1. Introduction

Autonomous Cleaning Robot(ACR) is a compact robotics system which provides floor cleaning service in room and big offices reducing human labor. Basically as a robot it eliminates human error and provide cleaning activity with much more efficiency. Also due to manual labor involved this is time consuming and irritating to clean the floor. Also in big offices floor area is very huge and the people involved there for cleaning purpose cannot clean it much more efficiently. This is where the robot comes as an advantage. Also the robot is small and compact in size. So we can carry it and place it wherever we can on the house. Also in industries the robot is very cost effective as compared to manual labor involved. The flexibility, time saving and efficiency make the robot a clean choice for cleaning the floor.

In our project we mainly concern about theoretical CS and Algorithm for AI-Robotics and Internet of Things for remotely handle real time data and control the robot from outside the network. Beside these this project also has involvement to Human Computer Interactions(HCI) for controlling via voice command and Digital Image Processing for object detection. With ACR there will be an Android App by which it will be controlled.

This ACR is inspired from Roomba -690 which had created a great impact on domestic life style. Roomba features a set of sensors that enable it to navigate the floor area of a home and clean it. For instance, Roomba's sensors can detect the presence of obstacles, detect dirty spots on the floor, and sense steep drops to keep it from falling down stairs. Roomba uses two independently operating side wheels, that allow 360° turns in place. A rotating, 3-pronged spinner brush can sweep debris from square corners to the cleaning head.

Outcomes

i. Making an AI robot which have endless utility features in human life
ii. To make the cleaning process easy and automatic
iii. To control the robot remotely and by voice command
iv. Use of IOT to make our life more dynamic

2. Glossary

i. **Compact Robotics System:** Compact Robotics System refers to such robot which is developed for particular task and for business purpose.

ii. **Artificial intelligence(AI):** AI is an area of computer science that emphasizes the creation of intelligent machines that work and react like humans.

iii. **Real Time Data(RTD):** Real-time data (RTD) is information that is delivered immediately after collection. There is no delay in the timeliness of the information provided. Real-time data is often used for navigation or tracking.

iv. **Internet of Things(Iot):** The Internet of Things is a system of interrelated computing devices that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

v. **Roomba:** Roomba is a series of autonomous robotic vacuum cleaners sold by iRobot.

vi. **Development Board:** Development Board refers to mini-computer which can connect to and be programmed by PC or Mac such as Arduino and Raspberry Pi.

vii. **Voice Control:** A voice command device is a device controlled with a voice user interface.

viii. **Human Computer Interaction(HCI):** HCI is a multidisciplinary field of study focusing on the design of computer technology and the interaction between humans (the users) and computers.

3. User Requirements Definition

3.1 Requirements Discovery

- We have found out several journals and IEEE papers about optimized cleaning strategies and how a robot is ubiquitous platform for that [1] - [6].
- We have also seen the resources which are available in earlier cleaning robots and how they solve practical requirements.
- We have used a Google form to conduct a QnA(interactive) session from which we can analyze the requirements [7].

  Questions and Responses:

  1. What do you prefer among manual vacuum cleaner or cleaning robot?

     => Most of the responses are preferring Robot.
  2. Would it be helpful if the robot is controlled through an android app instead of using traditional remote?

     => Approximately all of the responses are preferring Android app and few mentioned iOS app.
  3. Is it helpful to perform cleaning task on a particular time?

     => Most of the users give positive feedback towards it.

  And other questions related to our features.

3.2 Requirements Classification and Organization

- Robust architecture of robot and Cleaning mechanism: For better cleaning than regular broomsticks available in the market.
- Mobile Application: For remotely handle real time data.
- Networking: For better accessibility at home or outside of home.
- Theoretical CS and Algorithm: For ease of path selection.
- AI: For sensing the optimized way to track the obstacles in it's path.

3.3 Requirements Prioritization and Negotiation

Among several requirements that we found out through our discovery process were prioritized according to the user/stakeholders need(such as: optimized and reliable cleaning, interactive application with the robotic system, necessity of self-charging dock).

Earlier the robot was controlled through only a IR^{TM} remote but having a remote has no utility except for only powering it on or off. In fact, using a mobile app for all in all activity is more handy and has other utilities as well(such as: user can schedule the time of activity , can know the state of the machine whether it is idle or working).

3.4 User Requirements

- The robot shall automatically detect objects while cleaning
- The robot shall be reliable for optimal cleaning
- The robot shall be able to charge itself
- The robot shall activate itself at a certain time
- The robot shall remotely accessible from an android platform
- The robot shall perform or avoid cleaning at certain region

4. System Architecture

4.1 Logical View

This project is based on the connection between ACR itself and mobile app by whom the ACR will control via internet.

Fig-4.1 Logical View

4.2 Process View

Android based mobile will control the cleaning mechanism to collect dust. There shall be a battery level detector in ACR itself and if the battery level is low it will alert the user and return to charge dock.

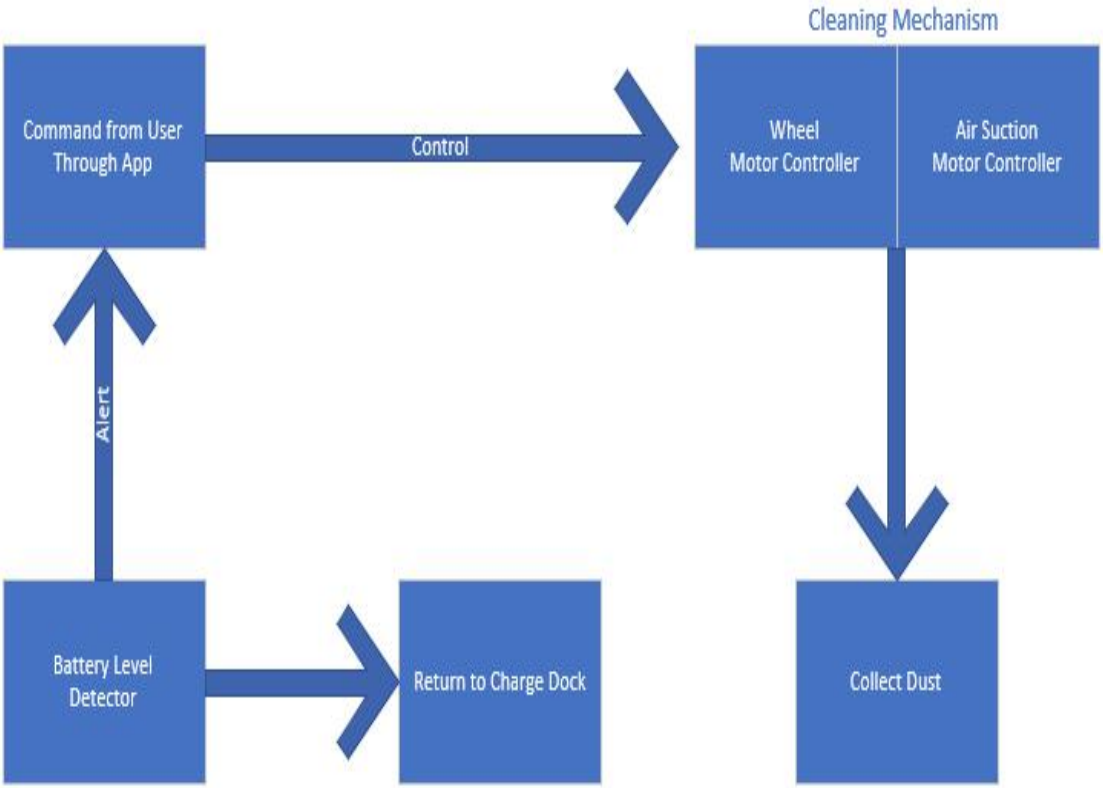

Fig-4.2 Process View

4.3 Development View

Development of this project is divided into main four sectors: Building ACR shape & body, interfacing hardware & sensors, develop an android app and the complex one implementation of AI.

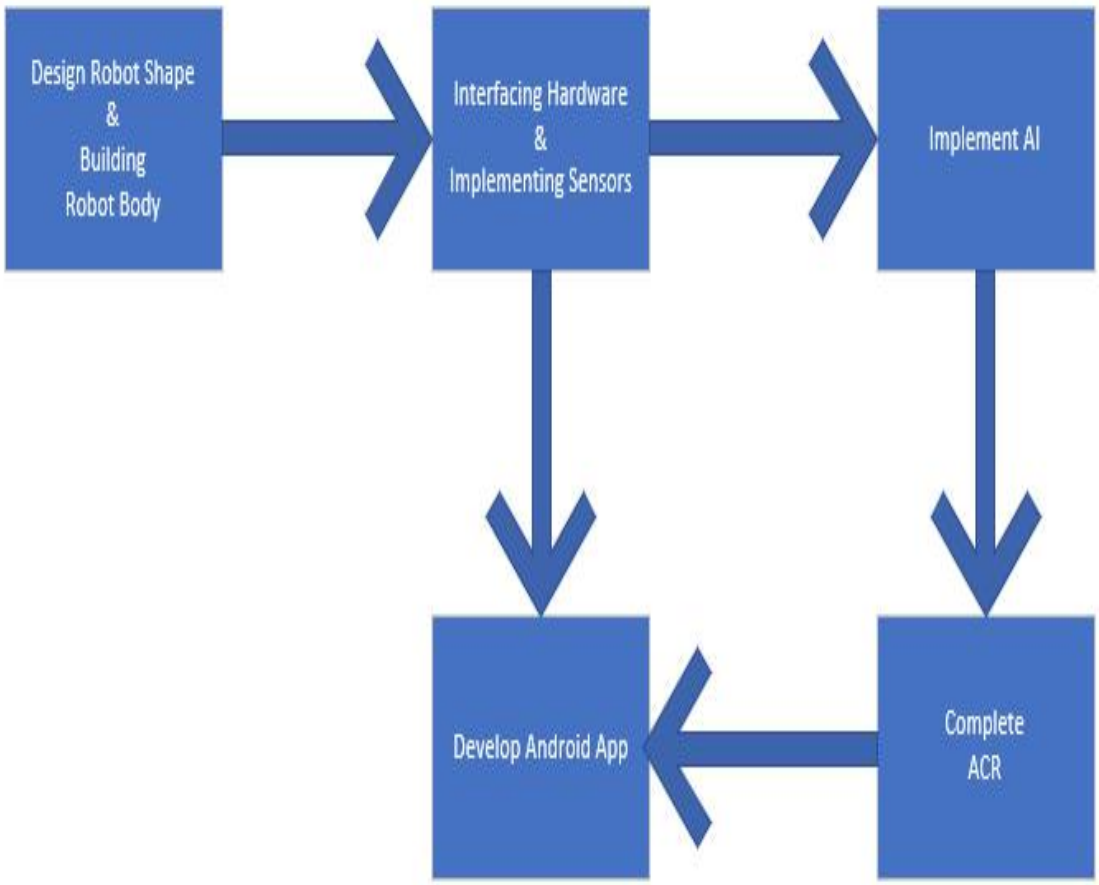

Fig-4.3 Development View

4.4 Physical View

The development board(processor) of ACR will distributed over the movement of wheel, the suction of dust, to detect battery level and to maintain connection with android app.

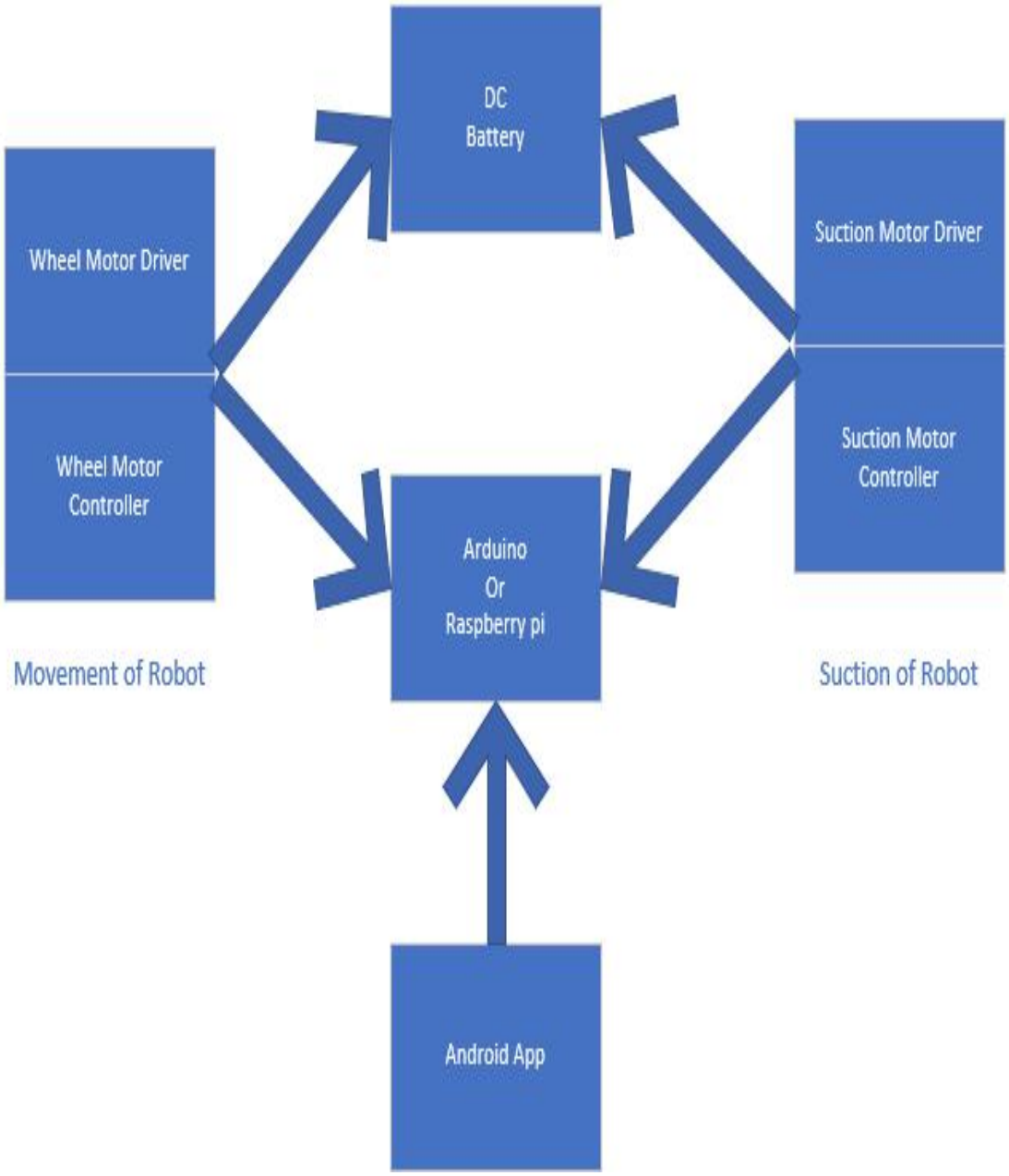

Fig-4.4 Physical View

5. System Requirements Specification

5.1 System Requirements

5.1.1 Object Detection

5.1.2 Reliable Cleaning Mechanism

5.1.3 Charging Dock

5.1.4 Time Scheduling

5.1.1 Object Detection

Sensors will be used for detecting objects. Raspberry pi shall receive data from the sensors to decide whether there is any object or not. The robot shall decide the path according to the object.

5.1.2 Reliable Cleaning Mechanism

Using ordinary broomsticks isn't enough for perfect cleaning rather one has to sweep the dirt at a corner then drag it to a dirt bin. That's why, the robot shall have two opposite rotational blades to have the darts aligned. It will have suction chamber to get the dirt. It shall store the dirt in the cleaning chamber.Using suction instead of sweeping is much more reliable and less time consuming.

5.1.3 Charging Dock

The robot shall sense battery level and decide whether to go for recharging or not. It shall have reliable algorithm to decide the optimal path to the charging dock. The robot shall receive it's direction in case of collision with objects.

5.1.4 Time Scheduling

The robot shall not be activated all of the time. Provided android app shall have time activity to maintain power activation of the robot.

5.1.5 Accessibility

It shall be able to interact with user through android platform. Internet connectivity makes the robot to be able to operate from remote location.

5.1.6 Floor Mapping

Provided android app shall have an activity to give input of the top view of the house. The robot shall measure in a specified region according to floor plan.

5.2 Mapping The System Requirements with Functional and Non-functional

Serial	User Requirements	Types of Requirement	
		Functional	Non Functional
1)	Detecting Objects		
	1.1 Reading sensor data	✓	
	1.2 Path avoidance	✓	
	1.3 Edge detection	✓	
2)	Cleaning Mechanism		
	2.1 Suction	✓	
	2.2 Storing dirt in bin	✓	
3)	Charging Dock		
	3.1 Sensing Battery Level		✓
	3.2 Return to charging dock	✓	
	3.3 Reliable path detection	✓	
4)	Time Scheduling		
	4.1 User Input	✓	
	4.2 Response Time		✓
5)	IOT using M.P		
	5.1 Fetching data from cloud	✓	
	5.2 Internet Connectivity		✓
	5.3 Voice Control	✓	
	5.4 Log Record	✓	
6)	Floor Map		
	6.1 Draw Map	✓	
	6.2 Restrict Area		✓

6. System Model

6.1 Context Model Diagram

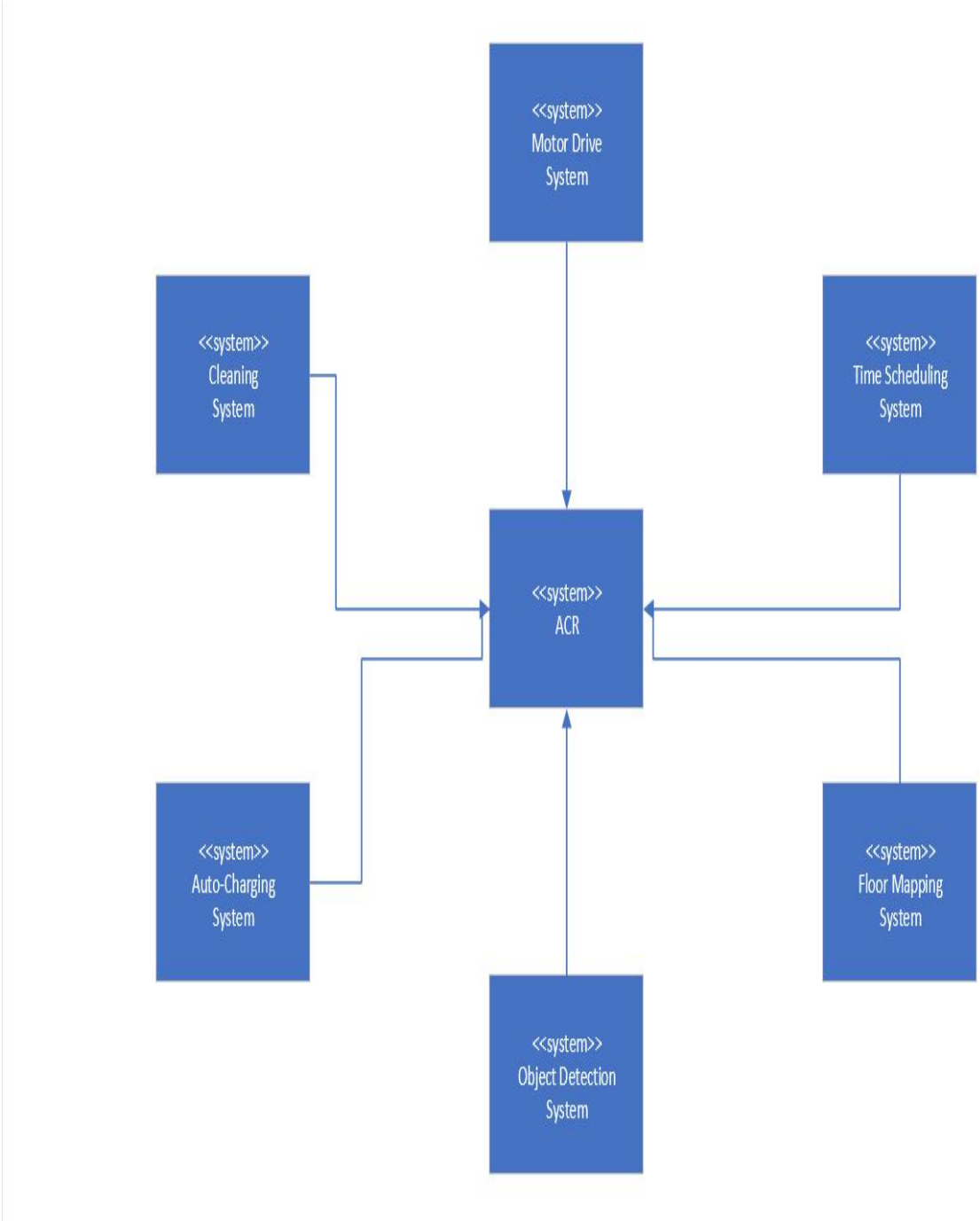

Fig-6.1 Context Model Diagram

6.2 Architecture Pattern

For the illustration of Architecture Pattern, see Appendix A.

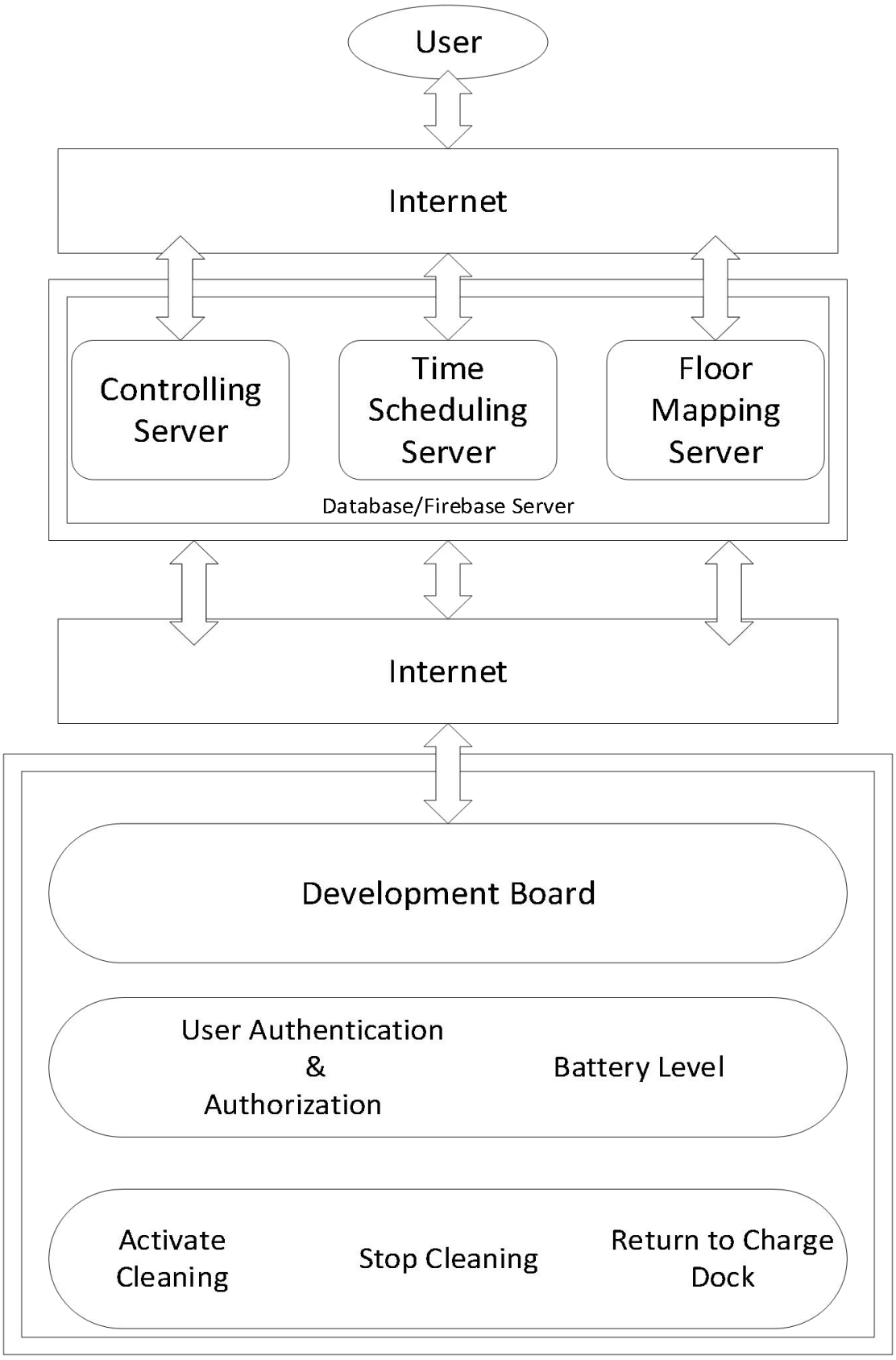

Fig-6.2 Architecture Pattern

6.3 Activity Diagram

For the illustration of Activity Diagram, see Appendix B.

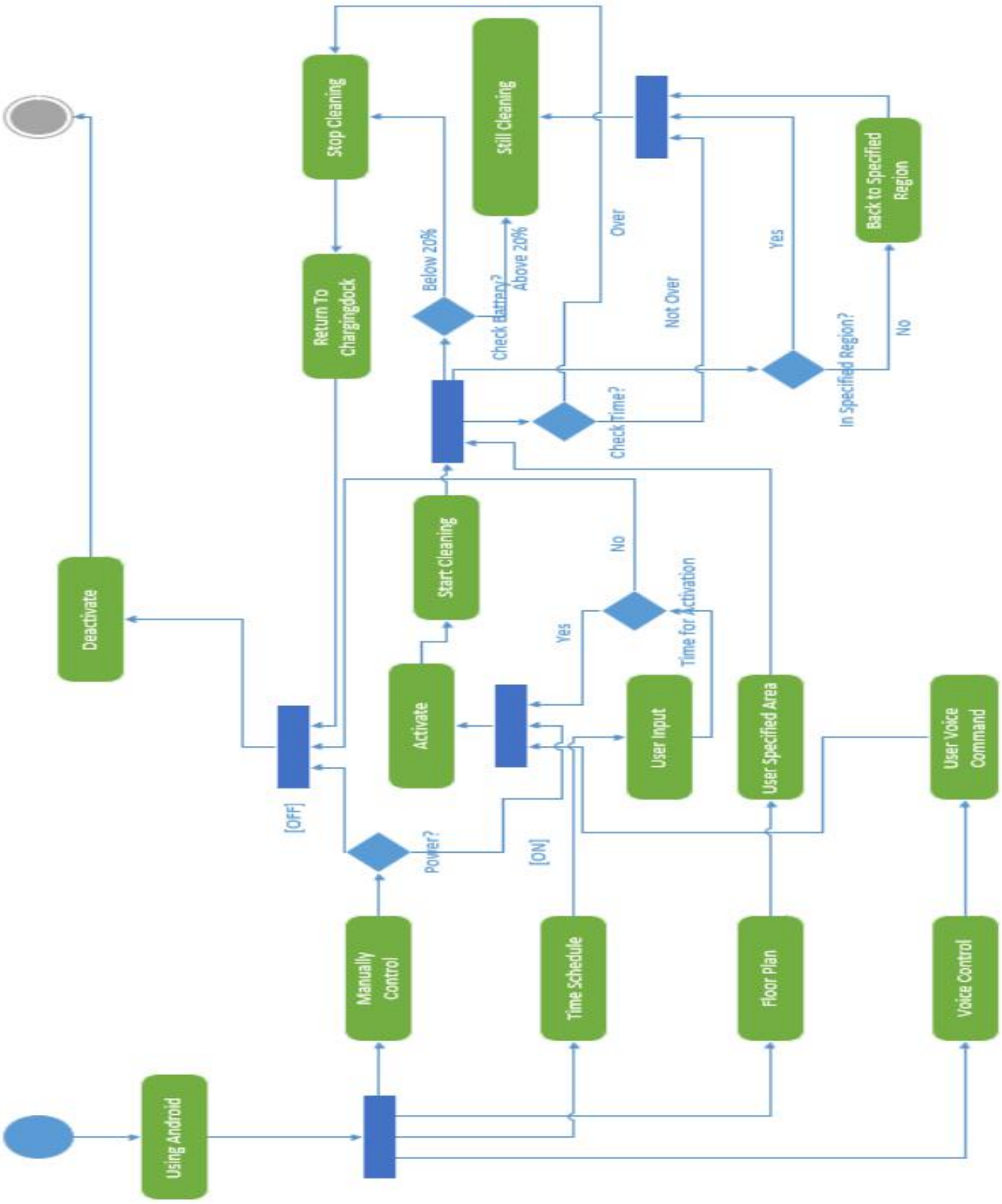

Fig-6.3 Activity Diagram

6.4 Use Case Diagram

6.4.1 Remotely Access and Cleaning

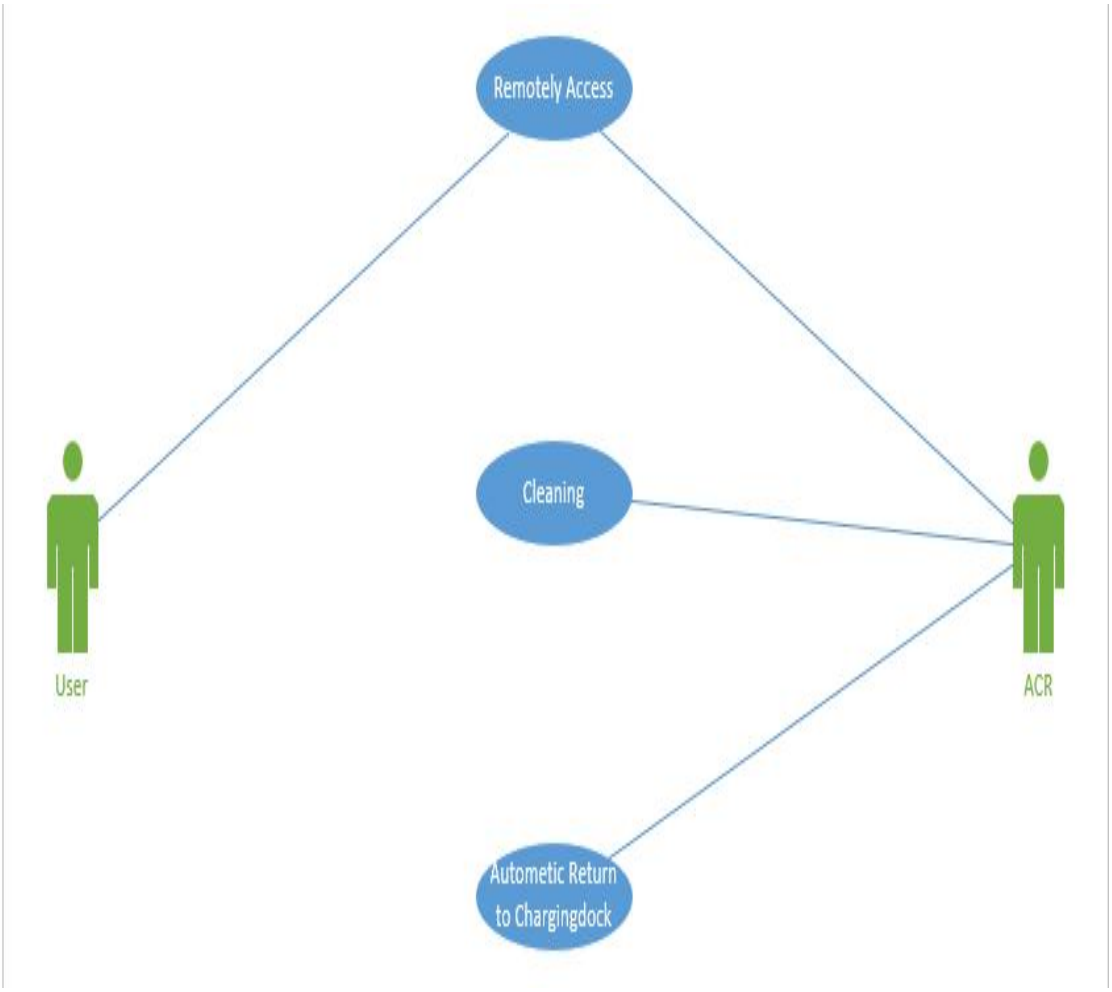

Fig-6.4.1 Use Case Diagram-01

ACR system: Remotely Access and Cleaning	
Actors	User, Autonomous Cleaning Robot (ACR)
Description	A user can access Autonomous Cleaning Robot (ACR) remotely and activate the robot for cleaning purpose. And after cleaning the robot is able to return to its charging dock.
Data	Command for cleaning or for return to charge dock
Stimulus	User command issued by internet of things(IOT)
Response	Confirmation signal that command is being executing
Comments	Both user and ACR must have connection with internet.

6.4.2 Time Scheduling

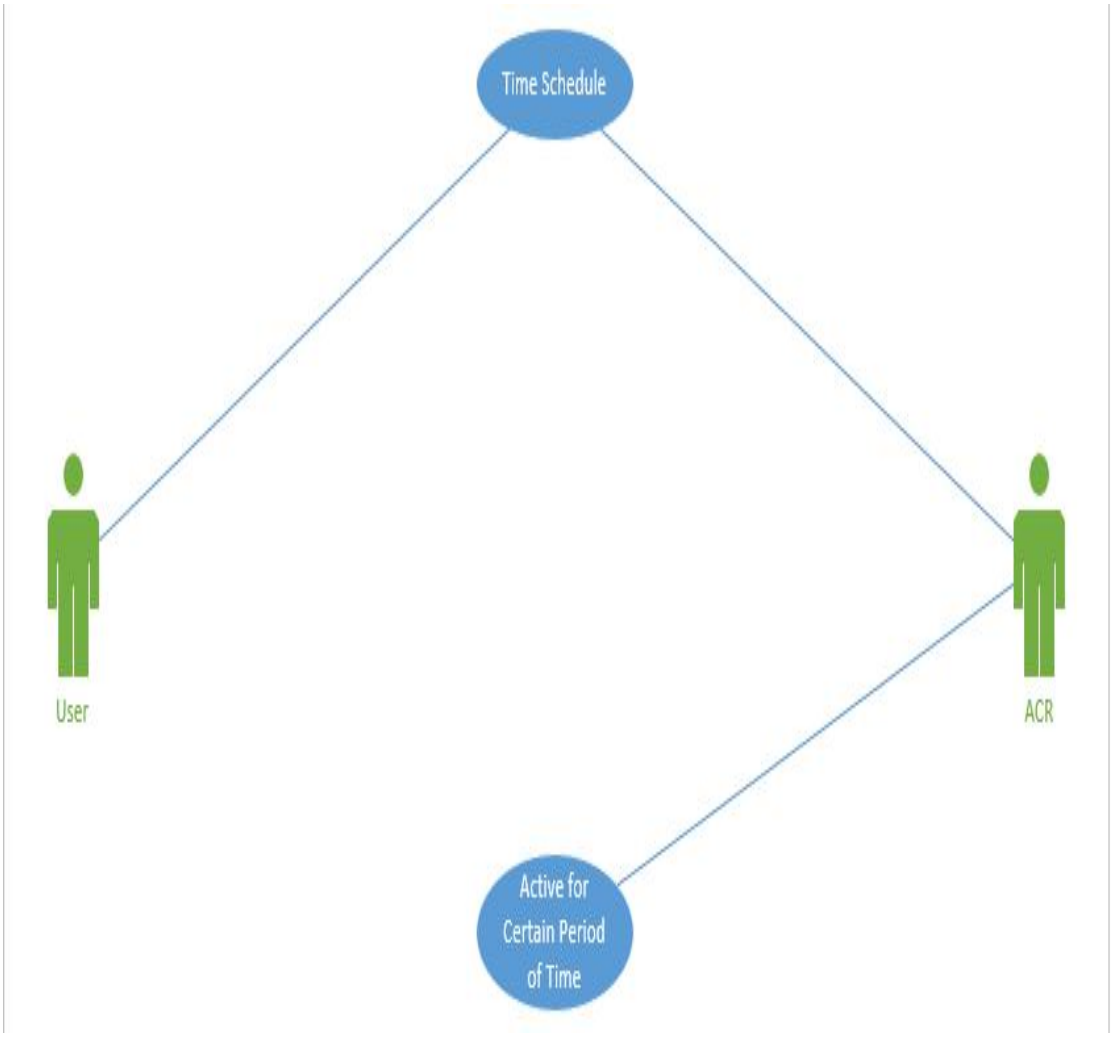

Fig-6.4.2 Use Case Diagram-02

ACR system: Time Scheduling	
Actors	User, Autonomous Cleaning Robot (ACR)
Description	A user can set a time schedule for cleaning. Autonomous Cleaning Robot (ACR) automatically activate itself during the time period.
Data	Start time & Finish time
Stimulus	User time schedule issued by manually or through App
Response	Confirmation signal that command is being executing
Comments	ACR will perform automatically.

6.4.3 Floor Mapping and Cloud Computing

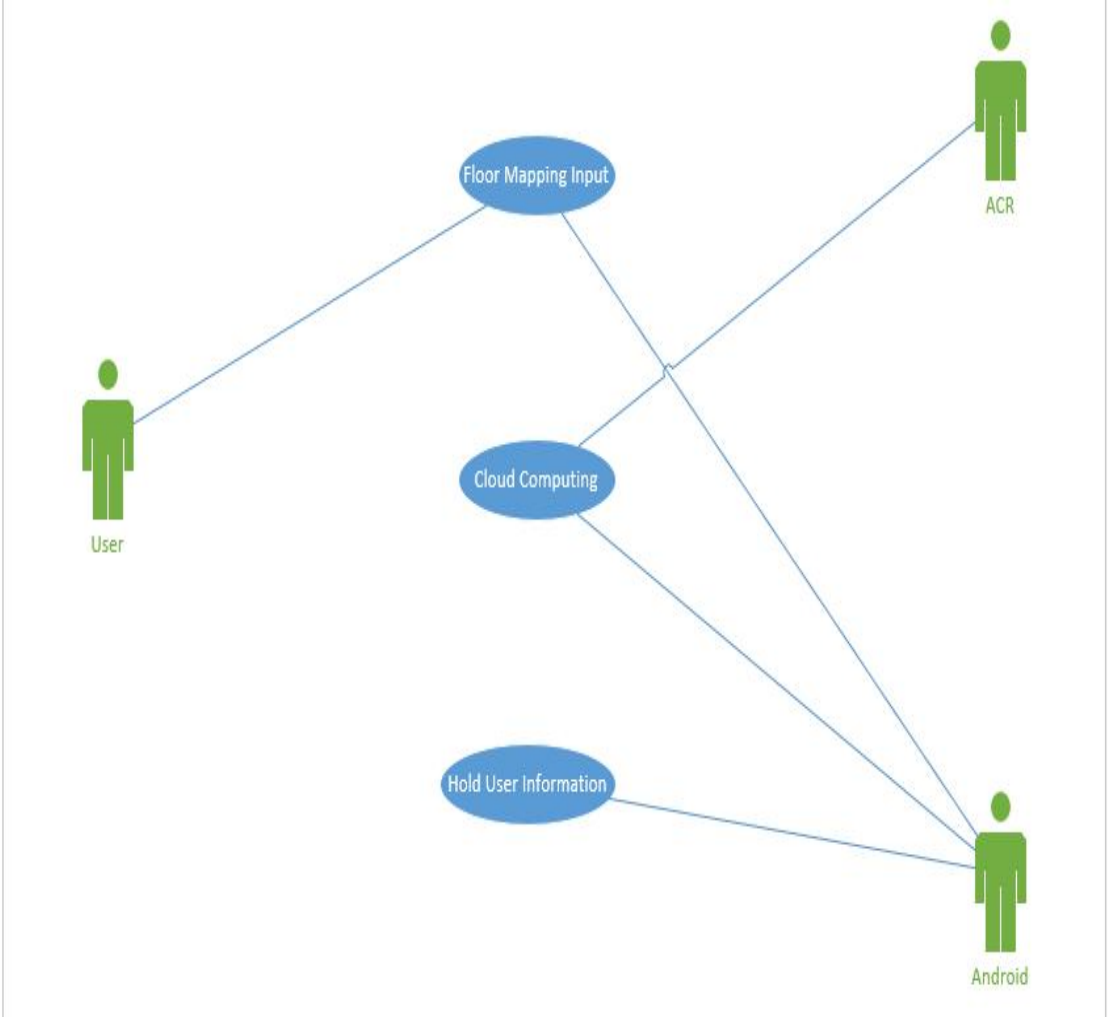

Fig-6.4.3 Use Case Diagram-03

ACR system: Floor Mapping and Cloud Computing	
Actors	User, Autonomous Cleaning Robot (ACR), Android App
Description	User have to give input of the top view of the house to the Android App. This map will send to ACR through cloud computing.
Data	Length, Width and Shape of the house
Stimulus	User value issued by Android App
Response	Confirmation signal that value has been received
Comments	Android App must need to provide reliable activity for take the values.

6.5 Sequence Diagram

For the illustration of Sequence Diagram, see Appendix C for Scenario-01 & D for Scenario-02.

6.5.1 Scenario-01

Remotely Access and Cleaning via Voice Command

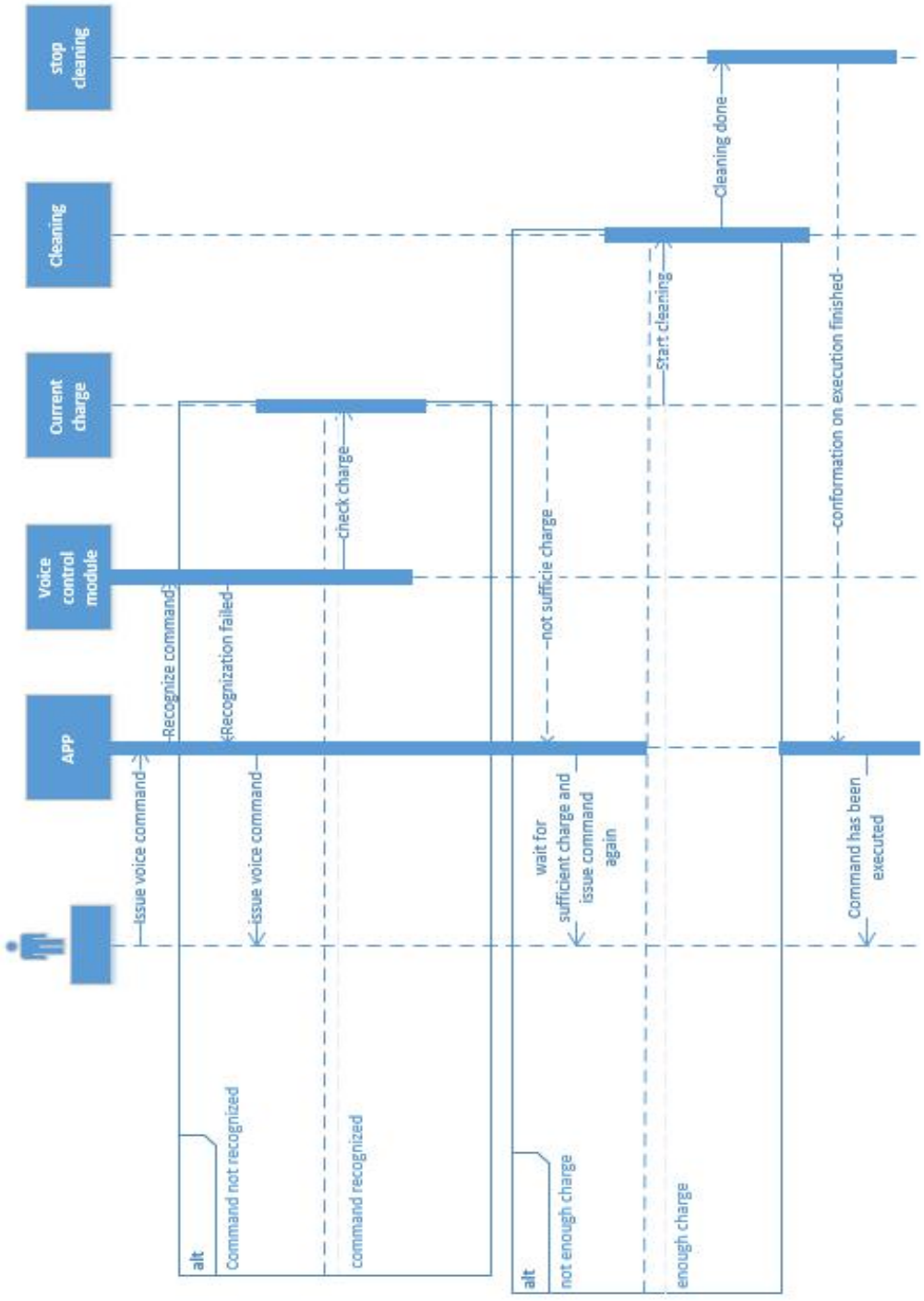

Fig-6.5.1 Sequence Diagram-01

6.5.2 Scenario-02

Time Scheduling via Android App

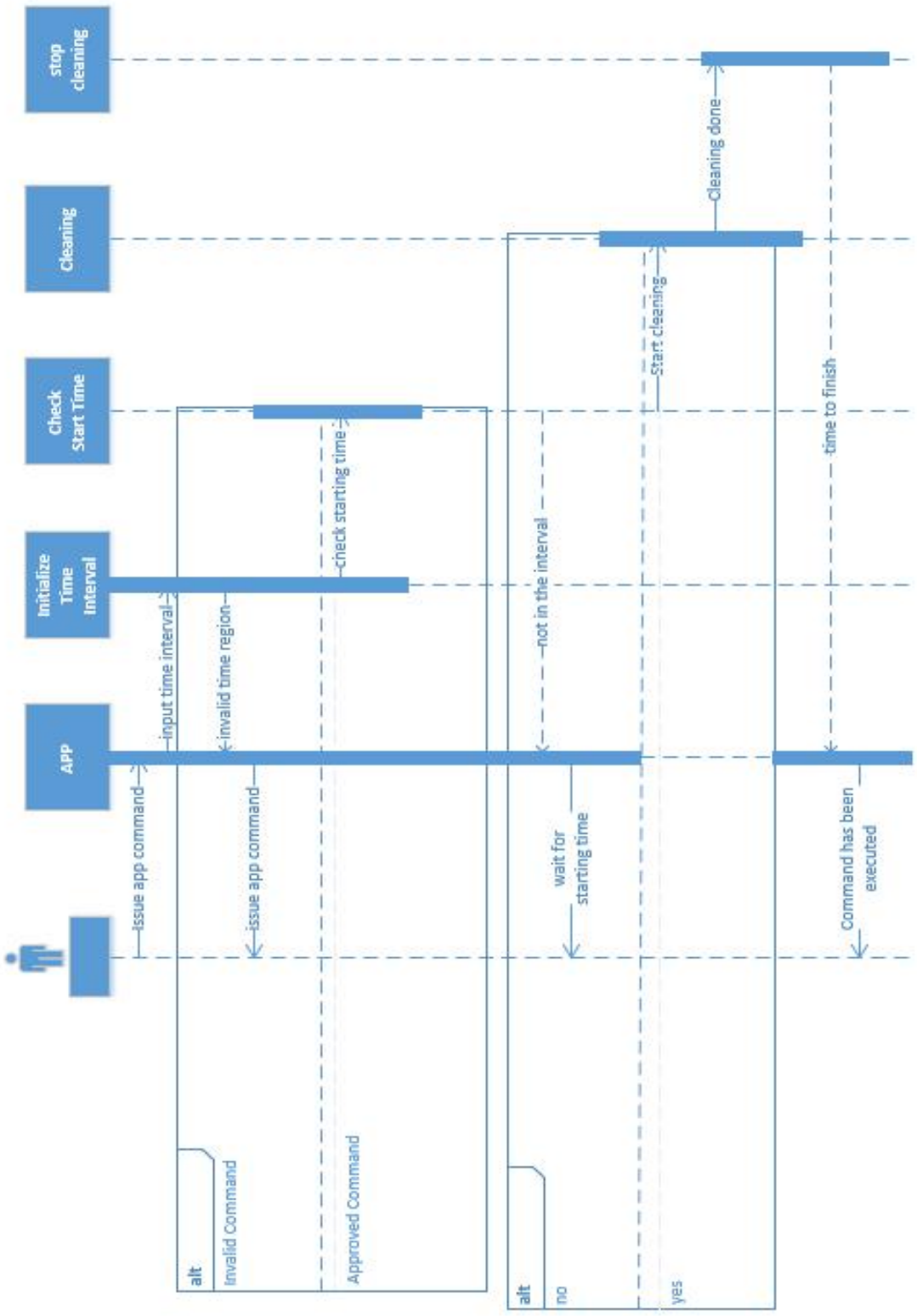

Fig-6.5.2 Sequence Diagram-02

7. System Evolution

The fundamental assumptions of the system on which the system is based are handling real time data and applying artificial intelligence to make ACR autonomous. Following are the some possible changes or requirements due to hardware evolution and changing user needs that may occur in future:

i. **It will able to predict obstacles from its previous experiences**

In our future version there will be a reliable AI program so that ACR can predict obstacles from its previous experience. This will make ACR quite faster than this version.

ii. **It will able to mop the floor**

We will add a robotic arm with ACR so that it can mop the floor which will complete the cleaning.

iii. **It will able to dispose the dirt**

In current version user have to make his/her hands dirty for disposing the dirt. In future we will make ACR able to dispose dirt by itself.

iv. **It will able to create the room map automatically**

In future we will add depth sensors so that ACR can create the room map by itself.