Let us try to create here, through different cells, all the necessary material to run a very first simulation. We need: user inputs for initial positions; user-given (only for now!) values of 'reward' probability amplitudes; a bunch of operations, a Qiskit extension, and a loop to run the code multiple times. If we are even able to create a visual representation which is updated at each time step, that would be so cool!

(We have to use ESC + M to write a text rather than a coding line in Jupyter). The following cell shouldn't change across time.

In [97]:

```
# Some resources on Python robot simulation can be found here: https://jyro.read
```

In [98]:

```
from ibm_quantum_widgets import CircuitComposer
from qiskit import QuantumRegister, ClassicalRegister, QuantumCircuit, Aer, exec
import numpy as np
from numpy import pi
from ibm_quantum_widgets import draw_circuit
from qiskit.providers.aer import QasmSimulator
from qiskit.utils import QuantumInstance
from qiskit.visualization import plot_histogram, plot_state_qsphere
from qiskit import *
import random
import matplotlib.pyplot as plt
import pylab
import pandas as pd
from sklearn import preprocessing
import collections
from collections import Counter
```

In [99]:

```
# from: https://stackoverflow.com/questions/39298928/play-multiple-sounds-at-the

# we can use this to play multiple notes (the chord!) at the same time

from pydub import AudioSegment
from pydub.playback import play

audio0 = AudioSegment.from_file("notes_/example_.wav") # play as an example
# play(audio0)

audio1 = AudioSegment.from_file("notes_/tC.mp3") # note 1 # C played with trumpe
audio2 = AudioSegment.from_file("notes_/fE.mp3") # note 2 # E played with flute
audio3 = AudioSegment.from_file("notes_/cG.mp3") # note 3 # G played with cello

mixed = audio1.overlay(audio2)          # combine , superimpose audio files
mixed1  = mixed.overlay(audio3)          # further combine , superimpose audio f

mixed1.export("notes_/mixed.mp3", format='mp3') # export mixed  audio file
play(mixed1)                                # play mixed audio file
# change this line at each time point, so in the end we can get a little piece s

```

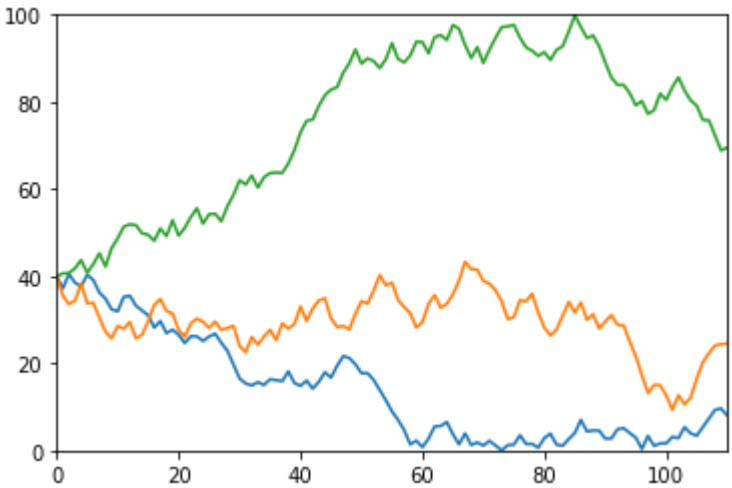
```
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmpjboysmqs.
wav':
  Duration: 00:00:07.31, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.26 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

In [100]:

```
# bounded random walk:
# example from https://stackoverflow.com/questions/46954510/random-walk-series-b


def bounded_random_walk(length, lower_bound,  upper_bound, start, end, std):
    assert (lower_bound <= start and lower_bound <= end)
    assert (start <= upper_bound and end <= upper_bound)

    bounds = upper_bound - lower_bound

    rand = (std * (np.random.random(length) - 0.5)).cumsum()
    rand_trend = np.linspace(rand[0], rand[-1], length)
    rand_deltas = (rand - rand_trend)
    rand_deltas /= np.max([1, (rand_deltas.max()-rand_deltas.min())/bounds])

    trend_line = np.linspace(start, end, length)
    upper_bound_delta = upper_bound - trend_line
    lower_bound_delta = lower_bound - trend_line

    upper_slips_mask = (rand_deltas-upper_bound_delta) >= 0
    upper_deltas =  rand_deltas - upper_bound_delta
    rand_deltas[upper_slips_mask] = (upper_bound_delta - upper_deltas)[upper_sli

    lower_slips_mask = (lower_bound_delta-rand_deltas) >= 0
    lower_deltas =  lower_bound_delta - rand_deltas
    rand_deltas[lower_slips_mask] = (lower_bound_delta + lower_deltas)[lower_sli

    return trend_line + rand_deltas

randomData1 = bounded_random_walk(1000, lower_bound=0, upper_bound =100, start=4
randomData2 = bounded_random_walk(1000, lower_bound=0, upper_bound =100, start=4
randomData3 = bounded_random_walk(1000, lower_bound=0, upper_bound =100, start=4
```

In [101]:

```
plt.figure()
# plt.plot(range(randomData.shape[0]), randomData1,randomData2,randomData3)
plt.plot(randomData1)
plt.plot(randomData2)
plt.plot(randomData3)
plt.axis([0, 110, 0, 100])
plt.show()
plt.close()
```



Circuit components initialization. The specific qubits are on $|0\rangle$ by default. They will get a gate later on, according on attributes of classes. The following cell shouldn't change across time.

In [102]:

```
q = QuantumRegister(5, 'q'); # qubits # changed to 9, formerly 15
m2 = ClassicalRegister(1, 'c1'); # classical bits (separated is better)
m3 = ClassicalRegister(1, 'c2');
m4 = ClassicalRegister(1, 'c3');

qc3 = QuantumCircuit(q, m2, m3, m4); # to reach the target
qc4 = QuantumCircuit(q, m2, m3, m4); # to get back to the nest
```

In [103]:

```
class Target:
    def __init__(self,name,x,y): # no indetermination in the target's position
        self.name = name
        self.x = x
        self.y = y
```

In [104]:

```
# let us change the reward position
#T = Target("T",0.9,0.5)

# changing the Target position
#T = Target("T",0.2,0.9)
#T = Target("T", 0.9, 0.9)
T = Target("T", 0.9, 0.5)
# for getting back to the beginning
T2 = Target("T2",0.2,0.5)
```

In [105]:

```
def reward(T, betax, betay):
    r = round(1 - ((T.x - betax)**2 + (T.y - betay)**2)**0.5, 2)
    # the closer the target, the less the distance, the higher the reward
    return r
```

Robot R_1: x-position $|q_0(t)\rangle = \alpha_1^x(t)|0\rangle + \beta_1^x(t)|1\rangle$; y-position $|q_1(t)\rangle = \alpha_1^y(t)|0\rangle + \beta_1^y(t)|1\rangle$; reward $|q_2(t)\rangle = \gamma_1(t)|0\rangle + \delta_1(t)|1\rangle$.

The class-initialization cells shouldn't change across time. However, cells with numerical values of class attributes should be updated.

In [106]:

```
class Robot1:
  def __init__(self,name, alphax, betax, alphay, betay, gamma, delta):
    self.name = name
    self.alphax = alphax
    self.betax = betax
    self.alphay = alphay
    self.betay = betay
    delta = reward(T, betax, betay)
    gamma = round(1 - delta, 2)
    self.gamma = gamma
    self.delta = delta
```

In [107]:

```
# manual intervention needed here to avoid circularity
reward(T, 0.2, 0.5) # value of delta
```

Out[107]:

```
0.3
```

In [108]:

```
# manual intervention needed here to avoid circularity
round(1 - reward(T, 0.2, 0.5), 2) # value of gamma
```

Out[108]:

```
0.7
```

The following cell, and the other corresponding cells, should be updated by hand at each time:

In [109]:

```
# (name, alphax, betax, alphay, betay, gamma, delta)
R1 = Robot1("R1",0.8, 0.2, 0.5, 0.5, 0.7, 0.3)
```

In [110]:

```
R1.gamma, R1.delta
```

Out[110]:

```
(0.7, 0.3)
```

Robot R_2: x-position $|q_3(t)\rangle = \alpha_2^x(t)|0\rangle + \beta_2^x(t)|1\rangle$; y-position $|q_4(t)\rangle = \alpha_2^y(t)|0\rangle + \beta_2^y(t)|1\rangle$; reward $|q_5(t)\rangle = \gamma_2(t)|0\rangle + \delta_2(t)|1\rangle$

In [111]:

```
class Robot2:
  def __init__(self,name,alphax, betax, alphay, betay, gamma, delta):
    self.name = name
    self.alphax = alphax
    self.betax = betax
    self.alphay = alphay
    self.betay = betay
    delta = reward(T, betax, betay)
    gamma = round(1 - delta, 2)
    self.gamma = gamma
    self.delta = delta
```

In [112]:

```
reward(T, 0.24, 0.5) # manual intervention needed here to avoid circularity
```

Out[112]:

```
0.34
```

In [113]:

```
round(1 - reward(T, 0.24, 0.5), 2) # manual intervention needed here to avoid ci
```

Out[113]:

```
0.66
```

In [114]:

```
R2 = Robot2("R2",0.76, 0.24, 0.5, 0.5, 0.66, 0.34) # update by hand this line
```

In [115]:

```
R2.delta, R2.gamma, R2.alphax, R2.betax, R2.alphay, R2.betay
```

Out[115]:

```
(0.34, 0.66, 0.76, 0.24, 0.5, 0.5)
```

Robot R_3: x-position $|q_6(t)\rangle = \alpha_3^x(t)|0\rangle + \beta_3^x(t)|1\rangle$; y-position $|q_7(t)\rangle = \alpha_3^y(t)|0\rangle + \beta_3^y(t)|1\rangle$; reward $|q_8(t)\rangle = \gamma_3(t)|0\rangle + \delta_3(t)|1\rangle$

In [116]:

```
class Robot3:
  def __init__(self, name, alphax, betax, alphay, betay, gamma, delta):
    self.name = name
    self.alphax = alphax
    self.betax = betax
    self.alphay = alphay
    self.betay = betay
    delta = reward(T, betax, betay)
    gamma = round(1 - delta, 2)
    self.gamma = gamma
    self.delta = delta
```

In [117]:

```
reward(T, 0.19, 0.54) # manual intervention needed here to avoid circularity
```

Out[117]:

```
0.29
```

In [118]:

```
round(1 - reward(T, 0.19, 0.54), 2) # manual intervention needed here to avoid c
```

Out[118]:

```
0.71
```

In [119]:

```
R3 = Robot3("R3", 0.8, 0.19, 0.46, 0.54, 0.71, 0.29) # to be updated by hand
```

In [120]:

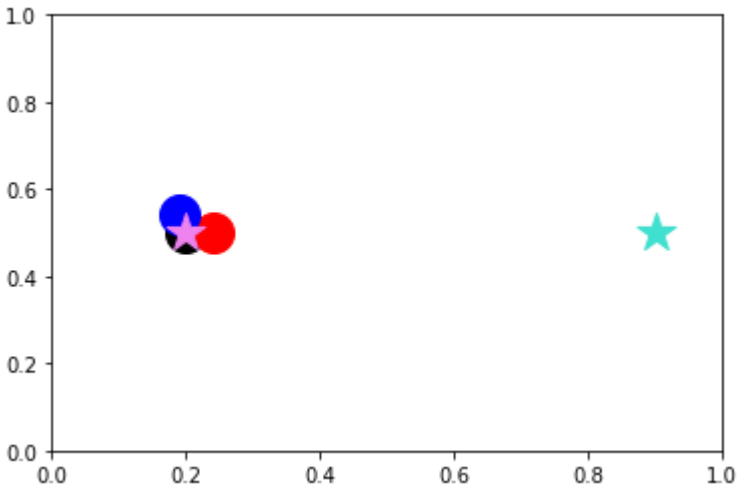
```
R3.gamma, R3.delta
```

Out[120]:

```
(0.71, 0.29)
```

In [121]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [122]:

```
R1.delta, R2.delta, R3.delta
```

Out[122]:

```
(0.3, 0.34, 0.29)
```

In [123]:

```
1 R3.alphay, R3.betay
```

Out[123]:

(0.46, 0.54)

In [124]:

```
1 # Audio section :)
```

In [125]:

```
1
2  # audio 1, R_1
3
4  if (R1.betax == 0):
5      if (R1.betay == 0.5):
6          audio1 = AudioSegment.from_file("notes_/tC.mp3")
7          print("tC")
8  if (R1.betax > 0 and R1.betax <= 0.17):
9      if (R1.betay < 0.5):
10         audio1 = AudioSegment.from_file("notes_/tB.mp3")
11         print("tB")
12     if (R1.betay >= 0.5):
13         audio1 = AudioSegment.from_file("notes_/tC#.mp3")
14         print("tC#")
15 if (R1.betax > 0.17 and R1.betax <= 0.3):
16     if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
17         audio1 = AudioSegment.from_file("notes_/tA#.mp3")
18         print("tA#")
19     if (R1.betay >= 0.5):
20         audio1 = AudioSegment.from_file("notes_/tD.mp3")
21         print("tD")
22 if (R1.betax > 0.3 and R1.betax <= 0.5):
23     if (R1.betay < 0.5): # (R1.betay == 1):
24         audio1 = AudioSegment.from_file("notes_/tD#.mp3")
25         print("tD#")
26     if (R1.betay >= 0.5):
27         audio1 = AudioSegment.from_file("notes_/tA.mp3")
28         print("tA")
29 if (R1.betax > 0.5 and R1.betax <= 0.64):
30     if (R1.betay < 0.5):
31         audio1 = AudioSegment.from_file("notes_/tE.mp3")
32         print("tE")
33     if (R1.betay >= 0.5):
34         audio1 = AudioSegment.from_file("notes_/tG#.mp3")
35         print("tG#")
36 if (R1.betax > 0.64 and R1.betax <= 0.84):
37     if (R1.betay < 0.5):
38         audio1 = AudioSegment.from_file("notes_/tF.mp3")
39         print("tF")
40     if (R1.betay >= 0.5):
41         audio1 = AudioSegment.from_file("notes_/tG.mp3")
42         print("tG")
43 if (R1.betax > 0.84 and R1.betax <= 1):
44     #if (R1.betay == 0.5):
45     audio1 = AudioSegment.from_file("notes_/tF#.mp3")
46     print("tF#")
47
48 # audio 2, R_2
49
50 if (R2.betax == 0):
51     if (R2.betay == 0.5):
52         audio2 = AudioSegment.from_file("notes_/fC.mp3")
53         print("fC")
54 if (R2.betax > 0 and R2.betax <= 0.17):
55     if (R2.betay < 0.5):
56         audio2 = AudioSegment.from_file("notes_/fB.mp3")
57         print("fB")
58     if (R2.betay >= 0.5):
59         audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")
```

```
tD
fD
cD
```

In [126]:

```
mixed_time1_ = audio1.overlay(audio2)          # combine , superimpose audio fil
mixed_time1  = mixed_time1_.overlay(audio3)          # further combine , superim

mixed_time1.export("notes_/mixed_time1.mp3", format='mp3') # export mixed  audio
play(mixed_time1)                                  # play mixed audio file
# change this line at each time point, so in the end we can get a little piece
```

```
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmp9il2k0m3.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.25 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.29 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

In [127]:

```
# NEW! ---> January 13, 2022
```

NEW LINES of code: if the initial reward is high for all the three robots, but not 0.99 yet: --> randomly shuffle one of the positions.

In [128]:

```
if (R1.delta and R2.delta and R3.delta) >= 0.8 and (R1.delta and R2.delta and R3
    print("ciao ciao")
    R1.alphax = round(np.random.uniform(0,0.2), 3) # slightly shuffle position c
    R1.betax = round(1 - R1.alphax, 3)
    #R1.alphay = round(np.random.uniform(0,0.2), 3) # slightly shuffle position
    #R1.betay = round(1 - R1.alphay, 3)
    print("the new x-positions for R1 are: ", R1.alphax, R1.betax)
```

In [129]:

```
R1.alphax, R1.betax, R1.alphay, R1.betay
```

Out[129]:

```
(0.8, 0.2, 0.5, 0.5)
```

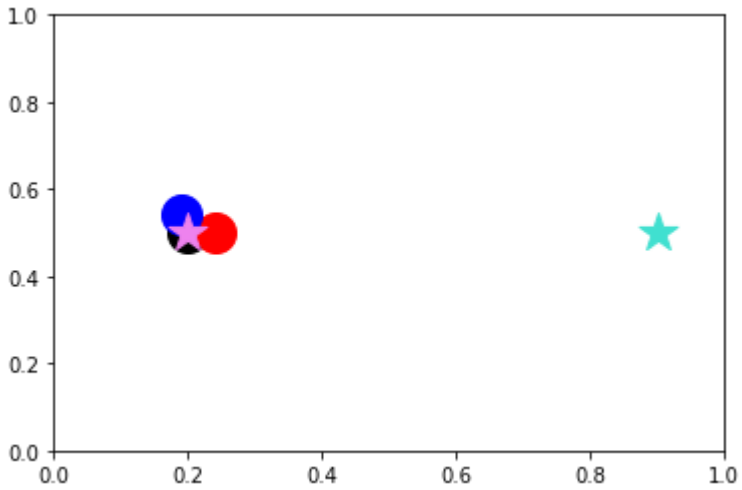
In [130]:

```
R1.delta = reward(T, R1.betax, R1.betay)
print(R1.delta)

R2.delta = reward(T, R2.betax, R2.betay)
print(R2.delta)

R3.delta = reward(T, R3.betax, R3.betay)
print(R3.delta)
```

```
0.3
0.34
0.29
```

In [131]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

Rewards: here, they are an attribute of each class. This information should be provided by robots themselves according to their observations.

First check: if robots' positions are too far from the target, that is, initial positions guarantee a reward lower than a given threshold for all robots, then we have to change position. We can accomplish this by randomly moving robots (as in an exploration task), and evaluating again their rewards.

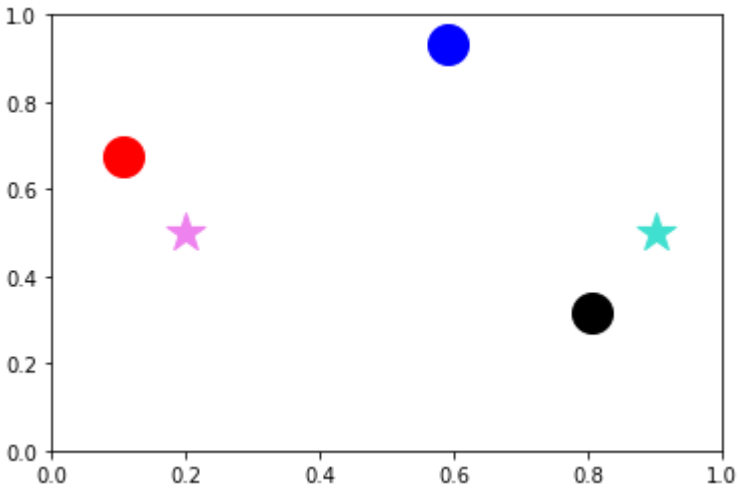
In [132]:

```
# threshold for initial reward
# random fluctuations

if (R1.delta <= 0.4) and (R2.delta <= 0.4) and (R3.delta <= 0.4):
    print("SOS")
    # R1
    R1.alphax = round(np.random.uniform(0,0.9), 3)
    R1.betax = round(1 - R1.alphax, 3)
    print("the new x-positions for R1 are: ", R1.alphax, R1.betax)
    R1.alphay = round(np.random.uniform(0,0.9), 3)
    R1.betay = round(1 - R1.alphay, 3)
    print("the new y-positions for R1 are: ", R1.alphay, R1.betay)
    # R2
    R2.alphax = round(np.random.uniform(0,0.9), 3)
    R2.betax = round(1 - R2.alphax, 3)
    print("the new x-positions for R2 are: ", R2.alphax, R1.betax)
    R2.alphay = round(np.random.uniform(0,0.9), 3)
    R2.betay = round(1 - R2.alphay, 3)
    print("the new y-positions for R2 are: ", R2.alphay, R1.betay)
    # R3
    R3.alphax = round(np.random.uniform(0,0.9), 3)
    R3.betax = round(1 - R3.alphax, 3)
    print("the new x-positions for R3 are: ", R3.alphax, R1.betax)
    R3.alphay = round(np.random.uniform(0,0.9), 3)
    R3.betay = round(1 - R3.alphay, 3)
    print("the new y-positions for R3 are: ", R3.alphay, R1.betay)

R1.delta = reward(T, R1.betax, R1.betay)
R1.gamma = 1 - R1.delta
R2.delta = reward(T, R2.betax, R2.betay)
R2.gamma = 1 - R2.delta
R3.delta = reward(T, R3.betax, R3.betay)
R3.gamma = 1 - R3.delta
print(R1.delta, R2.delta, R3.delta)
```

```
SOS
the new x-positions for R1 are:  0.193 0.807
the new y-positions for R1 are:  0.683 0.317
the new x-positions for R2 are:  0.894 0.807
the new y-positions for R2 are:  0.325 0.317
the new x-positions for R3 are:  0.409 0.807
the new y-positions for R3 are:  0.068 0.317
0.79 0.19 0.47
```

In [133]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [134]:

```
# audio 1, R_1

if (R1.betax == 0):
    if (R1.betay == 0.5):
        audio1 = AudioSegment.from_file("notes_/tC.mp3")
        print("tC")
if (R1.betax > 0 and R1.betax <= 0.17):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tB.mp3")
        print("tB")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tC#.mp3")
        print("tC#")
if (R1.betax > 0.17 and R1.betax <= 0.3):
    if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
        audio1 = AudioSegment.from_file("notes_/tA#.mp3")
        print("tA#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tD.mp3")
        print("tD")
if (R1.betax > 0.3 and R1.betax <= 0.5):
    if (R1.betay < 0.5): # (R1.betay == 1):
        audio1 = AudioSegment.from_file("notes_/tD#.mp3")
        print("tD#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tA.mp3")
        print("tA")
if (R1.betax > 0.5 and R1.betax <= 0.64):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tE.mp3")
        print("tE")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG#.mp3")
        print("tG#")
if (R1.betax > 0.64 and R1.betax <= 0.84):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tF.mp3")
        print("tF")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG.mp3")
        print("tG")
if (R1.betax > 0.84 and R1.betax <= 1):
    #if (R1.betay == 0.5):
    audio1 = AudioSegment.from_file("notes_/tF#.mp3")
    print("tF#")

# audio 2, R_2

if (R2.betax == 0):
    if (R2.betay == 0.5):
        audio2 = AudioSegment.from_file("notes_/fC.mp3")
        print("fC")
if (R2.betax > 0 and R2.betax <= 0.17):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fB.mp3")
        print("fB")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time2_ = audio1.overlay(audio2)          # combine , superimpose audio fi
mixed_time2  = mixed_time2_.overlay(audio3)          # further combine , superi

mixed_time2.export("notes_/mixed_time2.mp3", format='mp3') # export mixed  audi
play(mixed_time2)                                  # play mixed audio file
# change this line at each time point, so in the end we can get a little piece

```

```
tF
fC#
cG#
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmpx7_bx8bp.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.23 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.30 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

In [135]:

```
# January 22, 2022
```

I'm adding a check here as well.

NEW LINES of code: IF the initial reward is very high (greater than 0.8) for at least one of the three robots ("or"), THEN the other robots have to just reach it (with a pretty small fluctuation), without entering the circuit.

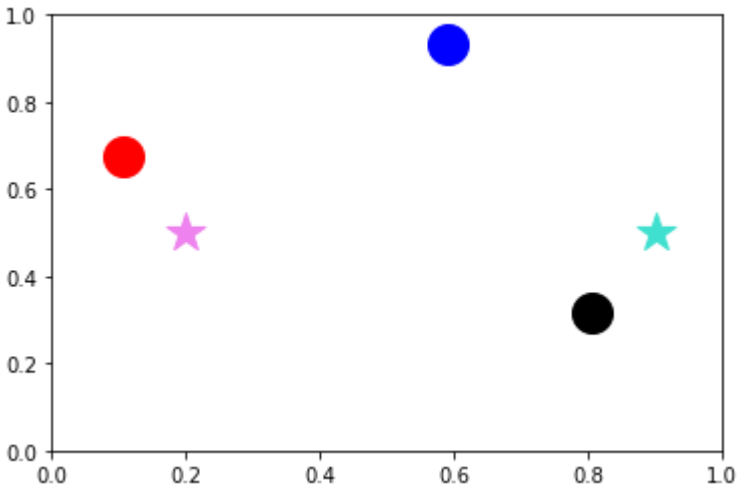
In [136]:

```
if((R1.delta >= 0.8) or (R2.delta >= 0.8) or (R3.delta >= 0.8)):
  print('yuk')
  if (R1.delta > R2.delta and R1.delta > R3.delta):
      print('quokka')
      R2.betax = round(R1.betax + np.random.uniform(0,0.1), 3) # Here and later
      R2.alphax = round(1 - R2.betax, 3)
      R2.betay = round(R1.betay + np.random.uniform(0,0.1), 3)
      R2.alphay = round(1 - R2.betay, 3)
      R3.betax = round(R1.betax + np.random.uniform(0,0.1), 3)
      R3.alphax = round(1 - R2.betax, 3)
      R3.betay = round(R1.betay + np.random.uniform(0,0.1), 3)
      R3.alphay = round(1 - R2.betay, 3)
  if (R2.delta > R1.delta and R2.delta > R3.delta):
      print('quagga')
      R1.betax = round(R2.betax + np.random.uniform(0,0.1), 3)
      R1.alphax = round(1 - R1.betax, 3)
      R1.betay = round(R2.betay + np.random.uniform(0,0.1), 3)
      R1.alphay = round(1 - R1.betay, 3)
      R3.betax = round(R2.betax + np.random.uniform(0,0.1), 3)
      R3.alphax = round(1 - R3.betax, 3)
      R3.betay = round(R2.betay + np.random.uniform(0,0.1), 3)
      R3.alphay = round(1 - R3.betay, 3)
  if (R3.delta > R1.delta and R3.delta > R2.delta):
      print('quark')
      R1.betax = round(R3.betax + np.random.uniform(0,0.1), 3)
      R1.alphax = round(1 - R1.betax, 3)
      R1.betay = round(R3.betay + np.random.uniform(0,0.1), 3)
      R1.alphay = round(1 - R1.betay, 3)
      R2.betax = round(R3.betax + np.random.uniform(0,0.1), 3)
      R2.alphax = round(1 - R2.betax, 3)
      R2.betay = round(R3.betay + np.random.uniform(0,0.1), 3)
      R2.alphay = round(1 - R2.betay, 3)

R1.delta = reward(T, R1.betax, R1.betay)
print(R1.delta)

R2.delta = reward(T, R2.betax, R2.betay)
print(R2.delta)

R3.delta = reward(T, R3.betax, R3.betay)
print(R2.delta)
```

```
0.79
0.19
0.19
```

In [137]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [138]:

```
# audio 1, R_1

if (R1.betax == 0):
    if (R1.betay == 0.5):
        audio1 = AudioSegment.from_file("notes_/tC.mp3")
        print("tC")
if (R1.betax > 0 and R1.betax <= 0.17):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tB.mp3")
        print("tB")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tC#.mp3")
        print("tC#")
if (R1.betax > 0.17 and R1.betax <= 0.3):
    if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
        audio1 = AudioSegment.from_file("notes_/tA#.mp3")
        print("tA#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tD.mp3")
        print("tD")
if (R1.betax > 0.3 and R1.betax <= 0.5):
    if (R1.betay < 0.5): # (R1.betay == 1):
        audio1 = AudioSegment.from_file("notes_/tD#.mp3")
        print("tD#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tA.mp3")
        print("tA")
if (R1.betax > 0.5 and R1.betax <= 0.64):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tE.mp3")
        print("tE")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG#.mp3")
        print("tG#")
if (R1.betax > 0.64 and R1.betax <= 0.84):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tF.mp3")
        print("tF")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG.mp3")
        print("tG")
if (R1.betax > 0.84 and R1.betax <= 1):
    #if (R1.betay == 0.5):
    audio1 = AudioSegment.from_file("notes_/tF#.mp3")
    print("tF#")

# audio 2, R_2

if (R2.betax == 0):
    if (R2.betay == 0.5):
        audio2 = AudioSegment.from_file("notes_/fC.mp3")
        print("fC")
if (R2.betax > 0 and R2.betax <= 0.17):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fB.mp3")
        print("fB")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time3_ = audio1.overlay(audio2)          # combine , superimpose audio fi
mixed_time3  = mixed_time3_.overlay(audio3)          # further combine , superi

mixed_time3.export("notes_/mixed_time3.mp3", format='mp3') # export mixed  audi
play(mixed_time3)

```

```
tF
fC#
cG#
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmpc7u_qb5p.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.24 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.27 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

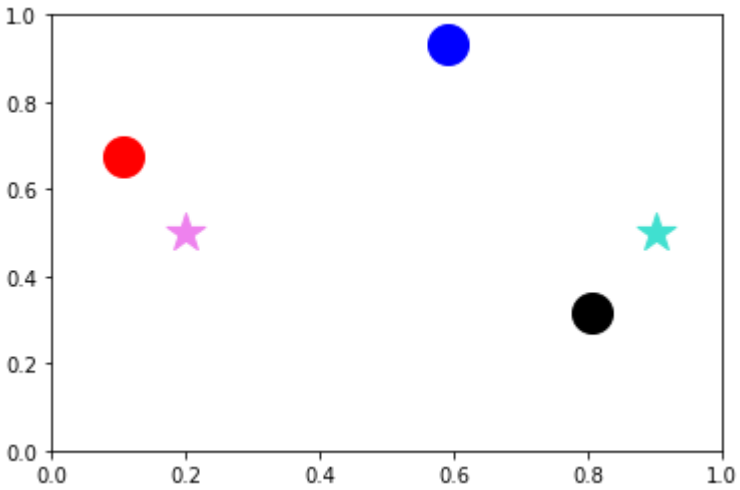
In [139]:

```
# Another round of SOS re-shuffle

# threshold for initial reward
# random fluctuations

if (R1.delta <= 0.4) and (R2.delta <= 0.4) and (R3.delta <= 0.4):
    print("SOS")
    # R1
    R1.alphax = round(np.random.uniform(0,0.9), 3)
    R1.betax = round(1 - R1.alphax, 3)
    print("the new x-positions for R1 are: ", R1.alphax, R1.betax)
    R1.alphay = round(np.random.uniform(0,0.9), 3)
    R1.betay = round(1 - R1.alphay, 3)
    print("the new y-positions for R1 are: ", R1.alphay, R1.betay)
    # R2
    R2.alphax = round(np.random.uniform(0,0.9), 3)
    R2.betax = round(1 - R2.alphax, 3)
    print("the new x-positions for R2 are: ", R2.alphax, R1.betax)
    R2.alphay = round(np.random.uniform(0,0.9), 3)
    R2.betay = round(1 - R2.alphay, 3)
    print("the new y-positions for R2 are: ", R2.alphay, R1.betay)
    # R3
    R3.alphax = round(np.random.uniform(0,0.9), 3)
    R3.betax = round(1 - R3.alphax, 3)
    print("the new x-positions for R3 are: ", R3.alphax, R1.betax)
    R3.alphay = round(np.random.uniform(0,0.9), 3)
    R3.betay = round(1 - R3.alphay, 3)
    print("the new y-positions for R3 are: ", R3.alphay, R1.betay)

R1.delta = reward(T, R1.betax, R1.betay)
R1.gamma = 1 - R1.delta
R2.delta = reward(T, R2.betax, R2.betay)
R2.gamma = 1 - R2.delta
R3.delta = reward(T, R3.betax, R3.betay)
R3.gamma = 1 - R3.delta
print(R1.delta, R2.delta, R3.delta)
```

```
0.79 0.19 0.47
```

In [140]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [141]:

```
1
2  # audio 1, R_1
3
4  if (R1.betax == 0):
5      if (R1.betay == 0.5):
6          audio1 = AudioSegment.from_file("notes_/tC.mp3")
7          print("tC")
8  if (R1.betax > 0 and R1.betax <= 0.17):
9      if (R1.betay < 0.5):
10         audio1 = AudioSegment.from_file("notes_/tB.mp3")
11         print("tB")
12     if (R1.betay >= 0.5):
13         audio1 = AudioSegment.from_file("notes_/tC#.mp3")
14         print("tC#")
15 if (R1.betax > 0.17 and R1.betax <= 0.3):
16     if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
17         audio1 = AudioSegment.from_file("notes_/tA#.mp3")
18         print("tA#")
19     if (R1.betay >= 0.5):
20         audio1 = AudioSegment.from_file("notes_/tD.mp3")
21         print("tD")
22 if (R1.betax > 0.3 and R1.betax <= 0.5):
23     if (R1.betay < 0.5): # (R1.betay == 1):
24         audio1 = AudioSegment.from_file("notes_/tD#.mp3")
25         print("tD#")
26     if (R1.betay >= 0.5):
27         audio1 = AudioSegment.from_file("notes_/tA.mp3")
28         print("tA")
29 if (R1.betax > 0.5 and R1.betax <= 0.64):
30     if (R1.betay < 0.5):
31         audio1 = AudioSegment.from_file("notes_/tE.mp3")
32         print("tE")
33     if (R1.betay >= 0.5):
34         audio1 = AudioSegment.from_file("notes_/tG#.mp3")
35         print("tG#")
36 if (R1.betax > 0.64 and R1.betax <= 0.84):
37     if (R1.betay < 0.5):
38         audio1 = AudioSegment.from_file("notes_/tF.mp3")
39         print("tF")
40     if (R1.betay >= 0.5):
41         audio1 = AudioSegment.from_file("notes_/tG.mp3")
42         print("tG")
43 if (R1.betax > 0.84 and R1.betax <= 1):
44     #if (R1.betay == 0.5):
45     audio1 = AudioSegment.from_file("notes_/tF#.mp3")
46     print("tF#")
47
48 # audio 2, R_2
49
50 if (R2.betax == 0):
51     if (R2.betay == 0.5):
52         audio2 = AudioSegment.from_file("notes_/fC.mp3")
53         print("fC")
54 if (R2.betax > 0 and R2.betax <= 0.17):
55     if (R2.betay < 0.5):
56         audio2 = AudioSegment.from_file("notes_/fB.mp3")
57         print("fB")
58     if (R2.betay >= 0.5):
59         audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time4_ = audio1.overlay(audio2)          # combine , superimpose audio fi
mixed_time4  = mixed_time4_.overlay(audio3)          # further combine , superi

mixed_time4.export("notes_/mixed_time4.mp3", format='mp3') # export mixed  audi
play(mixed_time4)
```

```
tF
fC#
cG#
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmpwgmxki1j.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.20 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.28 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

We can now attempt to relate class attributes with quantum states. This passage should be automatically changed when class attributes change, in the loop! (while).

Let us suppose that R_1 received a signal from R_2, R_3 with the message: ``Where I am, what I found.'' That is: xy-position and reward information. Then, R_1 chooses to follow the more successful robot that has the more precise position localization.

Before all of that, we use an if: if R_2 already has a high reward, it remains where it is. If we had the same minimization function for all robots, thus, already at the second step all robots would converge toward the same point.

Now: initialization of qubits.

If the robot with the highest reward is R_3, then $R_1 \rightarrow R_3$ and $R_2 \rightarrow R_3$ while entering the gate. $q[0]$, $q[1]$, $q[2]$ takes positions (x and y) and reward of R_3 in this case. The output with $q[3]$, $q[4]$ ($q[2]$

remains the same) goes to new x, y of R_1 and of R_2.

GATE HERE!! GATE 1

In [142]:

```
if (R1.delta > R2.delta) and (R1.delta > R3.delta):
    if (R1.alphax < 0.3): # I have to customize state vectors according to prec
        qc3.x(q[0])         # just using the NOT gate as a test
    if (R1.alphax == 0.5): # I have to customize state vectors according to pre
        qc3.h(q[0])
    if (R1.alphax >= 0.3) and (R2.alphax < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[0])
    if (R1.alphax >= 0.6) and (R2.alphax < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[0])
    if (R1.alphay <= 0.2): # else: the qubit sticks with the default value '0'
        qc3.x(q[1])
    if (R1.alphay == 0.5): # I have to customize state vectors according to pre
        qc3.h(q[1])
    if (R1.alphay >= 0.3) and (R2.alphay < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[1])
    if (R1.alphay >= 0.6) and (R2.alphay < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[1])
    if (R1.delta == 0.5):
        qc3.h(q[2])
    if (R1.delta == 0.6):
        qc3.h(q[2])
    if (R1.delta >= 0.7):
        qc3.x(q[2])
    if (R1.gamma >= 0.3) and (R2.gamma < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[2])
    if (R1.gamma >= 0.6) and (R2.gamma < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[2])
# elif (R1.delta > R2.delta) and (R1.delta > R3.delta): # February 13: NO!!!
elif (R2.delta > R1.delta) and (R2.delta > R3.delta):
    print('dog')
    if (R2.alphax < 0.3): # I have to customize state vectors according to prec
        qc3.x(q[0])         # just using the NOT gate as a test
    if (R2.alphax == 0.5): # I have to customize state vectors according to pre
        qc3.h(q[0])
    if (R2.alphax >= 0.3) and (R1.alphax < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[0])
    if (R2.alphax >= 0.6) and (R1.alphax < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[0])
    if (R2.alphay <= 0.2): # else: the qubit sticks with the default value '0'
        qc3.x(q[1])
    if (R2.alphay == 0.5): # I have to customize state vectors according to pre
        qc3.h(q[1])
    if (R2.alphay >= 0.3) and (R1.alphay < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[1])
    if (R2.alphay >= 0.6) and (R1.alphay < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[1])
    if (R2.delta == 0.5):
        qc3.h(q[2])
    if (R2.delta == 0.6):
```

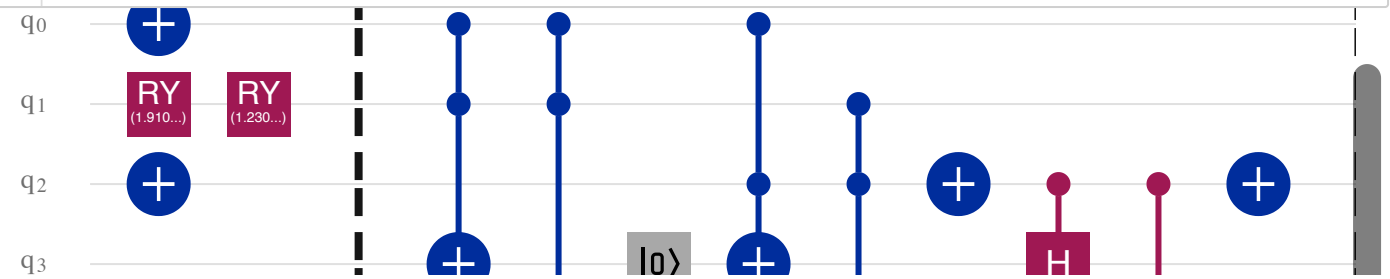
```
        qc3.h(q[2])
    if (R2.delta >= 0.7):
        qc3.x(q[2])
    if (R2.gamma >= 0.3) and (R1.gamma < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[2])
    if (R2.gamma >= 0.6) and (R1.gamma < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[2])
else:
    print('cat') # I made some tests to check the IF conditions
    if (R3.alphax < 0.3):
        qc3.x(q[0])
    if (R3.alphax == 0.5):
        qc3.h(q[0])
    if (R3.alphax >= 0.3) and (R3.alphax < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[0])
    if (R3.alphax >= 0.6) and (R3.alphax < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[0])
    if (R3.alphay < 0.3):
        qc3.x(q[1])
    if (R3.alphay == 0.5):
        qc3.h(q[1])
    if (R3.alphay >= 0.3) and (R3.alphay < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[1])
    if (R3.alphay >= 0.6) and (R3.alphay < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[1])
    if (R3.delta == 0.5):
        qc3.h(q[2])
    if (R3.delta == 0.6):
        qc3.h(q[2])
    if (R3.delta >= 0.7):
        qc3.x(q[2])
    if (R3.gamma >= 0.3) and (R3.gamma < 0.5):
        print('jungle!')
        qc3.ry(1.9106332, q[2])
    if (R3.gamma >= 0.6) and (R3.gamma < 0.7):
        print('ocean!')
        qc3.ry(1.2309594, q[2])
```

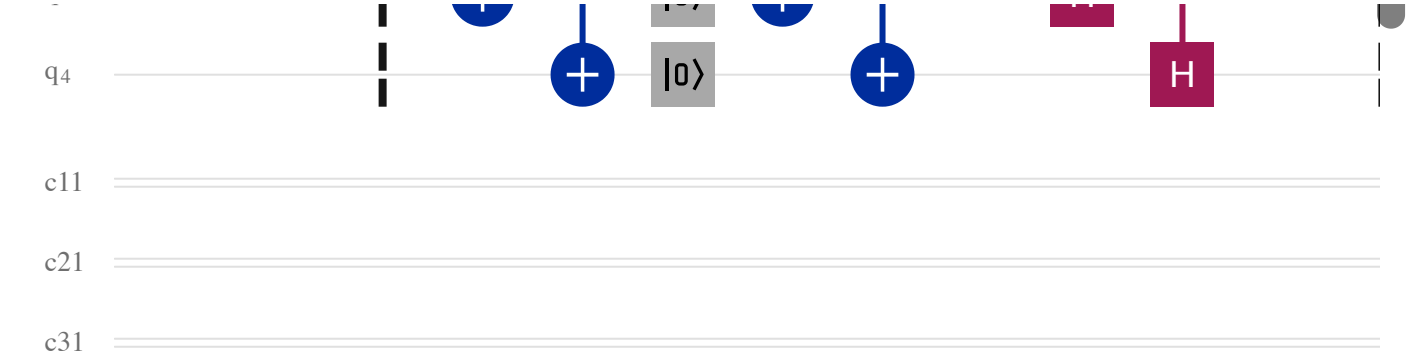
```
jungle!
ocean!
```

Numeration of qubits within IF instructions is slightly different than the initial one. In fact, some distinction across qubits was needed to clearly build the whole circuit later on. Thus, I decided to keep them apart.

In [143]:

```
# this is the core code, and it is unchanged across time

qc3.barrier(q)
qc3.ccx(q[0],q[1],q[3])
qc3.ccx(q[0],q[1],q[4])

qc3.reset(q[3]);
qc3.reset(q[4]);

qc3.ccx(q[0],q[2],q[3])
qc3.ccx(q[1],q[2],q[4])

qc3.x(q[2])

qc3.ch(q[2],q[3])
qc3.ch(q[2],q[4])

qc3.x(q[2])

qc3.barrier(q)

# perform measurements and store them in classical bits

qc3.measure(q[2],m2[0])
qc3.measure(q[3],m3[0])
qc3.measure(q[4],m4[0])

# visualization of the ciruit

draw_circuit(qc3)

# definition of quantum simulator

simulator = Aer.get_backend('qasm_simulator') # statevector_simulator # aer_simu
qc3 = transpile(qc3, simulator)
cc = collections.Counter()

# Run and get counts
result = simulator.run(qc3, shots=1024).result()
counts = result.get_counts(qc3)
counts2 = counts.most_frequent() # does not work if multiple states have the sam
# decide something if multiple states have the same count --> e.g., ``choose the
counts3 = cc.most_common(2)
print(counts)
print(counts2)
print(counts3)
result = simulator.run(qc3, shots=10, memory=True).result()
memory = result.get_memory(qc3)
print(memory)
plot_histogram(counts, title='outcomes')
# TAKE the TWO more present outcomes
```





In [54]:

```
1 # keep the two more present outcomes.
```

In [144]:

```
print(counts2) # order: R3, R2, R1. Add some uncertainty?
# export as an array
str = counts2
arr1 = str.split(' ') # to split the string and avoid empty spaces as array elem
print(arr1)
weight1 = 1024  # AT HAND ONLY FOR NOW

arr2 = ['1','1','1'] # 111 # 011
print(arr2)
weight2 = 1024
# BY HAND ONLY FOR NOW


# an attempt, not so good, to automatize this passage:

print(memory)

data = Counter(memory)
data.most_common()   # Returns all unique items and their counts
data.most_common(3)

print(data.most_common())
print(data.most_common(1))
arrx1 = data.most_common(2)[0]
print(arrx1)
arrx2 = data.most_common(2)[1]
print(arrx2)


```

```
1 1 1
['1', '1', '1']
['1', '1', '1']
['1 1 1', '1 1 1', '1 1 1', '1 1 1', '1 1 1', '1 1 1', '1 1 1', '1 1 1', '1 1 1',
'1 1 1']
[('1 1 1', 10)]
[('1 1 1', 10)]
('1 1 1', 10)

---------------------------------------------------------------------------
IndexError                                Traceback (most recent call last)
/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/ipykernel_3140/4264151028.py in <
module>
     24 arrx1 = data.most_common(2)[0]
     25 print(arrx1)
---> 26 arrx2 = data.most_common(2)[1]
     27 print(arrx2)
     28

IndexError: list index out of range
```

In [145]:

```
# array 1
arr1
```

Out[145]:

```
['1', '1', '1']
```

In [146]:

```
# array 2
arr2
```

Out[146]:

```
['1', '1', '1']
```

Let us create a sort of weighted sum.

It not convenient to set up q[3], q[4], because we need coordinates attribution....

Now, we re-calculate the positions of the robots that entered the gate. To this aim, use their reward (which is unchanged yet).

Position for R_1:

In [147]:

```
if (R1.delta > R2.delta) and (R1.delta > R3.delta):
    # if R1 didn't enter the gate, keep its position
    R1.alphax = R1.alphax
    R1.betax = R1.betax
    R1.alphay = R1.alphay
    R1.betay = R1.betay
else:
    # same outcome = 1 # January 23
    # x part

    # change of January 38: I'm substituting [0] with [1] and vice versa, becau
    if (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight1 - weight2) > 50
        print("bla")
        R1.alphax = 0.3
        R1.betax = 0.7
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 5
        print("gulp")
        R1.alphax = 0.7
        R1.betax = 0.3
    elif (arr1[1] == arr2[0]) and (arr1[1] == '1') and (weight1 == weight2 or n
        print("stra-gulp")
        R1.alphax = 0.5 # change temporarily made on January 24: random generat
        R1.betax = 0.5 # same as above
    elif (arr1[1] == arr2[0]) and (arr1[1] == '1') and ((weight2 - weight1) > 8
        print("thunderstorm!")
        R1.alphax = 0
        R1.betax = 1
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 2
        print("avalanche!")
        R1.alphax = 0.1
        R1.betax = 0.9
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 2
        print("earthquake!")
        R1.alphax = 0.9
        R1.betax = 0.1
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight1 - weight2) > 2
        print("avalanche bis!")
        R1.alphax = 0.1 # the same also in this case
        R1.betax = 0.9 # the same also in this case
    # same = outcome 0  # January 23
    elif (arr1[1] == arr2[1]) and (arr1[1] == '0') and ((weight1 - weight2) > 5
        print("bla 2")
        R1.alphax = 0.7  # the opposite??
        R1.betax = 0.3  # the opposite??
    elif (arr1[1] == arr2[0]) and (arr1[0] == '0') and ((weight2 - weight1) > 5
        print("gulp 2")
        R1.alphax = 0.3  # the opposite??
        R1.betax = 0.7  # the opposite??
    elif (arr1[1] == arr2[1]) and (arr1[1] == '0') and (weight1 == weight2 or n
        print("stra-gulp 2")
        R1.alphax = 0.5 # change temporarily made on January 24: random generat
        R1.betax = 0.5 # change temporarily made on January 24: random generato
    # different outcomes
    elif arr1[1] != arr2[1]:  # January 23
        print("blue")
        if (arr1[1] != arr2[1]) and (weight1 == weight2 or np.absolute(weight1
            print("google 1")
            R1.alphax = 0.5 # change temporarily made on January 24: random gen
            R1.betax = 0.5 # change temporarily made on January 24: random gene
```

```
60          if (arr1[1] == '1' and arr2[1] == '0') and (weight1 == weight2 or np.ab
61              # include the case of a very small difference!
62              print("uffdah")
63              R1.alphax = 0.5
64              R1.betax = 0.5
65          if (arr1[1] == '1' and arr2[1] == '0'):
66              if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
67                  print("abc")
68                  R1.alphax = 0.3
69                  R1.betax = 0.7
70              if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
71                  print("bca")
72                  R1.alphax = 0.7
73                  R1.betax = 0.3
74              if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
75                  print("news")
76                  R1.alphax = 0.2 #
77                  R1.betax = 0.8 #
78              if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
79                  print("idea")
80                  R1.alphax = 0.8 #
81                  R1.betax = 0.2 #
82              if ((weight1 - weight2) > 200 and (weight2 - weight1) >= 800): # no
83                  print("news")
84                  R1.alphax = 0.1 #
85                  R1.betax = 0.9 #
86              if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
87                  print("idea")
88                  R1.alphax = 0.9 #
89                  R1.betax = 0.1 #
90          if (arr1[1] == '0') and (arr2[1] == '1'):
91              if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
92                  print("bac")
93                  R1.alphax = 0.7
94                  R1.betax = 0.3
95              if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
96                  print("cba")
97                  R1.alphax = 0.3
98                  R1.betax = 0.7
99              if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
100                 print("brain")
101                 R1.alphax = 0.7 # 0.9
102                 R1.betax = 0.3 # 0.1
103             if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
104                 print("hand")
105                 R1.alphax = 0.3 # 0.1
106                 R1.betax = 0.7 # 0.9
107             if ((weight1 - weight2) > 200 and (weight2 - weight1) >= 800): # no
108                 print("brain2")
109                 R1.alphax = 0.9 # 0.9
110                 R1.betax = 0.1 # 0.1
111             if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
112                 print("hand2")
113                 R1.alphax = 0.1 # 0.1
114                 R1.betax = 0.9 # 0.9
115     # y part
116
117     # change of January 26
118
119     if (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight1 - weight2) > 50
120         print("bla")
```

```
        R1.alphay = 0.3
        R1.betay = 0.7
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 5
        print("gulp")
        R1.alphay = 0.7
        R1.betay = 0.3
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and (weight1 == weight2 or n
        print("stra-gulp")
        R1.alphay = 0.5 # change temporarily made on January 24: random generat
        R1.betay = 0.5 # same as above
    elif (arr1[0] == arr2[1]) and (arr1[0] == '1') and ((weight2 - weight1) > 8
        print("thunderstorm!")
        R1.alphay = 0
        R1.betay = 1
    elif (arr1[0] == arr2[1]) and (arr1[0] == '1') and ((weight2 - weight1) > 2
        print("avalanche!")
        R1.alphay = 0.1
        R1.betay = 0.9
    elif (arr1[0] == arr2[1]) and (arr1[0] == '1') and ((weight2 - weight1) > 2
        print("earthquake!")
        R1.alphay = 0.9
        R1.betay = 0.1
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight1 - weight2) > 2
        print("avalanche bis!")
        R1.alphay = 0.1 # the same also in this case
        R1.betay = 0.9 # the same also in this case
    # same = outcome 0  # January 23
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and ((weight1 - weight2) > 5
        print("bla 2")
        R1.alphay = 0.7  # the opposite??
        R1.betay = 0.3  # the opposite??
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and ((weight2 - weight1) > 5
        print("gulp 2")
        R1.alphay = 0.3  # the opposite??
        R1.betay = 0.7  # the opposite??
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and (weight1 == weight2 or n
        print("stra-gulp 2")
        R1.alphay = 0.5 # change temporarily made on January 24: random generat
        R1.betay = 0.5 # change temporarily made on January 24: random generato
    # different outcomes
    elif arr1[0] != arr2[0]:  # January 23
        print("blue")
        if (arr1[0] != arr2[0]) and (weight1 == weight2 or np.absolute(weight1
            print("google 1")
            R1.alphay = 0.5 # change temporarily made on January 24: random gen
            R1.betay = 0.5 # change temporarily made on January 24: random gene
        if (arr1[0] == '1' and arr2[0] == '0') and (weight1 == weight2 or np.ab
            # include the case of a very small difference!
            print("uffdah")
            R1.alphay = 0.5
            R1.betay = 0.5
        if (arr1[0] == '1' and arr2[0] == '0'):
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("abc")
                R1.alphay = 0.3
                R1.betay = 0.7
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("bca")
                R1.alphay = 0.7
                R1.betay = 0.3
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
```

```
                print("news")
                R1.alphay = 0.2 #
                R1.betay = 0.8 #
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("idea")
                R1.alphay = 0.8 #
                R1.betay = 0.2 #
        if (arr1[0] == '0') and (arr2[1] == '1'):
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("bac")
                R1.alphay = 0.7
                R1.betay = 0.3
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("cba")
                R1.alphay = 0.3
                R1.betay = 0.7
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
                print("brain")
                R1.alphay = 0.7 # 0.9
                R1.betay = 0.3 # 0.1
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("hand")
                R1.alphay = 0.3 # 0.1
                R1.betay = 0.7 # 0.9
            if ((weight1 - weight2) > 200 and (weight1 - weight2) >= 800): # no
                print("brain2")
                R1.alphay = 0.9 # 0.9
                R1.betay = 0.1 # 0.1
            if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
                print("hand2")
                R1.alphay = 0.1 # 0.1
                R1.betay = 0.9 # 0.9
```

Position for R_2

In [148]:

```
if (R2.delta > R1.delta) and (R2.delta > R3.delta):
    # if R2 didn't entered the gate, keep its position
    R2.alphax = R2.alphax
    R2.betax = R2.betax
    R2.alphay = R2.alphay
    R2.betay = R2.betay
else:
    # same outcome = 1 # January 23
    # x part
    if (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight1 - weight2) > 50
        print("bla")
        R2.alphax = 0.3
        R2.betax = 0.7
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 5
        print("gulp")
        R2.alphax = 0.7
        R2.betax = 0.3
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and (weight1 == weight2 or n
        print("stra-gulp")
        R2.alphax = 0.5 # change temporarily made on January 24: random generat
        R2.betax = 0.5 # change temporarily made on January 24: random generato
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 8
        print("thunderstorm!")
        R2.alphax = 0
        R2.betax = 1
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 2
        print("avalanche!")
        R2.alphax = 0.1
        R2.betax = 0.9
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 2
        print("earthquake!")
        R2.alphax = 0.9
        R2.betax = 0.1
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight1 - weight2) > 2
        print("avalanche bis!")
        R2.alphax = 0.1 # the same also in this case
        R2.betax = 0.9 # the same also in this case
    # same = outcome 0  # January 23
    elif (arr1[1] == arr2[1]) and (arr1[1] == '0') and ((weight1 - weight2) > 5
        print("bla 2")
        R2.alphax = 0.7  # the opposite??
        R2.betax = 0.3  # the opposite??
    elif (arr1[1] == arr2[1]) and (arr1[1] == '0') and ((weight2 - weight1) > 5
        print("gulp 2")
        R2.alphax = 0.3  # the opposite??
        R2.betax = 0.7  # the opposite??
    elif (arr1[1] == arr2[1]) and (arr1[1] == '0') and (weight1 == weight2 or n
        print("stra-gulp 2")
        R2.alphax = 0.5 #1   # the opposite
        R2.betax = 0.5 #0  # the opposite
    # different outcomes
    elif arr1[1] != arr2[1]:  # January 23
        print("blue")
        if (arr1[1] != arr2[1]) and (weight1 == weight2 or np.absolute(weight1
            print("google 1")
            R2.alphax = 0.5 # change temporarily made on January 24: random gen
            R2.betax = 0.5 # change temporarily made on January 24: random gene
        if (arr1[1] == '1' and arr2[1] == '0') and (weight1 == weight2 or np.ab
            # include the case of a very small difference!
```

```
            print("uffdah")
            R2.alphax = 0.5 # change temporarily made on January 24: random gen
            R2.betax = 0.5 # change temporarily made on January 24: random gene
        if (arr1[1] == '1' and arr2[1] == '0'):
            print("gasp")
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("abc")
                R2.alphax = 0.3
                R2.betax = 0.7
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("bca")
                R2.alphax = 0.7
                R2.betax = 0.3
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
                print("news")
                R2.alphax = 0.2 # or: 0.3
                R2.betax = 0.8 # or: 0.7
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("idea")
                R2.alphax = 0.8 #
                R2.betax = 0.2 #
            if ((weight1 - weight2) > 200 and (weight1 - weight2) >= 800): # no
                print("news")
                R2.alphax = 0.1 # or: 0.3
                R2.betax = 0.9 # or: 0.7
            if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
                print("idea")
                R2.alphax = 0.9 #
                R2.betax = 0.1 #
        if (arr1[1] == '0') and (arr2[1] == '1'):
            print("sigh")
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("bac")
                R2.alphax = 0.7
                R2.betax = 0.3
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("cba")
                R2.alphax = 0.3
                R2.betax = 0.7

    # y part
     # change of January 26

     # to be modified: R1 to R2

     if (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight1 - weight2) > 50
         print("bla")
         R2.alphay = 0.3
         R2.betay = 0.7
     elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 5
         print("gulp")
         R2.alphay = 0.7
         R2.betay = 0.3
     elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and (weight1 == weight2 or n
         print("stra-gulp")
         R2.alphay = 0.5 # change temporarily made on January 24: random generat
         R2.betay = 0.5 # same as above
     elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 8
         print("thunderstorm!")
         R2.alphay = 0
         R2.betay = 1
```

```
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 2
        print("avalanche!")
        R2.alphay = 0.1
        R2.betay = 0.9
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 2
        print("earthquake!")
        R2.alphay = 0.9
        R2.betay = 0.1
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight1 - weight2) > 2
        print("avalanche bis!")
        R2.alphay = 0.1 # the same also in this case
        R2.betay = 0.9 # the same also in this case
    # same = outcome 0  # January 23
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and ((weight1 - weight2) > 5
        print("bla 2")
        R2.alphay = 0.7  # the opposite??
        R2.betay = 0.3  # the opposite??
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and ((weight2 - weight1) > 5
        print("gulp 2")
        R2.alphay = 0.3  # the opposite??
        R2.betay = 0.7  # the opposite??
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and (weight1 == weight2 or n
        print("stra-gulp 2")
        R2.alphay = 0.5 # change temporarily made on January 24: random generat
        R2.betay = 0.5 # change temporarily made on January 24: random generato
    # different outcomes
    elif arr1[0] != arr2[1]:  # January 23
        print("blue")
        if (arr1[0] != arr2[0]) and (weight1 == weight2 or np.absolute(weight1
            print("google 1")
            R2.alphay = 0.5 # change temporarily made on January 24: random gen
            R2.betay = 0.5 # change temporarily made on January 24: random gene
        if (arr1[0] == '1' and arr2[0] == '0') and (weight1 == weight2 or np.ab
            # include the case of a very small difference!
            print("uffdah")
            R2.alphay = 0.5
            R2.betay = 0.5
        if (arr1[0] == '1' and arr2[0] == '0'):
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("abc")
                R2.alphay = 0.3
                R2.betay = 0.7
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("bca")
                R2.alphay = 0.7
                R2.betay = 0.3
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
                print("news")
                R2.alphay = 0.2 # January 26
                R2.betay = 0.8 #
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("idea")
                R2.alphay = 0.8 #
                R2.betay = 0.2 #
        if (arr1[0] == '0') and (arr2[1] == '1'):
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("bac")
                R2.alphay = 0.7
                R2.betay = 0.3
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("cba")
```

```
                R2.alphay = 0.3
                R2.betay = 0.7
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
                print("brain")
                R2.alphay = 0.7 # 0.9
                R2.betay = 0.3 # 0.1
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("hand")
                R2.alphay = 0.3 # 0.1
                R2.betay = 0.7 # 0.9
            if ((weight1 - weight2) > 200 and (weight1 - weight2) >= 800): # no
                print("brain")
                R2.alphay = 0.9 # 0.9
                R2.betay = 0.1 # 0.1
            if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
                print("hand")
                R2.alphay = 0.1 # 0.1
                R2.betay = 0.9 # 0.9
```

```
stra-gulp
stra-gulp
```

Position for R_3

In [149]:

```
if (R3.delta > R1.delta) and (R3.delta > R2.delta):
    # if R3 didn't entered the gate, keep its position
    R3.alphax = R3.alphax
    R3.betax = R3.betax
    R3.alphay = R3.alphay
    R3.betay = R3.betay
else:
    # same outcome = 1 # January 23
    # x part
    if (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight1 - weight2) > 50
        print("bla")
        R3.alphax = 0.3
        R3.betax = 0.7
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 5
        print("gulp")
        R3.alphax = 0.7
        R3.betax = 0.3
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and (weight1 == weight2 or n
        print("stra-gulp")
        R3.alphax = 0.5 # xx
        R3.betax = 0.5 # xx
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 8
        print("thunderstorm!")
        R3.alphax = 0
        R3.betax = 1
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 2
        print("avalanche!")
        R3.alphax = 0.1
        R3.betax = 0.9
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 2
        print("earthquake!")
        R3.alphax = 0.9
        R3.betax = 0.1
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight2 - weight1) > 2
        print("earthquake !")
        R3.alphax = 0.9
        R3.betax = 0.1
    elif (arr1[1] == arr2[1]) and (arr1[1] == '1') and ((weight1 - weight2) > 2
        print("avalanche bis!")
        R3.alphax = 0.1 # the same also in this case
        R3.betax = 0.9 # the same also in this case
    # same = outcome 0  # January 23
    elif (arr1[1] == arr2[1]) and (arr1[1] == '0') and ((weight1 - weight2) > 5
        print("bla 2")
        R3.alphax = 0.7  # the opposite??
        R3.betax = 0.3  # the opposite??
    elif (arr1[1] == arr2[1]) and (arr1[1] == '0') and ((weight2 - weight1) > 5
        print("gulp 2")
        R3.alphax = 0.3  # the opposite??
        R3.betax = 0.7  # the opposite??
    elif (arr1[1] == arr2[1]) and (arr1[1] == '0') and (weight1 == weight2 or n
        print("stra-gulp 2")
        R3.alphax = 0.5 # change temporarily made on January 24: random generat
        R3.betax = 0.5 # change temporarily made on January 24: random generato
    # different outcomes
    elif arr1[1] != arr2[1]:  # January 23
        print("blue")
        if (arr1[1] != arr2[1]) and (weight1 == weight2 or np.absolute(weight1
            print("google 1")
```

```
            R3.alphax = 0.5 # change temporarily made on January 24: random gen
            R3.betax = 0.5 # change temporarily made on January 24: random gene
        if (arr1[1] == '1' and arr2[1] == '0') and (weight1 == weight2 or np.ab
            # include the case of a very small difference!
            print("uffdah")
            R3.alphax = 0.5
            R3.betax = 0.5
        if (arr1[1] == '1' and arr2[1] == '0'):
            print("gasp")
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("abc")
                R3.alphax = 0.3
                R3.betax = 0.7
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("bca")
                R3.alphax = 0.7
                R3.betax = 0.3
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
                print("news")
                R3.alphax = 0.2 #
                R3.betax = 0.8 #
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("idea")
                R3.alphax = 0.8 #
                R3.betax = 0.2 #
            if ((weight1 - weight2) > 200 and (weight1 - weight2) >= 800): # no
                print("news")
                R3.alphax = 0.1 #
                R3.betax = 0.9 #
            if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
                print("idea")
                R3.alphax = 0.9 #
                R3.betax = 0.1 #
        if (arr1[1] == '0') and (arr2[1] == '1'):
            print("sigh")
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("bac")
                R3.alphax = 0.7
                R3.betax = 0.3
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("cba")
                R3.alphax = 0.3
                R3.betax = 0.7
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
                print("brain")
                R3.alphax = 0.7 # 0.9
                R3.betax = 0.3 # 0.1
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("hand")
                R3.alphax = 0.3 # 0.1
                R3.betax = 0.7 # 0.9
            if ((weight1 - weight2) > 200 and (weight1 - weight2) >= 800): # no
                print("brain")
                R3.alphax = 0.9 # 0.9
                R3.betax = 0.1 # 0.1
            if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
                print("hand")
                R3.alphax = 0.1 # 0.1
                R3.betax = 0.9 # 0.9
    # change of January 26

```

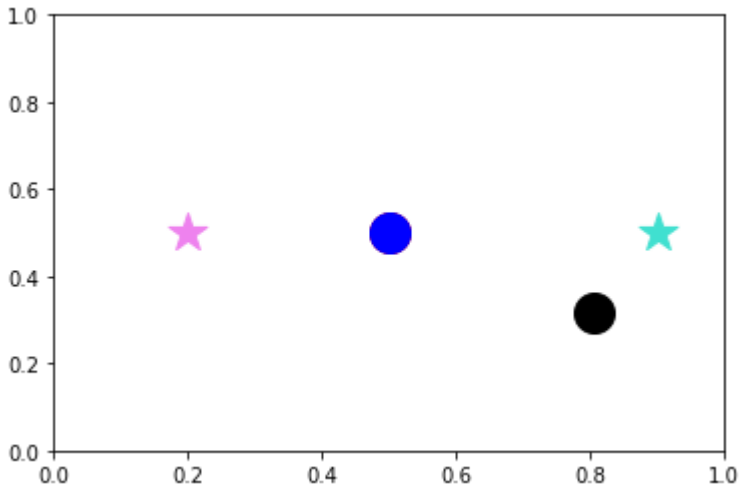
```
    # to be modified: R1 to R3

    if (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight1 - weight2) > 50
        print("bla")
        R3.alphay = 0.3
        R3.betay = 0.7
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 5
        print("gulp")
        R3.alphay = 0.7
        R3.betay = 0.3
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and (weight1 == weight2 or n
        print("stra-gulp")
        R3.alphay = 0.5 # change temporarily made on January 24: random generat
        R3.betay = 0.5 # same as above
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 8
        print("thunderstorm!")
        R3.alphay = 0
        R3.betay = 1
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 2
        print("avalanche!")
        R3.alphay = 0.1
        R3.betay = 0.9
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight2 - weight1) > 2
        print("earthquake!")
        R3.alphay = 0.9
        R3.betay = 0.1
    elif (arr1[0] == arr2[0]) and (arr1[0] == '1') and ((weight1 - weight2) > 2
        print("avalanche bis!")
        R3.alphay = 0.1 # the same also in this case
        R3.betay = 0.9 # the same also in this case
    # same = outcome 0  # January 23
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and ((weight1 - weight2) > 5
        print("bla 2")
        R3.alphay = 0.7  # the opposite??
        R3.betay = 0.3  # the opposite??
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and ((weight2 - weight1) > 5
        print("gulp 2")
        R3.alphay = 0.3  # the opposite??
        R3.betay = 0.7  # the opposite??
    elif (arr1[0] == arr2[0]) and (arr1[0] == '0') and (weight1 == weight2 or n
        print("stra-gulp 2")
        R3.alphay = 0.5 # change temporarily made on January 24: random generat
        R3.betay = 0.5 # change temporarily made on January 24: random generato
    # different outcomes
    elif arr1[0] != arr2[0]:  # January 23
        print("blue")
        if (arr1[0] != arr2[0]) and (weight1 == weight2 or np.absolute(weight1
            print("google 1")
            R3.alphay = 0.5 # change temporarily made on January 24: random gen
            R3.betay = 0.5 # change temporarily made on January 24: random gene
        if (arr1[0] == '1' and arr2[0] == '0') and (weight1 == weight2 or np.ab
            # include the case of a very small difference!
            print("uffdah")
            R3.alphay = 0.5
            R3.betay = 0.5
        if (arr1[0] == '1' and arr2[0] == '0'):
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("abc")
                R3.alphay = 0.3
                R3.betay = 0.7
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
```

```
                print("bca")
                R3.alphay = 0.7
                R3.betay = 0.3
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
                print("news")
                R3.alphay = 0.2 #
                R3.betay = 0.8 #
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("idea")
                R3.alphay = 0.8 #
                R3.betay = 0.2 #
            if ((weight1 - weight2) > 200 and (weight1 - weight2) >= 800): # no
                print("news")
                R3.alphay = 0.1 #
                R3.betay = 0.9 #
            if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
                print("idea")
                R3.alphay = 0.9 #
                R3.betay = 0.1 #
        if (arr1[0] == '0') and (arr2[1] == '1'):
            if (weight1 - weight2 >= 50 and weight1 - weight2 <= 200):
                print("bac")
                R3.alphay = 0.7
                R3.betay = 0.3
            if (weight2 - weight1 >= 50 and weight1 - weight2 <= 200):
                print("cba")
                R3.alphay = 0.3
                R3.betay = 0.7
            if ((weight1 - weight2) > 200 and (weight1 - weight2) < 800): # no
                print("brain")
                R3.alphay = 0.7 # 0.9
                R3.betay = 0.3 # 0.1
            if ((weight2 - weight1) > 200 and (weight2 - weight1) < 800): # no
                print("hand")
                R3.alphay = 0.3 # 0.1
                R3.betay = 0.7 # 0.9
            if ((weight1 - weight2) > 200 and (weight1 - weight2) >= 800): # no
                print("brain")
                R3.alphay = 0.9 # 0.9
                R3.betay = 0.1 # 0.1
            if ((weight2 - weight1) > 200 and (weight2 - weight1) >= 800): # no
                print("hand")
                R3.alphay = 0.1 # 0.1
                R3.betay = 0.9 # 0.9
```

```
stra-gulp
stra-gulp
```

In [150]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

And only NOW, change their rewards according to the new positions! If a robot didn't change the position, the reward will remain the same.

In [151]:

```
# the former ones

R1.delta, R2.delta, R3.delta
```

Out[151]:

```
(0.79, 0.19, 0.47)
```

In [152]:

```
# the new ones

R1.delta = reward(T, R1.betax, R1.betay)
print(R1.delta)

R2.delta = reward(T, R2.betax, R2.betay)
print(R2.delta)

R3.delta = reward(T, R3.betax, R3.betay)
print(R3.delta)
```

```
0.79
0.6
0.6
```

In [153]:

```
# audio 1, R_1

if (R1.betax == 0):
    if (R1.betay == 0.5):
        audio1 = AudioSegment.from_file("notes_/tC.mp3")
        print("tC")
if (R1.betax > 0 and R1.betax <= 0.17):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tB.mp3")
        print("tB")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tC#.mp3")
        print("tC#")
if (R1.betax > 0.17 and R1.betax <= 0.3):
    if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
        audio1 = AudioSegment.from_file("notes_/tA#.mp3")
        print("tA#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tD.mp3")
        print("tD")
if (R1.betax > 0.3 and R1.betax <= 0.5):
    if (R1.betay < 0.5): # (R1.betay == 1):
        audio1 = AudioSegment.from_file("notes_/tD#.mp3")
        print("tD#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tA.mp3")
        print("tA")
if (R1.betax > 0.5 and R1.betax <= 0.64):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tE.mp3")
        print("tE")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG#.mp3")
        print("tG#")
if (R1.betax > 0.64 and R1.betax <= 0.84):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tF.mp3")
        print("tF")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG.mp3")
        print("tG")
if (R1.betax > 0.84 and R1.betax <= 1):
    #if (R1.betay == 0.5):
    audio1 = AudioSegment.from_file("notes_/tF#.mp3")
    print("tF#")

# audio 2, R_2

if (R2.betax == 0):
    if (R2.betay == 0.5):
        audio2 = AudioSegment.from_file("notes_/fC.mp3")
        print("fC")
if (R2.betax > 0 and R2.betax <= 0.17):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fB.mp3")
        print("fB")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time5_ = audio1.overlay(audio2)          # combine , superimpose audio fi
mixed_time5  = mixed_time5_.overlay(audio3)          # further combine , superi

mixed_time5.export("notes_/mixed_time5.mp3", format='mp3') # export mixed  audi
play(mixed_time5)
```

```
tF
fA
cA
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmpfvhgm19e.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.22 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.29 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

In [154]:

```
# January 28: SOS with a higher threshold
```

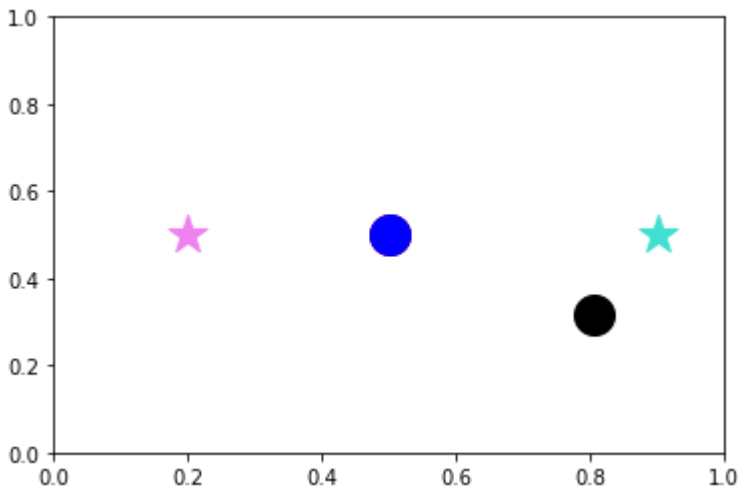
In [155]:

```
# Another round of SOS with a higher threshold. Added on January 28

# threshold for initial reward
# random fluctuations

if (R1.delta <= 0.6) and (R2.delta <= 0.6) and (R3.delta <= 0.6):
    print("SOS")
    # R1
    R1.alphax = round(np.random.uniform(0,0.9), 3)
    R1.betax = round(1 - R1.alphax, 3)
    print("the new x-positions for R1 are: ", R1.alphax, R1.betax)
    R1.alphay = round(np.random.uniform(0,0.9), 3)
    R1.betay = round(1 - R1.alphay, 3)
    print("the new y-positions for R1 are: ", R1.alphay, R1.betay)
    # R2
    R2.alphax = round(np.random.uniform(0,0.9), 3)
    R2.betax = round(1 - R2.alphax, 3)
    print("the new x-positions for R2 are: ", R2.alphax, R1.betax)
    R2.alphay = round(np.random.uniform(0,0.9), 3)
    R2.betay = round(1 - R2.alphay, 3)
    print("the new y-positions for R2 are: ", R2.alphay, R1.betay)
    # R3
    R3.alphax = round(np.random.uniform(0,0.9), 3)
    R3.betax = round(1 - R3.alphax, 3)
    print("the new x-positions for R3 are: ", R3.alphax, R1.betax)
    R3.alphay = round(np.random.uniform(0,0.9), 3)
    R3.betay = round(1 - R3.alphay, 3)
    print("the new y-positions for R3 are: ", R3.alphay, R1.betay)

R1.delta = reward(T, R1.betax, R1.betay)
R1.gamma = 1 - R1.delta
R2.delta = reward(T, R2.betax, R2.betay)
R2.gamma = 1 - R2.delta
R3.delta = reward(T, R3.betax, R3.betay)
R3.gamma = 1 - R3.delta
print(R1.delta, R2.delta, R3.delta)
```

```
0.79 0.6 0.6
```

In [156]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [157]:

```
1
2  # audio 1, R_1
3
4  if (R1.betax == 0):
5      if (R1.betay == 0.5):
6          audio1 = AudioSegment.from_file("notes_/tC.mp3")
7          print("tC")
8  if (R1.betax > 0 and R1.betax <= 0.17):
9      if (R1.betay < 0.5):
10         audio1 = AudioSegment.from_file("notes_/tB.mp3")
11         print("tB")
12     if (R1.betay >= 0.5):
13         audio1 = AudioSegment.from_file("notes_/tC#.mp3")
14         print("tC#")
15 if (R1.betax > 0.17 and R1.betax <= 0.3):
16     if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
17         audio1 = AudioSegment.from_file("notes_/tA#.mp3")
18         print("tA#")
19     if (R1.betay >= 0.5):
20         audio1 = AudioSegment.from_file("notes_/tD.mp3")
21         print("tD")
22 if (R1.betax > 0.3 and R1.betax <= 0.5):
23     if (R1.betay < 0.5): # (R1.betay == 1):
24         audio1 = AudioSegment.from_file("notes_/tD#.mp3")
25         print("tD#")
26     if (R1.betay >= 0.5):
27         audio1 = AudioSegment.from_file("notes_/tA.mp3")
28         print("tA")
29 if (R1.betax > 0.5 and R1.betax <= 0.64):
30     if (R1.betay < 0.5):
31         audio1 = AudioSegment.from_file("notes_/tE.mp3")
32         print("tE")
33     if (R1.betay >= 0.5):
34         audio1 = AudioSegment.from_file("notes_/tG#.mp3")
35         print("tG#")
36 if (R1.betax > 0.64 and R1.betax <= 0.84):
37     if (R1.betay < 0.5):
38         audio1 = AudioSegment.from_file("notes_/tF.mp3")
39         print("tF")
40     if (R1.betay >= 0.5):
41         audio1 = AudioSegment.from_file("notes_/tG.mp3")
42         print("tG")
43 if (R1.betax > 0.84 and R1.betax <= 1):
44     #if (R1.betay == 0.5):
45     audio1 = AudioSegment.from_file("notes_/tF#.mp3")
46     print("tF#")
47
48 # audio 2, R_2
49
50 if (R2.betax == 0):
51     if (R2.betay == 0.5):
52         audio2 = AudioSegment.from_file("notes_/fC.mp3")
53         print("fC")
54 if (R2.betax > 0 and R2.betax <= 0.17):
55     if (R2.betay < 0.5):
56         audio2 = AudioSegment.from_file("notes_/fB.mp3")
57         print("fB")
58     if (R2.betay >= 0.5):
59         audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time6_ = audio1.overlay(audio2)          # combine , superimpose audio fi
mixed_time6  = mixed_time6_.overlay(audio3)          # further combine , superi

mixed_time6.export("notes_/mixed_time6.mp3", format='mp3') # export mixed  audi
play(mixed_time6)
```

```
tF
fA
cA
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmp3uwuxgxh.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.23 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.30 M-A: -0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

In [158]:

```
# January 22, 2022
```

In [ ]:

```

```

NEW LINES of code: IF the initial reward is very high (greater than 0.8) for at least one of the three robots ("or"), THEN the other robots have to just reach it (with a pretty small fluctuation), without entering the circuit.

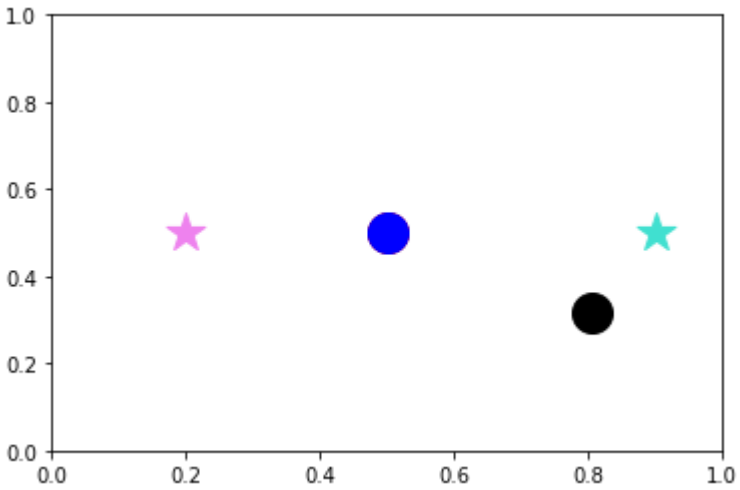
In [159]:

```
if((R1.delta >= 0.8) or (R2.delta >= 0.8) or (R3.delta >= 0.8)):
    print('yuk')
    if (R1.delta > R2.delta and R1.delta > R3.delta):
        print('quokka')
        R2.betax = round(R1.betax + np.random.uniform(0,0.1), 3)
        R2.alphax = round(1 - R2.betax, 3)
        R2.betay = round(R1.betay + np.random.uniform(0,0.1), 3)
        R2.alphay = round(1 - R2.betay, 3)
        R3.betax = round(R1.betax + np.random.uniform(0,0.1), 3)
        R3.alphax = round(1 - R2.betax, 3)
        R3.betay = round(R1.betay + np.random.uniform(0,0.1), 3)
        R3.alphay = round(1 - R2.betay, 3)
    if (R2.delta > R1.delta and R2.delta > R3.delta):
        print('quagga')
        R1.betax = round(R2.betax + np.random.uniform(0,0.1), 3)
        R1.alphax = round(1 - R1.betax, 3)
        R1.betay = round(R2.betay + np.random.uniform(0,0.1), 3)
        R1.alphay = round(1 - R1.betay, 3)
        R3.betax = round(R2.betax + np.random.uniform(0,0.1), 3)
        R3.alphax = round(1 - R3.betax, 3)
        R3.betay = round(R2.betay + np.random.uniform(0,0.1), 3)
        R3.alphay = round(1 - R3.betay, 3)
    if (R3.delta > R1.delta and R3.delta > R2.delta):
        print('quark')
        R1.betax = round(R3.betax + np.random.uniform(0,0.1), 3)
        R1.alphax = round(1 - R1.betax, 3)
        R1.betay = round(R3.betay + np.random.uniform(0,0.1), 3)
        R1.alphay = round(1 - R1.betay, 3)
        R2.betax = round(R3.betax + np.random.uniform(0,0.1), 3)
        R2.alphax = round(1 - R2.betax, 3)
        R2.betay = round(R3.betay + np.random.uniform(0,0.1), 3)
        R2.alphay = round(1 - R2.betay, 3)

R1.delta = reward(T, R1.betax, R1.betay)
print(R2.delta)

R2.delta = reward(T, R2.betax, R2.betay)
print(R2.delta)

R3.delta = reward(T, R3.betax, R3.betay)
print(R3.delta)
```

```
0.6
0.6
0.6
```

In [160]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [161]:

```
1
2  # audio 1, R_1
3
4  if (R1.betax == 0):
5      if (R1.betay == 0.5):
6          audio1 = AudioSegment.from_file("notes_/tC.mp3")
7          print("tC")
8  if (R1.betax > 0 and R1.betax <= 0.17):
9      if (R1.betay < 0.5):
10         audio1 = AudioSegment.from_file("notes_/tB.mp3")
11         print("tB")
12     if (R1.betay >= 0.5):
13         audio1 = AudioSegment.from_file("notes_/tC#.mp3")
14         print("tC#")
15 if (R1.betax > 0.17 and R1.betax <= 0.3):
16     if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
17         audio1 = AudioSegment.from_file("notes_/tA#.mp3")
18         print("tA#")
19     if (R1.betay >= 0.5):
20         audio1 = AudioSegment.from_file("notes_/tD.mp3")
21         print("tD")
22 if (R1.betax > 0.3 and R1.betax <= 0.5):
23     if (R1.betay < 0.5): # (R1.betay == 1):
24         audio1 = AudioSegment.from_file("notes_/tD#.mp3")
25         print("tD#")
26     if (R1.betay >= 0.5):
27         audio1 = AudioSegment.from_file("notes_/tA.mp3")
28         print("tA")
29 if (R1.betax > 0.5 and R1.betax <= 0.64):
30     if (R1.betay < 0.5):
31         audio1 = AudioSegment.from_file("notes_/tE.mp3")
32         print("tE")
33     if (R1.betay >= 0.5):
34         audio1 = AudioSegment.from_file("notes_/tG#.mp3")
35         print("tG#")
36 if (R1.betax > 0.64 and R1.betax <= 0.84):
37     if (R1.betay < 0.5):
38         audio1 = AudioSegment.from_file("notes_/tF.mp3")
39         print("tF")
40     if (R1.betay >= 0.5):
41         audio1 = AudioSegment.from_file("notes_/tG.mp3")
42         print("tG")
43 if (R1.betax > 0.84 and R1.betax <= 1):
44     #if (R1.betay == 0.5):
45     audio1 = AudioSegment.from_file("notes_/tF#.mp3")
46     print("tF#")
47
48 # audio 2, R_2
49
50 if (R2.betax == 0):
51     if (R2.betay == 0.5):
52         audio2 = AudioSegment.from_file("notes_/fC.mp3")
53         print("fC")
54 if (R2.betax > 0 and R2.betax <= 0.17):
55     if (R2.betay < 0.5):
56         audio2 = AudioSegment.from_file("notes_/fB.mp3")
57         print("fB")
58     if (R2.betay >= 0.5):
59         audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time7_ = audio1.overlay(audio2)          # combine , superimpose audio fi
mixed_time7  = mixed_time7_.overlay(audio3)          # further combine , superi

mixed_time7.export("notes_/mixed_time7.mp3", format='mp3') # export mixed  audi
play(mixed_time7)
```

```
tF
fA
cA
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmp7vs88g99.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.24 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.31 M-A: -0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

Now, all robots reach the robot with the highest reward, with fluctuations:

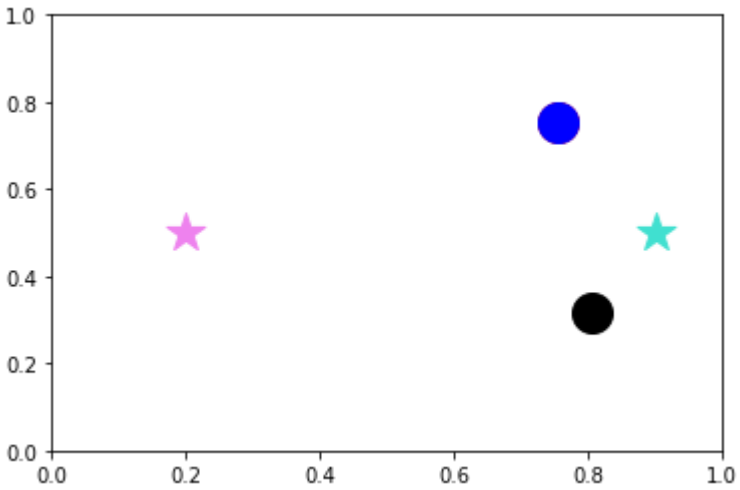
In [162]:

```
if (R1.delta > R2.delta) and (R1.delta > R2.delta): # now, brutally come close t
    print("ciao")
    # change R2, R3 but not R1
    # R2
    R2.alphax = round(R1.alphax + np.random.uniform(0,0.1), 3)
    R2.betax = round(1 - R2.alphax, 3)
    R2.alphay = round(R1.alphax + np.random.uniform(0,0.1), 3)
    R2.betay = round(1 - R2.alphax, 3)
    # R3
    R3.alphax = round(R1.alphax + np.random.uniform(0,0.1), 3)
    R3.betax = round(1 - R2.alphax, 3)
    R3.alphay = round(R1.alphax + np.random.uniform(0,0.1), 3)
    R3.betay = round(1 - R2.alphax, 3)
elif (R2.delta > R3.delta) and (R2.delta > R3.delta):
    print("glu glu")
    # change R1, R3 but not R2
    # R1
    R1.alphax = round(R2.alphax + np.random.uniform(0,0.1), 3)
    R1.betax = round(1 - R1.alphax, 3)
    R1.alphay = round(R2.alphay + np.random.uniform(0,0.1), 3)
    R1.betay = round(1 - R1.alphay, 3)
    # R3
    R3.alphax = round(R2.alphax + np.random.uniform(0,0.1), 3)
    R3.betax = round(1 - R2.alphax, 3)
    R3.alphay = round(R2.alphax + np.random.uniform(0,0.1), 3)
    R3.betay = round(1 - R2.alphax, 3)
elif (R3.delta > R1.delta) and (R3.delta > R2.delta):
    print("cri cri")
    # change R1, R2 but nor R3
    # R1
    R1.alphax = round(R3.alphax + np.random.uniform(0,0.1), 3)
    R1.betax = round(1 - R1.alphax, 3)
    R1.alphay = round(R3.alphay + np.random.uniform(0,0.1), 3)
    R1.betay = round(1 - R1.alphay, 3)
    # R2
    R2.alphax = round(R3.alphax + np.random.uniform(0,0.1), 3)
    R2.betax = round(1 - R2.alphax, 3)
    R2.alphay = round(R3.alphax + np.random.uniform(0,0.1), 3)
    R2.betay = round(1 - R2.alphax, 3)
```

```
ciao
```

In [163]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [164]:

```
# audio 1, R_1

if (R1.betax == 0):
    if (R1.betay == 0.5):
        audio1 = AudioSegment.from_file("notes_/tC.mp3")
        print("tC")
if (R1.betax > 0 and R1.betax <= 0.17):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tB.mp3")
        print("tB")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tC#.mp3")
        print("tC#")
if (R1.betax > 0.17 and R1.betax <= 0.3):
    if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
        audio1 = AudioSegment.from_file("notes_/tA#.mp3")
        print("tA#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tD.mp3")
        print("tD")
if (R1.betax > 0.3 and R1.betax <= 0.5):
    if (R1.betay < 0.5): # (R1.betay == 1):
        audio1 = AudioSegment.from_file("notes_/tD#.mp3")
        print("tD#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tA.mp3")
        print("tA")
if (R1.betax > 0.5 and R1.betax <= 0.64):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tE.mp3")
        print("tE")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG#.mp3")
        print("tG#")
if (R1.betax > 0.64 and R1.betax <= 0.84):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tF.mp3")
        print("tF")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG.mp3")
        print("tG")
if (R1.betax > 0.84 and R1.betax <= 1):
    #if (R1.betay == 0.5):
    audio1 = AudioSegment.from_file("notes_/tF#.mp3")
    print("tF#")

# audio 2, R_2

if (R2.betax == 0):
    if (R2.betay == 0.5):
        audio2 = AudioSegment.from_file("notes_/fC.mp3")
        print("fC")
if (R2.betax > 0 and R2.betax <= 0.17):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fB.mp3")
        print("fB")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time8_ = audio1.overlay(audio2)          # combine , superimpose audio fi
mixed_time8  = mixed_time8_.overlay(audio3)          # further combine , superi

mixed_time8.export("notes_/mixed_time8.mp3", format='mp3') # export mixed  audi
play(mixed_time8)
```

```
tF
fG
cG
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmpouq8cxg5.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.23 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.30 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

Let us now update γ, δ_i, $i = 1, 2, 3$ according to the target (fixed) positions and the new positions.

New reward amplitude probabilities for R_1:

In [165]:

```
R1.delta = reward(T,R1.betax,R1.betay)
R1.gamma = round((1 - R1.delta),3)
print(R1.delta)
```

```
0.79
```

New reward amplitude probabilities for R_2:

In [166]:

```
R2.delta = reward(T,R2.betax,R2.betay)
R2.gamma = round((1 - R2.delta),3)
print(R2.delta)
```

```
0.71
```

New reward amplitude probabilities for R_3:

In [167]:

```
R3.delta = reward(T,R3.betax,R3.betay)
R3.gamma = round((1 - R3.delta),3)
print(R3.delta)
```

```
0.71
```

In [168]:

```
# January 22, 2022
```

NEW LINES of code: IF the initial reward is very high (greater than 0.8) for at least one of the three robots ("or"), THEN the other robots have to just reach it (with a pretty small fluctuation), without entering the circuit.

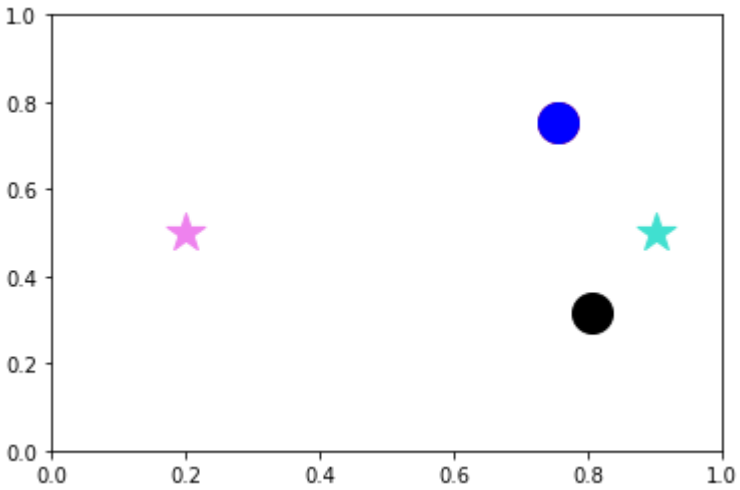
In [169]:

```
if((R1.delta >= 0.8) or (R2.delta >= 0.8) or (R3.delta >= 0.8)):
    print('yuk')
    if (R1.delta > R2.delta and R1.delta > R3.delta):
        print('quokka')
        R2.betax = round(R1.betax + np.random.uniform(0,0.1), 3)
        R2.alphax = round(1 - R2.betax, 3)
        R2.betay = round(R1.betay + np.random.uniform(0,0.1), 3)
        R2.alphay = round(1 - R2.betay, 3)
        R3.betax = round(R1.betax + np.random.uniform(0,0.1), 3)
        R3.alphax = round(1 - R2.betax, 3)
        R3.betay = round(R1.betay + np.random.uniform(0,0.1), 3)
        R3.alphay = round(1 - R2.betay, 3)
    if (R2.delta > R1.delta and R2.delta > R3.delta):
        print('quagga')
        R1.betax = round(R2.betax + np.random.uniform(0,0.1), 3)
        R1.alphax = round(1 - R1.betax, 3)
        R1.betay = round(R2.betay + np.random.uniform(0,0.1), 3)
        R1.alphay = round(1 - R1.betay, 3)
        R3.betax = round(R2.betax + np.random.uniform(0,0.1), 3)
        R3.alphax = round(1 - R3.betax, 3)
        R3.betay = round(R2.betay + np.random.uniform(0,0.1), 3)
        R3.alphay = round(1 - R3.betay, 3)
    if (R3.delta > R1.delta and R3.delta > R2.delta):
        print('quark')
        R1.betax = round(R3.betax + np.random.uniform(0,0.1), 3)
        R1.alphax = round(1 - R1.betax, 3)
        R1.betay = round(R3.betay + np.random.uniform(0,0.1), 3)
        R1.alphay = round(1 - R1.betay, 3)
        R2.betax = round(R3.betax + np.random.uniform(0,0.1), 3)
        R2.alphax = round(1 - R2.betax, 3)
        R2.betay = round(R3.betay + np.random.uniform(0,0.1), 3)
        R2.alphay = round(1 - R2.betay, 3)

R1.delta = reward(T, R1.betax, R1.betay)
print(R2.delta)

R2.delta = reward(T, R2.betax, R2.betay)
print(R2.delta)

R3.delta = reward(T, R3.betax, R3.betay)
print(R3.delta)
```

```
0.71
0.71
0.71
```

In [170]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [171]:

```
# audio 1, R_1

if (R1.betax == 0):
    if (R1.betay == 0.5):
        audio1 = AudioSegment.from_file("notes_/tC.mp3")
        print("tC")
if (R1.betax > 0 and R1.betax <= 0.17):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tB.mp3")
        print("tB")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tC#.mp3")
        print("tC#")
if (R1.betax > 0.17 and R1.betax <= 0.3):
    if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
        audio1 = AudioSegment.from_file("notes_/tA#.mp3")
        print("tA#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tD.mp3")
        print("tD")
if (R1.betax > 0.3 and R1.betax <= 0.5):
    if (R1.betay < 0.5): # (R1.betay == 1):
        audio1 = AudioSegment.from_file("notes_/tD#.mp3")
        print("tD#")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tA.mp3")
        print("tA")
if (R1.betax > 0.5 and R1.betax <= 0.64):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tE.mp3")
        print("tE")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG#.mp3")
        print("tG#")
if (R1.betax > 0.64 and R1.betax <= 0.84):
    if (R1.betay < 0.5):
        audio1 = AudioSegment.from_file("notes_/tF.mp3")
        print("tF")
    if (R1.betay >= 0.5):
        audio1 = AudioSegment.from_file("notes_/tG.mp3")
        print("tG")
if (R1.betax > 0.84 and R1.betax <= 1):
    #if (R1.betay == 0.5):
    audio1 = AudioSegment.from_file("notes_/tF#.mp3")
    print("tF#")

# audio 2, R_2

if (R2.betax == 0):
    if (R2.betay == 0.5):
        audio2 = AudioSegment.from_file("notes_/fC.mp3")
        print("fC")
if (R2.betax > 0 and R2.betax <= 0.17):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fB.mp3")
        print("fB")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time9_ = audio1.overlay(audio2)          # combine , superimpose audio fi
mixed_time9  = mixed_time9_.overlay(audio3)          # further combine , superi

mixed_time9.export("notes_/mixed_time9.mp3", format='mp3') # export mixed  audi
play(mixed_time9)
```

```
tF
fG
cG
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmpsam799cd.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.29 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

Let us now try to use entanglement, teleportation, or what is needed, to somehow `glue' together two or more robots which are pretty close to the target.

In [172]:

```
# to be improved: probabilistic representation of positions for more position-ur
# Python probability plot???
```

When we measure the position of R_1 and we get 1, 1, also R_2 are R_3 in 1, 1. If we measure and we get 0, 0, also R_2, R_3 are in 0, 0. In the following code lines, I separated x, y for clarity, but the idea is the same. In this way, we create an entangled GHZ state $\frac{1}{\sqrt{2}}(|11111\rangle + |00000\rangle)$, where the qubits indicate x- and y-positions. Reward is not included in this discussion, because this section is activated only if all robots present almost the same reward (here, pairwise difference ≤ 0.1).

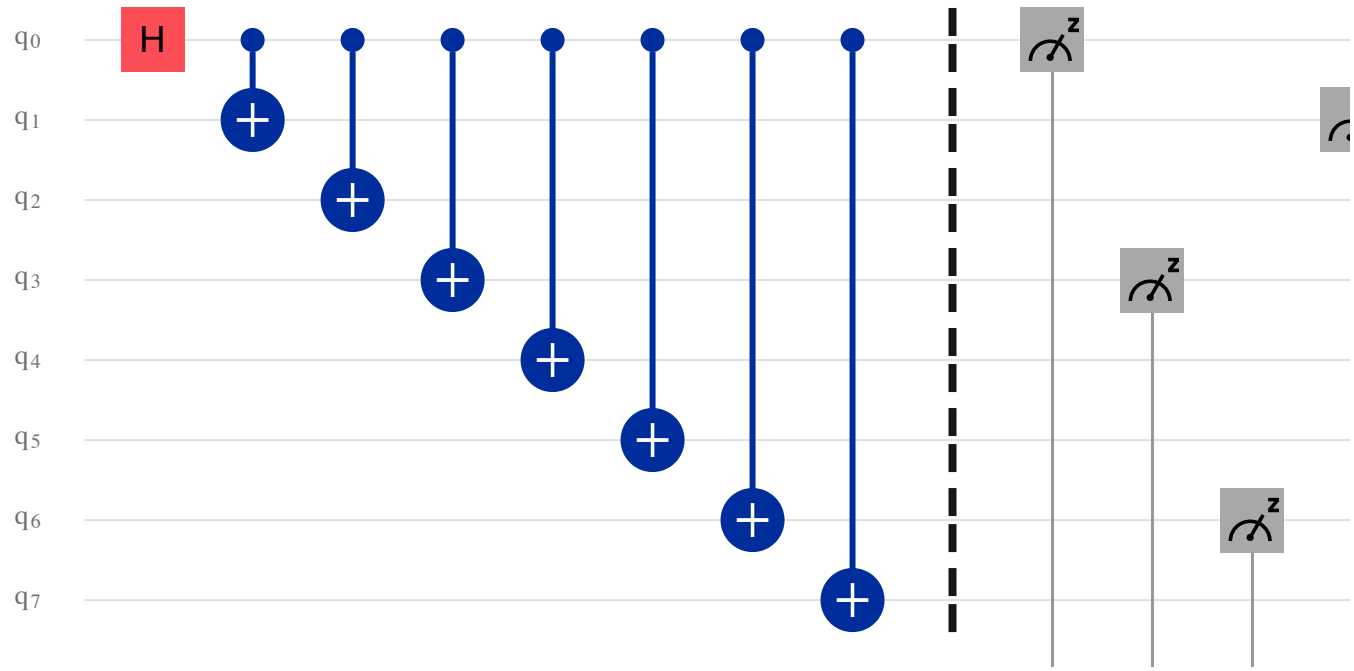
In [173]:

```
# a new circuit
q = QuantumRegister(9, 'q'); # qubits
#c0 = ClassicalRegister(6, 'c0');
c0 = ClassicalRegister(1, 'c0');
c1 = ClassicalRegister(1, 'c1');
c3 = ClassicalRegister(1, 'c3');
c4 = ClassicalRegister(1, 'c4');
c6 = ClassicalRegister(1, 'c6');
c7 = ClassicalRegister(1, 'c7');
qc_small = QuantumCircuit(q, c0, c1, c3, c4, c6, c7);
```

In [174]:

```
if ((R3.delta - R2.delta) <= 0.3) and ((R3.delta - R1.delta) <= 0.3) and ((R2.de
    # 0.3 rather than 0.1
    print("cometa")# GHZ for all
    qc_small.h(q[0]) # Hadamard
    qc_small.cx(q[0], q[1]) # CNOT
    qc_small.cx(q[0], q[2]) # CNOT
    qc_small.cx(q[0], q[3]) # CNOT
    qc_small.cx(q[0], q[4]) # CNOT
    qc_small.cx(q[0], q[5]) # CNOT
    qc_small.cx(q[0], q[6]) # CNOT
    qc_small.cx(q[0], q[7]) # CNOT
    # barrier
    qc_small.barrier(q[0], q[1], q[2], q[3], q[4], q[5], q[6], q[7])
    # measures
    qc_small.measure(q[0],c0[0])
    qc_small.measure(q[3],c3[0])
    qc_small.measure(q[6],c6[0])
    qc_small.measure(q[1],c1[0])
    qc_small.measure(q[4],c4[0])
    qc_small.measure(q[7],c7[0])
    # draw circuit
    draw_circuit(qc_small)
    # definition of quantum simulator
    simulator = Aer.get_backend('qasm_simulator') # statevector_simulator # aer_
    qc_small = transpile(qc_small, simulator)
    # Run and get counts
    result = simulator.run(qc_small, shots=1024).result()
    counts_GHZ_all = result.get_counts(qc_small)
    counts_GHZ = counts_GHZ_all.most_frequent() # does not work if multiple stat
    # decide something if multiple states have the same count --> e.g., ``choose
    print(counts_GHZ_all)
    print(counts_GHZ)
    #plot_histogram(counts_GHZ_all, title='outcomes')
    #plot_histogram(counts_GHZ, title='outcomes')
```

```
cometa
```




```
{'1 1 1 1 1 1': 517, '0 0 0 0 0 0': 507}
1 1 1 1 1 1
```

In [175]:

```
print(counts_GHZ) # order: R3, R2, R1. Add some uncertainty?
# export as an array
str_ = counts_GHZ
arr_GHZ = str_.split(' ') # to split the string and avoid empty spaces as array
print(arr_GHZ)
# We do not need to update rewards; they should be done externally... excluded s
```

```
1 1 1 1 1 1
['1', '1', '1', '1', '1', '1']
```

Define the 'new 0':

In [176]:

```
if (R1.delta >= R2.delta) and (R1.delta >= R3.delta):
    print('gosh')
    new_zero_betax = R1.betax + np.random.uniform(0,0.1)
    new_zero_alphax = 1 - R1.betax
    new_zero_betay = R1.betay + np.random.uniform(0,0.1)
    new_zero_alphay = 1 - R2.betay + np.random.uniform(0,0.1)

if (R2.delta >= R1.delta) and (R2.delta >= R3.delta):
    print('kinda')
    new_zero_betax = R2.betax + np.random.uniform(0,0.1)
    new_zero_alphax = 1 - R2.betax
    new_zero_betay = R2.betay + np.random.uniform(0,0.1)
    new_zero_alphay = 1 - R2.betay

if (R3.delta >= R2.delta) and (R3.delta >= R1.delta):
    print('uffdah')
    new_zero_betax = R3.betax + np.random.uniform(0,0.1)
    new_zero_alphax = 1 - R3.betax
    new_zero_betay = R3.betay + np.random.uniform(0,0.1)
    new_zero_alphay = 1 - R3.betay
```

```
gosh
```

Define the 'new 1':

In [177]:

```
# flip thanks to the 'minus' sign?
# I had tried with if(R1... < R2...) etc., but it is not ok,
# because we need to initialize all elements.

if (R1.delta >= R2.delta) and (R1.delta >= R3.delta):
    print('gosh')
    new_one_betax = R1.betax - np.random.uniform(0,0.1)
    new_one_alphax = 1 - R1.betax
    new_one_betay = R1.betay - np.random.uniform(0,0.1)
    new_one_alphay = 1 - R2.betay

if (R2.delta >= R1.delta) and (R2.delta >= R3.delta):
    print('kinda')
    new_one_betax = R2.betax - np.random.uniform(0,0.1)
    new_one_alphax = 1 - R2.betax
    new_one_betay = R2.betay - np.random.uniform(0,0.1)
    new_one_alphay = 1 - R2.betay

if (R3.delta >= R2.delta) and (R3.delta >= R1.delta):
    print('uffdah')
    new_one_betax = R3.betax - np.random.uniform(0,0.1)
    new_one_alphax = 1 - R3.betax
    new_one_betay = R3.betay - np.random.uniform(0,0.1)
    new_one_alphay = 1 - R3.betay
```

```
gosh
```

Choose the 'new 0' or the 'new 1' according to the outcome of GHZ circuit:

In [178]:

```
if (arr_GHZ[0] =='0'):
    R1.alphax = new_zero_alphax
    R1.betax = new_zero_betax
if (arr_GHZ[1] =='0'):
    R1.alphay = new_zero_alphay
    R1.betay = new_zero_betay
if (arr_GHZ[2] =='0'):
    R2.alphax = new_zero_alphax
    R2.betax = new_zero_betax
if (arr_GHZ[3] =='0'):
    R2.alphay = new_zero_alphay
    R2.betay = new_zero_betay
if (arr_GHZ[3] =='0'):
    R2.alphax = new_zero_alphax
    R2.betax = new_zero_betax
if (arr_GHZ[4] =='0'):
    R3.alphax = new_zero_alphax
    R3.betax = new_zero_betax
if (arr_GHZ[5] =='0'):
    R3.alphay = new_zero_alphay
    R3.betay = new_zero_betay


if (arr_GHZ[0] =='1'):
    R1.alphax = new_one_alphax
    R1.betax = new_one_betax
if (arr_GHZ[1] =='1'):
    R1.alphay = new_one_alphay
    R1.betay = new_one_betay
if (arr_GHZ[2] =='1'):
    R2.alphax = new_one_alphax
    R2.betax = new_one_betax
if (arr_GHZ[3] =='1'):
    R2.alphay = new_one_alphay
    R2.betay = new_one_betay
if (arr_GHZ[3] =='1'):
    R2.alphax = new_one_alphax
    R2.betax = new_one_betax
if (arr_GHZ[4] =='1'):
    R3.alphax = new_one_alphax
    R3.betax = new_one_betax
if (arr_GHZ[5] =='1'):
    R3.alphay = new_one_alphay
    R3.betay = new_one_betay

```

if (arr_GHZ[0] =='0'): # all the other bits are supposed to be equal in GHZ..... R3.alphax = new_zero_alphax R3.betax = new_zero_betax R2.alphax = new_zero_alphax R2.betax = new_zero_betax R1.alphax = new_zero_alphax R1.betax = new_zero_betax if (arr_GHZ[0] =='1'): R3.alphax = new_zero_alphax R3.betax = new_zero_betax R2.alphax = new_zero_alphax R2.betax = new_zero_betax R1.alphax = new_zero_alphax R1.betax = new_zero_betax

New reward for R_1 :

In [179]:

```
R1.delta = reward(T,R1.betax,R1.betay)
R1.gamma = round((1 - R1.delta),2)
print(R1.delta)
```

```
0.7
```

New reward for R_2:

In [180]:

```
R2.delta = reward(T,R2.betax,R2.betay)
R2.gamma = round((1 - R2.delta),2)
print(R2.delta)
```

```
0.7
```

New reward for R_3:

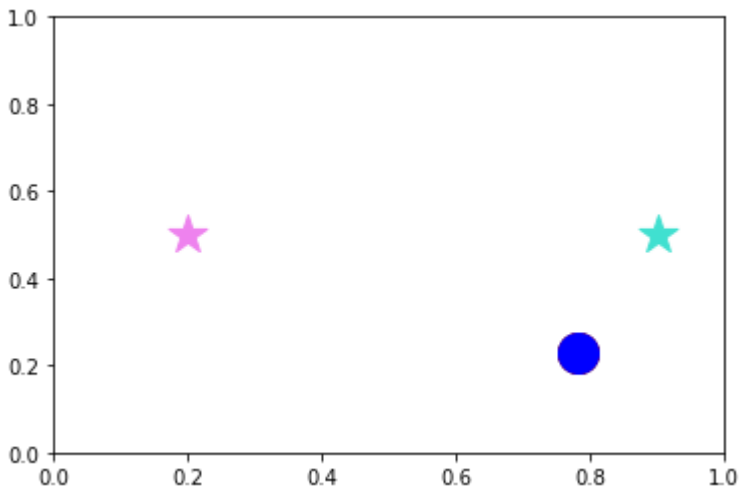
In [181]:

```
R3.delta = reward(T,R3.betax,R3.betay)
R3.gamma = round((1 - R3.delta),2)
print(R3.delta)
```

```
0.7
```

In [182]:

```
x = R1.betax
y = R1.betay
#plt.plot(x,y, 'o', c = 'black');
plt.scatter(x,y, s = 400, c = 'black')

x = R2.betax
y = R2.betay
plt.scatter(x, y, s = 400, c = 'red')

x = R3.betax
y = R3.betay
plt.scatter(x, y, s = 400, c = 'blue')

x = T.x
y = T.y
plt.scatter(x, y, s = 400, marker = '*', c = 'turquoise')

x = T2.x
y = T2.y
plt.scatter(x, y, s = 400, marker = '*', c = 'violet')


plt.axis([0, 1, 0, 1])
plt.show()
print('R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target
```




```
R_1 is black, R_2 is red, and R_3 is blue, Target 1 is turquoise, Target 2 is viol
et
```

In [183]:

```
1
2  # audio 1, R_1
3
4  if (R1.betax == 0):
5      if (R1.betay == 0.5):
6          audio1 = AudioSegment.from_file("notes_/tC.mp3")
7          print("tC")
8  if (R1.betax > 0 and R1.betax <= 0.17):
9      if (R1.betay < 0.5):
10         audio1 = AudioSegment.from_file("notes_/tB.mp3")
11         print("tB")
12     if (R1.betay >= 0.5):
13         audio1 = AudioSegment.from_file("notes_/tC#.mp3")
14         print("tC#")
15 if (R1.betax > 0.17 and R1.betax <= 0.3):
16     if (R1.betay < 0.5): # if (R1.betay >= 0.17 and R1.betay < 0.3):
17         audio1 = AudioSegment.from_file("notes_/tA#.mp3")
18         print("tA#")
19     if (R1.betay >= 0.5):
20         audio1 = AudioSegment.from_file("notes_/tD.mp3")
21         print("tD")
22 if (R1.betax > 0.3 and R1.betax <= 0.5):
23     if (R1.betay < 0.5): # (R1.betay == 1):
24         audio1 = AudioSegment.from_file("notes_/tD#.mp3")
25         print("tD#")
26     if (R1.betay >= 0.5):
27         audio1 = AudioSegment.from_file("notes_/tA.mp3")
28         print("tA")
29 if (R1.betax > 0.5 and R1.betax <= 0.64):
30     if (R1.betay < 0.5):
31         audio1 = AudioSegment.from_file("notes_/tE.mp3")
32         print("tE")
33     if (R1.betay >= 0.5):
34         audio1 = AudioSegment.from_file("notes_/tG#.mp3")
35         print("tG#")
36 if (R1.betax > 0.64 and R1.betax <= 0.84):
37     if (R1.betay < 0.5):
38         audio1 = AudioSegment.from_file("notes_/tF.mp3")
39         print("tF")
40     if (R1.betay >= 0.5):
41         audio1 = AudioSegment.from_file("notes_/tG.mp3")
42         print("tG")
43 if (R1.betax > 0.84 and R1.betax <= 1):
44     #if (R1.betay == 0.5):
45     audio1 = AudioSegment.from_file("notes_/tF#.mp3")
46     print("tF#")
47
48 # audio 2, R_2
49
50 if (R2.betax == 0):
51     if (R2.betay == 0.5):
52         audio2 = AudioSegment.from_file("notes_/fC.mp3")
53         print("fC")
54 if (R2.betax > 0 and R2.betax <= 0.17):
55     if (R2.betay < 0.5):
56         audio2 = AudioSegment.from_file("notes_/fB.mp3")
57         print("fB")
58     if (R2.betay >= 0.5):
59         audio2 = AudioSegment.from_file("notes_/fC#.mp3")
```

```
        print("fC#")
if (R2.betax > 0.17 and R2.betax <= 0.3):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fA#.mp3")
        print("fA#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fD.mp3")
        print("fD")
if (R2.betax > 0.3 and R2.betax <= 0.5):
    if (R2.betay < 0.5): # (R1.betay == 1):
        audio2 = AudioSegment.from_file("notes_/fD#.mp3")
        print("fD#")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fA.mp3")
        print("fA")
if (R2.betax > 0.5 and R2.betax <= 0.64):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fE.mp3")
        print("fE")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG#.mp3")
        print("fG#")
if (R2.betax > 0.64 and R2.betax <= 0.84):
    if (R2.betay < 0.5):
        audio2 = AudioSegment.from_file("notes_/fF.mp3")
        print("fF")
    if (R2.betay >= 0.5):
        audio2 = AudioSegment.from_file("notes_/fG.mp3")
        print("fG")
if (R2.betax > 0.84 and R2.betax <= 1):
    #if (R2.betay == 0.5):
    audio2 = AudioSegment.from_file("notes_/fF#.mp3")
    print("fF#")


# audio 3, R_3


if (R3.betax == 0):
    if (R3.betay == 0.5):
        audio3 = AudioSegment.from_file("notes_/cC.mp3")
        print("cC")
if (R3.betax > 0 and R3.betax <= 0.17):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cB.mp3")
        print("cB")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cC#.mp3")
        print("cC#")
if (R3.betax > 0.17 and R3.betax <= 0.3):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cA#.mp3")
        print("cA#")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cD.mp3")
        print("cD")
if (R3.betax > 0.3 and R3.betax <= 0.5):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cD#.mp3")
        print("cD#")
    if (R3.betay >= 0.5):
```

```
        audio3 = AudioSegment.from_file("notes_/cA.mp3")
        print("cA")
if (R3.betax > 0.5 and R3.betax <= 0.64):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cE.mp3")
        print("cE")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG#.mp3")
        print("cG#")
if (R3.betax > 0.64 and R3.betax <= 0.84):
    if (R3.betay < 0.5):
        audio3 = AudioSegment.from_file("notes_/cF.mp3")
        print("cF")
    if (R3.betay >= 0.5):
        audio3 = AudioSegment.from_file("notes_/cG.mp3")
        print("cG")
if (R3.betax > 0.84 and R3.betax <= 1):
    #if (R3.betay == 0.5):
    audio3 = AudioSegment.from_file("notes_/cF#.mp3")
    print("cF#")

mixed_time10_ = audio1.overlay(audio2)          # combine , superimpose audio f
mixed_time10  = mixed_time10_.overlay(audio3)          # further combine , supe

mixed_time10.export("notes_/mixed_time10.mp3", format='mp3') # export mixed  au
play(mixed_time10)
```

```
tF
fF
cF
Could not import the PyAudio C module '_portaudio'.

Input #0, wav, from '/var/folders/tc/5k6bdv0s421bnc52mnnj7p_w0000gn/T/tmpa3zbxihy.
wav':
  Duration: 00:00:07.34, bitrate: 1411 kb/s
  Stream #0:0: Audio: pcm_s16le ([1][0][0][0] / 0x0001), 44100 Hz, 2 channels, s1
6, 1411 kb/s
   7.25 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0



   7.28 M-A:  0.000 fd=   0 aq=    0KB vq=    0KB sq=    0B f=0/0
```

In [184]:

```
R1.delta, R2.delta, R3.delta
```

Out[184]:

```
(0.7, 0.7, 0.7)
```

In [88]:

```
# January 22, 2022
```

NEW LINES of code: IF the initial reward is very high (greater than 0.8) for at least one of the three robots ("or"), THEN the other robots have to just reach it (with a pretty small fluctuation), without entering the circuit.

In [185]:

```
if((R1.delta >= 0.8) or (R2.delta >= 0.8) or (R3.delta >= 0.8)):
    print('yuk')
    if (R1.delta > R2.delta and R1.delta > R3.delta):
        print('quokka')
        R2.betax = round(R1.betax + np.random.uniform(0,0.1), 3)
        R2.alphax = round(1 - R2.betax, 3)
        R2.betay = round(R1.betay + np.random.uniform(0,0.1), 3)
        R2.alphay = round(1 - R2.betay, 3)
        R3.betax = round(R1.betax + np.random.uniform(0,0.1), 3)
        R3.alphax = round(1 - R2.betax, 3)
        R3.betay = round(R1.betay + np.random.uniform(0,0.1), 3)
        R3.alphay = round(1 - R2.betay, 3)
    if (R2.delta > R1.delta and R2.delta > R3.delta):
        print('quagga')
        R1.betax = round(R2.betax + np.random.uniform(0,0.1), 3)
        R1.alphax = round(1 - R1.betax, 3)
        R1.betay = round(R2.betay + np.random.uniform(0,0.1), 3)
        R1.alphay = round(1 - R1.betay, 3)
        R3.betax = round(R2.betax + np.random.uniform(0,0.1), 3)
        R3.alphax = round(1 - R3.betax, 3)
        R3.betay = round(R2.betay + np.random.uniform(0,0.1), 3)
        R3.alphay = round(1 - R3.betay, 3)
    if (R3.delta > R1.delta and R3.delta > R2.delta):
        print('quark')
        R1.betax = round(R3.betax + np.random.uniform(0,0.1), 3)
        R1.alphax = round(1 - R1.betax, 3)
        R1.betay = round(R3.betay + np.random.uniform(0,0.1), 3)
        R1.alphay = round(1 - R1.betay, 3)
        R2.betax = round(R3.betax + np.random.uniform(0,0.1), 3)
        R2.alphax = round(1 - R2.betax, 3)
        R2.betay = round(R3.betay + np.random.uniform(0,0.1), 3)
        R2.alphay = round(1 - R2.betay, 3)

R1.delta = reward(T, R1.betax, R1.betay)
print(R2.delta)

R2.delta = reward(T, R2.betax, R2.betay)
print(R2.delta)

R3.delta = reward(T, R3.betax, R3.betay)
print(R2.delta)
```

```
0.7
0.7
0.7
```