



RoboCup@Home

Rules & Regulations

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About this rulebook

This is the official rulebook of the RoboCup@Home competition 2024. It contains the tests performed by the robots and the scoring associated with it. But excludes the organisational details, which can be found in the COMPETITION ORGANISATION DOCUMENT. The rulebook has been written by the 2024 RoboCup@Home Technical Committee.

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Chapter 1

Introduction

1.1 RoboCup

ROBOCUP is an international joint project to promote AI, robotics, and related fields. It is an attempt to foster AI and intelligent-robotics research by providing standard problems where a wide range of technologies can be integrated and examined. More information can be found at <http://www.robocup.org/>.

1.2 RoboCup@Home

The ROBOCUP@HOME league aims to develop service and assistive robot technology with high relevance for future personal domestic applications. It is the largest international annual competition for autonomous service robots and is part of the RoboCup initiative. A set of benchmark tests is used to evaluate the abilities and performance of different robots in a realistic, non-standardized home environment setting. The focus is on, but is not limited to, the following domains: human-robot interaction and cooperation, navigation and mapping in dynamic environments, computer vision and object recognition under natural light conditions, object manipulation, adaptive behaviors, behavior integration, ambient intelligence, standardization and system integration. The competition is co-located with the RoboCup symposium.

1.3 Competition

The competition consists of two *Stages* and a *Final*. Each stage consists of a series of *Tests* that are being held in a daily life environment. The best teams from *Stage I* advance to *Stage II*, which consists of more difficult tests. The competition ends with the *Final*, where only the two highest-ranked teams of each league compete to select the winner.

Chapter 2

General Rules and Regulations

These are the general rules and regulations for the competition in the ROBOCUP@HOME league. Every rule in this section can be considered to implicitly include the term “*unless stated otherwise*”. This means that additional or contrary rules, in particular with respect to the specification of tests, have a higher priority than those mentioned in the general rules and regulations.

2.1 Scenario

Most competition tests take place in the ROBOCUP@HOME *Arena*, but some tests may take place outside, in a previously unknown public place. In this section, the *Arena* and its contents are described, in particular the furnishing and other information that is common between tests and leagues.

2.1.1 RoboCup@Home Arena

The ROBOCUP@HOME *Arena* is a realistic home setting (an apartment) consisting of interconnected rooms. The minimal configuration consists of:

- a bedroom,
- a dining room,
- a living room, and
- a kitchen

There is usually one *Arena* per league. Depending on the local organization, there may also be multiple *Arenas* that may be different from each other, and a robot must be prepared to perform any task in any *Arena*.

The arena is arranged and decorated to resemble a typical apartment in the hosting country, including all necessities and decorations one can expect to find in a *normal* home. Note that what is considered *normal* may vary greatly based on the culture and location where ROBOCUP is hosted. Decorations may include, but are not limited to, plants, mirrors, paintings, posters, plates, picture frames, wall clocks, candles with holders, and books.

2.1.2 Walls, Doors, and Floor

The indoor home setting will be surrounded by high and low *walls*, which are built up using standard fair construction material.

1. **Walls:** Walls are fixed and cannot be modified during the competition. The minimum wall height is 60 cm; a maximum height is not specified, but must allow the audience to watch the competition.
2. **Doors:** Inside the *Arena*, rooms are connected by doors (at least one). All doors have handles, not knobs, and can be closed at any time; it is thus expected that robots are either able to open them or find a plan around them.
3. **Floor:** The floor and doorways of the *Arena* are even, so there are no significant steps or stairways; however, minor unevenness, such as carpets, transitions in floor covering between different areas, and minor gaps (especially at doorways) can be expected.
4. **Appearance:** The floor and walls are mostly monochromatic, but may contain textures, such as a carpet on the floor, or a poster or picture on the wall.

2.1.3 Furniture

The *Arena* is furnished with typical objects common for the host country. The minimal configuration consists of:

- a bed,
- a couch,
- a small table,
- a small dinner table with two chairs,
- two trash bins,
- an open cupboard or a small table with a television and remote control,
- a cupboard with drawers,
- a bookcase, and
- a coat rack

The *Arena*'s kitchen has:

- a dishwasher,
- a microwave,
- a sink, and
- a refrigerator (with some cans and plastic bottles inside)

A typical *Arena* setup is shown in Figure [2.1a](#).

Cupboard

The cupboard can be any shelf-like furniture in which objects can be placed, such that the minimum distance between shelves is 30 cm and at least two drawers are between 90 cm and 120 cm from floor level. The cupboard may have doors.

Fridge

At least one powered and functioning fridge is required in the *Arena*. The fridge must not be smaller than 120 cm.



Figure 2.1: An example of a ROBOCUP@HOMEScenario

2.1.4 Changes to the *Arena*

Since robots should be able to function in the real world, the *Arena* is not fixed and might change without further notice.

1. **Major changes:** Any furniture (at a *Predefined Location* or not) that cannot be expected to be fully static in an everyday environment might be moved slightly between tests. In particular, furniture will not change rooms or move drastically inside a room, but a couch or table may be slightly rotated or moved; fixed locations for such furniture items should not be assumed. Walls will stay in place and rooms will not change function. Passages might be blocked.
2. **Minor Changes:** Slightly moved chairs, slightly closed doors, or anything similar cannot be avoided and might happen at any time, even during a test.

2.1.5 Objects

Some tests in the RoboCup@Home league involve recognizing and manipulating objects (see Figure Figure 2.1b). The TC will compile a list of at least 30 objects for this purpose; the list will contain a picture of the each object, as well as its official name and *Object Category* (for instance, an *Apple* belongs to the *Fruits* category). Most objects are likely to be lightweight and easy to grasp with one hand. Every *Object Category* has an assigned *Predefined Location*, where objects of that category can usually be found during tests (for example, an *Fruits* can be found on the *Kitchen Table*); assignments are announced during the *Setup Days* (see COMPETITION ORGANISATION DOCUMENT).

Objects are provided at the competition for training. Teams may keep at most five training objects at a time and for at most one hour. Modifying the training objects is not allowed.

Two types of objects are used in the tasks:

1. **Known Objects:** Objects previously known to the robot, divided into:
 - 1.1. **Consistent Objects:** Objects whose image appears in the list of objects.
 - 1.2. **Similar Objects:** Objects whose image is not present in the list of objects, but look similar enough to one of them that a person would consider them the same kind of

object. For example, an apple whose color is different from the apple in the list of objects, or a piece of cloth with a different pattern.

- 1.3. **Standard Objects:** Objects chosen from the *YCB Dataset*.¹ They are published 6 months in advance on the ROBOCUP@HOME website², so that they can be acquired and trained beforehand.
2. **Unknown Objects:** Any other object that is not in the object list but can be grasped or handled (e.g., *Arena* decorations).

The minimal configuration of *Known Objects* consists of:

- **Tableware:** Dish, bowl, cup (or mug), and napkin (see Figure 2.2a).
- **Cutlery:** Fork, knife, and spoon.
- **Trash Bags:** Big plastic trash bags, preferably with a handle.
- **Bags:** Lightweight and with stiff, vertical handles (see Figure 2.2b).
- **Disks or books:** A set of discs (LP, CD, DVD, or BluRay) or books.
- **Coat rack:** A rack or pole to hang coats and other clothes.
- **Trays:** A transport object such as a tray or basket, intended for bimanual manipulation (see Figure 2.2c).
- **Pourable:** An object whose content can be poured (such as a cereal box).
- **Heavy object:** Weight between 1.0kg and 1.5kg.
- **Tiny object:** A lightweight object that is not bigger than 5 cm (such as paper, a teabag, or a pen).
- **Fragile object:** An easy-to-break object, (such as a chocolate egg).
- **Deformable object:** A flexible object that may take different shapes (such as cloth).
- **Garbage bag:** A garbage bag that can be tied.



Figure 2.2: Example of object containers

During the competition, objects can be requested based on their *Object Category*, physical attributes, or a combination of both. Relevant attributes to be used are:

- Color (such as red, blue, black with white dots, etc.).
- Relative estimated size (smallest, largest, big one, etc.).
- Relative estimated weight (lightest, heaviest).

¹<http://www.ycbbenchmarks.com/object-set/>

²<https://athome.robocup.org/standard-objects>

- Relative position (left of, rightmost, etc.).
- Object description (is fragile, is a container, can be poured, requires two hands, etc.).

Remark: Measurements are estimations and based on common sense. It is OK for robots to consider similar objects to be about the same size or weight.

2.1.6 Predefined Rooms and Locations

Some tests in the RoboCup@Home league involve a *Predefined Location* where people or objects can be found. There will also be at least two *doors*, named an *Entrance* and an *Exit*, which lead in and out of the *Arena*, respectively. Room names, predefined locations, and location classes are announced during the *Setup Days* (see COMPETITION ORGANISATION DOCUMENT).

2.1.7 Predefined Person Names

Some tests in the RoboCup@Home league involve memorizing a person's name. All people in the *Arena* have an assigned *Predefined Name* chosen by the TC. The list of names contains 25 % male, 25 % female, and 50 % gender-neutral names taken from the list of most commonly used names in the United States. Predefined names are announced during the *Setup Days* (see COMPETITION ORGANISATION DOCUMENT).

2.1.8 Wireless network

For wireless communication, an *Arena Network* is provided. The actual infrastructure depends on the local organization. Reliability and performance of the network is not guaranteed; robots are expected to be able to run without a wireless network.

The following rules apply:

- Only the *Arena Network* can be used during tests.
- Only the active team in a task is allowed to use the *Arena Network*.
- The *Arena Network* provides one Virtual Local Area Network (VLANs) per team.
- Each VLAN is most likely to have its own SSID/password.
- VLAN traffic is separated from any other team and is routed to the team's network cable in the team area.
- Each VLAN is also connected to the Internet.

Teams broadcasting unauthorized (aka rogue) wireless networks will be disqualified from the competition and their devices may be temporarily confiscated by the OC; this includes smart-phones and concealed SSIDs. It is thus advised to verify your devices for any breaches of this nature.

2.2 Deus Ex Machina: Bypassing Features With Human Help

Because the Show Must Go On

Robots can't score unless they accomplish the main goal of a task. However, in many real-life situations, a minor malfunction may prevent the robot from accomplishing a task. To prevent this situation, while fostering awareness and human-robot interaction, robots are allowed to request human assistance during a test.

2.2.1 Procedure

The procedure to request human assistance while solving a task is as follows:

1. **Request help:** The robot must indicate loud and clear that it requires human assistance. It must be clearly stated:
 - The nature of the assistance
 - The particular goal or desired result
 - How the action must be carried out (when necessary)
 - Details about how to interact with the robot (when necessary)
 - Detailed information to identify objects for picking and placing (e.g. object name, color or location). The provided information needs to show that objects were perceived by the robot.
2. **Supervise:** The robot must be aware of the human's actions, being able to tell when the requested action has been completed, as well as guiding the human assistant (if necessary) during the process.
3. **Acknowledge:** The robot must politely thank the human for the assistance provided.

Example

In the following example, a robot has to clean the table but is unable to grasp the spoon.

R: I am sorry, but the spoon is too small for me to take.
 Could you please help me with it?
 Please say "robot yes" or "robot no" to confirm.

H: *Robot, yes!*

R: Thank you! Please follow my instructions.
 Please take the purple spoon from the table. It is on my left.
 (The robot also shows the result of the perception, e.g. by pointing at the spoon or showing a picture with a bounding box on the screen)

H: (Referee takes purple spoon)

R: I saw you took the spoon.
 Would you be so kind as to follow me to the kitchen?
 Please keep the spoon visible in front of you so I can track you. Thank you!

R: You can stop following me now.
 As you can see, the dishwasher is already open.
 Please place the spoon in the gray basket on the lower tray.

R: Lovely! Thanks for your help.
 I'll let you know if I need further assistance.

2.2.2 Scoring

There is no limit in the amount of times a robot can request human assistance, but score reduction applies every time it is requested.

1. **Partial execution:** A reduction of 10% of the maximum attainable score is applied when the robot request a partial solution (e.g. pointing to the person the robot is looking for or placing an object within grasping distance). The referee decides whether the requested action is simple enough to corresponds to a partial execution or not.

2. **Full awareness:** A reduction of 20% of the maximum attainable score is applied when the robot is able to track and supervise activity, detecting possible, and when the requested action has been completed.
3. **No awareness:** A reduction of 30% of the maximum attainable score is applied when the robot has to be told when the requested action has been completed.
4. **Bonuses:** No bonus points can be scored when the robot requests help to solve part of a task that normally would grant a bonus.
5. **Score reduction overlap:** The score reduction for multiple requests of the same kind do not stack, but overlap. The total reduction applied correspond to the worse execution (higher reduction of all akin help requests). This means, a robot won't be reduced again for requesting help to transport a second object, but a second reduction will apply when the robot asks for a door to be opened.
6. **Allowed types of assistance:** The types of assistance allowed in a given task are specified in the respective task description. It should be noted that only the assistance types explicitly mentioned in a task description are actually allowed in a task; other types of assistance are not allowed and will nullify the obtained points for the part of the task in which they are applied. For instance, if a task focused on manipulation does not explicitly mention a Deus Ex Machina penalty for instructing a person to perform a manipulation activity, it should not be assumed that this is a loophole that can be exploited.

2.2.3 Bypassing Automatic Speech Recognition

Giving commands to the robot is essential in many tests. When the robot is not able to receive spoken commands, teams are allowed to provide means to bypass ASR via an Alternative method for HRI (see Section 2.2.3). Nonetheless, Automatic Speech Recognition is preferred.

The following rules apply in addition to the ones specified in section Section 2.2.2

1. **ASR with Default Operator:** No score reduction. The command is given by the human operator who must speak (not shout) loud and clear. The *default operator* may repeat the command up to three times.
2. **ASR with Custom Operator:** A reduction of 10% of the maximum attainable score is applied when a *custom operator* is requested. The Team Leader chooses a person who gives the command *exactly as instructed by the referee*.
3. **Gestures:** A reduction of 20% of the maximum attainable score is applied when a gesture (or set of gestures) is used to instruct the robot.
4. **QR Codes:** A reduction of 30% of the maximum attainable score is applied when a QR code is used to instruct the robot.
5. **Alternative Input Method:** A reduction of up to 30% of the maximum attainable score is applied when a *alternative HRI interface*, is used to instruct the robot. Alternative HRI interfaces (see Section 2.2.3) must be previously approved by the TC during the Robot Inspection (see COMPETITION ORGANISATION DOCUMENT).

Alternative interfaces for HRI

Alternative methods and interfaces for HRI offer a way for a robot to start or complete a task. Any reasonable method may be used, with the following criteria:

- **Intuitive to use and self-explanatory:** a manual should not be needed. Teams are not allowed to explain how to interface with the robot.
- **Effortless use:** Must be as easy to use as uttering a command.
- **Is smart and preemptive:** The interface adapts to the user input, displaying only the options that make sense or that the robot can actually perform.
- Exploits the best of the device being used (eg. touch screen, display area, speakers, etc.)

Preferably, the alternative HRI must be also adapted to the user. Consider localization (with English as the default), but also potential users of service robots at their home. For example: elderly people and people with physical disabilities.

Award: The best alternative is awarded the Best Human-Robot Interface award (Section ??).

Chapter 3

Tests in Stage I

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3.1 Carry My Luggage

The robot helps the operator to carry some luggage to a car which is parked outside.

Main Goal: The robot helps the operator to carry a bag to a car parked outside.

Optional Goals:

1. Re-entering the arena
2. Following the queue on the way back to the arena

Focus

Person following, navigation in unmapped environments, social navigation.

Setup

- **Locations:**
 - The test takes place both inside and outside the *Arena*.
 - The robot starts at a predefined location in the living room.
- **People:** The operator is standing in front of the robot and is pointing at the bag to be carried outside.
- **Objects:** At least two bags are placed near the operator (within a 2m distance and visible to the robot).

Procedure

1. **Picking up the bag:** The robot picks up the bag pointed at by the operator.
2. **Following the operator:** The robot should inform the operator when it is ready to follow them. The operator walks naturally towards the car; after reaching the car, the operator takes the bag back and thanks the robot.
3. **Obstacles:** The robot will face 4 obstacles along its way (in arbitrary order): (a) a small object on the ground, (b) a hard-to-see object, (c) a crowd of people obstructing the path outside, and (d) a small area blocked using retractable barriers.
4. **Optional goals:**
 - 4.1. **Re-entering the arena:** The robot returns to the arena, going back in through the entrance.
 - 4.2. **Following the queue:** After the robot has reached the car, a few of the people that formed the crowd obstructing the robot return to the arena in a queue. The robot can decide to join the queue on its way back to the arena, in a manner that appears natural to the people in the queue.

Additional Rules and Remarks

1. **Car location:** There is no real car outside; instead, a fixed location outside the *Arena* is designated as a car location.
2. **Reaching the car:** The robot can reach the car location only by following the operator (the location is unknown before the test).

3. **Deus ex Machina:** Score reductions for human assistance are applied in case the robot loses the operator, and needs to find them again through:

- 3.1. Natural interaction (e.g., waving and calling)
- 3.2. Unnatural interaction (e.g., raising both hands and jumping)
- 3.3. Touching the robot (e.g., pulling the robot's hand)

Referee Instructions

The referees need to:

- Select one volunteer to act as the operator.
- Select three to four people to obstruct the robot's path outside and form the queue on the way back to the arena.
- Choose positions for the bags and assign a bag to the operator.
- Choose the order of the obstacles that the robot will face outside while following the operator.
- Designate a location outside as a car location.
- Designate a location for the queue to form returning into the arena. The queue is composed of the same people that form the crowd.
- Mind the robot when it goes outside the *Arena*.

OC Instructions

At least two hours before test:

- Select and announce the robot's starting point.
- Select which bags will be used in the test.

Score Sheet

The maximum time for this test is 5 minutes.

Action	Score
<i>Main Goal</i>	
Perceiving the correct beg (visualize on screen or say which one)	15
Picking up the correct bag	100
Following the person to the car	300
Avoiding the crowd of people obstructing the path	50
Avoiding the small object on the ground	50
Avoiding the hard-to-see object	50
Avoiding the area blocked with retractable barriers	50
<i>Bonus rewards</i>	
Re-entering the arena	100
Joining and staying in the queue on the way to the arena	300
<i>Penalties</i>	
Dropping the bag	-50
<i>Deus Ex Machina Penalties</i>	
Rediscovering the operator by natural interaction	-50
Rediscovering the operator by unnatural interaction	-100
Rediscovering the operator by direct contact	-200
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	1015

3.2 General Purpose Service Robot

The robot is asked to understand and execute commands requiring a wide range of different abilities.

Main Goal: Execute 3 commands requested by the operator.

Optional Goals:

1. Understand a command given by a non-expert operator.

Focus

Task planning, object/people detection and recognition, object feature recognition, object manipulation

Setup

- **Locations:**

- **Task location:** The task takes place inside the *Arena*, but some commands may require the robot to go out. The *Arena* is in its nominal state for this task.
- **Start location:** The robot starts outside the *Arena*. When the door opens, the robot moves towards the *Instruction Point*.
- **Instruction point:** At the beginning of the test, as well as after finishing the first and second command, the robot moves to the *Instruction Point*.

- **People:**

- **Operators:** A *Professional Operator* (the referee) commands the robot to execute a task. Optionally, commands can be issued by a *Non-Expert Operator*, i.e. a person from the audience with no robotics background. In this case, the referee gives the goal of the command to the non-expert operator, who will then issue it to the robot in their own words. For example, the generated command might be “Bring me a coke from the kitchen.” then the non-expert operator will be told “The robot should bring you a coke, which is found in the kitchen.”, who then tells the robot “I want a coke. Go to the kitchen and get me one.” If the robot consistently fails to understand the non-expert operator (e.g. after two retries), teams can default to a custom operator.

Procedure

1. **Instruction point:** At least two hours before the test, the referees announce the location of the *Instruction Point*.
2. **Test start:** The robot moves to the *Instruction Point* when the arena door is open.
3. **Command execution:** The operator instructs the robot to execute a command and the robot performs the task.
4. **Back to the instruction point:** The robot goes back to the *Instruction Point* and waits for the next command.

Additional Rules and Remarks

1. **Partial scoring:** The main task allows partial scoring (per *completed* command).
2. **Command generator:** Tasks will be generated using the official command generator¹.
3. **Non-expert operators:** Referees are not allowed to instruct non-expert operators on how to operate the robot. Teams attempting to instruct or bias the operator will be disqualified from the task.
4. **Deus ex Machina:** The scores are reduced if human assistance is received, in particular for:
 - using a custom operator
 - bypassing speech recognition by using an alternative HRI
 - receiving human assistance to accomplish a task (score reduction is applied consistent with the other tasks in this rulebook)
 - instructing a human assistant to perform the whole task

Referee Instructions

- Provide the commands to the operators.

OC Instructions

At least two hours before the test:

- Generate the robot commands (don't reveal them to the teams!).
- Announce the location of the instruction point.
- Recruit volunteers to assist during the test.

During the test:

- Rearrange the arena so that it is in its nominal condition before each command.

Score Sheet

The maximum time for this test is 5 minutes.

¹<https://github.com/johaq/CommandGenerator>

Action	Score
<i>Main Goal</i>	
Executing the task associated with each command	3×400
<i>Bonus Rewards</i>	
Understanding a command given by a non-expert operator	3×100
<i>Deus Ex Machina Penalties</i>	
Using a custom operator	3×-50
Bypassing speech recognition	3×-50
Instructing a human to perform parts of the task will apply a percentage penalty according to similar penalties in other Stage I tests.	3×-400
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	1500

3.3 Receptionist

Description

The robot has to take two new guests to the living room to introduce them and offer a free place to sit.

Main goal: Introduce and usher two newcomers to a party and maintain appropriate gaze direction (at person, direction of navigation).

Optional goals:

1. Open the entrance door for each arriving guest.
2. Describe the first guest for the second guest.

Focus

System Integration, Human-Robot Interaction, Person Detection, Person Recognition

Setup

- **Location:**
 - The test takes place in the living room.
 - The robot starts inside the *Arena* at a predefined location near the entrance door.
 - **Entrance:** The entrance door is open by default. The team leader can request to close the door to score additional points by opening it for the guests.
- **People:**
 - **Host:** The host's name and favorite drink will be announced before the test. The host is already sitting in the living room.
 - **Guests:** Both guests have a name and favorite drink. An arriving guest will either step in front of the robot or ring the bell if the door is closed. Guests have to be guided to the living room to be introduced. Each of the guest will arrive separately. The sound of the bell will be provided to teams during setup period before competition.

Procedure

- **Introductions:** When introducing guests, the robot must clearly identify the person being introduced and state their name and favorite drink. Introducing two people means to introduce them to each other.
- **Seating People:** The robot must point at a place or location where the guest can sit.
- **Switching Places:** Guests may switch places after they were seated.
- **Describing the First Guest:** Naming at least 4 characteristics of the first guest, i.e., color of clothes, color of hair, gender, and age, earns bonus points.
- **Looking at person/direction of navigation:** During verbal interactions and descriptions of people, robot looks at the conversational partner. Robot can point at the person being introduce/described or alternate gaze between two people. During navigation robot looks in the direction where it is going. Persistently gazing towards unrelated person or incorrect direction while moving during the task deducts points.

Additional rules and remarks

1. **Misunderstanding:** Not understanding the guests and asking them again is fine. Continuing with a wrong name or drink causes a score reduction of 50pts.
2. **Partial Scoring:** The main task allows partial (per guest) scoring.
3. **Deus ex Machina:** Score reduction applies per guest as follows:
 - **Custom Operator:** Since the main focus of the test is HRI, no custom operator can be chosen.
 - **Alternative HRI:** Using an alternative HRI to understand a guest causes a score reduction of 75pts.
 - **Recognizing People:** If the robot has to ask for help to identify people, score is reduced by 200pts.

Instructions

To Referee

The referees need to:

- Assign name and drink to 3 volunteers.
- Arrange (and re-arrange) people in the living room.
- Open the door when requested by the robot.

To OC

During setup day:

- Provide the doorbell sound.

At least two hours before test:

- Announce starting position.
- Announce host's name and favorite drink.
- Recruit volunteers as host and guests.

Score sheet

The maximum time for this test is 5 minutes.

Action	Score
<i>Main Goal</i>	
Navigate to the door, when the door bell rings	2×15
Guide the guest to the other guests (navigate to the guest group)	2×100
Look in the direction of navigation or at the navigation goal	2×50
Introduce a new guest to every other guest	2×50
Offer a free seat to the new guest	2×100
Look at the person talking	2×25
Look at the person the robot is introducing the guest to	2×50
Qualitative robot social performance (see sec. ??)	50
<i>Bonus Rewards</i>	
Open the entrance door for a guest	2×100
Describe the first guest to the second guest	150
<i>Penalties</i>	
Wrong guest information was memorized (continue with wrong name or drink)	-50
Persistent inappropriate gaze (away from conversational partner)	-50
Persistent gaze not in the direction of the navigation while moving.	-10
<i>Deus Ex Machina</i>	
Alternative HRI	2×-75
Not recognizing people	2×-200
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Total Score (excluding special penalties & standard bonuses)	1180

3.4 Serve Breakfast

The robot has to set a table for breakfast for one person and prepare cereal for them.

Main Goal: Place breakfast items on a table (bowl, spoon, cereal box, and milk carton) and prepare cereal.

Optional Goals:

1. Pour milk into the bowl
2. Place the spoon next to the bowl

Focus

Object perception, manipulation, and task planning.

Setup

- **Locations:**
 - **Start location:** Before the test, the robot waits outside the *Arena* and navigates to the kitchen when the door is open.
 - **Test location:** The test itself takes place in the kitchen.
- **People:**
 - No people are involved in the test unless the robot requires human assistance.
- **Furniture:**
 - **Table:** The robot serves breakfast on the table which is announced beforehand.
 - **Chairs:** Chairs may be placed around the table and won't be removed.
 - **Doors:** The robot does not need to open any doors to find the breakfast items.
- **Objects:**
 - All objects used in the test are in their predefined locations when the test starts.

Procedure

1. **Table selection:** At least two hours before the test, the referees announce the surface that will be used as a table.
2. **Test start:** The robot moves to the kitchen when the arena door is open.
3. **Serving breakfast:** To serve breakfast, the robot has to place breakfast items on a table (bowl, spoon, cereal box, and milk carton).
4. **Pouring cereal:** After placing the breakfast items on the table, the robot should pour cereal into the bowl.
5. **Optional goals:**
 - **Pouring milk:** After pouring cereal, the robot pours milk into the bowl in order to fully prepare the breakfast.

- **Placing the spoon next to the bowl:** In principle, the spoon can be placed anywhere on the table, but placing it next to the bowl is desired so that it is easily reachable by a person.

Additional Rules and Remarks

1. **Safe placing:** Objects must be placed with care, namely the robot should place rather than throw or drop objects.
2. **Deus ex Machina:** The scores are reduced if human assistance is received, in particular for:
 - pointing to an object or telling the robot where an object is or where to place it
 - handing an object over to the robot
 - having a human place objects on the table
 - having a human pour cereal into the bowl

OC Instructions

During the *Setup Days*:

- Provide official cutlery and tableware for training.

At least two hours before the test:

- Announce the table that will be used.
- Announce a rough location of the table.

Referee Instructions

The referee needs to:

- Remove all objects from the table.
- Place all objects in their default locations.

Score sheet

The maximum time for this test is 5 minutes.

Action	Score
<i>Main Goal</i>	
Initial navigation to pick up area	15
Perceiving object and categorizing it correctly (visualize or say)	4×15
Picking up breakfast items for transportation to the table	4×50
Placing breakfast items on the table	4×50
Pouring cereal into the bowl	300
<i>Bonus Rewards</i>	
Pouring milk into the bowl	300
Placing a spoon next to the bowl	100
<i>Penalties</i>	
Throwing or dropping an object on the table	4×-30
Spilling cereal while pouring	-100
Spilling milk while pouring	-100
<i>Deus Ex Machina Penalties</i>	
Pointing at an object	4×-5
Handing an object over to the robot	4×-20
A human placing an object on the table	4×-60
A human pouring cereal in the bowl	-100
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	1175

3.5 Storing Groceries

The robot stores groceries into a cabinet with shelves. Objects are sorted on the shelves based on similarity, for instance an apple is stored next to other fruits.

Main goal: Move five objects from a table to the cabinet, grouping them by category or similarity.

Optional goals:

1. Opening the cabinet door
2. Moving a *tiny* object
3. Moving a *heavy* object

Focus

Object detection and recognition, object feature recognition, object manipulation.

Setup

- **Locations:**
 - **Start location:** Before the test, the robot waits outside the *Arena* and navigates to the testing area when the door is open.
 - **Test location:** The testing area has a cabinet and a table nearby.
- **People:**
 - No people are involved in the test, unless the robot requires human assistance.
- **Furniture:**
 - **Table:** The table has 5–10 objects placed on it and the robot can choose which ones to grasp and in what order. On small tables, objects will be added as the robot frees up space.
 - **Cabinet:** The cabinet contains objects arranged in groups — either by category or likeliness — on different shelves.
 - **Cabinet door:** The cabinet door is open by default, but the team leader can request the door to be closed and score additional points for opening it. If the robot fails to open the door, it must clearly state this and request the referee to open it.
- **Objects:**
 - **Table objects:** The object on the table are arranged arbitrarily.
 - **Cabinet objects:** Some of the objects are placed behind the cabinet door and cannot be accessed unless the door is open.

Procedure

1. **Table location:** At least two hours before the test, the referees announce the table and cabinet that will be used in the test, as well as a rough location of the table.

2. **Cabinet door; heavy and/or tiny object:** Half an hour before the test, the team informs the referees:
 - whether the cabinet door should be closed
 - whether a heavy and/or a tiny object should be used in the test
3. **Test start:** The robot moves to the testing area when the arena door is open.
4. **Storing groceries:** After identifying the table (and optionally opening the cabinet door), the robot moves the objects from the table to the cabinet.

Additional rules and remarks

1. **Table:** The table's rough location will be announced beforehand, having its position to the left, right, or behind the robot.
2. **Incorrect categorization:** The score is reduced if an object is stored on the cabinet, but not on a shelf with similar objects; this reduction is applied per incorrectly stored object.
3. **New category:** Objects that do not semantically belong to any of the categories represented on the shelves should be grouped together on a new shelf.
4. **Deus Ex Machina:** The scores are reduced if human assistance is received, in particular for:
 - telling or pointing out to the robot where to place an object
 - moving an object instead of the robot

OC Instructions

At least two hours before the test:

- Announce which table and cabinet will be used in the test.
- Announce a rough location for the table.

Referee Instructions

The referee needs to:

- Place 5–10 objects on the table.
- Place objects in the cabinet, grouping them by category or likeliness.
- Open the door of the cabinet (unless the team wants it closed).

Score sheet

The maximum time for this test is 5 minutes.

Action	Score
Main Goal	
Navigating to the table	15
Perceiving object and categorizing it correctly (visualize or say)	5×15
Picking up an object for transportation to the cabinet	5×50
Perceiving objects in shelf and saying on which layer the currently handled object should be placed (visualize or say)	5×15
Placing an object in the cabinet	5×15
Placing an object next to similar objects on the cabinet	5×50
Bonus Rewards	
Opening the cabinet door without human help	200
Picking and placing a tiny object	100
Picking and placing a heavy object	100
Penalties	
Storing an object without categorizing it correctly	5×−60
Deus Ex Machina Penalties	
A human handing an object over to the robot (the object is clearly indicated by the robot)	5×−15
A human handing an object over to the robot	5×−30
A human placing an object in the cabinet at a location clearly indicated by the robot	5×−45
A human placing an object in the cabinet	5×−90
A human placing an object in the cabinet at a location clearly indicated by the robot	5×−30
A human pointing at a target location	5×−45
Special Penalties & Bonuses	
Not attending (see sec. ??)	−500
Using alternative start signal (see sec. ??)	−100
<hr/>	
Total Score (excluding special penalties & standard bonuses)	1140

Chapter 4

Tests in Stage II

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4.1 Clean the Table

The robot has to remove all dishes and cutlery from a table and place them into the dishwasher.

Main goals: All tableware and cutlery on the table is placed inside the dishwasher (five objects in total).

Optional goals:

1. Opening the dishwasher door
2. Pulling out the dishwasher rack
3. Placing the items in the dishwasher correctly
4. Placing a dishwasher tab inside the dishwasher

Focus

Object perception, manipulation in narrow spaces, and task planning.

Setup

- **Locations:**
 - **Test location:** This test takes place in the kitchen.
- **People:**
 - No people are involved in the test, unless the robot requires human assistance.
- **Furniture:**
 - **Dining table:** A dining table is located close to the dishwasher.
 - **Tray:** A plastic tray, which may have other tableware and cutlery placed inside, is located either on top of the dishwasher or on one of the racks. Objects can be placed either in the dishwasher rack or in the tray, based on the team's choice.
- **Objects:**
 - **Table setting:** The table has a total of five objects disposed in a typical setting for a meal for one person. The object distribution is as follows:
 - * *Silverware:* Any two objects (fork, knife, or spoon).
 - * *Tableware:* Any three objects (except silverware), at least one of which is a dish.
 - **Dishwasher tab:** The tab can be found at a location that is announced before the test and should be autonomously placed inside the tab slot in the dishwasher.

Procedure

1. **Dishwasher door and rack:** Half an hour before the test, the team informs the referees:
 - whether objects will be placed in the dishwasher rack or in the tray
 - whether the dishwasher door should be closed and, if the door is open, whether the rack should be pushed in
2. **Test start:** The robot moves to the kitchen when the arena door is open.

3. **Table clean up:** The robot cleans the table by putting all items that are on it in the dishwasher.

Additional Rules and Remarks

1. **Safe placing:** Objects must be placed with care, namely the robot should place rather than throw or drop objects.
2. **Dishwasher:** The team decides whether the robot will place the objects in the dishwasher's rack or in the plastic tray.
3. **Dishwasher door:** The dishwasher door is open and with the racks pulled out by default. The team leader can, however, request the dishwasher to be closed for bonus points. If the robot fails to open the door, it must clearly state this and request the referee to open the door.
4. **Correct item placement:** The items should be placed in the rack/tray correctly, namely in the location and in a manner as a person would put them.
5. **Deus ex Machina:** The scores are reduced if human assistance is received, in particular:
 - pointing to an object or telling the robot where an object is
 - handing an object over to the robot

OC Instructions

During the *Setup Days*:

- Provide official cutlery and tableware for training.

At least two hours before the test:

- Announce the predefined location of the dishwasher tab.

Referee Instructions

The referee needs to:

- Place objects on the table.
- Place the plastic tray on the dishwasher or on a rack, as requested by the team.

Score sheet

The maximum time for this test is 10 minutes.

Action	Score
<i>Main Goal</i>	
Navigate to the table to pick up items	15
Picking tableware (cup, bowl) for transportation to the dishwasher	2×40
Picking up a plate for transportation to the dishwasher	50
Picking up cutlery (spoon, fork) for transportation to the dishwasher	2×80
Placing the tableware and cutlery inside the dishwasher	5×50
Placing an item correctly (cleanable, convenient like a human would) in the dishwasher	5×50
<i>Bonus Rewards</i>	
Pulling out the dishwasher rack	100
Pushing in the dishwasher rack	100
Opening the dishwasher door	200
Closing the dishwasher door	200
Picking up the dishwasher tab for transportation to the dishwasher	100
Placing the dishwasher tab inside the dishwasher's hatch intended for the tab	200
<i>Deus Ex Machina Penalties</i>	
Pointing at an object or telling the robot where an object is	5×−20
Handing an object over to the robot	5×−70
Placing an object	5×−180
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	−500
Using alternative start signal (see sec. ??)	−100
<hr/>	
Total Score (excluding special penalties & standard bonuses)	1705

4.2 Enhanced General Purpose Service Robot

The robot is asked to maintain the household by cleaning up the arena and assisting people.

Main Goal: Solve 3 problems in the arena.

Focus

Task planning, object/people detection and recognition, object feature recognition, object manipulation

Setup

The arena is in its default state apart from problems set up for the robot to solve:

1. Problems:

- **Objects:** Objects that are not in their default location should be returned there (see 2.1.5). Objects on the floor are to be thrown in the trash or returned to their default location.
- **Persons:** Some persons in the arena will have requests for the robot. They will raise their hand if the robot is in the same room.

Procedure

1. **Test start:** The robot enters when the arena door is open.
2. **Finding Problems:** The robot has to find problems to solve on its own.

Additional rules and remarks

1. **Partial scoring:** The main task allows partial scoring (per *solved* problem).
2. **Command generator:** Problems and commands will be generated using the official command generator¹.

Referee instructions

- Setup the problems in the arena.
- Provide commands to volunteers.

OC instructions

At least two hours before the test:

- Generate the problems and commands (don't reveal them to the teams!).
- Recruit volunteers to assist during the test.

¹<https://github.com/johaq/CommandGenerator>

Score sheet

The maximum time for this test is 10 minutes.

Action	Score
<i>Main Goal</i>	
Find and clearly state an encountered problem	3×150
Solve a problem	3×650
<i>Deus Ex Machina Penalties</i>	
Asking for location of a problem	3×-200
Instructing a human to perform parts of the task will apply a percentage penalty according to similar penalties in other Stage II tests.	3×-800
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	2400

4.3 Restaurant

Description

The robot retrieves and serves orders to several customers in a real restaurant previously unknown to the robot.

Main goal: Detect calling or waving customer, reach a customer's table without prior guidance/training. Take and serve all orders.

Optional goal: Use an unattached tray to transport the order.

Focus

This task focuses on *Task planning*, *Online mapping*, *Navigation in unknown environments*, *Gesture detection*, *Verbal interaction* and *Object manipulation*.

Setup

- **Locations:**

- This task takes place in a real restaurant fully equipped and in business. When this is not possible, the test can be conducted in any place with the appropriate locations other than the *Arena*.
- The *Restaurant* location will remain secret until the start of the test.
- The robot starts next to the *Kitchen-bar*. It is a table located near the restaurant's kitchen.

- **People:**

- A *Professional Barman* (member of the TC) awaits at the other side of the *Kitchen-bar* for orders to be placed. The *Professional Barman* assists the robot on request.
- There may be real customers and waiters around.
- There are at least three tables occupied with professional customers (member of the OC/TC).
- There are at least two tables occupied with regular customers.
- Customers may call the robot any time, even simultaneously.

- **Furniture:** The furniture is not standardized and will be kept the same as the restaurant or place selected for the task.

- **Objects:**

- Objects to fulfill orders are located on the *Kitchen-bar*.
- Orders have two or three objects randomly chosen.
- All edible/drinkable objects from the list of standard objects (see Section 2.1.5) are eligible to be part of the orders.

Procedure

1. The referee requests the team to move the robot to the start location.
2. The referee gives the start signal and starts the timer.
3. The team leaves the area after the start signal.

4. A TC member follows the robot ready to press the emergency stop button.
5. The robot detect calling or waving customer and reach a customer's table.
6. The robot take the customer's order, place the order, and deliver it.
7. **Optionally**, the robot can use an unattached tray to transport the order.

Additional rules and remarks

- **Remarks:**

- This test takes place in a public area. The robot is expected to not even slightly touch anyone or anything and is immediately stopped in case of danger.
- Since this task is performed outside the arena, the time limit may be longer than the others tasks.
- The availability of wireless, external computing devices, or electrical outlets can't be guaranteed. Assume unavailability.
- The robot interacts with the operators, not the team. The team is not allowed to instruct anyone. All instructions should be provided by the robot itself.
- The robot may use up to one minute to instruct the *Professional Barman*.
- The robot can request to be guided to a customer's table.
- The robot can choose to take several orders and place them later on, place an order and pick the next one while the former is being served, or dispatch one order at a time.
- The robot can either transport each object individually, or using a tray. All delivered objects must be placed on the customer's table.
- By default, the barman will place the order in a basket or tray for the robot to deliver it.
- Upon arrival to the restaurant, only the team leader is allowed next to the robot for watching and charging.
- If a person from the audience (severely) interferes with the robot in a way that makes it impossible to solve the task, the teams may repeat the test immediately.
- Each Deus Ex Machina penalty for skipping manipulation will only be applied twice per order so receiving an order with three objects is not more punishing.
- If the robot detects a customer but does not reach their table, the robot must clearly show who was detected to receive points, i.e. displaying a picture of the person.

- **Disqualification:**

- Touching the robot after the start signal.
- Tweaking, coding, debugging, or mapping the area in place.

Instructions:

To Referee

The referee needs to:

- Prepare orders for each client.

To OC

The OC needs to:

- **During Setup days:** Check with local (security) management if the possible location, including a sufficient queuing area, can be used for the restaurant test.
- **1 hour before the test:** Gather all teams and robots to move to some nearby queuing area and instruct the teams how/when to move to the actual test location.

Score sheet

Maximum time:

15 minutes

Action	Score
<i>Regular Rewards</i>	
Detect calling or waving customer	2×100
Reach a customer's table without prior guidance/training	2×100
Take an order.	2×300
Serve an order.	2×300
Qualitative robot social performance (see sec. ??)	50
<i>Bonus Rewards</i>	
Use an unattached tray to transport	2×200
<i>Regular Penalties</i>	
Not making eye-contact when taking an order	2×-100
<i>Deus ex Machina Penalties</i>	
Being guided to a table	2×-200
Asking the Barman to handover object to the robot	4×-100
Guest needing to take the object from a tray or the robot's hand	4×-100
Being told/pointed where is a table/ <i>Kitchen-bar</i>	2×-100
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	2050

4.4 Stickler for the Rules

Description

The robot needs to make sure the house rules are followed.

Main goal: Identify party guests breaking the house rules, politely clarify to the guest what to do and confirm that the guest is following the rule.

Optional goal: Politely clarify to the guest what rule is being broken.

Focus

This task focuses on *Object perception*, *Human perception*, *Action recognition* and *Verbal interaction*.

Setup

- **Locations:**
 - This task takes place inside the *Arena*.
 - The robot starts at a predefined location in the living room.
 - There are a forbidden room in the house.
- **People:**
 - There are at least five party guests inside the *Arena*.
 - Four of the guests are breaking rules.
 - Guests may not follow the robot's instructions.
- **Furniture:** All furniture are in their predefined locations.
- **Objects:** All objects are in their predefined locations.

Procedure

1. The referee requests the team to move the robot to the start location.
2. The referee gives the start signal and starts the timer.
3. The team leaves the area after the start signal.
4. A TC member follows the robot ready to press the emergency stop button.
5. The robot Identify party guests breaking the house rules.
6. The robot politely clarify to the guest what to do.
7. The robot confirm that the guest is following the rule.
8. **Optionally** and **Politely**, the robot clarify to the guest what rule is being broken.

Additional rules and remarks

- **House Rules:**
 1. *No shoes inside the house.*
Policy: All guests have to take off their shoes at the entrance.
Action: Take the guests to the entrance and verify they take off their shoes.
 2. *Forbidden room*
Policy: No guests are allowed in the *Forbidden Room*.
Action: Take the offenders to the other party guests and verify they don't enter back.
 3. *No littering*
Policy: Guests are not allowed to leave garbage on the floor.
Action: Make the (closest) offender pick up the garbage and throw it into the bin.

4. *Compulsory hydration***Policy:** All guests must have a drink in hand at all times.**Action:** Take the guests to the kitchen/bar and make sure they grab a drink.**Instructions:****Referee instructions**

- Instruct party guests on which rules to break.
- Assign each party guest a drink.

OC Instructions

At least two hours before the test:

- Select and announce the robot start location.
- Select and announce which room is forbidden.

Score sheet**Maximum time:**

10 minutes

Action	Score
<i>Regular Rewards</i>	
Identify a guest breaking a house rule (indicating the rule by voice or log).	4×100
Making eye-contact, politely clarify to the guest what action he should take.	4×100
Confirm that the guest is following the rule.	4×200
<i>Bonus Rewards</i>	
Making eye-contact, politely clarify to the guest what rule is being broken.	4×100
<i>Regular Penalties</i>	
Talking to a guest about a rule they are not breaking	4×-100
<i>Deus ex Machina Penalties</i>	
A human directs the robot towards a guest who is breaking a rule	4×-50
A human tells the robot which rule is being broken	4×-100
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	2000

Chapter 5

Finals

The competition ends with the Finals on the last day, where the two teams with the highest total score compete. The *Finals* are conducted as a final themed demonstration.

Even though each league has its own first, second and third place, the *Finals* are meant to show the best of all leagues to the jury members as well as the audience and, thus, warrants a single schedule slot.

5.1 Structure and Theme

The *Finals* are a demonstration of achieving an objective that is pre-selected by the TC/EC. These objectives are chosen as a type of yearly theme of the competition, and to provide a baseline for the juries (not to mention the audience) to state which team is the winner.

The objectives for each league for this year are:

- *OPL/DSPL*: The robot helps a person in preparing dinner.
- *SSPL*: The robot helps a person in preparing dinner.

The teams are expected to provide a demonstration that is telling a story which includes achieving the objective. The teams can choose freely how to achieve it, which includes choosing the participants, what items to use, the methods employed, etc. The juries, as explained later, will reward elegance and difficulty.

As it can be seen, the objectives are open enough that a story can be told around them which can include additional objectives that the team wants their robot to also solve. Thus, the teams are welcome to include in their demonstration any additional tasks to be solved, which can serve as a type of forum where they can present their own research. The innovation and success of these tasks will also be used as part of the score (as it is described later). In this regard, it is expected that teams present the scientific and technical contributions they submitted in both *team description paper* and the *RoboCup@Home Wiki*.

In addition, teams may provide a printed document to the jury (max 1 page) that summarizes the demonstrated robot capabilities and contributions. However, teams are discouraged to provide any material that would distract from their demonstration.

Story-telling is an important factor, so it is recommended to spend the least amount of time using the microphone to explain the demonstration and let the demonstration speak for itself.

5.2 Evaluating Juries for Final Demonstrations

The *Finals* are evaluated by two juries, here described.

1. **League-internal jury:** The league-internal jury is formed by the Executive Committee. The evaluation of the league-internal jury is based on the following criteria:
 - 1.1. Efficacy/elegance of the solution
 - 1.2. Innovation/contribution to the league of the additional tasks solved
 - 1.3. Difficulty of the overall demonstration

2. **League-external jury:** The league-external jury consists of people not being involved in the RoboCup@Home league, but having a related background (not necessarily robotics). They are appointed by the Executive Committee. The evaluation of the league-external jury is based on the following criteria:
 - 2.1. Originality and presentation (story-telling is to be rewarded)
 - 2.2. Relevance/usefulness to everyday life
 - 2.3. Elegance/success of overall demonstration

5.3 Scoring

The final score and ranking are determined by the jury evaluations and by the previous performance (in Stages I and II) of the team, in the following manner:

1. The influence of the league-internal jury to the final ranking is 25 %.
2. The influence of the league-external jury to the final ranking is 25 %.
3. The influence of the total sum of points scored by the team in Stage I and II is 50 %.

These demonstrations are carried out in a serialized fashion, one League performing after another in one *Arena*.

5.3.1 Task

The procedure for the demonstration and the timing of slots is as follows:

1. **Setup and demonstration:** The team has a maximum of *ten minutes* for setup, presentation and demonstration.
2. **Interview and cleanup:** After the demonstration, there is another *five minutes* where the team answers questions by the jury members.
During the interview time, the team has to undo its changes to the environment.

5.3.2 Changes to the environment

1. **Making changes:** As in the other open demonstrations, teams are allowed to make modifications to the arena as they like, but under the condition that they are reversible.
2. **Undoing changes:** In the interview and cleanup team, changes need to be made undone by the team. The team has to leave the arena in the *very same* condition they entered it.

5.4 Final Ranking and Winner

There will be an award for 1st, 2nd and 3rd place of each league.

The winner of the competition is the team that gets the highest ranking in the *Finals*.

The second place will be the team that got the second-highest ranking in the *Finals*.

The third place will be the team with the highest score that did not made it to the *Finals*.

Additional certificates would be granted if:

1. If the number of teams in the league is above 11, a certificate will be awarded to the 4th ranked team.
2. If the number of teams in the league is above 14, a certificate will be awarded to the 5th ranked team.

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