FIREFIGHTING ROBOT

1. Introduction

Firefighting is the act of extinguishing fires with precedence to saving life, property and nature.

In urban India, there has been an exponential increase in population density which has resulted in congestion and numerous high-rises. In these cities, the complexity of advanced lifestyle has increased the threat caused by fire hazards. These include weak implementation of development guidelines, old buildings, haphazard constructions, compromised and old electrical infrastructure and so on. Even a minor fire in a single apartment, if not contained in a timely manner, can jeopardize the lives of hundreds of civilians, in and around a building. Such extreme demands of firefighting operations within enclosed spaces stretch the capability of human firefighters, making the job severe and often lethal.

Automated robotic technology will obviate risking the lives of human firefighters. Furthermore, robotic firefighters will be better than their human counterparts at enduring the toxic environments of combusting material. Due to such reasons, robotic firefighting technology holds great promise in the future.

e-Yantra has designed a theme, "Firefighting Robot" to bring awareness to these issues. We have modelled the theme on an apartment consisting of four rooms. The pivotal task of the theme is for an autonomous robot to meticulously extinguish fires in this apartment.

The robot has to navigate through the entire apartment. While doing so, it has to detect and extinguish all the fires, without damaging the arena.

Like in the case of any fires, the critical factor is time and the challenge is to complete this task in the shortest time possible. The robot that performs the task best as per the set rules will be declared the **WINNER.**

2. Theme Description

Make an autonomous robot that performs the following tasks:

1. The robot starts from the **HOME** position in the center of the arena (Refer to Figure 1).
2. It then has to traverse through all the four rooms **A, B, C** and **D.**
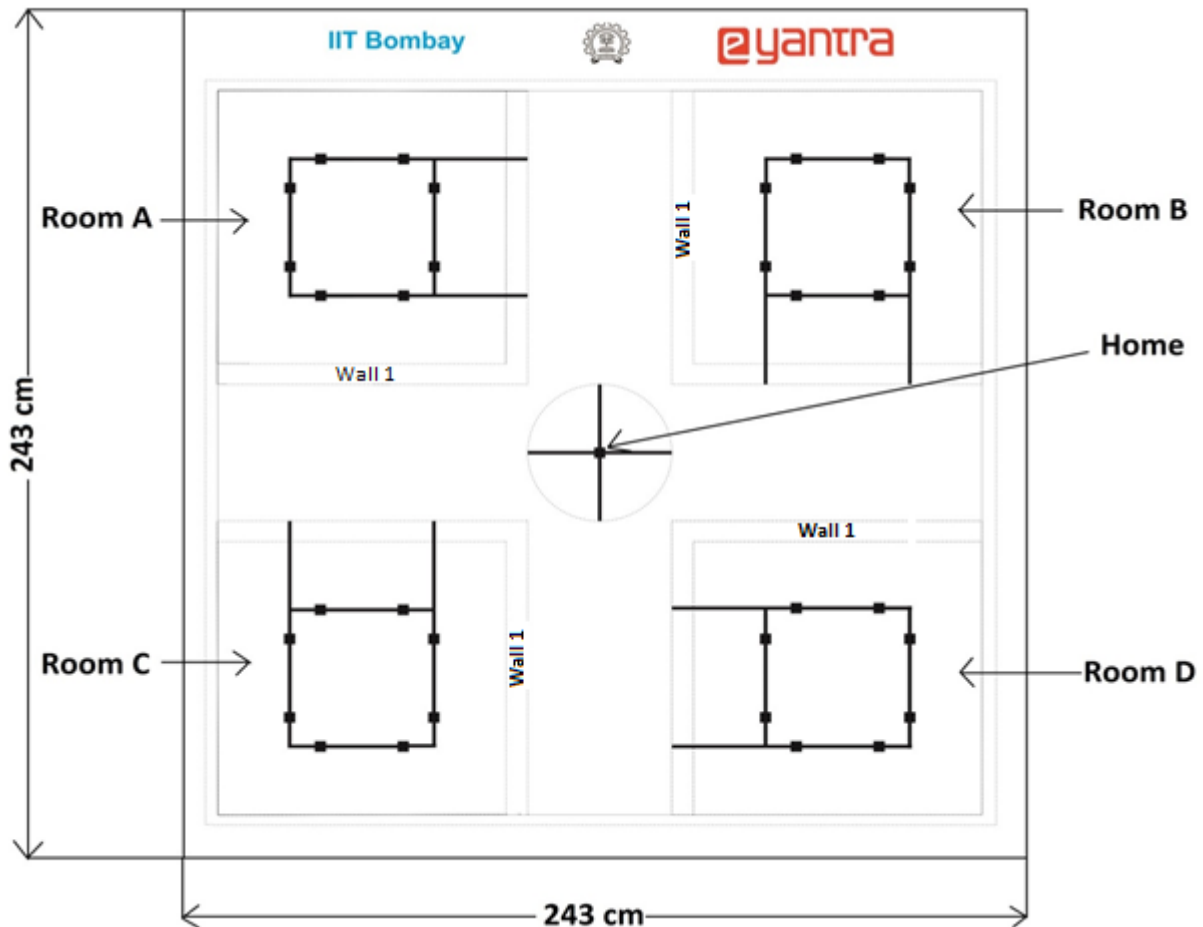

Figure 1: Flex Design

3. The apartment will have **maximum of four fires**, placed in any of the four rooms. **A room may or may not contain a fire, but a room will not contain more than one fire.** The robot has to detect the presence of a fire and sound a buzzer of 1 second to indicate detection.
   - **Fire**: To represent a fire, we use an array of four red LEDs (in pairs of 2), instead of an actual candle, as shown in Figure 2. Henceforth this array is interchangeably referred to as **LED Array** or **fire** in this document.

4. After detection the robot has to **extinguish that fire.**
   - **Deposition Slot:** Every LED Array has its own **Deposition Slot**. A deposition Slot is a conical funnel in the close vicinity of the respective LED Array.
   - **Extinguishing a fire:** The robot has to drop a magnet into a Deposition Slot to switch off the corresponding LED Array i.e. extinguish the fire. Henceforth in this document, this action is referred to as "**extinguishing a fire".**
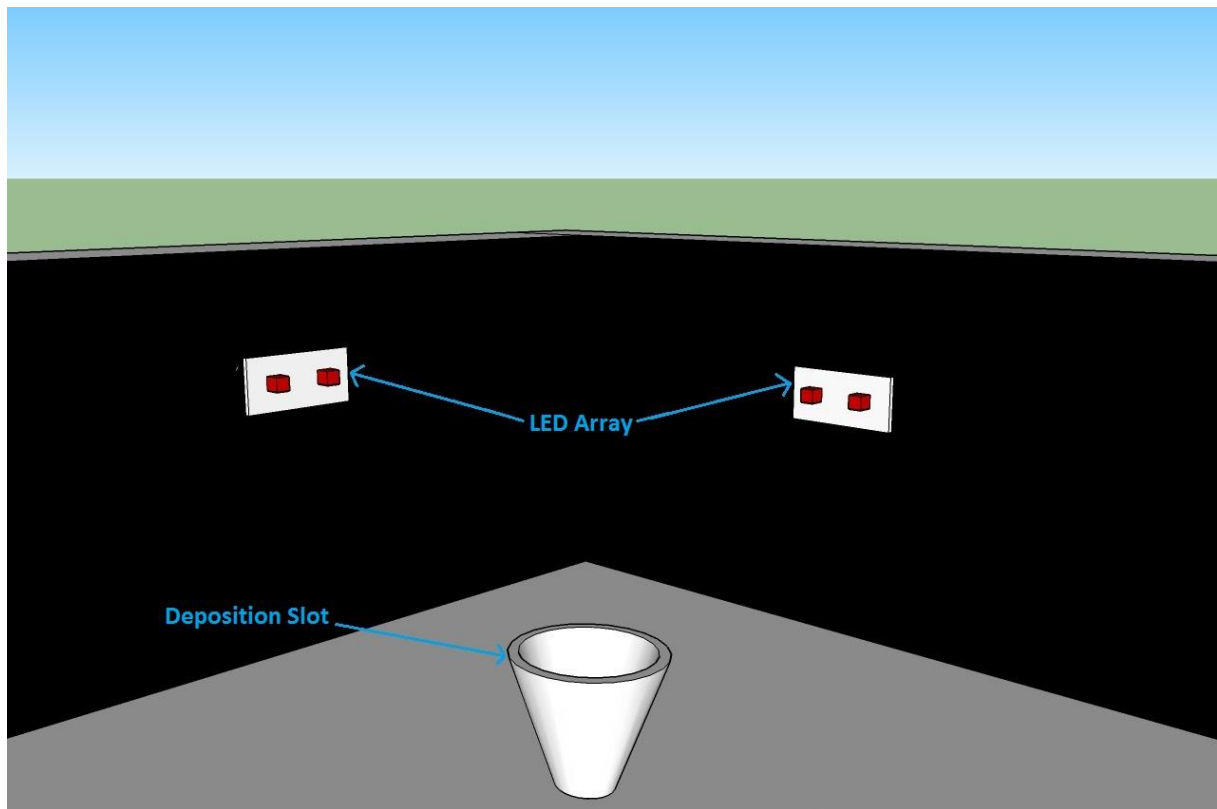

Figure 2: An instance of a fire with a Deposition Slot

5. After checking all the rooms and extinguishing all the fires, the robot should return to the HOME position and sound a continuous buzzer of more than 5 seconds to indicate the end of the task.

In this competition, teams are free to design the mechanism for detecting the presence of a fire and extinguishing it.

3. Arena

Preparing the arena:

Each team has to prepare the arena. Preparing the arena consists of four major steps.

1. Printing the arena design on flex sheet.
2. Preparing and placing the walls.
3. Assembling the LED Array circuits.
4. Positioning the door and placing the LED Array circuits.

NOTE: Teams are not allowed to make any changes in the arena design. Any team making unauthorized modifications will be disqualified from the competition.

3.1. Printing the arena design on flex sheet:

Flex design is shown in Figure 1. A Corel Draw (.cdr) file containing the flex design will be provided to the teams. Each team prints the flex design according to the direction given in the .cdr file.

WARNING: Please be careful while handling the flex sheet – avoid folding it like a bed-sheet since the resultant folds will cause problems while the robot moves. One way of "flattening" flex if it has been compromised is to hang it for a few hours in the sun -- it tends to straighten out. Never attempt ironing it or applying heat of any kind -- it may be a fire hazard.

Details of arena design: (Refer to Figure 3)
- Dimension of the flex sheet is 243cm x 243 cm.
- All rooms have the same dimensions: 80cm x 80cm.
- Each room consists of a path of black lines of 1 cm thickness as shown in the arena.
- Square nodes of 3cm x 3cm dimension have been provided along the black lines for localization.
- **Door:** Every room has only one Door, i.e. opening of 40 cm, which will be used for entering, as well as exiting, the room. Positioning of doors is explained in detail in Section 3.4.
- **Fire Zone:** The four inner corners of a room where a fire can be placed are called Fire Zones. They are referred to as **FZ1, FZ2, FZ3** and **FZ4**. In a room, a fire can be placed in any corner, except the corner where the entrance is. An instance of a fire zone with dimensions is illustrated in Figure 3.
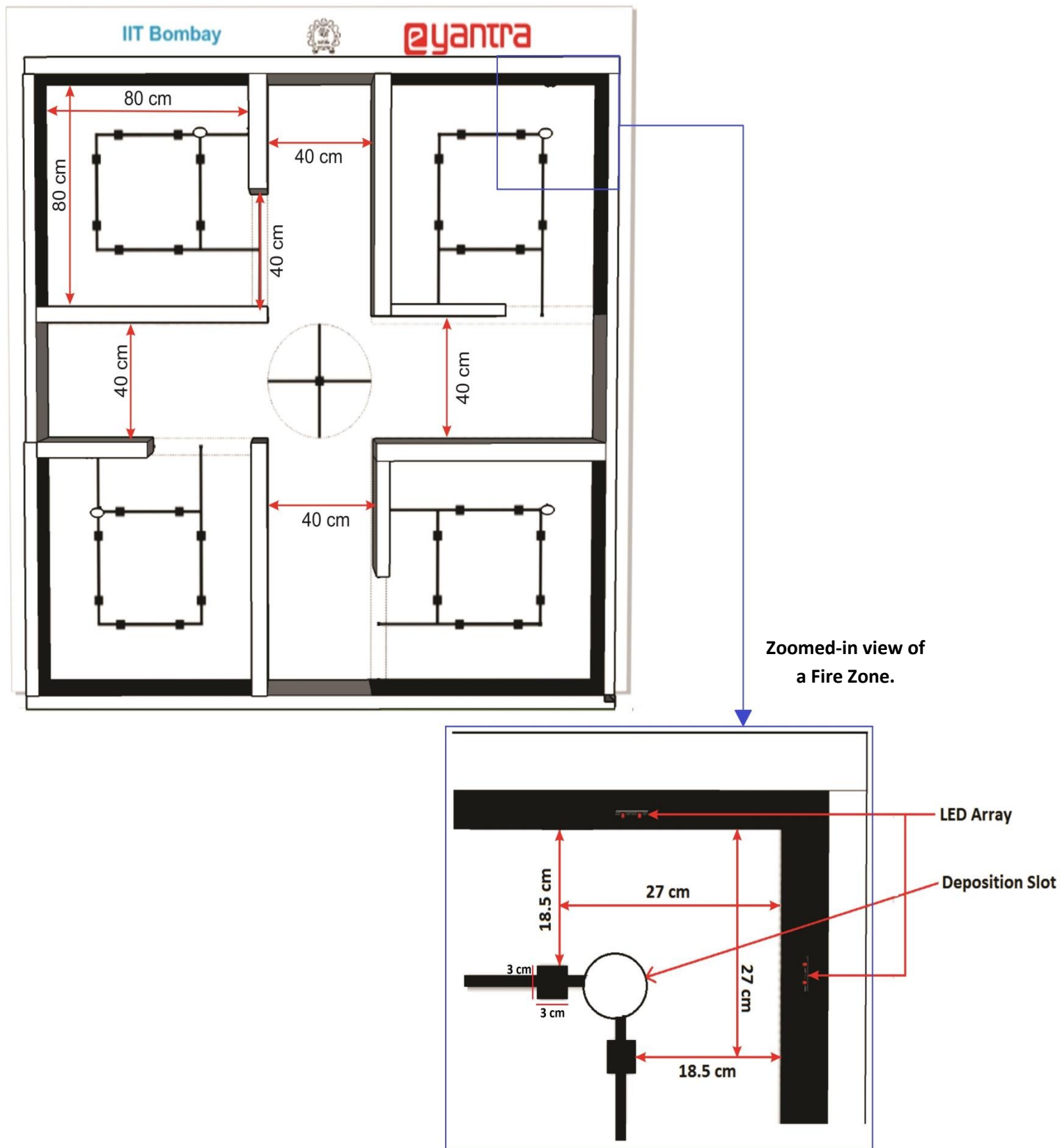
Figure 3: Apartment with an Instance of a Fire Zone with Dimensions

3.2. Preparing and placing the walls:

Materials required for preparing walls:

- Thermocol sheets.
- Black color chart paper.

Preparing Walls:

There are 3 types of **wall sections** used in the arena:

- **Outer Wall**: Four Outer walls (212cm x 20cm x 4cm) are placed on the periphery of the apartment. These are fixed permanently to the flex (Refer to Figure 4).
- **Wall 1**: Wall 1 is the longer wall (84cm x 20cm x 4cm), used in the interior of the apartment. Every room is fitted with only **one** Wall 1 section. These are also permanently attached to the arena as shown in Figure 4.
- **Wall 2**: Wall 2 is the shorter wall (40cm x 20cm x 4cm), used in the interior of the apartment. It should be detachable. Every room is fitted with only **one** Wall 2 section.
- Cut the thermocol sheets to prepare walls of dimensions given in Table 1.

Table 1: Dimensions of Walls.

Position	Quantity	Length (cm)	Height (cm)	Thickness (cm)	Fixed or Detachable
Outer Wall	4	212	20	4	Fixed
Wall 1	4 (one for each room)	84	20	4	Fixed
Wall 2	4 (one for each room)	40	20	4	Detachable

Note: If a single sheet of required length is not available, then two or more smaller pieces can be joined to form a single wall of required size. For example: Sheet 1 (116cm x 20cm x 4cm) + Sheet 2 (100cm x 20cm x 4cm) can work as an outer wall (216cm x 20cm x 4cm) when joined together.

Placing walls:

- Stick the Outer Walls and all the Wall 1 sections permanently to the arena using double side tape or any other suitable adhesives. After this step the arena should look like Figure 4. (Note that on the flex design "Wall 1" is marked on the appropriate wall section for each room.)
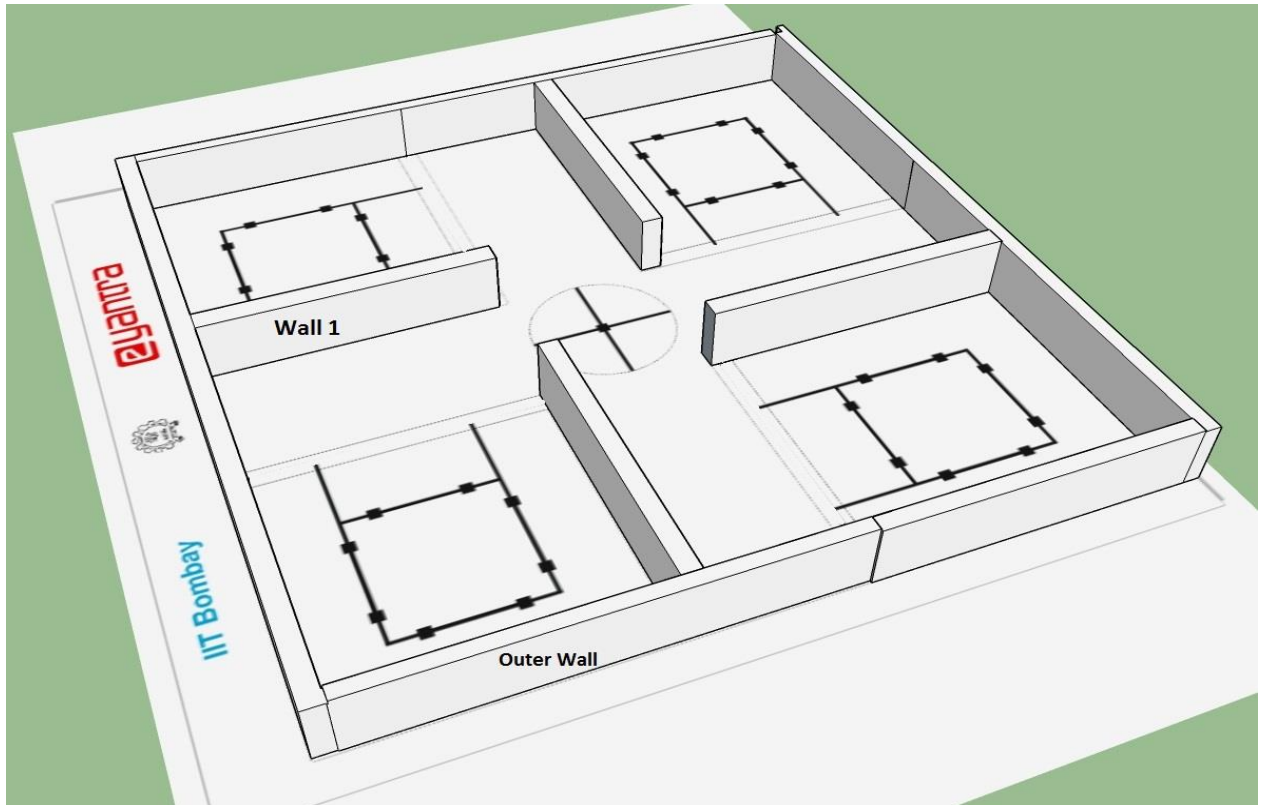

Figure 4: Arena with Outer Walls and Wall 1 Sections

- Wall 2 needs to be arranged depending on the position of the door, as explained in Section 3.4.

Covering the walls:

- Line the three inner fixed sides (as shown in Figure 5) of all the rooms with black chart paper.
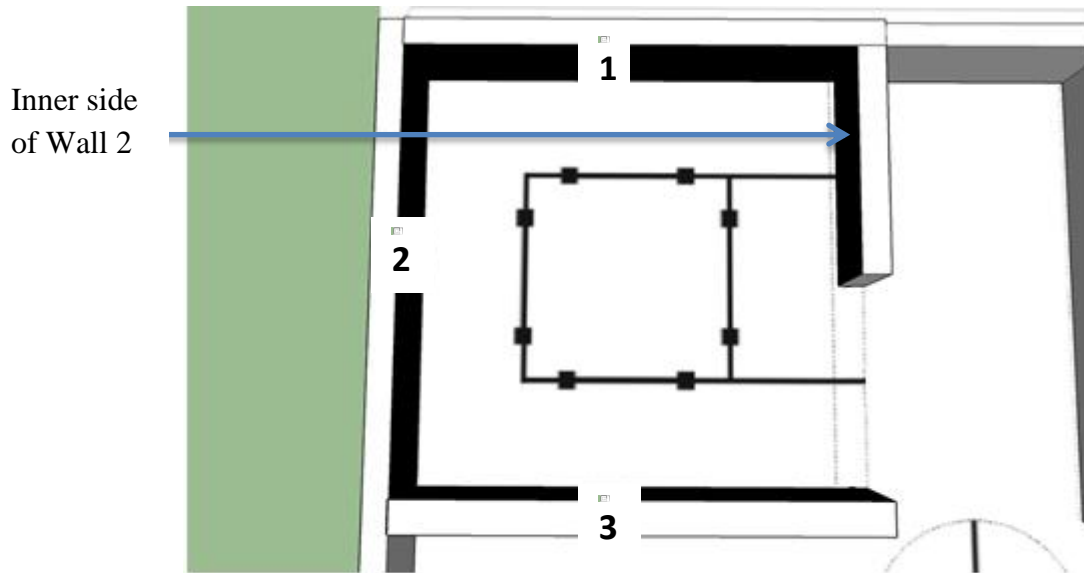
Inner side of Wall 2 →

Figure 5: Room with three inner sides

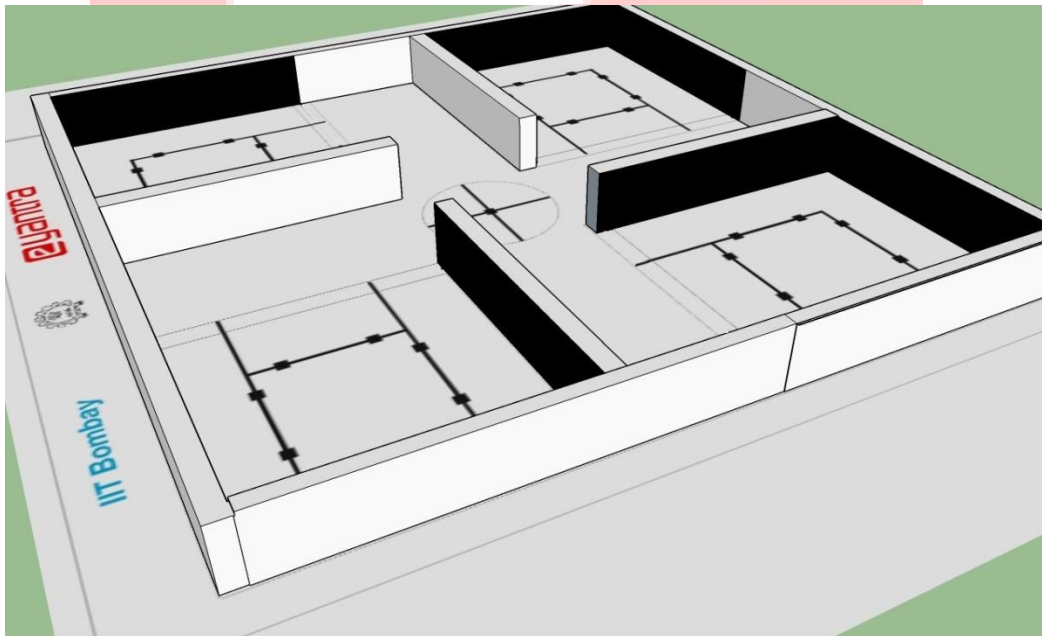After this step, the arena should appear as seen in Figure 6.

Figure 6: Arena with Outer Walls & Wall 1 covered with chart paper.

- Next line the inner side of all the Wall 2 sections with black chart paper (as shown in Figure 5).

Note: Faces of the wall outside the room should be left uncovered.

3.3. Assembling the LED Array circuits:

- Five LED Array circuits and five magnets will be provided to every team as accessories in the Robotic Kit.
- Assemble all the LED Array circuits as per the steps presented in the **tutorial 'Assembling the LED Array circuits'.**
- Now you should have five working LED Array circuits.

3.4. Positioning the door and placing the LED Array circuits:

- For each of the 4 rooms, the door can be in one of the two possible positions **d1 or d2** as shown in Figure 7.
- We can obtain door position d1 or d2 in a room by repositioning the detachable Wall 2 in that room.
- In each room there are four corners that are termed **Fire Zones** where an LED Array circuit can be placed. In Figure 7 we present the arena with all the doors and fire zone positions marked.
- In each room, for every door position (d1 or d2), there are three fire zones in which a LED Array circuit can be placed as per Table 2.
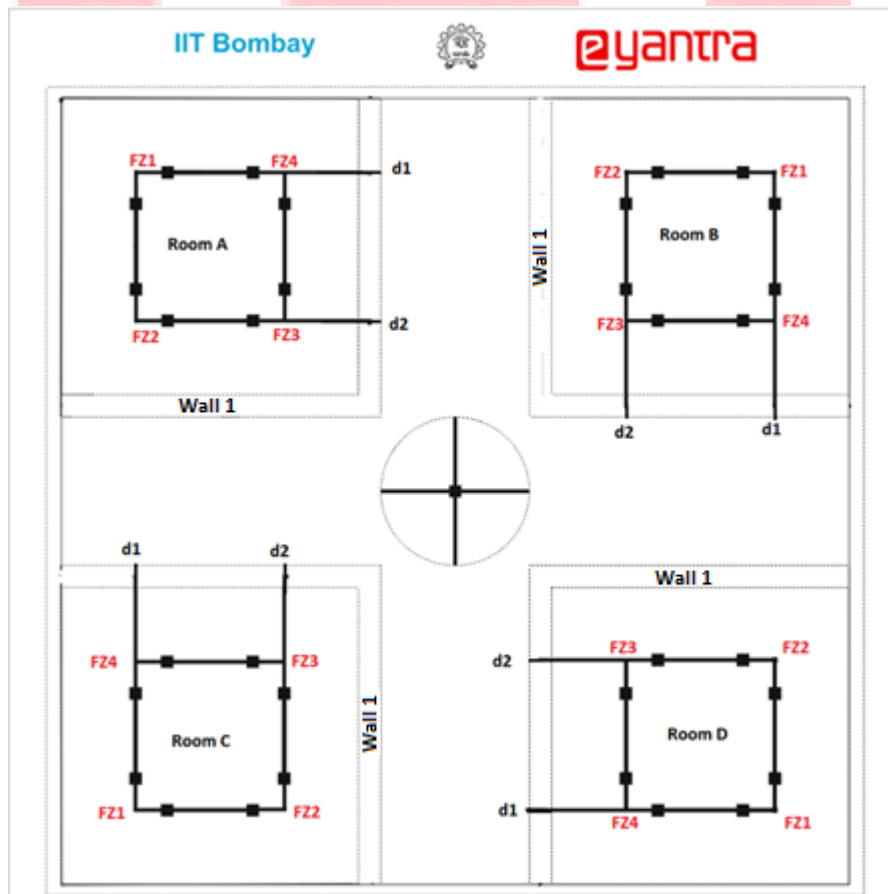

Figure 7: Arena with all Doors and Fire Zones marked

- Refer to Table 2 for possible combinations of doors and fire zones for each room.

Table 2: Combination of Door and Fire Zones in a Room

Door Position	Possible Fire Zones
d1	FZ1, FZ2, FZ3
d2	FZ1, FZ2, FZ4

- Door positions d1 and d2 for Room A are illustrated along with the possible fire zones in Figure 8-A and 8-B respectively.
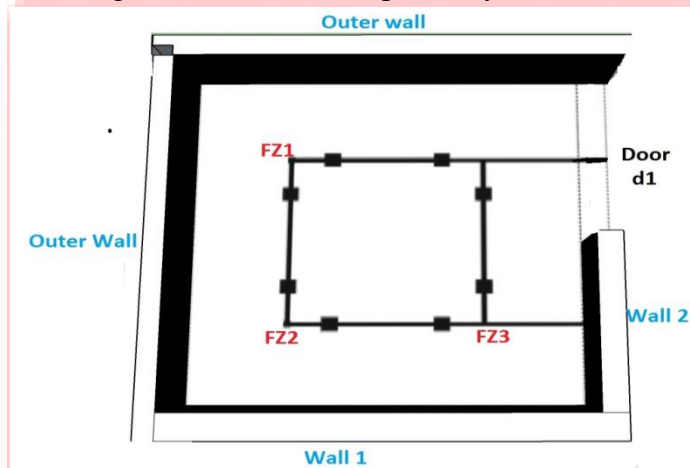

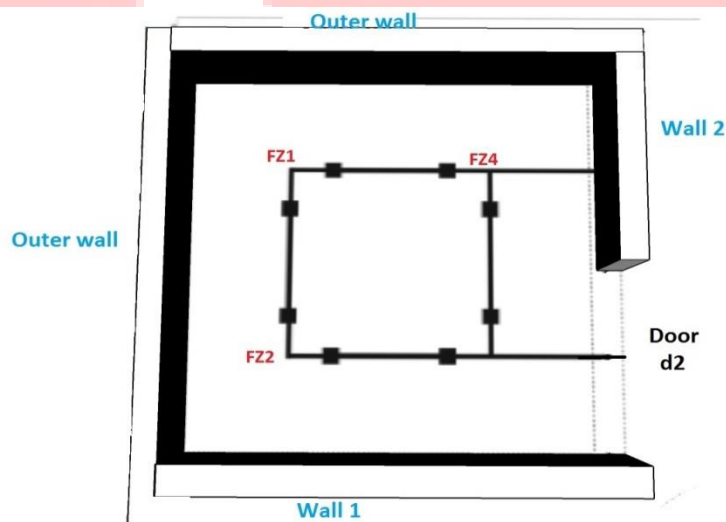
Figure 8-A: Door d1 with Fire Zones for Room A

Figure 8-B: Door d2 with Fire Zones for Room A

- Positioning of the doors and the placement of LED Arrays in the rooms are defined in the **configuration table**. An example configuration table, with four LED Arrays is given in Table 3.

Table 3: Configuration Table

Room	Door Position	Fire location
A	d2	FZ4
B	d1	FZ1
C	d2	FZ4
D	d1	FZ2

Suppose this table is used for positioning doors and placing LED Arrays, the completed arena would look like **Figure 9**.

- This is an example used to illustrate the positioning of doors and placement of fires. In the competition, you will be given a configuration table with the door positions and fire placements chosen **randomly, with a maximum of four fires.**

NOTE: Please accurately calibrate sensors, since this is typically the cause of errors and much heartburn. You should make the sensing as robust as possible under different lighting conditions. Also take care in the fabrication of the walls since the proper sizing, positioning and positional stability of the walls might make the difference between failure and success.
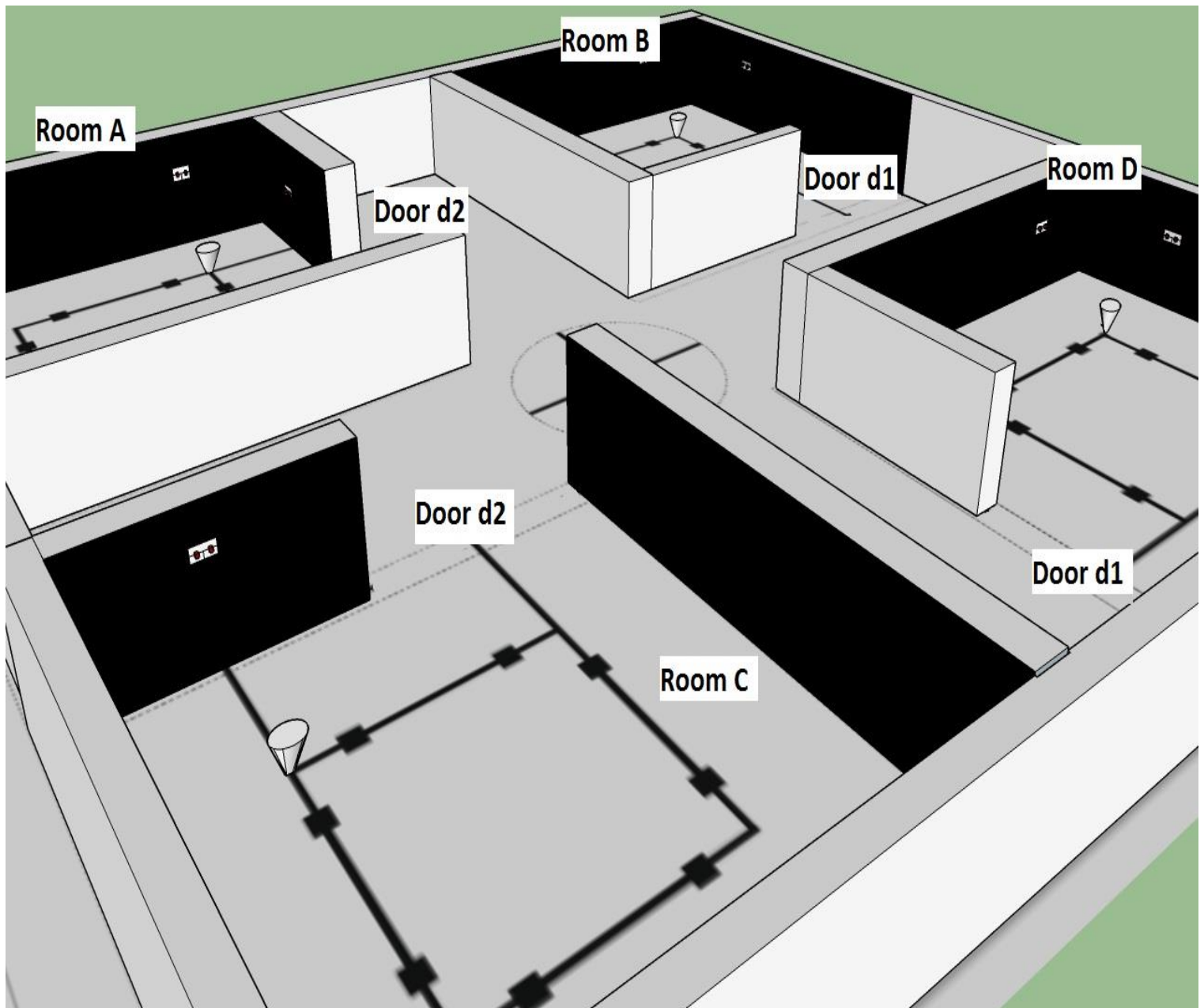
Figure 9: Final Arena (as per Configuration Table given in Table 3)

NOTE: If the arena is found damaged or in a condition that makes evaluation difficult, e-Yantra has the right to disqualify a team. The final decision is at the discretion of the reviewer.

4. Hardware Specifications

4.1 Use of Firebird V:
- All participating teams must use **only** the Firebird V robot sent to them in the kit. **Only one** robot given in the kit is allowed per team.
- Team shall not dismantle the robot.
- The robot should be **completely autonomous**. The team is not allowed to use any wireless remote or any other communication protocol or devices such as a camera while the robot is performing the task.

4.2 Use of additional components not provided in the kit:
- No other microcontroller-based board shall be attached to the Firebird-V robot.
- Teams may connect external actuators along with their driver circuits to the Firebird V robot only on the condition that the actuators must be controlled through the Firebird V robot.
- The team is not allowed to use any other sensors apart from those provided in the kit.

4.3 Power Supply:
- The robot can be charged through battery or auxiliary power supply. These are shipped with the robot.
- The team cannot use any other power source for powering the robot.
- The team can use auxiliary power during practice but the final demonstration should only be made using only battery powered robot.

5. Software Specifications

- e-Yantra has provided all teams with ATMEL STUDIO 6, a free software for programming AVR microcontroller. Participating teams are free to use any other open source Integrated Development Environment (IDE) for programming AVR microcontroller.
- As per e-Yantra policy, all your code and documents are open-source and maybe published on the e-Yantra website.

6. Theme Rules

- The maximum time given for completing all the tasks is 10 minutes. A maximum of **two runs** will be given to a team (the better score from the two runs will be considered as team's final score). A maximum of **two repositions** (explained below) are allowed in each run.
- Participants are not allowed to keep anything inside the arena other than the robot.
- The time measured by the reviewer will be final and will be used for scoring the teams. Time measured by any participant by any other means is not acceptable for scoring.
- Once the robot starts moving on the arena, participants are not allowed to touch the robot.
- The team should **Switch ON** the robot when asked by the reviewer. This is the start of a **run**. The timer will start the same time.
- A **configuration table**, which defines the door position and LED Array placement, will be given before the start of the run.
- The maximum number of magnets that the robot can carry is equal to the total number of fires in the arena. There will be a **maximum** of **four fires** in the apartment, with no room containing more than one fire.
- The configuration table will remain the same for the 2 runs of the team.
- Robot should be kept at the HOME position with the castor wheel of the robot positioned on the node.
- Once the robot is switched on, human intervention is NOT allowed.
- After each fire is detected, the robot has to sound a buzzer of 1 sec.
- Robot should drop magnet into the cone (deposition slot) to extinguish the fire.
- A fire is considered extinguished when the LED Array Circuit is turned off.
- A run ends and the timer is stopped when:
  - The robot stops and sounds continuous buzzer or
  - If the maximum time limit for completing is reached or
  - If the team needs repositioning but has used both reposition options for that run.
- Buzzer sound for more than **5 seconds** will be considered as continuous buzzer.
- The second run will start once again with resetting the score, timer and arena. The score of both runs will be recorded and best of two runs will be considered as the team's final score.
- Participants are not allowed to keep anything inside the arena other than the robot.
- Once the robot starts moving on the arena, participants are not allowed to touch the robot.
- The robot is not allowed to make any marks while traversing the arena. Any robot found damaging the arena will be immediately stopped; repositioning will be allowed as per the rules. **The final decision is at the discretion of the e-Yantra team.**

Repositioning of robot:

- Robot repositioning can be or may be done under following circumstances:
  - If robot is found to be displacing any wall or fire, or damaging the arena then it will be sent back at the HOME position.
  - If the robot gets stuck in the arena or goes off the arena, teams can ask for the reposition.

- For a reposition, the robot should be in Power Off mode, and turned on again at the HOME position, upon signal from the reviewer. **During a reposition, the timer will not be set back to zero.**
- Each team will be allowed a maximum of two repositions in each run. All repositions require the approval of the reviewer; the team will be disqualified if the robot is handled within the arena without approval.
- During repositions, a participant must not feed any information to the robot. A participant shall not alter a robot in a manner that alters its weight. The reviewer's decision is final.
- Note that during reposition, any LED Array that is not previously extinguished will remain as it is.
- After reposition the robot has to complete the remaining task; the tasks completed previously will be counted in the score.

Note:

- **You will be given a configuration table just before the submission of Task 3: Video submission along with instructions to complete this task.**
- **After completion of all tasks, teams will be selected as finalists based on their cumulative scores across all the tasks. Complete rules and instructions for the finals at IIT Bombay will be sent to those teams that qualify for the finals.**
- **In case of any disputes/discrepancies, e-Yantra's decision is final and binding. e-Yantra reserves the rights to change any or all of the rules as we deem fit. Any change in rules will be highlighted on the website and notified to the participating teams.**

7. Judging and Scoring System

- The competition time for a team starts from the moment the robot is switched ON. The timer will stop as soon as the robot finishes the task.
- The better score of the two runs for a team will be considered as the final score of the team.
- The team's total score is calculated by the following formula:

Total Score = (600 - T) + (D * 100) + (E*100) – (iD*100) – (iE*100) + (B *40) + OB – (P*30)

Where:

✓ **Total time (T):**
T is the total time in seconds taken to complete the task.

✓ **Correct Detection (D):**
D is the total number of correctly detected fires. Fire Detection is considered correct if the robot sounds a buzzer beep of 1 second after detecting a fire.

✓ **Correct Extinguishment (E):**

E is the total number of correctly extinguished fires. Extinguishing is considered correct when a magnet is dropped inside the Deposition Slot.

✓ **Incorrect Detection (iD):**

iD is the total number of fires incorrectly detected. It is considered incorrect detection when the robot beeps without presence of any fire or when the robot doesn't beep in the presence of a fire.

✓ **Incorrect Extinguishment (iE):**

iE is the total number of fires incorrectly extinguished. It is deemed incorrect extinguishing when the robot drops the magnet anywhere in the arena instead of dropping it in the deposition slot.

✓ **Bonus (B):**

B are the bonus points awarded for every fire which is both correctly detected and correctly extinguished.

✓ **Penalty (P):**

P is penalty where thirty points are deducted each time the robot dashes against the walls or displaces any part of the arena during the run.

✓ **Overall Bonus Points (OB):**

100 Bonus points will be awarded, if the robot does **ALL** of the following:

- Detects all fires correctly.
- Extinguishes all fires correctly.
- Completes task before 10 minutes.
- Doesn't incur any penalties.
- Returns to HOME position and sounds a continuous buzzer of more than 5 seconds.

ALL THE BEST...!!!