Domination Game Documentation

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Contents

CHAPTER 1

Intro

The domination game is a game played by two teams of agents. They will combat one another and accumulate points through capturing control points on the map. The team with the most agents on a control point will capture that control point. These control points remain captured by the same team even when left alone. Agents are capable of picking up ammo, that spawns at designated positions on the map, and use it to shoot other agents. Upon death, agents will respawn in their teams' designated spawn areas. Agents can freely roam the map, but are unable to walk through walls or other agents.

Within one iteration an agent can turn, change its speed, and shoot (in that order). To assure that simulations can terminate in reasonable time, there is a reaction time limit per iteration per agent. Simply, if the agent exceeds this limit it will not do anything. Map layouts (walls, control points and such) are known at the start of the game, but other info are not commonly known and have to be observed by the agents (ammopacks and agents).

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2.1 Running a Game

In order to run a game, you need to import the domination module, and either create a *`Scenario`*, or create a *`Game`* object directly.

2.1.1 Creating a Game object directly

The simplest way you can use the game object, is to just instantiate it and call its *`run()`* method. This will run a game with all its default settings:

```
from domination import core
core.Game(rendered=True).run() # Set rendered=False if you don't have pygame.
```

However, creating a game object directly is useful mainly if you want to do some fiddling with its internals, so we recommend skipping right to Creating Agents or Using Scenarios.

If we like, we can mess around a bit with the game object and its properties:

```
from domination import core

# Make it a short game
settings = core.Settings(max_steps=20)

# Initialize a game
game = core.Game('domination/agent.py','domination/agent.py',
    record=True, rendered=False, settings=settings)

# Will run the entire game.
game.run()

# And now let's see the replay!
replay = game.replay
playback = core.Game(replay=replay)
playback.run()
```

2.1.2 Game

The *`Game`* class has the following specification.

class `domination.core.`**`Game`**(*red=<open file '/home/docs/checkouts/readthedocs.org/user_builds/domination-game/checkouts/stable/domination/agent.py', mode 'r'>, blue=<open file '/home/docs/checkouts/readthedocs.org/user_builds/domination-game/checkouts/stable/domination/agent.py', mode 'r'>, red_init={}, blue_init={}, settings=Settings(), field=None, record=False, replay=None, rendered=True, verbose=True, step_callback=None*)

The main game class. Contains game data and methods for simulation.

Constructor for Game class

Parameters

- **`red`** – Descriptor of the red agent. Can be either a path, an open file, a string with the class definition, or an instance of `Team`
- **`blue`** – Descriptor of the blue agent
- **`red_init`** – A dictionary of keyword arguments passed to the red agent constructor.
- **`blue_init`** – Like red_init.
- **`settings`** – Instance of the settings class.
- **`field`** – An instance of Field to play this game on.
- **`record`** – Store all actions in a game replay.
- **`replay`** – Pass a game replay to play it.
- **`rendered`** – Enable/disable the renderer.
- **`verbose`** – Print game log to output.
- **`step_callback`** – Function that is called on every step. Useful for debugging.

`log` = **None**

The game log as an instance of class:~*domination.core.GameLog*

`replay` = **None**

The replay object, can be accessed after game has run

`stats` = **None**

Instance of *`GameStats`*.

`red` = **None**

Instance of `Team`.

`blue` = **None**

Instance of `Team`.

`run`()

Start and loop the game.

class `domination.core.`**`GameStats`**

`score_red` = **None**

The number of points scored by red

`score_blue` = **None**

The number of points scored by blue

`score` = **None**

The final score as a float (red/total)

`steps` = None
Number of steps the game lasted

`ammo_red` = None
Number of ammo packs that red picked up

`ammo_blue` = None
Idem for blue

`deaths_red` = None
Number red agents that got shot

`deaths_blue` = None
Number blue agents that got shot

`think_time_red` = None
Total time in seconds that red took to compute actions

`think_time_blue` = None
Idem for blue

2.1.3 Replays

Running replays is easy, first you need to unpack them:

```
>>> import pickle
>>> from domination import core
>>> rp = pickle.load(open('replay20120215-1341_t2v1_vs_t6v1.pickle','rb'))
>>> print rp
<domination.core.ReplayData object at 0x10fca5fd0>
```

Then you call the play method:

```
>>> rp.play()
```

class `domination.core.`**`ReplayData`**(*game*)
Contains the replaydata for a game.

`play`()
Convenience method for setting up a game to play this replay.

2.1.4 Settings

class `domination.core.`**`Settings`**(*max_steps=600, max_score=1000, max_turn=1.0471975511965976, max_speed=40, max_range=60, max_see=100, field_known=True, ammo_rate=20, ammo_amount=3, agent_type='tank', spawn_time=10, tilesize=16, think_time=0.01, capture_mode=0, end_condition=1*)
Constructor for Settings class

Parameters

- **`max_steps`** – How long the game will last at most
- **`max_score`** – If either team scores this much, the game is finished
- **`max_speed`** – Number of game units each tank can drive in its turn
- **`max_turn`** – The maximum angle that a tank can rotate in a turn

- **max_range** – The shooting range of tanks in game units
- **max_see** – How far tanks can see (Manhattan distance)
- **field_known** – Whether the agents have knowledge of the field at game start
- **ammo_rate** – How long it takes for ammo to reappear
- **ammo_amount** – How many bullets there are in each ammo pack
- **agent_type** – Type of the agents ('tank' or 'vacubot')
- **spawn_time** – Time that it takes for tanks to respawn
- **think_time** – How long the tanks have to do their computations (in seconds)
- **capture_mode** – One of the CAPTURE_MODE constants.
- **end_condition** – One of the ENDGAME flags. Use bitwise OR for multiple.
- **tilesize** – How big a single tile is (game units), change at risk of massive bugginess

The `Settings.capture_mode` can be one of:

`domination.core.`**CAPTURE_MODE_NEUTRAL = 0**
: Controlpoints are neutral when occupied by both teams

`domination.core.`**CAPTURE_MODE_FIRST = 1**
: Controlpoints stay in control of first team that captures them

`domination.core.`**CAPTURE_MODE_MAJORITY = 2**
: Controlpoints are owned by the team with the most occupiers

The `Settings.end_condition` can be one of:

`domination.core.`**ENDGAME_NONE = 0**
: End game when time expires

`domination.core.`**ENDGAME_SCORE = 1**
: End game when either team has 0 score

`domination.core.`**ENDGAME_CRUMBS = 2**
: End game when all crumbs are picked up

2.2 Creating Agents

Writing agents consists of creating a Python class that implements *five* methods, some of which are optional. The agents are imported using Python's exec method, after which the class named *Agent* is extracted. It is probably easiest to refer to and modify the default agent. But there is a quick rundown of the functions below as well.

The first thing you need to do is create a new file with a class named *Agent* that contains these 5 methods:

```
class Agent(object):

    NAME = "my_agent" # Replay filenames and console output will contain this name.

    def __init__(self, id, team, settings=None, field_rects=None, field_grid=None, nav_mesh=None, **
        pass

    def observe(self, observation):
        pass

    def action(self):
        return (0,0,False)

    def debug(self, surface):
        pass

    def finalize(self, interrupted=False):
        pass
```

2.2.1 Initialize

It needs to implement an *__init__* method that accepts a number of setup arguments. This method will be called for each agent at the beginning of each game.

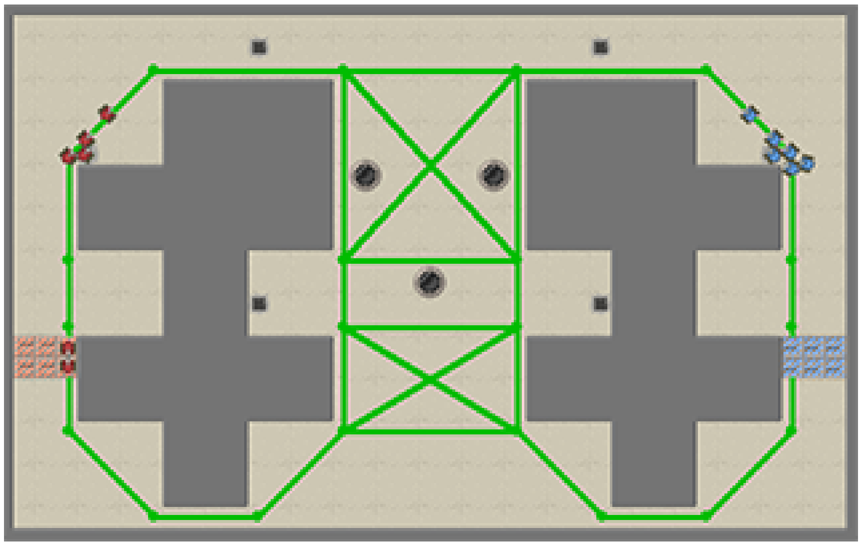
`Agent.`**`__init__`**`(`*id*, *team*, *settings=None*, *field_rects=None*, *field_grid=None*, *nav_mesh=None*, *blob=None*`)`

Each agent is initialized at the beginning of each game. The first agent (id==0) can use this to set up global variables. Note that the properties pertaining to the game field might not be given for each game.

The *settings* object is an instance of `Settings`, and contains all the game settings such as game length and maximum score. The `field_rects`, `field_grid`, and `nav_mesh` arguments provide some information about the map that the game will be played on. The first contains a list of walls on the map as `(x,y,width,height)` tuples, the second contains the same information, but as a 2D binary array instead.

Navigation Mesh

Also passed to the agent constructor is a 'navigation mesh'. This is a directed graph containing **the set of points from which all points on the map can be seen**, and the straight lines connecting them. You can use it in conjunction with `find_path()` to plan paths.



It is structured as a dictionary where the keys are `(x, y)` tuples defining connectivity and distances. All connections are in this dictionary *two times*, both A → B and B → A are in there. The example below shows a point at `(0, 0)` connected to two other points, at `(1, 0)` and `(0 ,2)`:

```
{(0, 0): {(1, 0): 1.0,
          (0, 2): 2.0},
 (1, 0): {(0, 0): 1.0},
 (0, 2): {(0, 0): 2.0}}
```

Agent Parameters

Finally, you can provide extra arguments to "parametrize" your agents. You can set these arguments when you start a new game. For example, if your initialization looks as follows:

```
def __init__(self, id, team, settings, field_rects, field_grid, nav_mesh, aggressiveness=0.0):
```

Then you can set this parameter to different values when you start the game:

```
MyScenario('my_agent.py','opponent.py',red_init={'aggressiveness':10.0}).run()
MyScenario('my_agent.py','opponent.py',red_init={'aggressiveness':20.0}).run()
```

2.2.2 Observe

The second method you need to implement is `observe`. This method is passed an *observation* of the current game state, depending on the settings, agents usually don't observe the entire game field, but only a part of it. Agents use this function to update what they know about the game, e.g. computing the most likely locations of enemies. The properties of the *Observation* object are listed below.

`Agent.`**`observe`**`(`*observation*`)`

Each agent is passed an observation using this function, before being asked for an action. You can store either the observation object or its properties to use them to determine your action. Note that the observation object is modified in place.

```
class Observation(object):
    def __init__(self):
        self.step        = 0      #: Current timestep
        self.loc         = (0,0)  #: Agent's location (x,y)
        self.angle       = 0      #: Current angle in radians
        self.walls       = []     #: Visible walls around the agent: a 2D binary array
        self.friends     = []     #: All/Visible friends: a list of (x,y,angle)-tuples
        self.foes        = []     #: Visible foes: a list of (x,y,angle)-tuples
        self.cps         = []     #: Controlpoints: a list of (x,y,TEAM_RED/TEAM_BLUE)-tuples
        self.objects     = []     #: Visible objects: a list of (x,y,type)-tuples
        self.ammo        = 0      #: Ammo count
        self.score       = (0,0)  #: Current game score
        self.collided    = False  #: Whether the agent has collided in the previous turn
        self.respawn_in  = -1     #: How many timesteps left before this agent can move again.
        self.hit         = None   #: What the agent hit with its last shot. Can be None/TEAM_RED/TEAM_
        # The following properties are only set when
        # the renderer is enabled:
        self.selected = False     #: Indicates if the agent is selected in the UI
        self.clicked = None       #: Indicates the position of a right-button click, if there was one
        self.keys = []            #: A list of all keys pressed in the previous turn

    def __str__(self):
        items = sorted(self.__dict__.items())
        maxlen = max(len(k) for k,v in items)
        return "== Observation ==\n" + "\n".join(('%s : %r'%(k.ljust(maxlen), v)) for (k,v) in items
```

2.2.3 Action

This is the most important function you have to implement. It should return a tuple containing a representation of the action you want the agent to perform. In this game, the action tuples are supposed to look like `(turn, speed, shoot)`.

- **Turn** indicates how much your tank should spin around it's center.
- **Speed** indicates how much you want your tank to drive forward after it has turned.
- **Shoot** is set to True if you want to fire a projectile in this turn.

Turn is given in radians, and **Speed** is given in game units (corresponding to pixels in the renderer). Note that any exceptions raised by your agent are ignored, and the agent simply loses it's turn. Turn and speed are capped by the game settings.

`Agent.`**`action`**`()`

This function is called every step and should return a tuple in the form: (turn, speed, shoot)

2.2.4 Debug

Allows the agents to draw on the game UI, refer to the pygame reference to see how you can draw on a pygame.surface. The given surface is not cleared automatically. Additionally, this function will only be called when the renderer is active, and it will only be called for the active team.

`Agent.`**`debug`**`(`*surface*`)`

Allows the agents to draw on the game UI, Refer to the pygame reference to see how you can draw on a pygame.surface. The given surface is not cleared automatically. Additionally, this function will only be called when the renderer is active, and it will only be called for the active team.

2.2.5 Finalize

This method gives your agent an opportunity to store data or clean up after the game is finished. Learning agents could store their Q-tables, which they load up in `__init__`.

`Agent.`**`finalize`**`(`*interrupted=False*`)`

This function is called after the game ends, either due to time/score limits, or due to an interrupt (CTRL+C) by the user. Use it to store any learned variables and write logs/reports.

2.2.6 Communication

The recommended way to establish communication between agents is to define static attributes in the `Agent` class definition. Static attributes are variables that are identical for every instance of the class, essentially, they are attributes of the *class*, not of the instances.

In Python, static variables can be defined in the class body, and accessed through the class definition. Be careful, setting `Agent.attribute` is quite different from setting `my_agent = Agent(); my_agent.attribute`:

```python
class Agent:
    shared_knowledge = 1

    def __init__(self, etc):
        print Agent.shared_knowledge
        # is identical to
        print self.__class__.shared_knowledge

        # BUT THIS IS DIFFERENT:
        self.shared_knowledge = 5
```

2.2.7 (Binary) Data

You might want to supply your agent with additional (binary) data, for example a Q/value table, or some kind of policy representation. The convention for doing this is to pass an open file-pointer to the agent's constructor:

```
Game(..., red_init={'blob': open('my_q_table','rb')} )
```

This is also the way that your data will be passed to the agent in the web app. If you have stored your data as a pickled file, you can simply read it with:

```
# In class Agent
def __init__(..., blob=None ):
    if blob is not None:
        my_data = pickle.reads(blob.read())
        blob.seek(0) #: Reset the filepointer for the next agent.
                     #  if you omit this, the next agent will raise an EOFError
```

Of course, the way you store your data in this file is up to you, you can store it in any format, and even read it line-by-line if you want.

2.3 Using Scenarios

Because most usage of the game will be more or less the same, some stuff has been automated in the form of a Scenario. Scenarios offer a way to define settings and score conditions, and automatically save the results of repeated runs.

For example, we subclass the Scenario module from domination.run:

```
import domination

class MyScenario(domination.run.Scenario) :
   REPEATS  = 10
   SETTINGS = core.Settings()
   FIELD    = core.FieldGenerator().generate()

   def before_each():
       # Regenerate the field before each game.
       self.FIELD = core.FieldGenerator().generate()
```

We can now run our scenario and save the results:

```
ms.one_on_one('agent_one.py', 'agent_two.py', output_folder='results')
```

2.3.1 Reference

class `domination.run.`**`Scenario`**

A scenario is used to run multiple games under the same conditions.

`SETTINGS` **= Settings()**

The settings with which these games will be played

`GENERATOR` **= <domination.core.FieldGenerator object>**

Will generate FIELD before each game if defined

`FIELD` **= None**

Will play on this field if GENERATOR is None

REPEATS = 2
How many times to repeat each game

SWAP_TEAMS = True
Repeat each run with blue/red swapped

setup()
Function is called once before any games

before_each()
Function that is run before each game. Use it to regenerate the map, for example.

after_each(*game*)
Function that is run after each game.

Parameters **game** – The previous game

classmethod test(*red*, *blue*)
Test this scenario, this will run a single game and render it, so you can verify the FIELD and SETTINGS.

Parameters

- **red** – Path to red agent
- **blue** – Path to blue agent

classmethod one_on_one(*red*, *blue*, *output_folder=None*)
Runs the set amount of REPEATS and SWAP_TEAMS if desired, between two given agents.

Parameters **output_folder** – Folder in which results will be stored

classmethod tournament(*folder=None*, *agents=None*, *output_folder=None*)
Runs a full tournament between the agents specified, respecting the REPEATS and SWAP_TEAMS settings.

Parameters

- **agents** – A list of paths to agents
- **folder** – A folder that contains all agents, overrides the agents parameter.
- **output_folder** – Folder in which results will be stored.

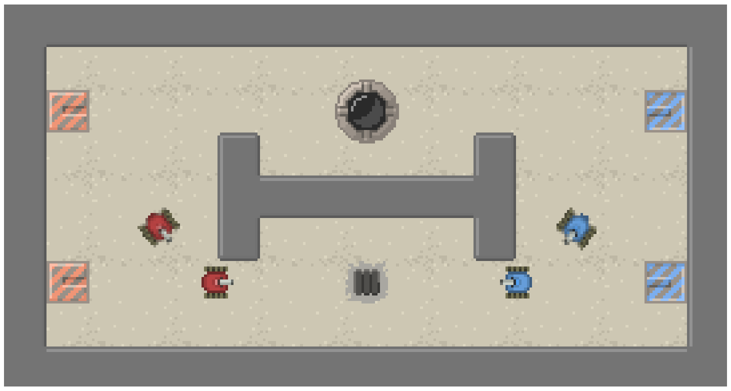
2.4 Customizing the Field

Game fields are based on a tilemap where each tile can only be occupied by a single object. This means they can be represented conveniently by an ASCII representation. You can instantiate fields from these ASCII representations as well. Suppose we create a file *field.txt* with the following contents:

```
w w w w w w w w w w w w w w w w w
w _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ w
w R _ _ _ _ _ _ C _ _ _ _ _ _ B w
w _ _ _ _ w _ _ _ _ _ w _ _ _ _ w
w _ _ _ _ w w w w w w w _ _ _ _ w
w _ _ _ _ w _ _ _ _ _ w _ _ _ _ w
w R _ _ _ _ _ _ A _ _ _ _ _ _ B w
w _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ w
w w w w w w w w w w w w w w w w w
```

We can then load it up using the `domination.core.Field.from_string()` function, the map defined aboves looks like the image below:

```
field = core.Field.from_string(open('field.txt').read())
core.Game(field=field).run()
```



The default maps are randomly generated using the `FieldGenerator` class, it has a number of paramters for generating maps.

class `domination.core.`**`FieldGenerator`**(*width=41*, *height=24*, *tilesize=16*, *mirror=True*, *num_red=6*, *num_blue=6*, *num_points=3*, *num_ammo=6*, *num_crumbsource=0*, *wall_fill=0.4*, *wall_len=(3, 7)*, *wall_width=4*, *wall_orientation=0.5*, *wall_gridsize=6*)

Generates field objects from random distribution

Create a FieldGenerator object with certain parameters for a random distribution of fields.

Parameters

- **`width`** – The width of the field in tiles
- **`height`** – The height of the field in tiles
- **`tilesize`** – The size of each tile (don't change from 16)
- **`mirror`** – Make a symmetrical map
- **`num_blue`** – The number of blue spawns
- **`num_red`** – The number of red spawns
- **`num_points`** – The number of controlpoints
- **`num_ammo`** – The number of ammo locations on the map
- **`num_crumbsource`** – The number of crumb fountains
- **`wall_fill`** – What portion of the map is occupied by walls
- **`wall_len`** – A range for the length of wall sections (min, max)
- **`wall_width`** – The width of each wall section
- **`wall_orientation`** – The probability that each wall will be placed horizontally i.e. that the walls length will be along a horizontal axis
- **`wall_gridsize`** – Place walls only at every n-th tile with their top-left

`generate`()

Generates a new field using the parameters for random distribution set in the constructor.

Returns A `Field` instance.

2.5 Utilities

This module holds functions, exceptions and constants that are or might be used by both the game, renderer and perhaps the agents. By putting this code in a separate module, each of them can access it without requiring the other modules.

`domination.utilities.`**`frange`**(*limit1*, *limit2=None*, *increment=1.0*)
Like xrange, but for real numbers.

`domination.utilities.`**`mean`**(*iterable*)
Returns mean of given list or generator.

`domination.utilities.`**`stdev`**(*iterable*)
Returns standard deviation of given list or generator.

```
>>> stdev([1,2,3])
1.0
```

`domination.utilities.`**`point_add`**(*a*, *b*)
Add the coordinates of two points (Inline this if you can, function calls are slow)

`domination.utilities.`**`point_sub`**(*a*, *b*)
Subtract two 2d vectors (Inline this if you can, function calls are slow)

`domination.utilities.`**`point_mul`**(*a*, *f*)
Multiply a vector by a scalar (Inline this if you can, function calls are slow)

`domination.utilities.`**`point_dist`**(*a*, *b*)
Distance between two points.

`domination.utilities.`**`line_intersects_rect`**(*p0*, *p1*, *r*)
Check where a line between p1 and p2 intersects given axis-aligned rectangle r. Returns False if no intersection found. Uses the Liang-Barsky line clipping algorithm.

```
>>> line_intersects_rect((1.0,0.0),(1.0,4.0),(0.0,1.0,4.0,1.0))
((0.25, (1.0, 1.0)), (0.5, (1.0, 2.0)))
```

```
>>> line_intersects_rect((1.0,0.0),(3.0,0.0),(0.0,1.0,3.0,1.0))
False
```

`domination.utilities.`**`line_intersects_circ`**(*(p0x, p0y)*, *(p1x, p1y)*, *(cx, cy)*, *r*)
Computes intersections between line and circle. The line runs between (p0x,p0y) and (p1x,p1y) and the circle is centered at (cx,cy) with a radius r. Returns False if no intersection is found, and one or two intersection points otherwise. Intersection points are (t, (x, y)) where t is the distance along the line between 0-1. (From stackoverflow.com/questions/1073336/circle-line-collision-detection)

```
>>> line_intersects_circ((0,0), (4,0), (2,0), 1)
[(0.25, (1.0, 0.0)), (0.75, (3.0, 0.0))]
```

```
>>> line_intersects_circ((0,0), (2,0), (2,0), 1)
[(0.5, (1.0, 0.0))]
```

```
>>> line_intersects_circ((0,0), (0,1), (2,0), 1)
False
```

`domination.utilities.`**`line_intersects_grid`**(*(x0, y0)*, *(x1, y1)*, *grid*, *grid_cell_size=1*)
Performs a line/grid intersection, finding the “super cover” of a line and seeing if any of the grid cells are occupied. The line runs between (x0,y0) and (x1,y1), and (0,0) is the top-left corner of the top-left grid cell.

```
>>> line_intersects_grid((0,0),(2,2),[[0,0,0],[0,1,0],[0,0,0]])
True
```

```
>>> line_intersects_grid((0,0),(0.99,2),[[0,0,0],[0,1,0],[0,0,0]])
False
```

`domination.utilities.`**`rect_contains_point`**(*rect*, *point*)
Check if rectangle contains a point.

`domination.utilities.`**`rect_offset`**(*rect*, *offset*)
Offsets (grows) a rectangle in each direction.

`domination.utilities.`**`rect_corners`**(*rect*)
Returns cornerpoints of given rectangle.

```
>>> rect_corners((1,2,1,3))
((1, 2), (2, 2), (2, 5), (1, 5))
```

`domination.utilities.`**`rects_bound`**(*rects*)
Returns a rectangle that bounds all given rectangles

```
>>> rects_bound([(0,0,1,1), (3,3,1,1)])
(0, 0, 4, 4)
```

`domination.utilities.`**`rects_merge`**(*rects*)
Merge a list of rectangle (xywh) tuples. Returns a list of rectangles that cover the same surface. This is not necessarily optimal though.

```
>>> rects_merge([(0,0,1,1),(1,0,1,1)])
[(0, 0, 2, 1)]
```

`domination.utilities.`**`angle_fix`**(*theta*)
Fixes an angle to a value between -pi and pi.

```
>>> angle_fix(-2*pi)
0.0
```

`domination.utilities.`**`reachable`**(*grid*, *(x*, *y)*, *border=1*)
Performs a 'flood fill' operation to find reachable areas on given tile map from (x,y). Returns as binary grid with 1 for reachable.

Parameters **`border`** – can be a value or a function indicating borders of region

```
>>> reachable([[0,1,0],[0,1,0]], (0,0))
[[1, 0, 0], [1, 0, 0]]
```

`domination.utilities.`**`make_nav_mesh`**(*walls*, *bounds=None*, *offset=7*, *simplify=0.001*, *add_points=[]*)
Generate an almost optimal navigation mesh between the given walls (rectangles), within the world bounds (a big rectangle). Mesh is a dictionary of dictionaries:

mesh[point1][point2] = distance

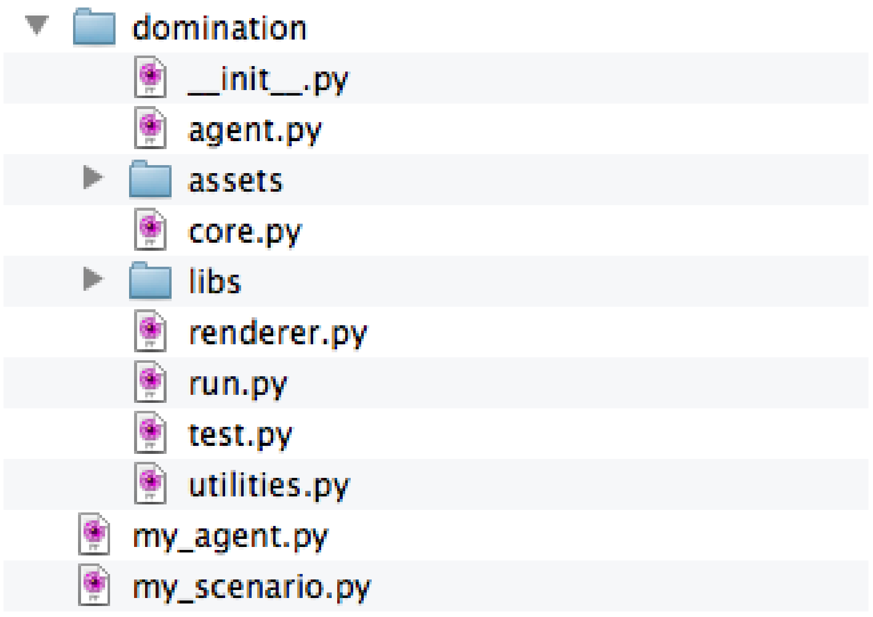
`domination.utilities.`**`find_path`**(*start*, *end*, *mesh*, *grid*, *tilesize=16*)
Uses astar to find a path from start to end, using the given mesh and tile grid.

```
>>> grid = [[0,0,0,0,0],[0,0,0,0,0],[0,0,1,0,0],[0,0,0,0,0],[0,0,0,0,0]]
>>> mesh = make_nav_mesh([(2,2,1,1)],(0,0,4,4),1)
>>> find_path((0,0),(4,4),mesh,grid,1)
[(4, 1), (4, 4)]
```

Quickstart

If you're not going to read any of the other documentation, just do the following.

1. Copy and modify the basic agent found in the source code (agent.py).
2. Make sure your folder structure looks like this (you only need the *domination* module):



```
domination
    __init__.py
    agent.py
    assets
    core.py
    libs
    renderer.py
    run.py
    test.py
    utilities.py
my_agent.py
my_scenario.py
```

3. Create another file, put the following code in there, and run it:

```
from domination import core, run

class MyScenario(run.Scenario):
   REPEATS = 10
   SETTINGS = core.Settings(max_steps=100)

MyScenario.test(red='my_agent.py', blue='domination/agent.py')
```

CHAPTER 4

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