimate user ● Building shall have vacant space	
Flows	**Basic flows**	1. Login into the BMS. 2. Enter the tenant's space requirements. 3. Check for availability of space. 3.1. If available, create zone and allocate 3.2. Else, check allocation reports and notify about earliest space availability date.
	Alternate flows	
Post -Conditions	Business tenants shall specify the initial set points.	
Special Requirements	Only Building owners shall modify the allocation of zones.	
Extension Points	Not Applicable	

Set-Point Establishment		
Description	This use case helps the business tenants to specify the initial set points for light and climate control.	
Pre – conditions	● Must be a legitimate user ● Must have signed the lease before establishment of set.	
Flows	**Basic flows**	1. Login into the BMS. 2. Enter the light and temperature requirements. 3. Specify the set-point activation schedule.
	Alternate flows	

Post Conditions	Selection of set points is determined by pre-allocated schedule unless any changes noted.
Special Requirements	• Creation of set points done prior to lease start period. • System removes the set points for the respective tenant as soon as the lease expires unless the tenants apply for extension in lease. • For tenants with more than one zone in the building, the newer zones are entitled to reuse the initial set points.
Extension Points	Not Applicable

Report Generation		
Description	This use case helps to provides customizable reports to business covering a detailed business analysis with each tenant.	
Pre – conditions	• Must be a legitimate user and shall be authorized to generate the customized reports	
Flows	**Basic flows**	1. Login into the BMS. 2. Choose the report generation criteria, viz. lease duration, light and climate control system, security logs etc. 3. Generate report and maintain an archive.
	Alternate flows	
Post Conditions		
Special Requirements	Only Building owners shall customize the report based on their requirements.	
Extension Points	Not Applicable	

Bill and Invoice Generation		
Description	This use case helps to generate bills and invoices of services consumed and charges incurred for each tenant.	
Pre – conditions	● Must be a legitimate user and shall be authorized to generate the customized reports	
Flows	**Basic flows**	1. Login into the BMS. 2. Select the tenants and duration. 3. Generate bills and invoices.
	Alternate flows	
Post Conditions		
Special Requirements	Only Building owners shall customize the outcome based on their requirements.	
Extension Points	Not Applicable	

Enforcing Premises Security Services		
Description	This use case helps each tenant to customize explicit security.	
Pre – conditions	● Must be a legitimate user and authorized user	
Flows	**Basic flows**	1. Login into the BMS. 2. Business chooses to enable or disable security at his level. 2.1. If enabled, then security level, clearance level is defined at room level and secure room access logs are maintained in the database. 2.1.1. If five unsuccessful attempts are made to enter secure room by same employee of a business, then notify security guard with the alarm going off.

		2.1.2. Else, the employee of a business shall be allowed to enter room with door being opened for 3 seconds. 2.2. If disabled, then the default security mechanism of the BMS system still prevails.
	Alternate flows	
Post Conditions	Business tenants shall specify the initial set points.	
Special Requirements	Only Building owners shall modify the allocation of zones.	
Extension Points	Not Applicable	

Facilitating Climate and Light Control Services		
Description	This use case helps each tenant to customize climate and light	
Pre – conditions	• Must be a legitimate and authorized user • Building shall have vacant space	
Flows	**Basic flows**	1. Login into the BMS. 2. Enter the tenant's space requirements. 3. Check for availability of space. 3.1. If available, create zone and allocate 3.2. Else, check allocation reports and notify about earliest space availability date.
	Alternate flows	
Post Conditions	Business tenants shall specify the initial set points.	
Special Requirements	Only Building owners shall modify the allocation of zones.	

Extension Points	Not Applicable

5.4 Non-functional Descriptive Detailed Requirements

5.4.1 System Capabilities, conditions, and constraints

BMS system shall be a real-time processing system running 24 hours with multi-processors. It shall have an availability of 99.9%. Secure methods of extracting sensitive information about each business tenant shall be provided.

5.4.2 Physical Resource Requirements

The system user shall be equipped with proper functioning **peripheral devices** such as Monitor, CPU, Mouse, Keyboard and **networking devices** such as hub/ switch, network cable, network port etc. and cooling devices for servers.

5.4.3 Computer Hardware Requirements

- **For MAC:**
  RAM: 4 GB or more.
  CPU Type: 2.3 GHz Quad-core Intel® Core i5™ or better.
  Memory: 10 GB.
  Hard Drive speed: 12000+ rpm.

- **For Windows:**
  RAM: 8 GB or more.
  CPU Type: 2.3 GHz Quad-core Intel® Core i5™ or better.
  Memory: 10 GB.
  Hard drive speed: 12000+ rpm.

5.4.4 Computer Hardware Resource Requirements

None

5.4.5 Computer Software Requirements

- **For MAC:**
  Operating System:
  - Mac® OS X® 10.9.1 ‘Mavericks’ or never
  - MacBook Pro® 10 (Early 2013) 13.3 or newer.

- **For Windows:**
  Operating System:
  - Microsoft® Windows® 7 (Professional, Home, Ultimate or Home Premium)
  - Microsoft® Windows® 8/8.1 (Pro, Enterprise, Windows 8, Windows 8.1)

  System type: 64 - bit Operating System, x64 - based processor.

5.4.6 Computer Communications Requirements

- The end user terminal must be connected to a stable Internet connection of at least speed of 25Mbps. It is recommended to choose an Internet Service Provider (ISP), which provides dedicated line rather than shared line for Internet.
- It is advised that each end user has a dedicated computer for working with the Building Management System.
- The network load capacity for the LAN shall be up to 40 %

5.4.7 Environmental Conditions

- The room temperature shall not be above 86 ^{0}F.
- The room shall be virus-free.

5.4.8 System Performance characteristics

- The system shall respond to user input within 3 seconds.
- The system shall be available 96% of the time.

5.4.9 Safety Requirements

- The system shall not operate in case of a fire.
- The business owner cannot send the security level of any room for changing until the previous change is accepted/rejected.
- System backup shall trigger in occurrence of catastrophic condition

5.4.10 Security and Privacy Requirements

The integrity of the data shall be kept intact, system authorization levels shall be maintained for each user group

5.4.11 System Human Interfaces

- The end user shall enter the input.
- The output shall be stored and reflected by the BMS.
- The format of the input shall be fixed. For example, Date shall be formatted as MM-DD-YYYY and room number shall be numeric only, etc.
- New room numbers shall not be allocated by anyone other than building owner.

5.4.12 System Maintainability

The system shall have a maintainability of 80% for one hour, i.e. the probability that the system shall be repaired from failure within one hour is 0.8.

5.4.13 System Quality Factors

- The system shall trap faults and automatically create a log of faults.
- The system shall be easy to operate.
- Mean time between failures shall not exceed to 2 failures per 24 hours. In case of a failure, the end user shall restart the system completely and BMS shall be good to go.

5.4.14 Design and Construction Constraints

BMS shall follow the agile methodology in meeting the software engineering requirements of scheduling, cost, and quality.

5.4.15 Life Cycle Model

Life cycle model used in Building Management System is the agile methodology.

5.4.16 Policies and standards -- Methods, tools, and techniques

BMS shall be in compliance with location specific federation laws and policies; BMS shall follow software development and distribution standards.

5.4.17 Personnel- Related Requirements

- There shall be at most 3 business owners for any specific business organization. There shall be 3 types of users to BMS, viz., building owner, and business owner and company employee.
- Privileges shall differ depending on the type of end user. For example, company employee shall not change access level of a room, but shall send the change to be approved by the business owner.

5.4.18 Training- Related Requirements

End user shall be provided hands on training of the system, online system support shall be available during business hours and easy to understand user manual shall be provided with delivery of the BMS

5.4.19 Logistics- Related Requirements

The BMS shall be installed on system users user terminal by the company, with special consideration to the hardware for high-speed communication and process related to the backups of systems in case of natural calamity.

5.4.20 Packaging Requirements

- The BMS setup shall be copied on a CD- Drive with the support of help documents, which shall be installed on computer systems (including both computer & Laptop).
- Each CD- Drive shall be used for installation only once.
- 100 CD- Drives shall be provided by the company (more CD's shall be demanded later and shall be provided by the company if all 100 CD's are legally used by the client/building owner).

5.4.21 Precedence and Criticality Requirements

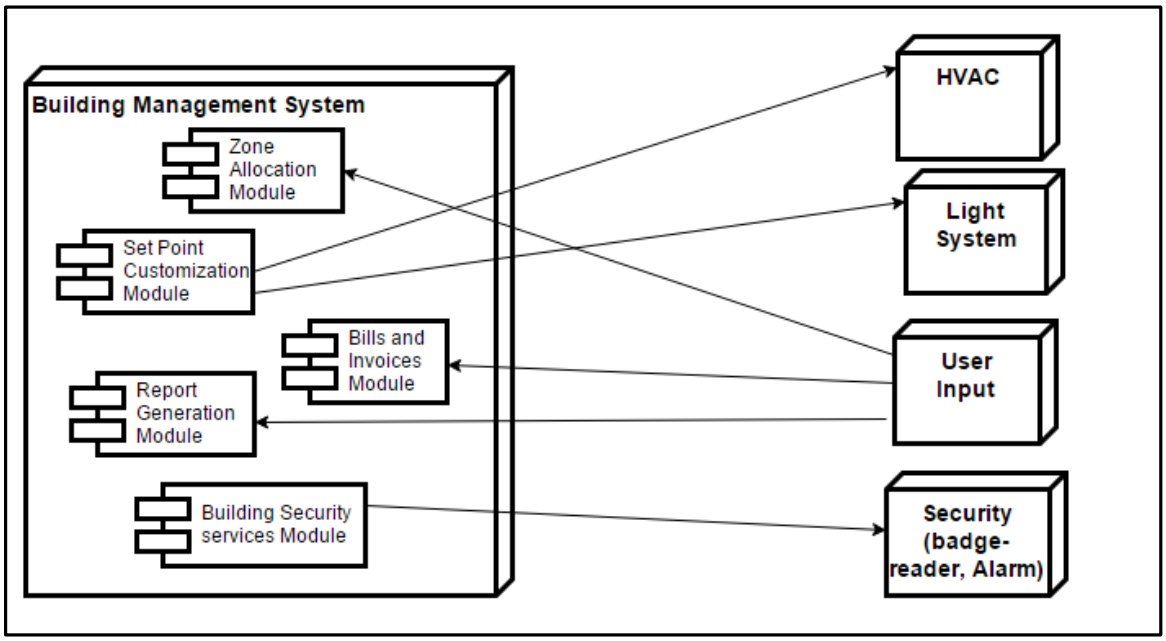
Building owner shall be the one to authenticate and authorize different system users into the BMS system.

5.4.22 Other Non-Functional Requirements

None

6. Analysis

6.1 Component Diagram:



6.2 Component Descriptions:

- **Zone Allocation:** This component allows building owners to keep track of vacant business premises in the building and group those rooms to form zones in most profitable way. Information related to vacant spaces and user input is processed by BMS to allocate zones to each business tenant. Each of these records related to the business tenants' and its associated zones is maintained in the database.

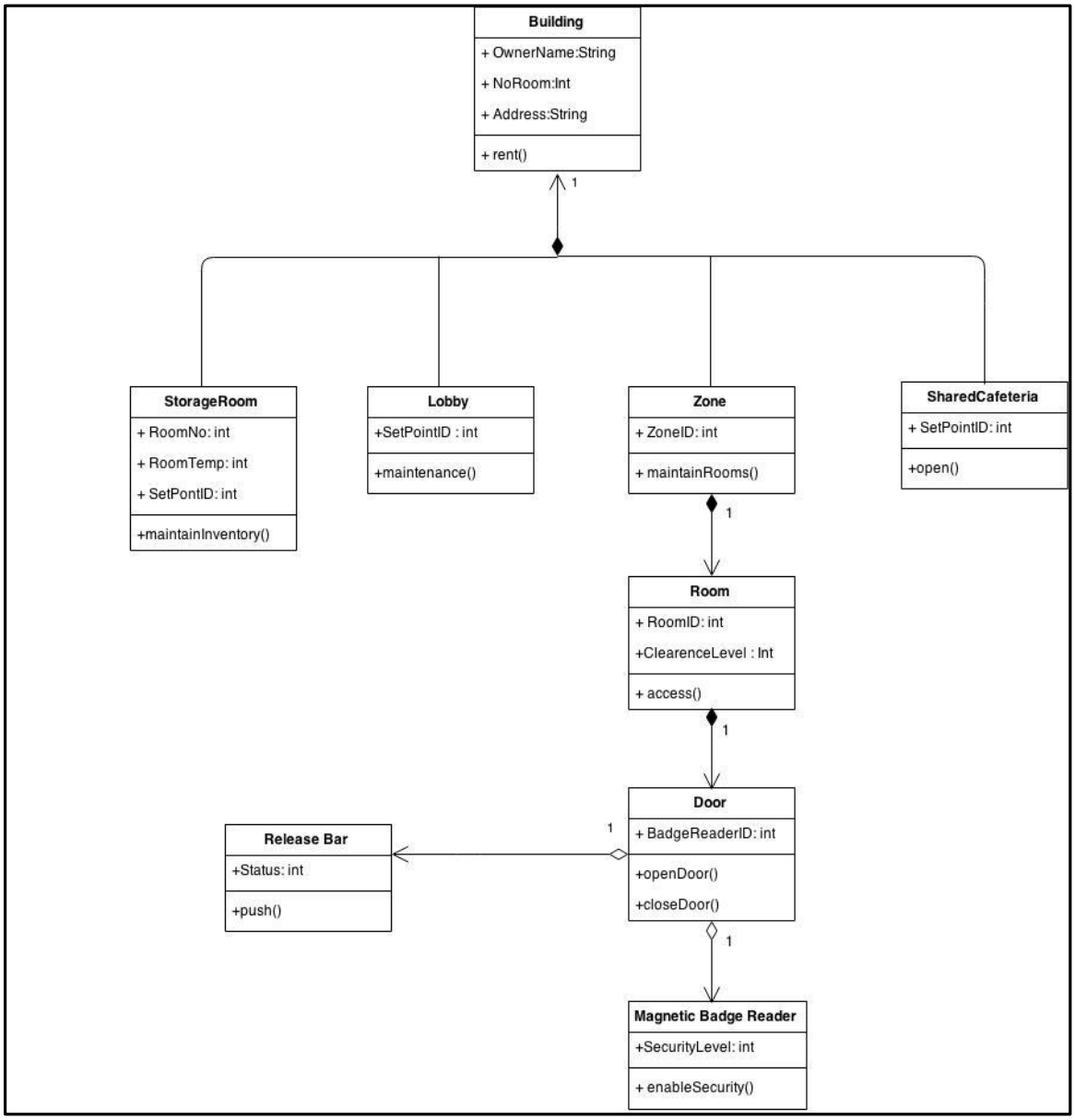
- **Set point Customization:** This component allows business tenants to establish the initial climate conditions. This includes light, heat and temperature control signals, which is stored in the database and maintained by external systems: Heating, Ventilating, and Cooling (HVAC) Systems and Lighting System.

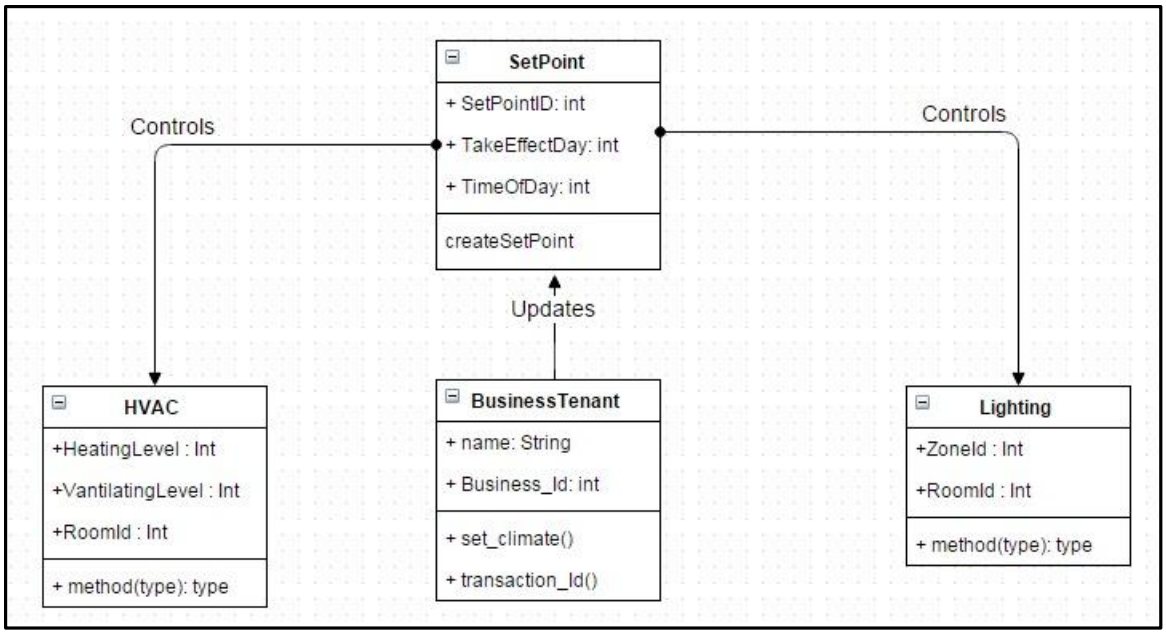
- **Report generation for space availability, system performance and maintenance**: This component allows smooth functioning of the system flow between building owner and the different business tenants. It allows to generate customizable reports to provide a detailed inward outlook on various issues regarding lease duration, zone or individual room allocation, security logs, light and climate, etc. The data fetched identifies prospective opportunities for competitive advantage.

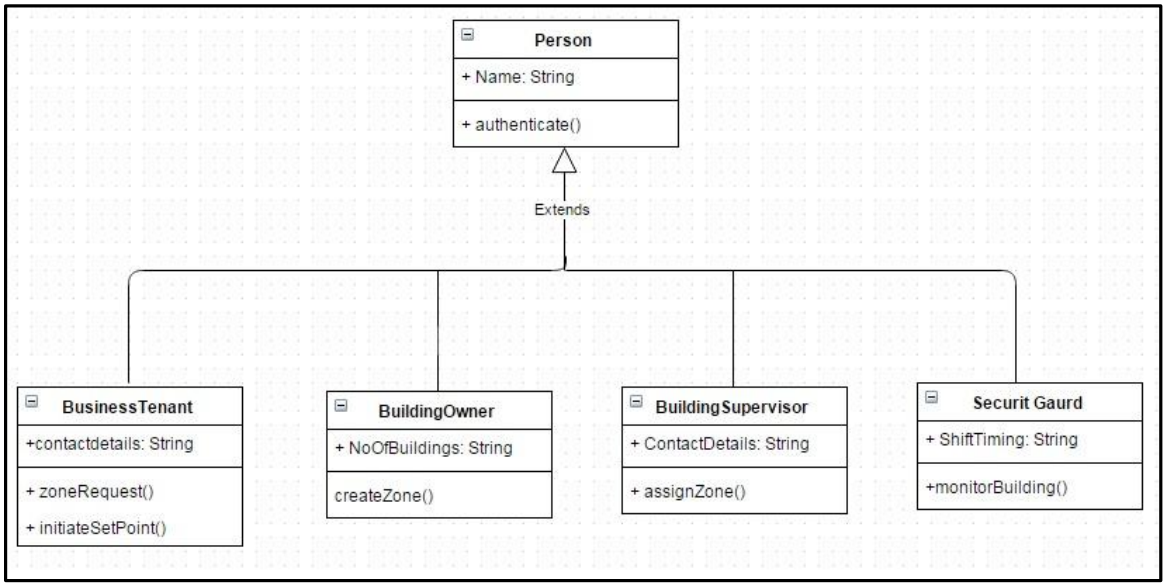
- **Generate bills and invoices on regular-basis**: This component allows a check on services consumed and respective charges incurred for each business tenant. It considers location-specific tax and legislative laws while generating bills and invoices.

- **Security Services:** This component allows each business tenants' to enable or disable authorization levels. If the tenant pursues with the former option, then a magnetic badge reader controls the entrance to each room. For the overall security of the premises, the occurrence of any potential breach is notified to the security guards.

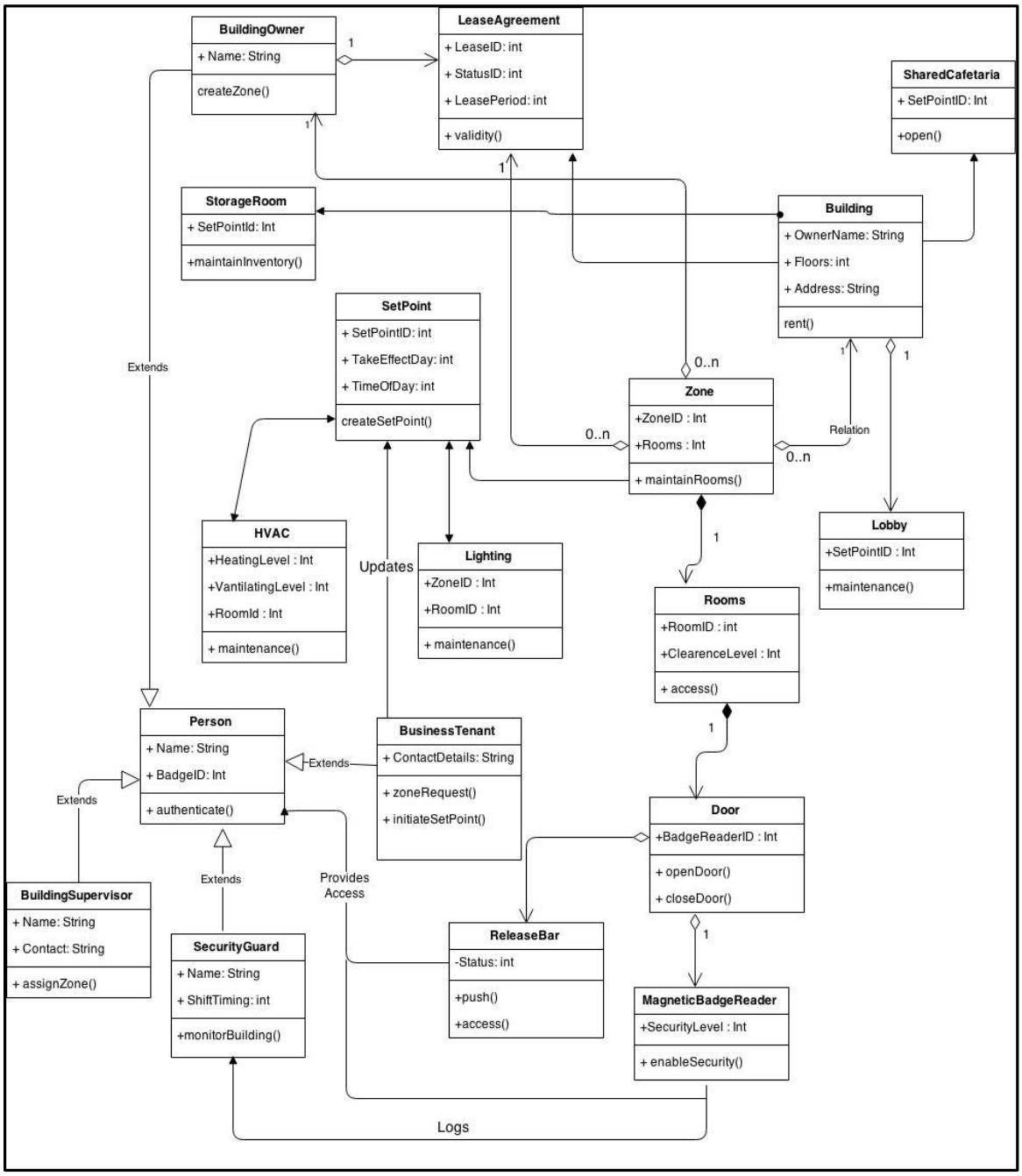
6.3 Class Diagrams




SetPoint
+ SetPointID: int
+ TakeEffectDay: int
+ TimeOfDay: int
createSetPoint
Controls
Controls
Updates
HVAC
+HeatingLevel : Int
+VantilatingLevel : Int
+RoomId : Int
+ method(type): type
BusinessTenant
+ name: String
+ Business_Id: int
+ set_climate()
+ transaction_Id()
Lighting
+ZoneId : Int
+RoomId : Int
+ method(type): type


Person
+ Name: String
+ authenticate()
Extends
BusinessTenant
+contactdetails: String
+ zoneRequest()
+ initiateSetPoint()
BuildingOwner
+ NoOfBuildings: String
createZone()
BuildingSupervisor
+ ContactDetails: String
+ assignZone()
Securit Gaurd
+ ShiftTiming: String
+monitorBuilding()

6.4 Class Relationship / Interaction Diagram

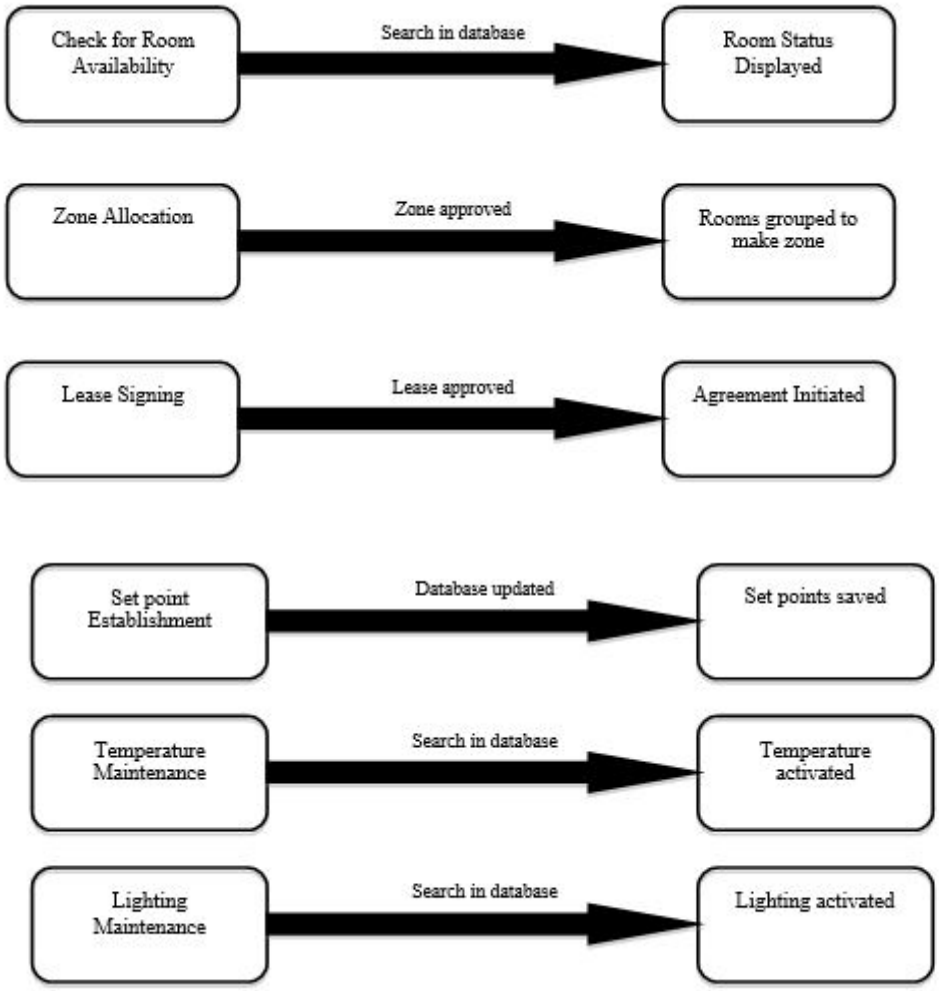


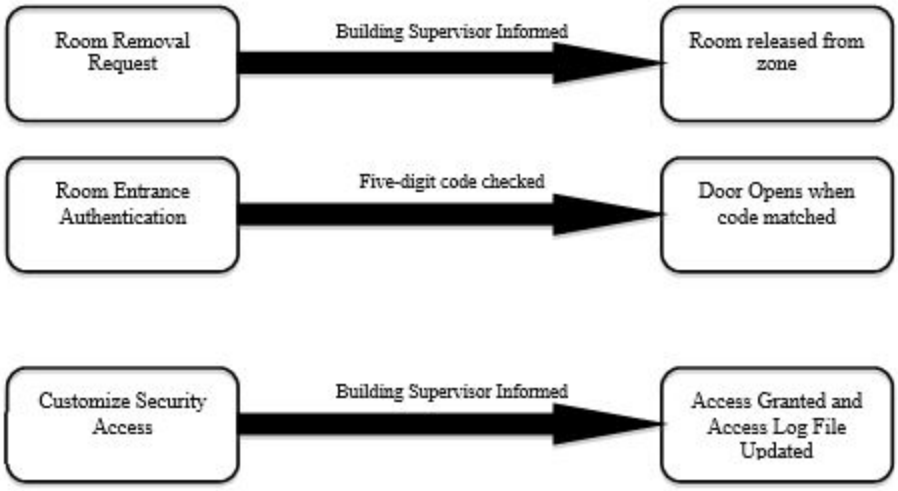
6.5 Events:

6.5.1 Motives:

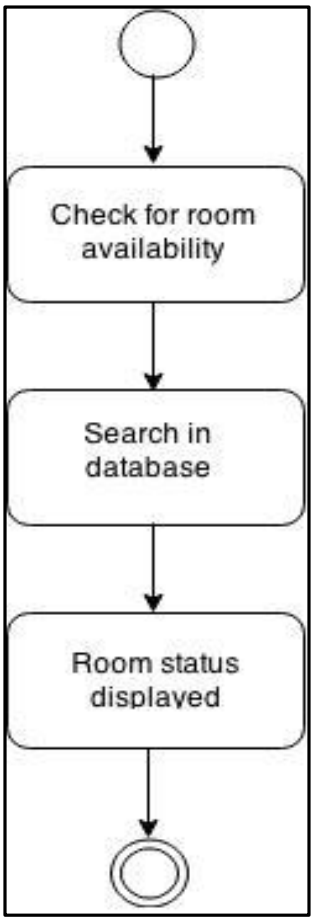
- **Check for Room Availability** – The prospective business tenant, building owner, or facilities supervisor can check the availability of a zone of interest in BMS, before booking an appointment for zone visit or before submitting an application for the zone of interest.
- **Zone Allocation** - Building owners or supervisors can combine several rooms to form zone and allocate them to the business tenants.
- **Lease signing -** This event includes implicit formalities related to signing of lease for particular period of time. The agreement between tenant and owner also includes clauses such as the condition of rental unit, permissible business type, threshold limit for number of employees, attorney fees and court cost in lawsuit, etc.
- **Set Point Establishment** – This event occurs when all the legal formalities are complete and tenant needs to provide the desired settings for temperature and lighting, prior to start using the facilities.
- **Temperature Maintenance -** This event allows building supervisor to temporarily change or update the temperature of each room in a zone by an external system: HVAC. An employee of a business can send a remote request to make the changes.
- **Lighting Maintenance-** This event allows building supervisor to temporarily change or update the light settings of each room in a zone by an external system: Lighting System. An employee of a business can send a remote request to make the changes.
- **Room Removal Request** – The purpose of this event is to permanently remove the temperature and light set points of a room in a zone from its initial settings and provide the employees of a business to make manual adjustments via a thermostat. The building supervisor who might receive a remote request from the employees' performs this request.
- **Room Entrance Authentication** –This event allows the employees of a business to be authenticated through a magnetic badge reader before they enter a room with a certain clearance level. This authentication happens when business has chosen to opt-in with the locking mechanism.
- **Customize Security Access -** This event allows each tenant to opt in or out of the locking mechanism at room-level. The building owner establishes these mechanisms, so even in case if the business opts out, a high level security is provided through security guards.

6.5.2 Event Diagrams:

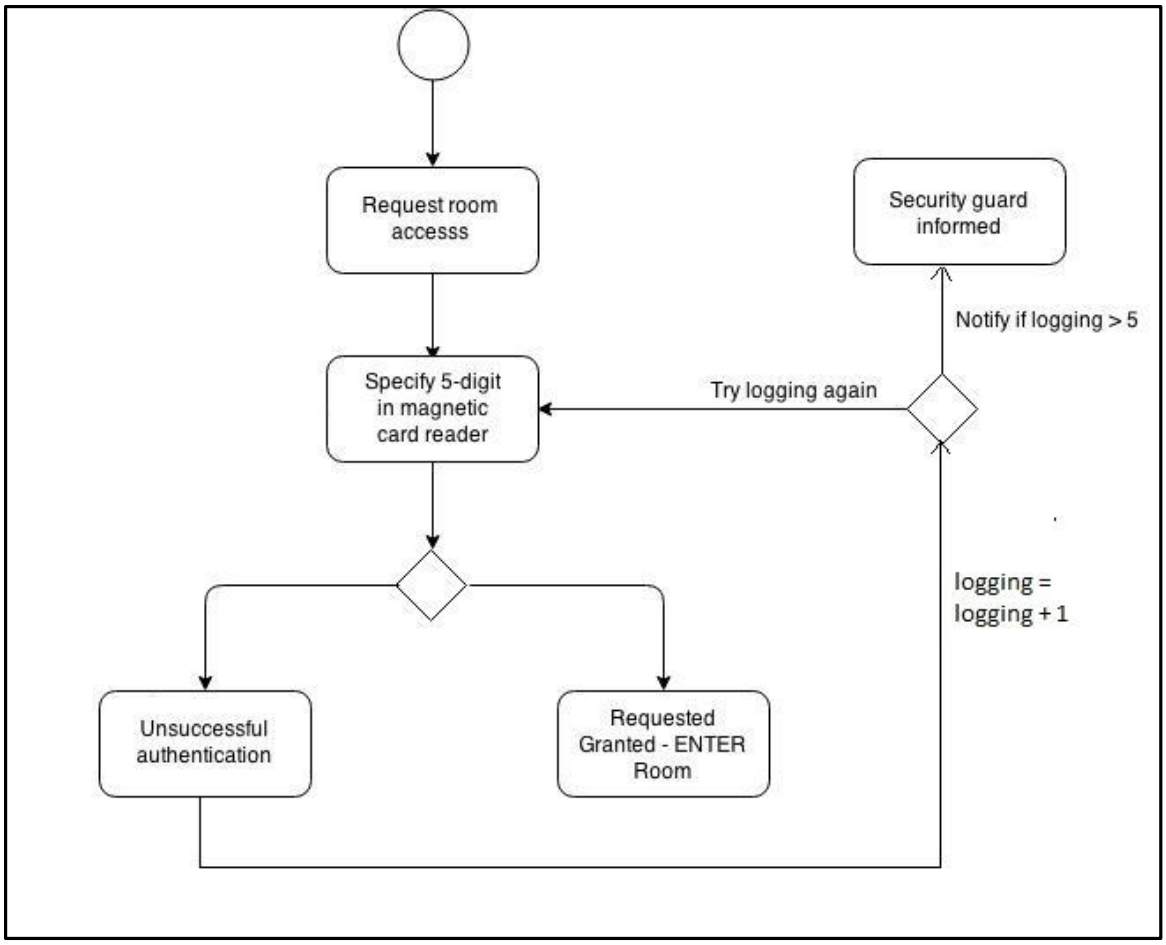




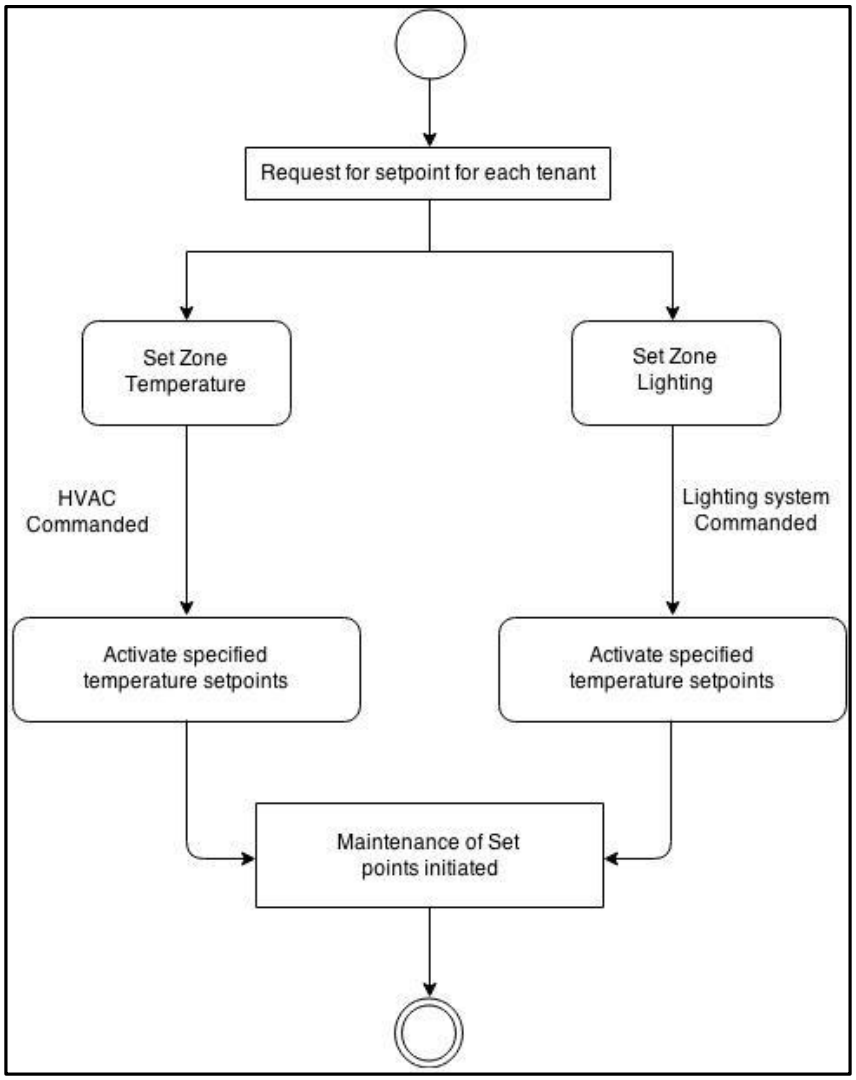
6.6 Activity State Section



Activity diagram for room availability

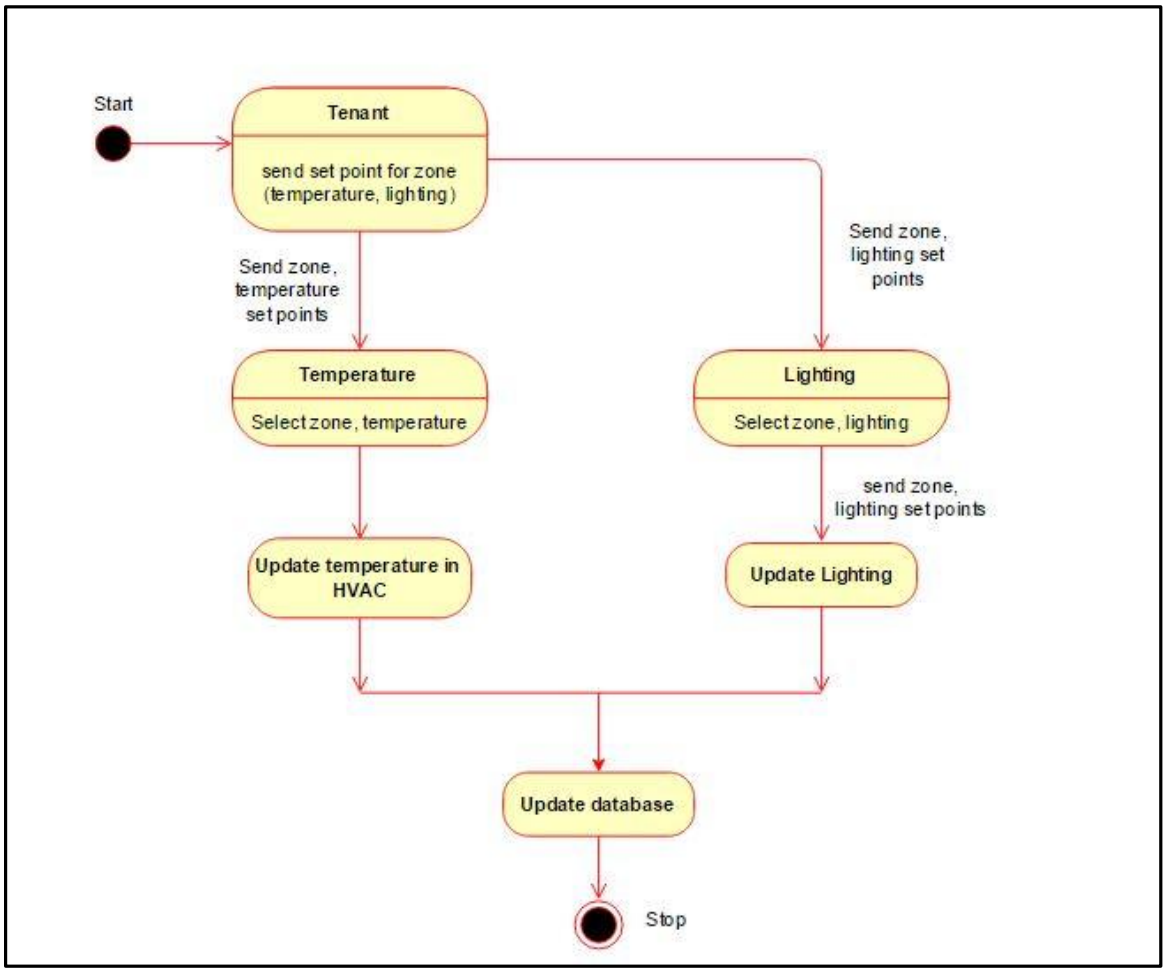


Activity diagram for entering a room

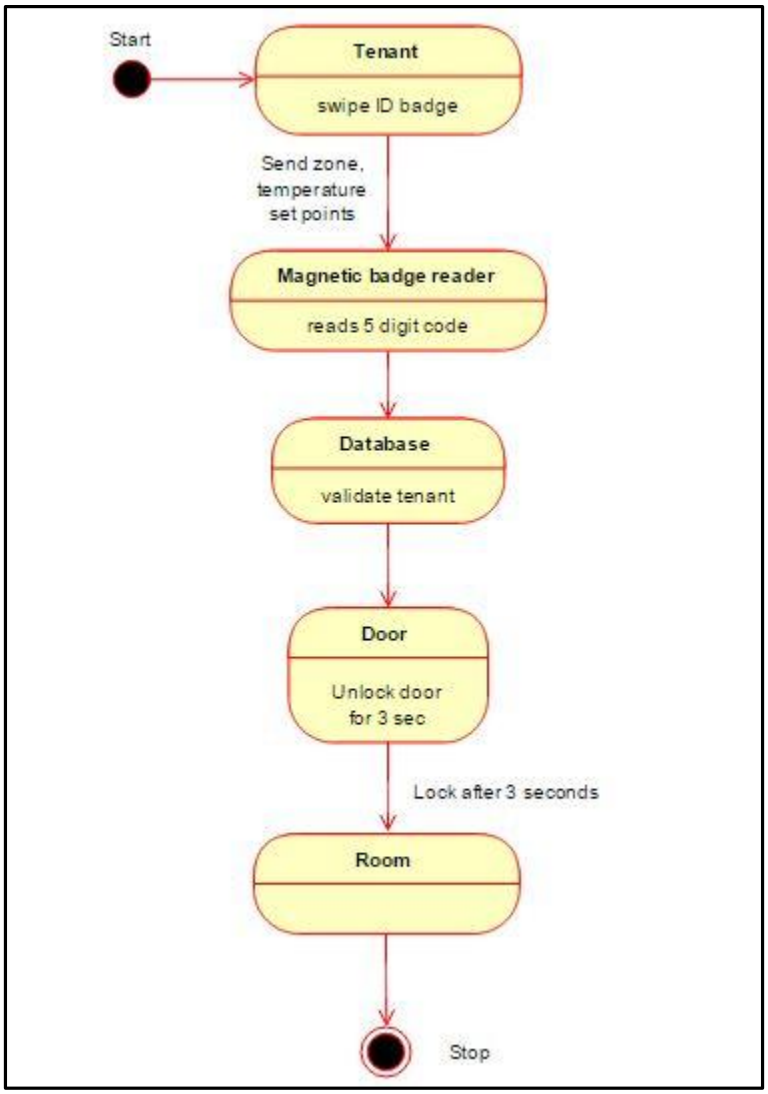


Activity diagram for climate control

6.7 State Logic



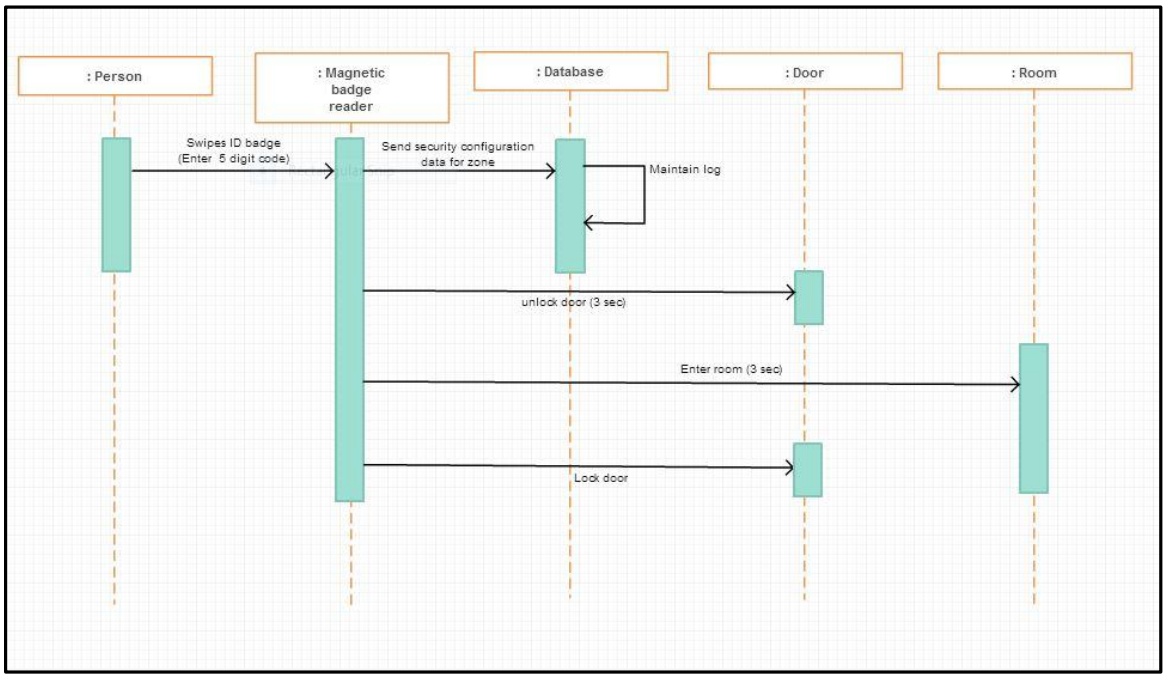
State diagram for climate control



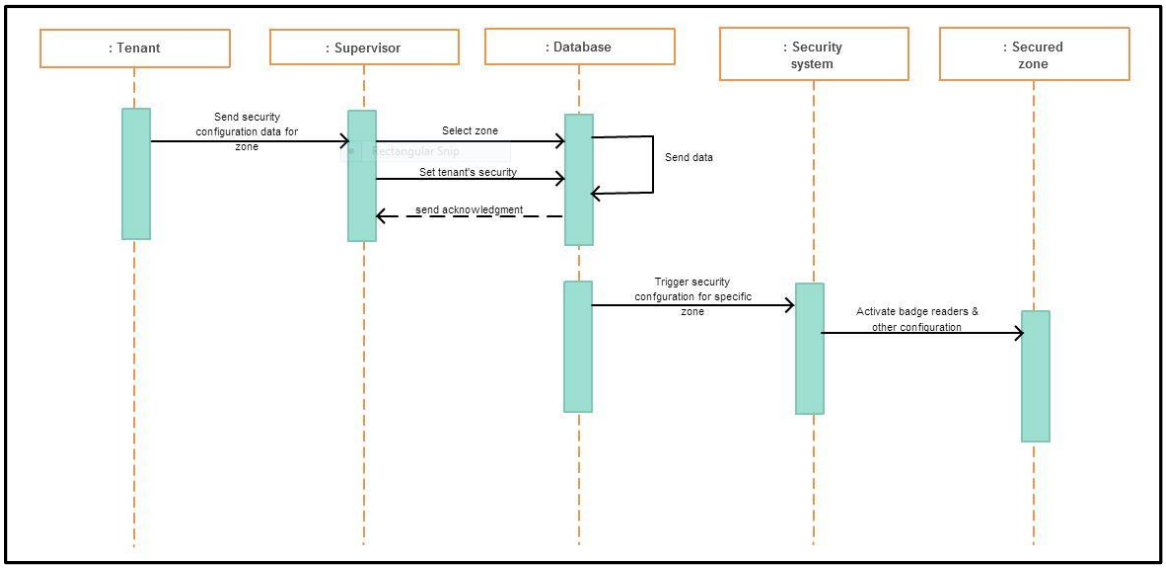
State logic diagram for entering a room

6.8 Behavior

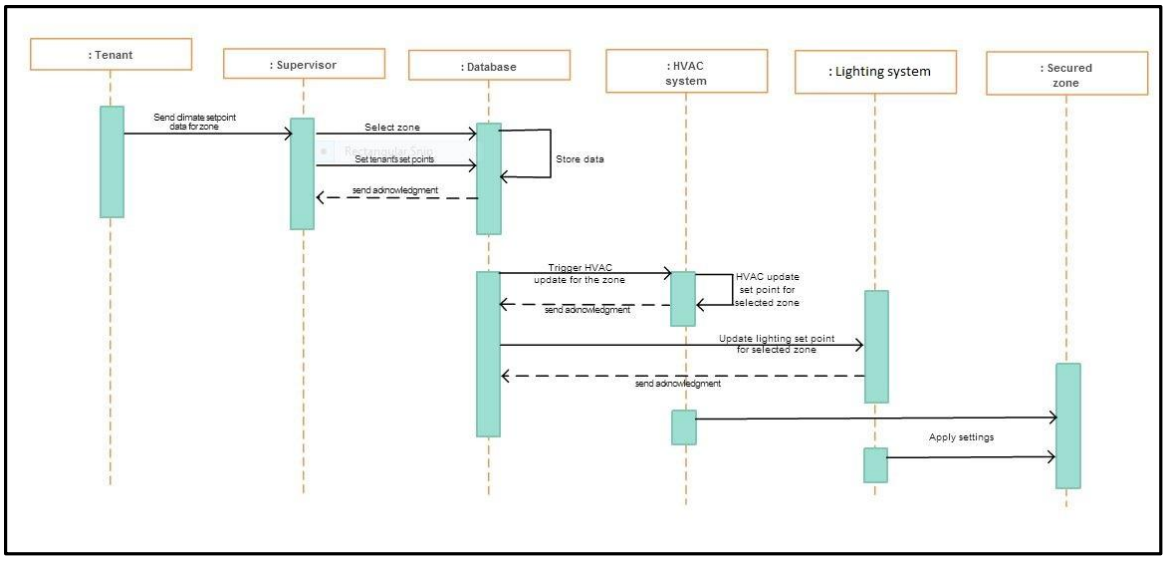
6.8.1 Sequence Diagram



Sequence diagram for entering a room

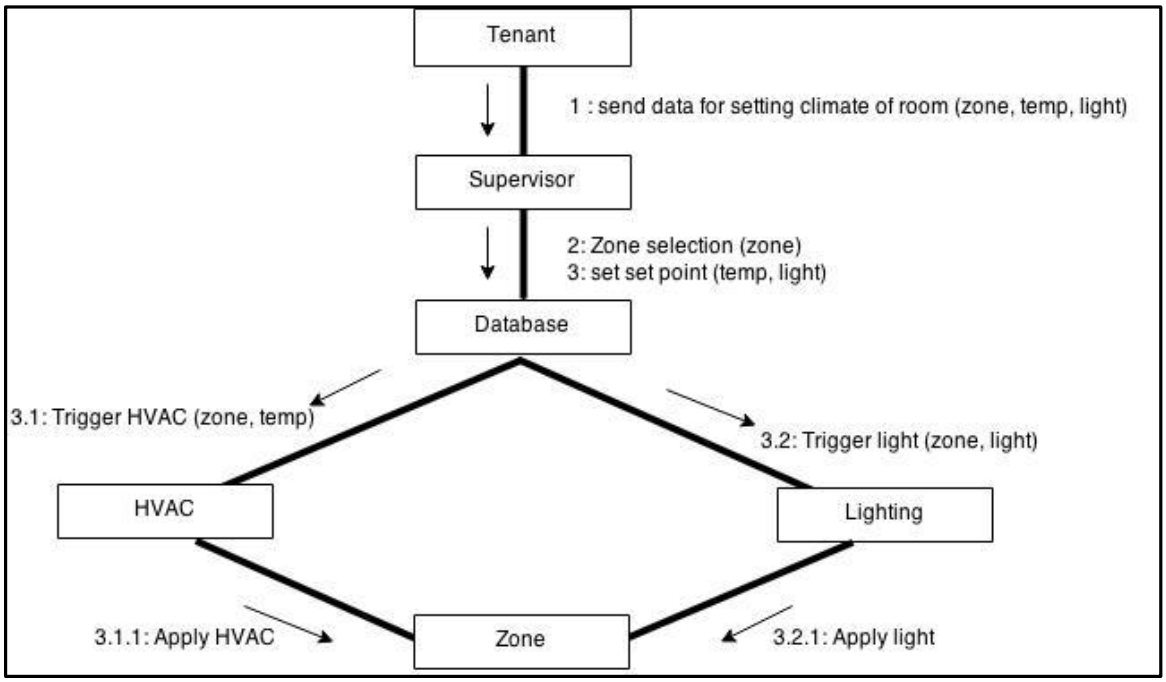


Sequence diagram for room security

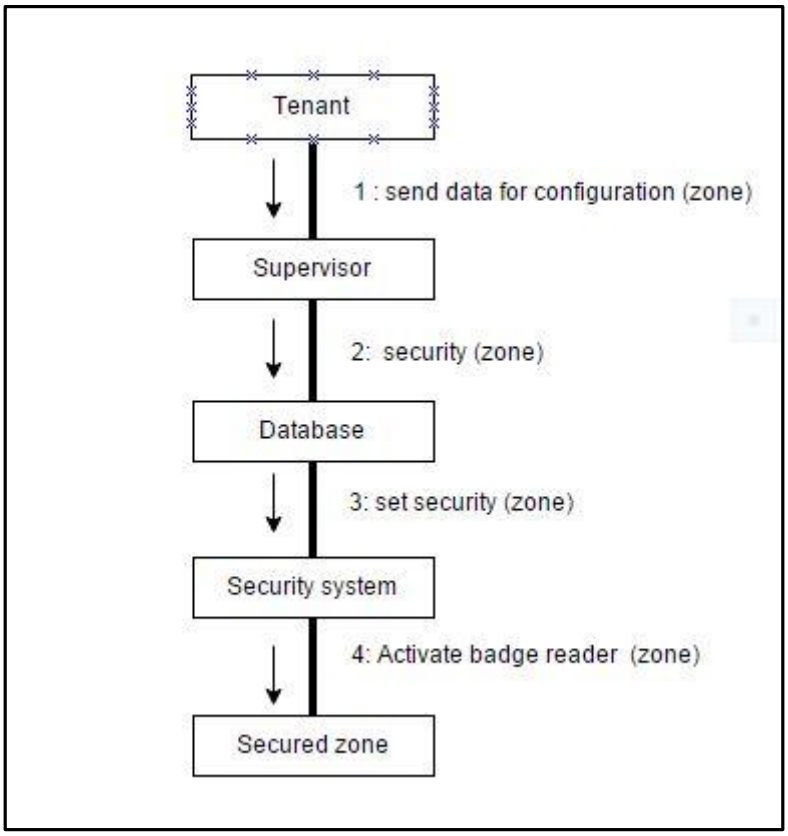


Sequence diagram for climate control

6.8.2 Collaboration Diagram



Collaboration diagram for climate control



Collaboration diagram for room security

7. Dictionaries (Initiated here and completed in design)

7.1 Class

Class Name	Description	Attributes	Methods
Building	This class would maintain details related to building.	· ownerName · numberOfFloors · address	· rent()
BuildingOwner	This class would maintain details related to Building Owner	· name · badgeId · contactDetails	· CreateZone()
BusinessTenant	This class would store details related to tenants and allow to perform tasks related to owned zone	· Name · badgeID · contactDetails	· zoneRequest() · initiateSetPoints()
BuildingSupervisor	This class would maintain details related to Building Supervisor and methods performed by supervisor	· Name · badgeID · contactDetails	· assignZones()
StorageRoom	This class would maintain details related to Storage room and related methods	· setpointID	· maintainInventory()
SecurityGuard	This class would maintain details related to SecurityGuard and its desired functions	· name · badgeId	· monitorBuilding()
Zone	This class would maintain details related to Zone details and methods associated with it.	· id · numberOfRooms · setPointId	· maintainRooms()

Room	This class would store details related to Room and methods offered by this class	· id · clearanceLevel	
Door	This class would store details related to each door of rooms and methods offered by it.	· badgeReaderID	· openRoom() · closeRoom()
MagneticBadgeReader	This class would store details related to each magnetic badge reader at each entrance and methods offered by it.	· Id · securityLevel	· enableSecurity()
ReleaseBar	This class would store the status of each release bar on each door and its associated methods	· isPushed	· push()
SetPoint	This class would store settings required to maintain weather and lighting	· id · status · zoneId · takeEffectDay · status · timeOfDay	· createSetPoint()
LeaseAgreement	This class would store details related to lease associated with all the zones of tenants and its associated methods	· id · Status · zoneID · period	· validity()
Person	This class would store details each individual associated with BMS and its associated methods	· name · badgeID	· authenticate()
HVAC	This class would store details related external entity HVAC and its associated methods	· heatingLevel · ventilatingLevel · aircondition Level · roomID	· maintenance()

Lighting	This class would store details related external entity Lighting system and its associated methods	· zoneID · roomID	· maintenance()

7.2 Method

- **Building:** rent()
- **BuildingOwner:** createZone() : allows building owner to group rooms to form zone
- **BusinessTenant:** zoneRequest(): allows tenant to request for a business premises, initiateSetPoints() : allows tenant to activate the climate and lighting settings
- **BuildingSupervisor:** assignZones(): allows supervisor to assign created zones
- **StorageRoom:** maintainInventory()
- **SecurityGuard:** monitorBuilding(): security Guard monitors the building premises
- **Zone:** maintainRooms()
- **Door:** openRoom(), closeRoom()
- **MagneticBadgeReader:** enableSecurity() : enables the security settings for zone
- **ReleaseBar:** push()
- **SetPoint:** createSetPoint() : allows to create initial climate and lighting settings
- **LeaseAgreement:** validity() :allows to check the validity of the contract
- **Person:** authenticate()
- **HVAC:** maintenance()
- **Lighting:** maintenance()

7.3 Attribute

- **Building:**
  - ownerName
  - numberOfFloors
  - address
- **BuildingOwner:**
  - name
  - badgeID
  - contactDetails
- **BusinessTenant:**
  - name
  - badgeID
  - contactDetails
- **BuildingSupervisor:**
  - name
  - badgeID
  - contactDetails
- **StorageRoom:**
  - setpointID

- **SharedCafetaria:**
  - setpointID
- **SecurityGuard:**
  - name
  - badgeID
- **Lobby:**
  - setpointID
- **Zone:**
  - id
  - numberOfRooms
  - setpointID
- **Room:**
  - id
  - clearanceLevel
- **Door:**
  - badgeReaderID
- **MagneticBadgeReader**:
  - id
  - securityLevel
- **ReleaseBar:**
  - isPushed
- **SetPoint:**
  - id
  - status
  - zoneID
  - takeEffectDay
  - timeOfDay
- **LeaseAgreement:**
  - id
  - status
  - zoneID
  - period
- **Person:**
  - name
  - badgeID
- **HVAC:**
  - heatingLevel
  - ventilatingLevel
  - airconditionLevel
  - roomID
- **Lighting**:
  - zoneID
  - roomID

7.4 Relationship:

Relationship between key classes like Person, Building, Set Point and Person as described in 6.3.

Class(s) A	Class(s) B	Relationship
SetPoint	HVAC, Lighting	A Controls B
BusinessTenant	Set Point	A Updates B
ReleaseBar, MagneticBadgeReader	Person	A Provides Access to B
MagneticBadgeReader	Security Guard	A logs B

7.5 Key Events:

Key events are the essential instructions that changes the state of the system. Building Management System (BMS) has following key events:

Key Event	Functionality (Impact on the System)
Enable Security	Enable security controls in given zone of the building.
Initiate Set Point	Initialize the settings for the climate control and lighting system for the given zone of the building.
Change Clearance Level	Changes the security parameters at given locations of the building.
Create Zone	Creates zone and hence security and climate control gets reinitialized for that zone.