

StarCraft-GOAL Connector Manual

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Chapter 1

Connector

This connector is the first Environment Interface Standard (EIS) compatible connector that provides cognitive agents full access to StarCraft (Brood War). It brings the challenges of Real-Time Strategy (RTS) games to the field of multi-agent programming whilst also facilitating the development of AI solutions for such games, allowing the development of problem-solving techniques before being applied to similar but more complex real-world problems.

The design of this connector was guided by two conflicting objectives:

1. The connector should facilitate multi-agent systems that operate at a level of *abstraction* that is as high as possible.
2. The connector should facilitate multi-agent system implementations with as many different *strategies* as possible.

In other words, it does not aim for a multi-agent system that operates at the same level of detail as bots written in C or Java, but such a system should in contrast also not consist of a single action ‘*win*’ that will delegate the control to some other subsystem instead. To make optimal use of the reasoning typically employed by cognitive agents, low-level details are handled in the environment whilst still allowing agents sufficiently fine grained control.

RTS games like StarCraft involve very large amounts of units that can come and go during the game and that have to deal with major challenges such as uncertainty and long-term (collaborative) goals, requiring multiple levels of abstraction and reasoning in the vast space of actions and game states that such games have. Therefore, a major factor that was also considered is the performance of the connector; a substantial performance impact caused by for example an enormous amount of percepts will limit the amount

of viable implementations (and thus possible strategies).

The remainder of this chapter will demonstrate how to set-up and start a bot with the StarCraft connector using a multi-agent system in the GOAL language. For the latest installation instructions, we refer to:
<https://github.com/eishub/StarCraft/wiki/Install-Guide>

1.1 Chaoslauncher

The Chaoslauncher facilitates plug-ins for StarCraft Brood War, like the *BWAPI Injector* which is necessary for using the BWAPI library that facilitates connecting to the internals of the game. It is recommended to make use of the *APMAAlert* plugin, which shows the current actions per minute of all your units together. It is also recommended to make use of the *W-Mode* plugin. This plugin automatically starts your StarCraft game in windowed mode which is easier for debugging. You can also make use of the *ChaosPlugin* to take advantage of its autoreplay function which automatically saves a replay at the end of each game. You can play these replays by turning off the *BWAPI Injector*, starting StarCraft (with the Chaoslauncher), selecting *Single Player* with gametype *Expansion*, pressing the ‘Ok’ button and then the ‘Load Replay’ button. If you then open the **Autoreplay** directory in that screen, you should be able to see all the replays which were saved by the autoreplay function. Alternatively, view replays in your browser at <http://www.openbw.com/replay-viewer>

1.2 Init Parameters

The StarCraft connector offers multiple configurable items through the init parameters of a mas2g file. When updating any parameters, do not forget to fully close the Chaoslauncher (i.e., closing it in the system tray) before launching a new game, as otherwise your changes will not be applied. The example below demonstrates all parameters and their defaults.

```
use "connector.jar" as environment with
  own_race="",
  enemy_race="random",
  map="",
  starcraft_location="C:\\StarCraft",
  auto_menu="SINGLE_PLAYER",
  game_type="MELEE",
```

```
game_speed=50.  
debug="false",  
draw_mapinfo="false",  
draw_unitinfo="false",  
invulnernable="false",  
managers=0,  
percepts=[].
```

1.2.1 Own Race

You have to specify the race of your bot. This will make sure that the Chaoslauncher will automatically launch a game with the specified race. You can do this by inserting the following line: *own_race = <RaceName>*, where *<RaceName>* can either be *zerg*, *protoss*, *terran* or *random*. The option *random* will choose one race with a 1/3 chance for each race.

1.2.2 Enemy Race

The enemy race parameter can be used for specifying which race of the game's built-in AI you want to play against. To this end, you can insert *enemy_race=<RaceName>*, where *<RaceName>* can either be *zerg*, *protoss*, *terran*, *random*, *randomtp*, *randomtz*, or *randompz*. The option *random* will choose a race with a 1/3 chance for each race, whilst the other options will choose one of the two indicates races with a 1/2 chance for each race.

1.2.3 Map

You have to specify which map the Chaoslauncher will automatically load when starting the game. This can be done by inserting the following line: *map = <filename>*, where *<filename>* is the exact filename of the map (with extension). Please note that the environment only supports maps that are located in the directory *StarCraft/maps*, and that subdirectories (like *sscait*) should be indicated. Also note that the first time the environment runs on a certain map, it will take some time (around 2 minutes) to generate a datafile for the given map (if it is not already present in the *StarCraft/AI/BWTA* directory).

1.2.4 StarCraft Location

You have to specify the location of the StarCraft game if it is not installed in *C:/Starcraft*. Using this location, the Chaoslauncher will automatically start when launching a MAS. When the Chaoslauncher is already running, it will not start again until you close it (in the system tray), but this is fine as long as you use the same init parameters (although you have to start the next game manually in the existing Chaoslauncher instance then). You can specify the location of StarCraft by inserting *StarCraft_location* = *<FilePath>*, where *<FilePath>* is the absolute path to the StarCraft installation folder.

1.2.5 Auto Menu

The auto menu parameter is used to automatically go through the menus of the game when starting a MAS. This can be used for single player games and multi player games. To use the auto menu function you can insert the following line: *auto_menu=<MenuChoice>*, where *<MenuChoice>* can take the following values:

SINGLE_PLAYER: for a single player game (against built-in AI).

LAN: for a local multiplayer game.

OFF: for disabling the auto menu.

1.2.6 Game Type

The game type is used to indicate what kind of game the Chaoslauncher should start. Generally, you want this to be the default (*MELEE*), but other game types can be used by inserting *game_type=<GameType>*.

1.2.7 Game Speed

The game speed parameter can be used to set the initial speed of the game when the StarCraft game is launched (the speed can be changed during the game by using the development tool; see the next item). StarCraft makes use of a logical frame rate, which means that the *game_speed* depends on the amount of frames per second (fps) used to update the game. The higher the fps, the faster the game will go. For using the *game_speed* parameter you can insert the following line: *game_speed=<FPS>*, where *<FPS>*. If a number lower than 1 is given, there will be no limit on the amount of FPS used, and the game will run as fast as it possibly can on your CPU.

1.2.8 Debug

The environment offers a development tool for debugging purposes. With this development tool, you can increase or decrease the game speed, enable cheats and toggle the drawing of map and/or unit details in the game. More information about the development tool can be found in Section 1.4. In order to enable or disable launching the development tool, you can insert *debug=<Boolean>*.

1.2.9 Draw Map Info

This parameter can be used to draw info about the map (bases, regions, chokepoints) without having to enable it the development tool (or without starting the development tool at all) by inserting *draw_mapinfo=<Boolean>*.

1.2.10 Draw Unit Info

This parameter can be used to draw info about units (counts, IDs, health, targets) without having to enable it the development tool (or without starting the development tool at all) by inserting *draw_unitinfo=<Boolean>*.

1.2.11 Invulnerable

The invulnerable parameter can be used to automatically make your units invulnerable from the start of the game (which can also be done manually in the development tool). This can come in handy for testing purposes when you do not want to fight your opponent. To use the invulnerable function you can insert *invulnerable=<Boolean>*.

1.2.12 Managers

If higher than 0, the connector will generate the specified number of entities (N) with type ‘manager’ and name ‘managerN’ at the start of the game. Such manager entities will not receive any percepts by default, but can subscribe to global percepts (see the following subsection). Manager entities can even take a few actions: *cancel/1*, *debugdraw/1*, *debugdraw/3*, *forfeit/0*, *startManager/0*. To use managers you can thus insert *managers=<Integer>*.

1.2.13 Percepts

By default, the entity for any unit will only receive those percepts that are specific to it, i.e. generic unit and unit-specific percepts (see the next chapter). Through this `init` parameter, however, it is possible to specify that units of a certain type (including managers) should receive certain global percepts (static or dynamic). This is possible through a list of lists, where the first element of each sublist is the entity type (see Section 4.2 and use the exact name for managers), and the following the names of the global percepts that should be received by corresponding units. For example, *percepts: [[manager1,base,chokepoint], [zergZergling,friendly,enemy]]* will ensure that the first manager will receive base and chokepoint percepts, whilst any zergling will receive friendly and enemy percepts.

1.3 Entity Types

When defining a launch rule it is important that a correct entity type is used (see Section 4.2). This value has to be the same type of the StarCraft unit without spaces and where the first letter is uncapitalised. So when you for example want to connect an agent to a **Terran SCV**, this can be done by using the entity type *terranSCV*. Note that each unit type starts with the race of the unit, followed by the exact name of the unit type, and please be aware that the environment will wait in the first game frame until *at least four actions* have been requested, e.g., until all initial workers have called *gather/1*. This will allow all initial agents (including managers) to fully start-up (and possibly execute a few cycles already) before the game starts.

```
define myAgent as agent {
    ...
}
launchpolicy {
    when type = terranSCV launch myAgent.
}
```

With mind control (an advanced Protoss ability), units from other races can be taken over. These units will also get an entity. A possible way to accomodate such entities is by making sure any other unit type is connected to a generic agent through a wildcard launch rule at the end of your `mas2g`:

```
when type=* launch ...
```

1.4 The Development Tool

The development tool can be automatically launched by using the *debug* init parameter. It provides several actions that are useful for debugging purposes.

1.4.1 Game Speed

The Game Speed slider can be found at the top of the development tool window. When the slider is used, the speed of the game will be changed immediately. The slider always starts on a value of 50 fps (it will **not** reflect the *game_speed* init parameter if that was used). The slowest speed is 20 fps, and from there you can set it as fast as you want. Please note that the agents are supposed to play at 50 fps, as that is the default game speed for AI tournaments. Especially when the speed is set to more than 100 fps, your agents might act differently than they would on the tournament speed, as they have much less time to process each frame. Setting the game speed to more than 100 fps should thus only be used for quick testing purposes.

1.4.2 Cheat Actions

The development tool offers 3 buttons which instantly enable StarCraft cheats. Note that these cheats should be used for testing purposes only. The first cheat is called: *Give resources* which gives the player 10000 minerals and 10000 gas. The second cheat is called: *Enemy attacks deal 0 damage* which makes the units of the player immune for damage (note: this can be automatically enabled with the init parameter *invulnerable*). The last cheat is called: *Show map* which makes the whole map visible for the player. Note that all your agents will then also perceive everything on the map.

1.4.3 Draw Actions

The development tool can also be used to show map or unit details in StarCraft itself. There are 2 buttons to this end, reflecting the matching *draw_mapinfo* and *draw_unitinfo* init parameters. Please see the information above on these parameters for more information.

Chapter 2

Percepts

This chapter lists all the percepts that are generated by the StarCraft connector, which vary per unit and on the *percepts* init parameter (see the previous chapter). For the implementation of these percepts in your agent programs, we refer to the GOAL programming guide. Note that both buildings and moving soldiers are called ‘units’ in StarCraft.

In order to reduce the number of percepts, one generic guideline used in this connector is to *only create percepts for information that changes in a single match or between matches*. Even though there is a lot of static information in a game like StarCraft, like the type of a unit (i.e., biological or mechanic), what a certain unit costs to produce, or the units a certain building can produce, this information remains the same for any execution of any agent system, and is thus much better suited to be encoded in the agent system itself. To this end, a Prolog file is supplied in the connector’s installer that contains a large list of predicates representing static information about the game. The predicates available in this file are listed at the end of this section. Note that it is not expected that agents ‘hardcode’ information about specific maps on which matches can be played, and thus agents will be informed about changes between matches (i.e., map-specific information).

Another guideline used in this connector is that *no data is sent through percepts that can either be calculated based on other data, (e.g., the number of friendly units by adding the amount of percepts about their status) or retrieved from other agents (e.g., the position of a friendly unit)*. Relaying such information through messaging(channels) is usually much more efficient, as one can then selectively choose at which times and to which units to send information, as opposed to percepts always being sent to certain units even when they do not require them (at that time) for their decision making.

2.1 Global Static Percepts

These percepts represent global information (i.e., not specific to a certain unit) that will not change during a match. Note that all coordinates (X,Y) reflect tile positions; one such tile is actually 16 by 16 pixels.

2.1.1 base/6

| | |
|-------------|--|
| Description | Information about all base locations on the map. These are possible construction sites for resource centers (or spawning sites for the initial centers). |
| Type | Send once |
| Syntax | <code>base(<IsPossibleStart>,<Minerals>,<Gas>,<X>,<Y>,<Region>)</code> |
| Example | <code>base(true, 13500, 5000, 28, 32, 8)</code> |

| | | |
|------------|--------------------------------|---|
| Parameters | <IsPossibleStart> | Indicates whether the location is a potential starting location or not (i.e., there are 2 on a 2-player map and 4 on a 4-player map). Boolean [true,false] |
| | <Minerals> | The total amount of minerals available at/near the base location (at the start of the game). Integer [0-∞] |
| | <Gas> | The total amount of vespene gas available at/near the base location (at the start of the game). Integer [0-∞] |
| | <X> | The x-coordinate of the base location. Integer [0-∞] |
| | <Y> | The y-coordinate of the base location. Integer [0-∞] |
| | <Region> | The region the base is located in, which can for example be used to find matching resources. Integer [1-∞] |

2.1.2 chokepoint/6

Description Information about all chokepoints on the map. These are the narrow points on the map where only a limited amount of units can go through at the same time (depending on the specific chokepoint's width). All regions on the map are connected through chokepoints.

Type Send once

Syntax `chokepoint(<X1>,<Y1>,<X2>,<Y2>,<Region1>,<Region2>)`

Example `chokepoint(12, 15, 14, 17, 1, 2)`

| | | |
|-------------------|------------------------|--------------------------------------|
| Parameters | <X1> | The x-coordinate of the first side. |
| | Type | Integer |
| | Range | [0-∞] |
| | <Y1> | The y-coordinate of the first side. |
| | Type | Integer |
| | Range | [0-∞] |
| | <X2> | The x-coordinate of the second side. |
| | Type | Integer |
| | Range | [0-∞] |
| | <Y2> | The y-coordinate of the second side. |
| | Type | Integer |
| | Range | [0-∞] |
| | <Region1> | The ID of the first region. |
| | Type | Integer |
| | Range | [1-∞] |
| | <Region2> | The ID of the second region. |
| | Type | Integer |
| | Range | [1-∞] |

2.1.3 enemyPlayer/1

Description The name and race of the opponent (it is assumed there is only one opponent in this connector).

Type Send once

Syntax `enemyPlayer(<Name>,<Race>)`

Example `enemyRace('ForceBot', zerg)`

Note When playing against a random race ($\langle Race \rangle = unknown$), you can use something like:

```
if bel(enemyRace(unknown), enemy(Type,_,_,_,_),
sub_string(Type,0,1,_,Race)) then {
  if bel(Race = "z") then delete(enemyRace(unknown))
  + insert(enemyRace(zerg)).
  if bel(Race = "p") then delete(enemyRace(unknown))
  + insert(enemyRace(proto)).
  if bel(Race = "t") then delete(enemyRace(unknown))
  + insert(enemyRace(terran)).
}
```

| | | |
|------------|---------------------|-------------------------------|
| Parameters | <Race> | The enemy race. |
| | Type | String |
| | Range | [terran,proto, zerg, unknown] |

2.1.4 map/3

Description The name, width, and the height of the map (in tiles).

Type Send once

Syntax `map(<Name>,<Width>,<Height>)`

Example `map('Destination 1.1', 96, 128)`

| | | |
|------------|-----------------------|---|
| Parameters | <Name> | The name of the map (ASCII characters only). |
| | Type | String |
| | <Width> | The width of the map (no. of horizontal tiles). |
| | Type | Integer |
| | Range | [1-∞] |
| | <Height> | The height of the map (no. of vertical tiles). |
| | Type | Integer |
| | Range | [1-∞] |

2.1.5 ownRace/1

Description The race of yourself (useful when playing as random).

Type Send once

Syntax `ownRace(<Race>)`

Example `ownRace(protooss)`

| | | |
|------------|---------------------|------------------------------|
| Parameters | <Race> | The player's race. |
| | Type | String |
| | Range | <i>[terran,protoss,zerg]</i> |

2.1.6 region/5

Description Information about all regions on the map. Regions are connected by chokepoints and can be on high or low ground.

Type Send once

Syntax `region(<Id>,<CenterX>,<CenterY>,<Height>,<ConnectedRegionsList>)`

Example `region(12, 15, 14, 17, [1,2])`

| | | |
|------------|-------------------------------------|--|
| Parameters | <Id> | The ID of the region. |
| | Type | Integer |
| | Range | $[1-\infty]$ |
| | <CenterX> | The x-coordinate of the center of the region. |
| | Type | Integer |
| | Range | $[0-\infty]$ |
| | <CenterY> | The y-coordinate of the center of the region. |
| | Type | Integer |
| | Range | $[0-\infty]$ |
| | <Height> | The (relative) height of the region. |
| | Type | Integer |
| | Range | $[0-\infty]$ |
| | <ConnectedRegionsList> | A list of regions (by ID) that are connected to this region (i.e., through chokepoints). |
| | Type | List |

2.2 Global Dynamic Percepts

These percepts represent information that changes during a match, but is still global to the match (i.e., not specific to a certain unit). Note that units will keep the same ID after a morph or merge.

2.2.1 attacking/2

Description All enemy units that are attacking / going to attack and the corresponding friendly units that they have targeted.

Type Send always

Syntax `attacking(<Id>,<TargetId>)`

Example `attacking(123, 177)`

| | | |
|------------|-----------------------------|---|
| Parameters | <Id> | The ID of the enemy unit that is attacking / going to attack. |
| | Type Range | Integer [1- ∞] |
| | <TargetId> | The ID of the friendly unit that is being targeted. |
| | Type Range | Integer [1- ∞] |

2.2.2 constructionSite/3-4

| | |
|-------------|--|
| Description | All visible and non-obstructed locations at which buildings can potentially be constructed. Such construction sites are squares containing 4 tiles, as the minimum size of any building is 2 by 2 tiles. This information is updated every 50 game frames only. Note that resource centers require a minimum distance to mineral patches and geysers (which the locations as indicated by <i>base/4</i> conform to for example). |
| Type | Send always |
| Syntax | (Protoss) <code>constructionSite(<X>,<Y>,<Region>,<InPylonRange>)</code> (Zerg) <code>constructionSite(<X>,<Y>,<Region>,<OnCreep>)</code> (Terran) <code>constructionSite(<X>,<Y>,<Region>)</code> |
| Example | <code>constructionSite(66, 98, 4, false)</code> <code>constructionSite(66, 98, 4)</code> |

| | | |
|------------|--|---|
| Parameters | <X> Type Range | The x-coordinate of the construction site. Integer [0-∞] |
| | <Y> Type Range | The y-coordinate of the construction site. Integer [0-∞] |
| | <Region> Type Range | The region the construction site is in. Integer [1-∞] |
| | <InPylonRange> Type Range | Indicates whether the construction site is in range of a pylon (for Protoss only). Boolean [true,false] |
| | <OnCreep> Type Range | Indicates whether the construction site is on creep (for Zerg only). Boolean [true,false] |

2.2.3 enemy/11

| | |
|-------------|--|
| Description | Information about all enemy units. Note that this also includes unfinished units (like buildings under construction) or cloaked units that cannot be attacked until they are detected (see <i><Conditions></i>). Moreover, this percept will be sent for any enemy unit that has ever been visible (see <i><LastUpdated></i>); percepts will no longer be sent for only those enemy units that were destroyed in our view. |
| Type | Send always |
| Syntax | enemy(<Id>,<Type>,<Health>,<Shield>,<Energy>,<Conditions> <Orientation>,<X>,<Y>,<Region>,<LastUpdated>) |
| Example | enemy(12, 'Zerg Overlord', 100, 0, 0, [flying], 0, 12, 96, 3, 50) |

| | | | | | | | | | | | | | | | | | | | |
|--------------------------------|--|-----------------------|---|-------------------------|--|---------------------------|---|---------------------------|--|---------------------------|---|-------------------------------|---|--------------------------------|---|----------------------|---|----------------------|---|
| Parameters | <table> <tr> <td><Id> Type Range</td><td>The ID of the unit. Integer [1-∞]</td></tr> <tr> <td><Type> Type Range</td><td>The type of the unit. This consists of a string with the race of the unit and the name of the unit parted by a space. String See 4.2</td></tr> <tr> <td><Health> Type Range</td><td>The current amount of health of the unit. Integer [1-<maxHealth>]</td></tr> <tr> <td><Shield> Type Range</td><td>The current amount of shields of the unit. Integer [0-<maxShield>]</td></tr> <tr> <td><Energy> Type Range</td><td>The current amount of energy of the unit. Integer [0-<maxEnergy>]</td></tr> <tr> <td><Conditions> Type Range</td><td>A list representing the current conditions of the unit. Each unit can have multiple or no conditions depending on the unit and situation. Note that not all conditions are available for enemies. List of Strings See 2.5</td></tr> <tr> <td><Orientation> Type Range</td><td>The orientation of the unit, rounded to the nearest multiple of 45 degrees. Integer [0-360]</td></tr> <tr> <td><X> Type Range</td><td>The x-coordinate of the unit. Integer [0-∞]</td></tr> <tr> <td><Y> Type Range</td><td>The y-coordinate of the unit. Integer [0-∞]</td></tr> </table> | <Id> Type Range | The ID of the unit. Integer [1-∞] | <Type> Type Range | The type of the unit. This consists of a string with the race of the unit and the name of the unit parted by a space. String See 4.2 | <Health> Type Range | The current amount of health of the unit. Integer [1-<maxHealth>] | <Shield> Type Range | The current amount of shields of the unit. Integer [0-<maxShield>] | <Energy> Type Range | The current amount of energy of the unit. Integer [0-<maxEnergy>] | <Conditions> Type Range | A list representing the current conditions of the unit. Each unit can have multiple or no conditions depending on the unit and situation. Note that not all conditions are available for enemies. List of Strings See 2.5 | <Orientation> Type Range | The orientation of the unit, rounded to the nearest multiple of 45 degrees. Integer [0-360] | <X> Type Range | The x-coordinate of the unit. Integer [0-∞] | <Y> Type Range | The y-coordinate of the unit. Integer [0-∞] |
| <Id> Type Range | The ID of the unit. Integer [1-∞] | | | | | | | | | | | | | | | | | | |
| <Type> Type Range | The type of the unit. This consists of a string with the race of the unit and the name of the unit parted by a space. String See 4.2 | | | | | | | | | | | | | | | | | | |
| <Health> Type Range | The current amount of health of the unit. Integer [1-<maxHealth>] | | | | | | | | | | | | | | | | | | |
| <Shield> Type Range | The current amount of shields of the unit. Integer [0-<maxShield>] | | | | | | | | | | | | | | | | | | |
| <Energy> Type Range | The current amount of energy of the unit. Integer [0-<maxEnergy>] | | | | | | | | | | | | | | | | | | |
| <Conditions> Type Range | A list representing the current conditions of the unit. Each unit can have multiple or no conditions depending on the unit and situation. Note that not all conditions are available for enemies. List of Strings See 2.5 | | | | | | | | | | | | | | | | | | |
| <Orientation> Type Range | The orientation of the unit, rounded to the nearest multiple of 45 degrees. Integer [0-360] | | | | | | | | | | | | | | | | | | |
| <X> Type Range | The x-coordinate of the unit. Integer [0-∞] | | | | | | | | | | | | | | | | | | |
| <Y> Type Range | The y-coordinate of the unit. Integer [0-∞] | | | | | | | | | | | | | | | | | | |

| | | |
|-----------|---|---|
| Continued | <Region> Type Range | The region the unit is in. Can be 0 if the unit is on a chokepoint (and thus ‘in-between’ regions). Integer $[0-\infty]$ |
| | <LastUpdated> Type Range | The game frame in which information about this unit was last updated. If this is equal to the current game frame, the enemy unit is within our view; otherwise it is within the fog-of-war. Only enemy units that are destroyed within our view are removed from the perceived enemies. Integer $[0-\infty]$ |

2.2.4 friendly/2

Description Information about all (living) units of the player. Note that this also includes unfinished units that do not have an entity and thus agent yet (like buildings under construction), see also the *underConstruction/6* percept.

Type Send always

Syntax friendly(<Id>,<Type>)

Example friendly(26, ‘Protoss Gateway’)

| | | |
|------------|--|---|
| Parameters | <Id> Type Range | The ID of the unit. Integer $[1-\infty]$ |
| | <Type> Type Range | The type of the unit. This consists of a string with the race of the unit and the name of the unit parted by a space. String See 4.2 |

2.2.5 gameframe/1

Description The current game frame. For more information see 1.2.7.

Type Send on change

Syntax gameframe(<Number>)

Example gameframe(150)

| | | |
|------------|--|---|
| Parameters | <Number> Type Range | The game frame count. Integer $[0-\infty]$ |
|------------|--|---|

2.2.6 mineralField/5

Description Information about visible (non-empty) mineral fields.
 Type Send always
 Syntax `mineralField(<Id>,<Resources>,<X>,<Y>,<Region>)`
 Example `mineralField(57, 5000, 6, 22, 32)`

| | | | | | | | | | | | |
|---|--|------------------------------------|--|---|---|-----------------------------------|--|-----------------------------------|--|--|---|
| Parameters | <table> <tr> <td><Id> Type Range</td><td>The ID of the mineral field. Integer [1–∞]</td></tr> <tr> <td><Resources> Type Range</td><td>The amount of minerals left in the field, rounded to the nearest (upper) multiple of 100. Can be 0 for mineral fields that obstruct e.g. chokepoints (mined out fields disappear). Integer [0–5000]</td></tr> <tr> <td><X> Type Range</td><td>The x-coordinate of the mineral field. Integer [0–∞]</td></tr> <tr> <td><Y> Type Range</td><td>The y-coordinate of the mineral field. Integer [0–∞]</td></tr> <tr> <td><Region> Type Range</td><td>The region the mineral field is in. Integer [1–∞]</td></tr> </table> | <Id> Type Range | The ID of the mineral field. Integer [1–∞] | <Resources> Type Range | The amount of minerals left in the field, rounded to the nearest (upper) multiple of 100. Can be 0 for mineral fields that obstruct e.g. chokepoints (mined out fields disappear). Integer [0–5000] | <X> Type Range | The x-coordinate of the mineral field. Integer [0–∞] | <Y> Type Range | The y-coordinate of the mineral field. Integer [0–∞] | <Region> Type Range | The region the mineral field is in. Integer [1–∞] |
| <Id> Type Range | The ID of the mineral field. Integer [1–∞] | | | | | | | | | | |
| <Resources> Type Range | The amount of minerals left in the field, rounded to the nearest (upper) multiple of 100. Can be 0 for mineral fields that obstruct e.g. chokepoints (mined out fields disappear). Integer [0–5000] | | | | | | | | | | |
| <X> Type Range | The x-coordinate of the mineral field. Integer [0–∞] | | | | | | | | | | |
| <Y> Type Range | The y-coordinate of the mineral field. Integer [0–∞] | | | | | | | | | | |
| <Region> Type Range | The region the mineral field is in. Integer [1–∞] | | | | | | | | | | |

2.2.7 nuke/3

Description Indicates that a nuclear strike will land on the given position.

Type Send always

Syntax `nuke(<X>,<Y>,<Region>)`

Example `nuke(22, 37, 1)`

Parameters

| | |
|--|--|
| <X> Type Range | The x-coordinate of the incoming nuclear strike. Integer [0–∞] |
| <Y> Type Range | The y-coordinate of the incoming nuclear strike. Integer [0–∞] |
| <Region> Type Range | The corresponding region for the incoming nuclear strike. Integer [1–∞] |

2.2.8 resources/4

| | |
|-------------|--|
| Description | The amount of minerals, gas and supply available to the player (i.e. shared by all units). Note that in order to avoid halves, supply is multiplied by 2 throughout this interface, so 10 supply in-game corresponds with 20 supply in this environment. |
| Type | Send on change |
| Syntax | <code>resources(<Minerals>,<Gas>,<UsedSupply>,<TotalSupply>)</code> |
| Example | <code>resources(350, 100, 25, 41)</code> |

| | | | | | | | | | |
|---|---|--|---|-------------------------------------|--|--|---|---|---|
| Parameters | <table> <tr> <td><Minerals> Type Range</td><td>The current amount of minerals available. Integer [0-∞]</td></tr> <tr> <td><Gas> Type Range</td><td>The current amount of gas available. Integer [0-∞]</td></tr> <tr> <td><UsedSupply> Type Range</td><td>The amount of supply that is in use Integer [0-400]</td></tr> <tr> <td><TotalSupply> Type Range</td><td>The total amount of supply that is available. Note that usually <TS> is always greater or equal to <CS>, but this can change when supply providing units are killed. Integer [0-400]</td></tr> </table> | <Minerals> Type Range | The current amount of minerals available. Integer [0-∞] | <Gas> Type Range | The current amount of gas available. Integer [0-∞] | <UsedSupply> Type Range | The amount of supply that is in use Integer [0-400] | <TotalSupply> Type Range | The total amount of supply that is available. Note that usually <TS> is always greater or equal to <CS>, but this can change when supply providing units are killed. Integer [0-400] |
| <Minerals> Type Range | The current amount of minerals available. Integer [0-∞] | | | | | | | | |
| <Gas> Type Range | The current amount of gas available. Integer [0-∞] | | | | | | | | |
| <UsedSupply> Type Range | The amount of supply that is in use Integer [0-400] | | | | | | | | |
| <TotalSupply> Type Range | The total amount of supply that is available. Note that usually <TS> is always greater or equal to <CS>, but this can change when supply providing units are killed. Integer [0-400] | | | | | | | | |

2.2.9 underConstruction/6

Description Indicates a new friendly unit that is under construction (i.e. by a worker, through morphing, or warping in). This percept allows getting information about unfinished units that do not have an entity (and thus agent) yet.

Type Send always

Syntax `underConstruction(<Id>,<BuilderId><Vitality>,<X>,<Y>,<Region>)`

Example `underConstruction(44, 3, 74, 22, 37, 2)`

| | | |
|-------------------|--|---|
| Parameters | <Id> Type Range | The ID of the (unfinished) unit. Integer [1-∞] |
| | <Id> Type Range | The ID of the unit that is responsible for the construction or training of this unit (if any applicable; -1 otherwise). Integer [-1-∞] |
| | <Vitality> Type Range | The combined amount of health and shield of the unit. This generally increases whilst the unit is nearing completion, though it can simultaneously be brought down as well by enemy attacks. Integer [0-∞] |
| | <X> Type Range | The x-coordinate of the unit (cannot change). Integer [0-∞] |
| | <Y> Type Range | The y-coordinate of the unit (cannot change). Integer [0-∞] |
| | <Region> Type Range | The region the unit is in. Can be 0 if for example a morphing unit is on a chokepoint (and thus 'in-between' regions). Integer [0-∞] |
| | | |

2.2.10 vespeneGeyser/5

Description Information about visible (though possibly empty) vespene geysers. Empty geysers can still be mined from, though at a reduced rate.

Type Send always

Syntax `vespeneGeyser(<Id>,<Resources>,<X>,<Y>,<Region>)`

Example `vespeneGeyser(57, 5000, 22, 32, 6)`

| | | |
|------------|---|--|
| Parameters | <Id> Type Range | The ID of the vespene geyser. Integer [1–∞] |
| | <Resources> Type Range | The amount of gas left in the vespene geyser, rounded to the nearest (upper) multiple of 100. Can be 0, after which mining workers will obtain much less gas per trip. Integer [0–∞] |
| | <X> Type Range | The x-coordinate of the vespene geyser. Integer [0–∞] |
| | <Y> Type Range | The y-coordinate of the vespene geyser. Integer [0–∞] |
| | <Region> Type Range | The region the vespene geyser is in. Integer [1–∞] |

2.2.11 winner/1

Description Indicates if the player has won or lost at the end of the game. Used mainly for automated testing purposes.

Type Send once

Syntax `winner(<HasWon>)`

Example `winner(true)`

| | | |
|------------|-----------------------------|------------------------------------|
| Parameters | <HasWon> | Whether the player has won or not. |
| | Type Range | Boolean [true,false] |

2.3 Generic Unit Percepts

These percepts are generated for all individual units in the game (thus excluding managers). Although the *self/2* percept represents static information that does not change during the match, the *status/7* and the *order/3* percepts are updated frequently.

2.3.1 *self/2*

Description Indicates the ID and type of the unit itself.

Type Send once

Syntax `self(<Id>,<Type>)`

Example `self(21, 'Terran SCV')`

| | | |
|------------|---------------------|---|
| Parameters | <Id> | The ID of the unit. |
| | Type | Integer |
| | Range | [1-∞] |
| | <Type> | The type of the unit. This consists of a string with the race of the unit and the name of the unit parted by a space. |
| | Type | String |
| | Range | See Section 4.2 |

2.3.2 status/8

| | |
|-------------|---|
| Description | The current amount of health, shield and energy of the unit. The status percept also shows the conditions of the unit and its current orientation and position. |
| Type | Send on change |
| Syntax | status (<Health> , <Shield> , <Energy> , <Conditions> , <Orientation> , <X> , <Y> , <Region>) |
| Example | status (250, 0, 0, [moving, carrying], 180, 24, 36, 1) |
| Parameters | |

| | |
|---|---|
| <Health> Type Range | The current amount of health of the unit. Integer [0- <MaxHealth>] where <MaxHealth> is the maximum health of the given unit. |
| <Shield> Type Range | The current amount of shields of the unit. Integer [0- <MaxShield>] where <MaxShield> is the maximum shield of the given unit. |
| <Energy> Type Range | The current amount of energy of the unit. Integer [0- <MaxEnergy>] where <MaxEnergy> is the maximum energy of the given unit. |
| <Conditions> Type Range | A list representing the current conditions of the unit. Each unit can have multiple or no conditions depending on the unit and situation. List of Strings See Section 2.5 |
| <Orientation> Type Range | The orientation of the unit, rounded to the nearest multiple of 45 degrees. Integer [0-360] |
| <X> Type Range | The x-coordinate of the unit. Integer [0- ∞] |
| <Y> Type Range | The y-coordinate of the unit. Integer [0- ∞] |
| <Region> Type Range | The region the unit is in. Can be 0 if the unit is on a chokepoint (and thus 'in-between' regions). Integer [0- ∞] |

2.3.3 order/5

Description Indicates what order(s) a unit is executing. A unit always has an order (e.g., even 'Nothing' is an order).

Type Send on change

Syntax `order(<Primary>,<TargetUnit>,<TargetX>,<TargetY>,<Secondary>)`

Example `order('AttackMove', -1, 34, 8, 'None')`

| | | |
|------------|--|--|
| Parameters | <div> <Primary> Type Range </div> | <div> The primary order of the unit. Some actions are converted into race or unit specific orders. String See https://bwapi.github.io/namespace_b_w_a_p_i_1_1_orders.html </div> |
| | <div> <TargetUnit> Type Range </div> | <div> The ID of the unit the order is targeted at if any; -1 otherwise. Integer [-1-∞] </div> |
| | <div> <TargetX> Type Range </div> | <div> The X coordinate of the position the order is targeted at if any; -1 otherwise. Integer [-1-∞] </div> |
| | <div> <TargetY> Type Range </div> | <div> The Y coordinate of the position the order is targeted at if any; -1 otherwise. Integer [-1-∞] </div> |
| | <div> <Secondary> Type Range </div> | <div> The secondary order of the unit. This is usually 'None', but is used when for example a Protoss Carrier is both moving and producing units. String See https://bwapi.github.io/namespace_b_w_a_p_i_1_1_orders.html </div> |

2.4 Unit-Specific Percepts

These percepts are generated only for specific units in the game. All of these (dynamic) percepts represent information that can change during the match.

2.4.1 defensiveMatrix/1

| | | |
|-------------|--|---|
| Description | Information about how much health the defensive matrix has left on the unit. This only applies to friendly Terran units having received such a matrix from a Science Vessel. | |
| Type | Send always | |
| Syntax | defensiveMatrix(<Health>) | |
| Example | defensiveMatrix(200) | |
| Parameters | <Health> | The amount of health left for the defensive matrix. |
| | Type | Integer |
| | Range | [0–250] |

2.4.2 queueSize/1

| | | |
|-------------|---|------------------|
| Description | <p>The number of units that are in the queue of any production unit, thus including e.g. Protoss Carriers.</p> <p>(Zerg Hatchery/Lair/Hive) the number of of available larva.</p> <p>(Terran Nuclear Silo) 1 if a nuke is ready (after a corresponding <i>train/1</i> action); 0 otherwise.</p> <p>(Terran Vulture) the number of spider mines left (which are automatically granted upon production of the vulture).</p> <p>(Protoss Carrier) the number of interceptors (ready and in production).</p> <p>(Protoss Reaver) the number of scarabs (ready and in production).</p> | |
| Type | Send on change | |
| Syntax | queueSize(<Size>) | |
| Example | queueSize(2) | |
| Parameters | <Size> | See description. |
| | Type | Integer |
| | Range | [0–5] |

2.4.3 researching/1

Description Indicates which upgrade is being researched by the unit (i.e., a building).

Type Send always

Syntax **researching**(<Type>)

Example **researching**('Stim Packs')

| | | |
|------------|---------------------|---|
| Parameters | <Type> | The upgrade that is being researched. |
| | Type | String |
| | Range | See Section 4.3 |
| | Note | The level of the upgrade (if applicable) is not included. |

2.4.4 unitLoaded/1

Description Indicates which unit(s) are loaded inside the loadable unit (e.g. a Terran Bunker or a Protoss Shuttle).

Type Send always

Syntax **unitLoaded**(<Id>)

Example **unitLoaded**(154)

| | | |
|------------|-------------------|----------------------------|
| Parameters | <Id> | The ID of the loaded unit. |
| | Type | Integer |
| | Range | [0–∞] |

2.5 Conditions

This section lists the conditions a unit can potentially have. The race-specific conditions are either only applicable to or caused by units from that race.

2.5.1 Workers

| | |
|--------------|--|
| carrying | Indicates when a worker unit is carrying minerals or vespene gas. |
| constructing | Shows that a worker unit is busy constructing a building. |
| gathering | Show that a worker unit is busy gathering minerals or vespene gas. |
| repairing | Shows that a (Terran) worker unit is busy repairing a building. |

2.5.2 Generic

| | |
|------------------|---|
| attacking | Indicates when a unit is attacking an other unit (includes medic heal). |
| beingConstructed | Indicates that a unit is incomplete (includes morphing). |
| cloaked | Indicates that a unit is cloaked. |
| coolingDown | Indicates that a unit cannot attack due to cooldown. |
| detected | Indicates that an enemy cloaked/burrowed unit has been detected (and thus can be attacked). |
| flying | Indicates that a unit is flying. |
| following | Indicates that a unit is following an other unit. |
| holding | Indicates that a unit is holding a position. |
| idle | Indicates that the unit is idle (not doing anything). |
| loaded | Indicates that a unit is loaded (i.e. has one or more units in it). |
| moving | Indicates that a unit is moving. |
| patrolling | Indicates that a unit is patrolling between 2 positions. |
| underAttack | Indicates that a unit is under attack. |

2.5.3 Zerg

| | |
|-------------|---|
| acidSpored | Indicates that a unit is under Acid Spores from a Defiler. |
| burrowed | Indicates that a unit is burrowed. |
| darkSwarmed | Indicates that a unit is under a Dark Swarm from a Defiler. |
| ensnared | Indicates that a unit is ensnared by a Queen. |
| morphing | Indicates that a unit is morphing. |
| parasited | Indicates that a unit is parasited by a Queen. |
| plagued | Indicates that a unit is plagued by a Defiler. |

2.5.4 Terran

| | |
|-----------------|---|
| <addonName> | Indicates that an addon of a building is present. |
| beingHealed | Indicates that a unit is being healed by a Medic or repaired by a SCV. |
| blinded | Indicates that a unit is blinded by a Medic. |
| defenseMatrixed | Indicates that a unit has a defensive matrix on it (from a Science Vessel). |
| hasMines | Indicates that a Vulture has at least one Spider Mine. |
| irradiated | Indicates that a unit is irradiated by a Science Vessel. |
| lifted | Indicates that a building is lifted (and thus can move). |
| lockDowned | Indicates that a unit is under lockdown by Ghost. |
| nukeReady | Indicates that a Nuclear Silo is ready to launch a Nuclear Missile. |
| sieged | Indicates that a Siegetank is in siegemode. |
| stimmed | Indicates that a Firebat or Marine is stimmed. |

2.5.5 Protoss

| | |
|-------------------------------|--|
| <code>disruptionWebbed</code> | Indicates that a unit is in a disruption web from a Corsair. |
| <code>hallucination</code> | Indicates that a friendly unit is a hallucination (from a High Templar) |
| <code>hasScarabs</code> | Indicates that a Reaver has at least one Scarab. |
| <code>maelstrommed</code> | Indicates that a unit is maelstrommed by a Dark Archon. |
| <code>stasised</code> | Indicates that a unit is stuck in stasis from an Arbiter. |
| <code>underStorm</code> | Indicates that a unit is under a storm from a High Templar. |
| <code>unpowered</code> | Indicates that a building is no longer powered by a pylon (e.g. a Photon Cannon then no longer functions). |

Chapter 3

Actions

This chapter lists all the actions that are usable in the StarCraft environment, which vary per unit.

3.1 All Units

The following actions can be executed by any agent (i.e., including managers).

3.1.1 `cancel`/1

| | |
|-------------|---|
| Description | Cancel the construction or morphing of a unit. |
| Syntax | <code>cancel(<TargetId>)</code> |
| Example | <code>cancel(3)</code> |
| Parameters | <code><TargetId></code> : The ID of the unit of which the construction or morphing should be cancelled. |
| Pre | The targeted unit is incomplete (not fully constructed or morphed). |
| Post | The targeted unit's construction or morphing will be cancelled; 75% of the invested resources will be refunded (and for Zerg the original unit will be restored). |

3.1.2 debugdraw/1

| | |
|-------------|--|
| Description | Draw text above the unit in the game window. |
| Syntax | <code>debugdraw(<Text>)</code> |
| Example | <code>debugdraw("Power Overwhelming")</code> |
| Parameters | <Text> : The text(string) that should be drawn; this can include characters like tabs and newlines. |
| Pre | - |
| Post | The given text will be drawn above the unit (i.e., it will stay with the unit in the game window). If the given text is empty, any existing drawing will be cancelled. |
| Note | For managers, the text will be drawn on a fixed position on the left top of the game window. |

3.1.3 debugdraw/2

| | |
|-------------|---|
| Description | Draw text above any unit in the game window. |
| Syntax | <code>debugdraw(<TargetId>,<Text>)</code> |
| Example | <code>debugdraw(5, "Power Overwhelming")</code> |
| Parameters | <TargetId> : The ID of the (possibly enemy or even neutral) unit above which the text should be drawn. <Text> : The text(string) that should be drawn; this can include characters like tabs and newlines. |
| Pre | - |
| Post | The given text will be drawn above the unit (i.e., it will stay with the unit in the game window), as long as it is visible (or becomes visible again). If the given text is empty, any existing drawing will be cancelled. |

3.1.4 debugdraw/3

| | |
|-------------|--|
| Description | Draw text on a specific location on the map (in the game window). |
| Syntax | <code>debugdraw(<X>,<Y>,<Text>)</code> |
| Example | <code>debugdraw(1, 23, "Important Location")</code> |
| Parameters | <p><code><X></code>: The X coordinate of the location to draw on.</p> <p><code><Y></code>: The Y coordinate of the location to draw on.</p> <p><code><Text></code>: The text(string) that should be drawn; this can include characters like tabs and newlines.</p> |
| Pre | - |
| Post | The given text will be drawn on the given location (i.e., it will stay on the location in the game window). If the given text is empty, any existing drawing will be cancelled. |

3.1.5 forfeit/0

| | |
|-------------|---|
| Description | Forfeit the game. |
| Syntax | <code>forfeit</code> |
| Pre | The game is in progress. |
| Post | The game ends with a loss for the player. |

3.1.6 morph/1 (Zerg units only)

| | |
|-------------|--|
| Description | Morph a unit into another unit(type). |
| Syntax | <code>morph(<Type>)</code> |
| Example | <code>morph('Zerg Lurker')</code> |
| Parameters | <code><Type></code> : The type to morph into. See Section 4.2. |
| Pre | The unit is capable of morphing into the given unit type. |
| Post | The unit's corresponding agent terminates and a new agent is created for the new unit when it is completed (with the same ID). |

3.1.7 **startNewManager/0**

| | |
|-------------|---|
| Description | Starts a new manager entity. |
| Syntax | startNewManager |
| Pre | - |
| Post | A new manager entity is launched (with a number that follows the existing sequence of managers). To stop a manager entity, the corresponding agent's main module should be terminated (which can be done with either an exit condition or an exit-module action). |

3.2 Buildings

The actions in this section can only be executed by buildings (or by some special units that can be loaded or that can produce units of their own).

3.2.1 buildAddon/1 (Terran only)

| | |
|-------------|--|
| Description | Build an addon. |
| Syntax | <code>buildAddon(<Name>)</code> |
| Example | <code>buildAddon('Terran Comsat Station')</code> |
| Parameters | <code><Name></code> : The name of the addon that is to be constructed. See Section 4.2. |
| Pre | The building is capable of building the addon and does not already have an addon. |
| Post | The building starts constructing the addon. |

3.2.2 cancel/0

| | |
|-------------|---|
| Description | Cancel the last train or research action. |
| Syntax | <code>cancel</code> |
| Pre | The unit is training, researching, or constructing an add-on (Terran-only). |
| Post | The last train, research, or add-on build is cancelled; the resources are refunded. |

3.2.3 land/2 (Terran only)

| | |
|-------------|--|
| Description | Land a lifted building on a given location. |
| Syntax | <code>land(<X>,<Y>)</code> |
| Example | <code>land(22, 33)</code> |
| Parameters | <code><X></code> : The x-coordinate of the chosen landing location. <code><Y></code> : The y-coordinate of the chosen landing location. |
| Pre | The unit is currently lifted and the landing location is visible, not obstructed, and fitting for the building. |
| Post | The unit moves to (if needed) and lands on the chosen location. It reconnects with any addon if applicable. |

3.2.4 lift/0 (Terran only)

| | |
|-------------|--|
| Description | Lift a building into the air. |
| Syntax | <code>lift</code> |
| Pre | The unit is capable of lifting and is not currently performing any other action. |
| Post | The building lifts into the air. |

3.2.5 load/2

| | |
|-------------|---|
| Description | Load a given unit into the unit. |
| Syntax | <code>load(<Id>)</code> |
| Example | <code>load(2)</code> |
| Parameters | <code><Id></code> : The ID of the unit to load into this unit. |
| Pre | The unit is capable of loading the targeted unit and has enough space provided for the targeted unit. |
| Post | The targeted unit moves towards to the loadable unit and loads into it. |

3.2.6 research/1

| | |
|-------------|---|
| Description | Research an upgrade. |
| Syntax | <code>research(<Type>)</code> |
| Example | <code>research('Cloaking Field')</code> |
| Parameters | <code><Type></code> : The type of upgrade to research. See Section 4.3. |
| Pre | The unit is capable of researching the given upgrade. |
| Post | The unit starts researching the given upgrade. |
| Note | The level of an upgrade (if applicable) is optional; this stacks automatically. |

3.2.7 train/1

| | |
|-------------|---|
| Description | Train a unit. |
| Syntax | <code>train(<Type>)</code> |
| Example | <code>train('Protoss Zealot')</code> |
| Parameters | <code><Type></code> : The type of unit to train. See Section 4.2. |
| Pre | The unit is capable of producing the given unit. |
| Post | The unit starts producing the given unit. |

3.2.8 unload/1

| | |
|-------------|--|
| Description | Unload a loaded unit from the unit. |
| Syntax | <code>unload(<Id>)</code> |
| Example | <code>unload(3)</code> |
| Parameters | <code><Id></code> : The ID of the unit to unload from this unit. |
| Pre | The given unit is currently loaded into the unit. |
| Post | The targeted unit is unloaded from the unit. |

3.2.9 unloadAll/0

| | |
|-------------|---|
| Description | Unload all loaded units from the unit. |
| Syntax | <code>unloadAll</code> |
| Pre | There are units currently loaded into the unit. |
| Post | All loaded units are unloaded from the unit. |

3.3 Moving Units

The action in this section can only be executed by moving units (i.e. non-buildings or lifted Terran buildings).

3.3.1 ability/1

| | |
|-------------|--|
| Description | Use an ability. |
| Syntax | <code>ability(<Type>)</code> |
| Example | <code>ability('Burrowing')</code> |
| Parameters | <Type> : The type of ability to use. See Section 4.4. |
| Pre | The unit is capable of performing the ability (on itself, i.e., without a target unit or location). |
| Post | The unit performs the ability. |
| Note | Behaviour that can be toggled on and off (e.g. Burrow/-Cloak/Siege) is also executed by using this action (i.e. once for enabling and then again for disabling). |

3.3.2 ability/2

| | |
|-------------|--|
| Description | Use an ability on a target unit. |
| Syntax | <code>ability(<Type>, <Target>)</code> |
| Example | <code>ability('Archon Warp', 3)</code> |
| Parameters | <Type> : The type of ability to use. See Section 4.4. <Target> : The target to use the technology on. |
| Pre | The unit is capable of performing the ability (with some target unit), and the target unit is visible |
| Post | The unit performs the ability on the target unit. |

3.3.3 ability/3

| | |
|-------------|--|
| Description | Use an ability on a location. |
| Syntax | <code>ability(<Type>, <X>, <Y>)</code> |
| Example | <code>ability('Dark Swarm', 11, 8)</code> |
| Parameters | <Type> : The type of ability to use. See Section 4.4. <X> : The x-coordinate of the chosen location. <Y> : The y-coordinate of the chosen location. |
| Pre | The unit is capable of performing the ability (with some target location), and the location is visible. |
| Post | The unit performs the ability on the given location. |

3.3.4 attack/1

| | |
|-------------|--|
| Description | Attack a given unit. |
| Syntax | <code>attack(<TargetId>)</code> |
| Example | <code>attack(12)</code> |
| Parameters | <code><TargetId></code> : The ID of the unit that should be attacked. |
| Pre | The unit is attack capable and the targeted unit is visible and reachable. |
| Post | The targeted unit is being attacked by your unit. The unit will keep moving towards the enemy unit in order to attack it as long as it is visible and alive. |
| Note | Terran Medics can use this action to heal friendly units; they cannot attack enemies. |

3.3.5 attack/2

| | |
|-------------|--|
| Description | Move to a given location and attack everything on the way. |
| Syntax | <code>attack(<X>,<Y>)</code> |
| Example | <code>attack(9, 21)</code> |
| Parameters | <code><X></code> : The x-coordinate of the chosen location. <code><Y></code> : The y-coordinate of the chosen location. |
| Pre | The unit is attack capable. |
| Post | The unit moves to the chosen location (or as close as it can get) whilst attacking any enemy unit that it encounters along the way; all such enemy units will be chased until they are no longer visible or alive. |
| Note | Terran Medics will heal any friendly units they encounter. |

3.3.6 follow/1

| | |
|-------------|---|
| Description | Follow a given unit. |
| Syntax | <code>follow(<given>)</code> |
| Example | <code>follow(5)</code> |
| Parameters | <code><given></code> : The ID of the unit that should be followed. |
| Pre | The targeted unit is visible. |
| Post | The unit follows the selected unit; any enemy will be ignored (i.e. the unit will not automatically attack anything). |

3.3.7 hold/0

| | |
|-------------|--|
| Description | Hold a position. |
| Syntax | <code>hold</code> |
| Pre | - |
| Post | The unit will hold its current position; any enemy will be ignored (i.e. the unit will not automatically attack anything). |

3.3.8 move/2

| | |
|-------------|--|
| Description | Move to a given location. |
| Syntax | <code>move(<X>,<Y>)</code> |
| Example | <code>move(19, 1)</code> |
| Parameters | <X>: The x-coordinate of the chosen location. <Y>: The y-coordinate of the chosen location. |
| Pre | - |
| Post | The unit moves to the chosen location (or as close as it can get) whilst ignoring any enemy unit along the way (i.e. the unit will not automatically attack anything). |

3.3.9 patrol/2

| | |
|-------------|---|
| Description | Patrol between a unit's current position and the given location. |
| Syntax | <code>patrol(<X>,<Y>)</code> |
| Example | <code>patrol(7,8)</code> |
| Parameters | <X>: The x-coordinate of the chosen location. <Y>: The y-coordinate of the chosen location. |
| Pre | - |
| Post | The unit patrols between its current position and the chosen location (or as close as it can get); any enemy unit that it encounters will be chased until it is no longer visible or alive, after which the unit will return to its patrol route. |
| Note | Terran Medics will heal any friendly units they encounter. |

3.3.10 stop/0

| | |
|-------------|---|
| Description | Stop performing an action. |
| Syntax | <code>stop</code> |
| Pre | The unit is performing some kind of action. |
| Post | The unit stops performing its current action. |

3.4 Workers

The actions in this section can only be executed by worker units.

3.4.1 build/3

| | |
|-------------|---|
| Description | Build a building on the given location. |
| Syntax | <code>build(<Type>,<X>,<Y>)</code> |
| Example | <code>build('Terran Supply Depot', 24, 6)</code> |
| Parameters | <code><Type></code> : The type of building that should be built. See 4.2. <code><X></code> : The x-coordinate of the build location <code><Y></code> : The y-coordinate of the build location |
| Pre | The unit is capable of constructing the chosen building and the build location is visible, not obstructed, and fitting for the given building. |
| Post | The unit goes moves the build location (if needed) and starts constructing the building there. Zerg Drones will morph (i.e., the drone will be lost), Terran SCVs will be busy constructing for a while, and Protoss Probes will instantiate a warp (i.e., the probe does not have to remain at the build location). See also <i>cancel/1</i> and <i>repair/1</i> . |

3.4.2 gather/1

| | |
|-------------|--|
| Description | Gather a specific resource (i.e., from a mineral cluster or a vespene gas building). |
| Syntax | <code>gather(<Id>)</code> |
| Example | <code>gather(32)</code> |
| Parameters | <code><Id></code> : The ID of the chosen resource. |
| Pre | The given resource is visible and reachable. |
| Post | The unit starts gathering the chosen resource. It automatically moves back and forth between the resource and the closest resource center. |

3.4.3 **repair/1 (Terran only)**

| | |
|-------------|---|
| Description | Repair a unit or complete an unfinished building. |
| Syntax | repair (<Id>) |
| Example | repair (17) |
| Parameters | <Id>: The ID of the unit to repair or of the building to complete construction of. |
| Pre | The unit is a Terran SCV, has the resources to repair, and the target unit is visible (and reachable) |
| Post | The SCV moves towards the selected unit (if needed) and repairs it or resumes its construction. |

Chapter 4

Knowledge

This chapter lists the knowledge predicates that are supplied in a Prolog file with all the example agents in the connector’s installer. These represent static knowledge about StarCraft that does not change in between matches. For easy reference, this section also includes a list of all unit and upgrade types per race (and where they can be trained/researched). Moreover, the upgrade types that have a corresponding ability are listed at the end (including by which unit they can be used and at what target). We end with listing some of the known limitations of the connector.

4.1 Predicates

4.1.1 unit/2

Description Indicates all possible unit types. If a matching *combat/6* predicate exists, units of this type are attack capable.

Syntax `unit(<Name>,<Race>)`

Example `unit('Protoss Reaver',protoss)`

| | | |
|------------|-----------------------------|--|
| Parameters | <Name> | The full name of the unit type (i.e. as used in actions and percepts). |
| | Type Range | String See Section 4.2 |
| | <Race> | The race the unit type belongs to. |
| | Type Range | String [terran,zerg,protoss] |

4.1.2 upgrade/2

Description Indicates all possible upgrade types. If a matching *combat/6* predicate exists, the upgrade represents an ability. Not all abilities actually need their matching upgrade to be researched at a building first (costs in *costs/6* will be zero for such abilities/upgrades).

Syntax `upgrade(<Name>,<Race>)`

Example `upgrade('Tank Siege Mode',terran)`

| | | |
|-------------------|---------------------|--|
| Parameters | <Name> | The full name of the upgrade type (i.e. as used in the research actions and percepts). |
| | Type | String |
| | Range | See Section 4.3 |
| | <Race> | The race the upgrade type belongs to. |
| | Type | String |
| | Range | [terran,zerg,protoss] |

4.1.3 costs/6

Description Information about the costs in resources, time and existing units or upgrades of a unit or upgrade type.

Syntax `costs(<Name>,<Minerals>,<Gas>,<SupplyOrEnergy>,<BuildFrames>,<RequiredUnitsOrUpgrades>)`

Example `costs('Zerg Lurker', 50, 100, 4, 600, ['Lurker Aspect','Zerg Hydralisk'])`.

| | | |
|-------------------|---|---|
| Parameters | <Name> Type Range | The name of the unit or upgrade type. String See Sections 4.2 and 4.3 |
| | <Minerals> Type Range | The required amount of minerals to train/research the type. Integer $[0-\infty]$ |
| | <Gas> Type Range | The required amount of gas to train/research the type. Integer $[0-\infty]$ |
| | <SupplyOrEnergy> Type Range | For units: the required (or supplied, represented with a negative number) amount of supply (x2 compared to what is visible in the game). For upgrades (if applicable): the required amount of energy to use (as an ability). Integer $[0-\infty]$ |
| | <BuildFrames> Type Range | The number of game frames that are required to complete training/researching the type. Integer $[0-\infty]$ |
| | <RequiredUnitsOrUpgrades> Type Range | A (possibly empty) list of unit and/or upgrade types that are required to be present when starting to train/research the type. For upgrade types this is list is always either empty (for abilities that do not need to be research first) or of size one (indicating at which building type the upgrade needs to be researched). List of Strings See Sections 4.2 and 4.3 |

4.1.4 stats/6

Description Information about the static properties of unit types.
 Syntax `stats(<Name>,<MaxHealth>,<MaxShield>,<MaxEnergy>,<TopSpeed>,<Conditions>)`
 Example `stats('Protoss High Templar', 40, 40, 200, 32, [canMove,organic]).`

| | | |
|------------|--|--|
| Parameters | <Name> Name Range | The name of the unit type. String See Section 4.2 |
| | <MaxHealth> Type Range | The maximum amount of health for units of the type. Invincible units (like spells) have 0 here. Integer [0–∞] |
| | <MaxShield> Type Range | The maximum amount of shield for units of the type. Integer [0–∞] |
| | <MaxEnergy> Type Range | The maximum amount of energy for units of the type. 0 for units that do not use energy at all. Integer [0–∞] |
| | <TopSpeed> Type Range | The top movement speed for units of the type (without upgrades). Integer [0–∞] |
| | <Conditions> Type Range | A (possibly empty) list static conditions for units of the type. List of Strings [addon, building, canBurrow, canDetect, canLift, canMove, canTrain, flies, mechanical, organic, requiresCreep, requiresPsi, robotic, spell] |

4.1.5 metrics/5

Description Information about the metrics (i.e. on the map) of unit types.

Syntax `metrics(<Name>,<Width>,<Height>,<SightRange>,<SpaceRequired>)`

Example `metrics('Terran Bunker', 3, 2, 10, -4).`

| | | |
|------------|---|---|
| Parameters | <Name> Name Range | The name of the unit type. String See Section 4.2 |
| | <Width> Type Range | The number of build tiles the unit is wide. Integer [0-∞] |
| | <Height> Type Range | The number of build tile the unit is high. Integer [0-∞] |
| | <SightRange> Type Range | The number of build tiles the unit's visibility reaches (without upgrades). Integer [0-∞] |
| | <SpaceRequired> Type Range | The space required to load the unit into a loadable unit if positive; a negative number indicates the space a loadable unit provides for other units (although e.g. Overlords require an upgrade to actually use this space). Integer [-8-8] |

4.1.6 combat/6

Description Information about the offensive capabilities of unit types or upgrade types (i.e abilities used on units or locations). All damages take attack speed into account, but not specific trade-offs (e.g. damage against organic vs. mechanic units). None of the properties take possible upgrades into account.

Syntax `combat(<Name>, <GroundDamage>, <AirDamage>, <CooldownFrames>, <Range>, <SplashRadius>)`

Example `combat('Psionic Storm', 14, 14, 45, 9, 1).`

| | | |
|-------------------|--|--|
| Parameters | <Name> Name Range | The name of the unit or upgrade type (that can be used as an ability) String See Sections 4.2 and 4.3 |
| | <GroundDamage> Type Range | The amount of damage the type does to ground units. 0 means it cannot attack ground. Integer [0-∞] |
| | <AirDamage> Type Range | The amount of damage the type does to air units. 0 means it cannot attack air. Integer [0-∞] |
| | <CooldownFrames> Type Range | The number number of game frames the type needs to cool down after an attack (i.e. wait before launching another attack). Integer [0-∞] |
| | <Range> Type Range | The number of build tiles the type's attack can span. Integer [0-∞] |
| | <SplashRadius> Type Range | The number of build tiles the type's attack can do splash damage (0 means no splash). Integer [0-∞] |

4.2 Unit Types

StarCraft's unit types (per race and category).

4.2.1 Terran

Ground

Terran Firebat
Terran Ghost
Terran Goliath
Terran Marine
Terran Medic
Terran SCV
Terran Siege Tank
Terran Vulture
Terran Vulture Spider Mine

Air

Terran Battlecruiser
Terran Dropship
Terran Nuclear Missile
Terran Science Vessel
Terran Valkyrie
Terran Wraith

Buildings

Terran Academy
Terran Armory
Terran Barracks
Terran Bunker
Terran Command Center
Terran Engineering Bay
Terran Factory
Terran Missile Turret
Terran Refinery
Terran Science Facility
Terran Starport
Terran Supply Depot

Addons

Terran Comsat Station
Terran Control Tower
Terran Covert Ops
Terran Machine Shop
Terran Nuclear Silo
Terran Physics Lab

Spells

Spell Scanner Sweep

4.2.2 Protoss

Ground

Protoss Archon
Protoss Dark Archon
Protoss Dark Templar
Protoss Dragoon
Protoss High Templar
Protoss Probe
Protoss Reaver
Protoss Scarab
Protoss Zealot

Air

Protoss Arbiter
Protoss Carrier
Protoss Corsair
Protoss Interceptor
Protoss Observer
Protoss Scout
Protoss Shuttle

Buildings

Protoss Arbiter Tribunal
Protoss Assimilator
Protoss Citadel of Adun
Protoss Cybernetics Core
Protoss Fleet Beacon
Protoss Forge

Protoss Gateway
Protoss Nexus
Protoss Observatory
Protoss Photon Cannon
Protoss Pylon
Protoss Robotics Facility
Protoss Robotics Support Bay
Protoss Shield Battery
Protoss Stargate
Protoss Templar Archives

Spells

Spell Disruption Web

4.2.3 Zerg

Ground

Zerg Broodling
Zerg Defiler
Zerg Drone
Zerg Egg
Zerg Hydralisk
Zerg Larva
Zerg Lurker
Zerg Lurker Egg
Zerg Ultralisk
Zerg Zergling

Air

Zerg Cocoon
Zerg Devourer
Zerg Guardian
Zerg Mutalisk
Zerg Overlord
Zerg Queen
Zerg Scourge

Buildings

Zerg Creep Colony
Zerg Defiler Mound

Zerg Evolution Chamber
Zerg Extractor
Zerg Greater Spire
Zerg Hatchery
Zerg Hive
Zerg Hydralisk Den
Zerg Lair
Zerg Nydus Canal
Zerg Queens Nest
Zerg Spawning Pool
Zerg Spire
Zerg Spore Colony
Zerg Sunken Colony
Zerg Ultralisk Cavern

Spells

Spell Dark Swarm

4.3 Upgrade Types

All upgrade types that can be researched for each race at the indicated building. Brackets with numbers indicate that the upgrade is available at multiple levels (i.e. *Zerg Carapace 1* > *Zerg Carapace* > *Zerg Carapace 3*). Upgrades that can be used as abilities are indicated in the next section.

4.3.1 Terran

Academy

Caduceus Reactor
Optical Flare
Restoration
Stim Packs
U-238 Shells

Armory

Terran Vehicle Plating (1,2,3)
Terran Vehicle Weapons (1,2,3)
Terran Ship Plating (1,2,3)
Terran Ship Weapons (1,2,3)

Control Tower

Cloaking Field

Covert Ops

Lockdown
Moebius Reactor
Ocular Implants
Personnel Cloaking

Engineering Bay

Terran Infantry Armor (1,2,3)
Terran Infantry Weapons (1,2,3)

Machine Shop

Charon Boosters
Ion Thrusters
Spider Mines
Tank Siege Mode

Physics Lab

Colossus Reactor

Yamato Gun

Science Facility

EMP Shockwave

Irradiate

Titan Reactor

Control Tower

Apollo Reactor

4.3.2 Protoss

Arbiter Tribunal

Khaydarin Core

Recall

Stasis Field

Citadel of Adun

Leg Enhancements

Cybernetics Core

Protoss Air Armor (1,2,3)

Protoss Air Weapons (1,2,3)

Singularity Charge

Fleet Beacon

Apial Sensors

Argus Jewel

Carrier Capacity

Disruption Web

Gravitic Thrusters

Forge

Protoss Ground Armor (1,2,3)

Protoss Ground Weapons (1,2,3)

Protoss Plasma Shields (1,2,3)

Observatory

Gravitic Boosters

Sensor Array

Robotics Support Bay

Gravitic Drive

Reaver Capacity

Scarab Damage

Templar Archives

Argus Talisman

Hallucination

Khaydarin Amulet

Maelstrom

Mind Control

Psionic Storm

4.3.3 Zerg

Defiler Mound

Consume

Metasynaptic Node

Plague

Evolution Chamber

Zerg Carapace (1,2,3)

Zerg Melee Attacks (1,2,3)

Zerg Missile Attacks (1,2,3)

Hatchery

Burrowing

Hydralisk Den

Grooved Spines

Lurker Aspect

Muscular Augments

Lair / Hive

Antennae

Pneumatized Carapace

Ventral Sacs

Queens Nest

Ensnare

Gamete Meiosis

Spawn Broodlings

Spawning Pool

Adrenal Glands

Metabolic Boost

(Greater) Spire

Zerg Flyer Attacks (1,2,3)

Zerg Flyer Carapace (1,2,3)

Ultralisk Cavern

Anabolic Synthesis

Chitinous Plating

4.4 Abilities

All abilities that can be used by the indicated units of each race, usually after having researched the corresponding upgrade (exceptions to this are noted). The potential target(s) is/are indicated in brackets.

4.4.1 Terran

Battle Cruiser

Yamato Gun (*unit*)

Comsat Station

Scanner Sweep (*position or unit*)

Ghost

Lockdown (*unit*)

Personnel Cloaking (*self*)

Nuclear Strike (*position or unit*)

Marine / Firebat

Stim Packs (*self*)

Medic

Healing (*position or unit*)

Restoration (*unit*)

Optical Flare (*unit*)

Science Vessel

Defensive Matrix (*unit*)

EMP Shockwave (*position or unit*)

Irradiate (*unit*)

Siege Tank

Tank Siege Mode (*self*)

Vulture

Spider Mines (*position*)

WraithCloaking Field (*self*)**4.4.2 Protoss****Arbiter**Recall (*position or unit*)Stasis Field (*position or unit*)**Corsair**Disruption Web (*position or unit*)**Dark Archon**Feedback (*unit*)Maelstrom (*position or unit*)Mind Control (*unit*)**Dark Templar**Dark Archon Meld (*unit*)**High Templar**Archon Warp (*unit*)Psionic Storm (*position or unit*)Hallucination (*unit*)**4.4.3 Zerg****Generic**Burrowing (*self*)

Lurkers can use this ability without having it researched; for Zerglings, Defilers, Hydralisks and Drones the upgrade needs to be researched.

DefilerDark Swarm (*position or unit*)Plague (*position or unit*)Consume (*unit*)**Queen**Infestation (*unit*)Parasite (*unit*)

Ensnare (*position or unit*)

Spawn Broodlings (*unit*)

4.5 Known Limitations

Here we list functionalities that the connector does not support at this time:

- Getting more detailed information about the map like the exact shapes of regions and non-walkable locations.
- Detecting ‘bullets’ like Psionic Storms and Subterranean Spikes.
- Detecting upgrades performed by the enemy player.
- Specifying the random seed used for a match.
- Automatically pausing the game when a whole MAS is paused.